INDUSTRY-DRIVEN COLLABORATIVE RESEARCH AND DEVELOPMENT SUB-PROGRAM

FINAL EVALUATION REPORT

PREPARED FOR:

NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL OF CANADA

JUNE 2016

PREPARED BY:

R.A. MALATEST & ASSOCIATES LTD.

858 Pandora Avenue	300, 10621 – 100 Avenue	**500, 294 Albert Street**	1201, 415 Yonge St	1301 – 1959 Upper Water St
Victoria, BC V8W 1P4	Edmonton, AB T5J 0B3	**Ottawa, ON K1P 6E6**	Toronto, ON M5B 2E7	Halifax, NS B3J 3N2

TABLE OF CONTENTS

SECTION 1:	**INTRODUCTION**	**1**
1.1	The Industry-driven Collaborative Research and Development Sub-Program	1
1.2	Funding Statistics	3
1.3	Evaluation Objectives	4
SECTION 2:	**APPROACH AND METHODOLOGY**	**6**
2.1	Secondary Data Review	6
2.2	Key Informant Interviews	8
2.3	Case Studies	8
2.4	Document Review	9
2.5	Cost-Efficiency Analysis	9
2.6	Challenges and Limitations	9
SECTION 3:	**RELEVANCE**	**10**
3.1	Continued Need for the Sub-Program	10
3.2	Appropriateness of Federal Involvement	13
3.3	Alignment with Government Priorities	13
SECTION 4:	**EFFECTIVENESS**	**15**
4.1	Differences Among Grants	15
4.2	Importance of the Partner Contribution	15
4.3	Achievement of Immediate Outcomes	15
4.4	Achievement of Intermediate Outcomes	20
4.5	Factors Contributing to or Inhibiting the Achievement of Program Outcomes	29
SECTION 5:	**DESIGN AND DELIVERY**	**31**
5.1	Management of Intellectual Property	31
5.2	Program Features that Facilitate or Inhibit Application	32
5.3	Performance Measurement	32
SECTION 6:	**EFFICIENCY AND ECONOMY**	**33**
6.1	Cost-Efficiency of the Management of the Funding Opportunities	33
6.2	Qualitative Feedback on Efficiency	34
SECTION 7:	**CONCLUSIONS AND RECOMMENDATIONS**	**35**
7.1	Conclusions	35
7.2	Recommendations	36

SUMMARY

This report presents the findings of an evaluation of the Natural Science and Engineering Research Council's (NSERC) Industry-driven Collaborative Research and Development sub-program. The sub-program represents NSERC's largest suite of initiatives supporting industry-academic partnerships. It fosters partnerships in natural sciences and engineering that facilitates the transfer of knowledge and skills to the user sector through awards that support research projects and network activities intended for socioeconomic impact. The partnerships encouraged and enabled by these awards also increase the commercialization of Canada's research through new products, services, and processes for the benefit of all Canadians. This evaluation, conducted in FY 2015/16, covers three of the Industry-driven Collaborative Research and Development grants with total expenditures of $643 million from 2009 to 2014. These three funding opportunities are:

- Collaborative Research and Development (CRD) grants, which provide funding for up to 5 years to well-defined projects undertaken as partnerships between university researchers and partners in private industry;
- Industrial Research Chairs (IRC) grants, which award professorships to individuals for an initial period of 5 years (renewable in 5 year increments) who leverage their outstanding stature by integrating an industry-based collaboration at a university; and
- Engage grants, which support well-defined 6 month research projects that are new partnerships between university researchers and private industry with amounts limited to $25,000.[1]

This evaluation is based on a variety of sources of information: a secondary data review; an administrative data review; key informant interviews; case studies; a literature review; and a cost-efficiency analysis. The conclusions of the evaluation are as follows.

Relevance

The Industry-driven Collaborative Research and Development sub-program is designed to meet the needs of both industrial partners and academic researchers: projects address real world challenges that are relevant to industry, help build sustainable relationships between the two sectors, and connect people and skills. Each funding opportunity included in the sub-program adopts a different means to achieve common objective: fosters partnerships in natural sciences and engineering that facilitates the transfer of knowledge and skills to the user sector through awards that support research projects and activities intended for socioeconomic impact. The partnerships encouraged and enabled by the sub-program also increase the commercialization of Canada's research through new products, services, and processes for the benefit of all Canadians. While industry R&D expenditures in Canada decline, these grants are attracting increased levels of partner contributions, and the partners tend to maintain or increase their R&D expenditure after the grants.[2] At the same time, university researchers benefit from establishing and maintaining partnerships between academia and industry by having an opportunity to conduct research and create new knowledge and technology for company-specific needs. Students become exposed to R&D in industrial environment, as well as gain expertise and knowledge required for future employment.

The sub-program is well aligned with the priorities of the federal government and NSERC. The 2014 Government of Canada S&T strategy "Seizing Canada's Moment: Moving Forward in Science, Technology and Innovation" encouraged partnerships and justified federal government involvement in industry-focused research as one contributor in a large innovation ecosystem of funding and support. In the recent years, the Federal Government continued to play an important role in encouraging collaborations since the level of private investment in R&D in Canada has decreased.

The sub-program objectives also mirror the priorities of the current government, which focuses on improvement of programs that support innovation, scientific research and entrepreneurship, as well as the development of an Innovation Agenda with intent to expand effective support for the emerging national network for business innovation and cluster support. The Government believes that investing in an appropriate balance between fundamental research to support new discoveries and the commercialization of ideas will lead to sustainable economic growth. The sub-program has been

[1] IRC grants have been in operation since 1978; CRD grants since 1983; and Engage grants since 2009.
[2] During this period, NSERC implemented the Strategy for Partnerships and Innovation (SPI). The Industry-driven Collaborative Research and Development sub-program was the most important vehicle in the strategy for funding additional industry-academic partnerships. As a result of the strategy implementation, the number of industry partners was doubled and private sector investment in R&D conducted with universities increased.

shown to be a flexible and effective tool that allows industry access to the 'brain trust' that has been developed in universities across Canada and therefore is a perfect fit within the larger Innovation Agenda.

Performance

The university-industry partnerships supported by the industry-driven funding opportunities are generally successful at fostering meaningful collaborations that last beyond the funding period. IRC grants are more likely to result in collaborations beyond the original group than CRD; though they are both effective at doing so. There is evidence that IRCs tend to reinforce existing partnerships rather than create new ones which is not surprising considering the size of the investment by the industry. It has been noted that the relationship between a company and a university can begin by satisfaction in completion of a project funded through a CRD grant followed by further investment in an IRC based on that success. By design, Engage grants involve new partnerships and, therefore, contribute to bridging the gap between researchers and industry.

Long-term relationships, defined as relationships that have continued past the completion of the initial grant, are typically established as part of the industry-driven funding opportunities – less so after the small Engage grants but still leaving the parties intending to continue collaborating. The nature of the long-term relationships is varied and consistent with the interests and resources of the parties.

The industry-driven funding opportunities have substantially contributed to enhancing the research capacity of the university researchers involved – through improved access to facilities, expertise, data, equipment, and intelligence on future research directions as well as additional resources for hiring personnel. There have also been positive effects on the research capacity of universities. The grants opened up new opportunities for research beyond the original objectives, influenced the direction towards more industrially relevant topics, assisted in attracting better qualified personnel, and generally contributed to the improved knowledge base of universities.

As part of the evidence gathered, industrial partners reported that the grants had significant impacts on competitiveness and productivity. Increased market visibility was the most frequently reported type of impact on competitiveness, followed by access to new markets. About one-half of partners indicated that their revenues increased since the end of the grant; representing on average an increase of 22 percent over all grant types. When asked how much of the increase could be attributed to the grant, the result is more modest; roughly 5 percent. The survey results indicate that partners who participated in these grants tend to maintain or grow their R&D budgets after their participation. When reported decreases to R&D budgets are factored in against reported increases, the estimated net effect is in the range of a 5 percent increase in R&D budgets.

The transfer of knowledge to industrial partners is another benefit that companies can obtain, and was a motivating factor at the outset for three-quarters of partners. Evaluation evidence indicated that such transfer does occur, sometimes with a single company and other times to an entire industry. Almost 85 percent of partners surveyed indicated that the skill and knowledge base of the organization had been, or was likely to be enhanced as a result of the grant. Reports provided to partners and formal publications were the main mechanisms used in transferring knowledge to industrial partners.

The industry-driven funding opportunities involved substantial numbers of students and fellows in applied industrial research and their involvement was multifaceted, including interacting with industry partners and presenting results. Students and fellows frequently described developing their skills and gaining experience in diverse areas as a direct result of their participation in the research program. Positive impacts on highly qualified personnel (HQP) employment were also documented. Training of HQP was an important motivator for many industry partners to get involved in these types of grants: it is seen as a way to train and to assess potential future employees and, therefore, to contribute to the value proposition. It has been shown that transfer of knowledge through the hiring of university graduates who worked on the project can be very effective.

While a number of benefits for industrial partners were identified, it is clear that the desire of industry partners to continue to partner for R&D depends on the economic benefits of research outcomes in which the grants are one factor among many others.

Efficiency

Over the period of 2010-2011 to 2013-2014, the average administrative cost ratio was 8.17 cents for every $1 of CRD grants (which was slightly higher than the overall ratio for the RP Directorate[3]) and 6.73 cents for every $1 of IRC grants, (which was in line with the ratio for the RP Directorate). The average administrative cost ratio for Engage grants was slightly higher at 10.18 cents for every $1 of awarded grants. This is due to the higher administrative costs in the beginning of the program. Launched in 2009, Engage is a new funding opportunity and administrative costs are often higher at the initial stage. Over the evaluation period, Engage administrative costs dropped by almost one-half and are currently in line with the costs of the other industry-driven grants.

Recommendations

Recommendation #1. Maintain the Industry-Driven funding opportunities. . The grants support the role of NSERC in contributing to the Canadian ecosystem of innovation by encouraging research collaborations between industry and universities and are well aligned with government priorities. They are designed to meet the needs of both industrial partners and academic researchers, in which each funding opportunity adopts different means to achieve common objective: fosters partnerships in natural sciences and engineering and facilitate the transfer of knowledge and skills to the user sector. Program management has demonstrated that it is equipped to address the changing landscape of university-industry collaboration via incremental changes to the programs.

Recommendation #2. Continue efforts to develop common metrics for the measurement of impacts on industry and consider homogenizing vocabulary among grants. All three grants have very evolved performance measurement systems that have contributed to the on-going management of the program, as well as to this evaluation. These systems could be improved by increasing the use of common measurements to assess impacts on industry. Additionally, some terminology would benefit from more homogeneity across the grants use, such as the notions of partnership, collaboration, and networking as well as the various activities associated with knowledge (creation, dissemination, exchange, translation, mobilisation, etc.).

Recommendation #3. Consider revising the Engage logic model to improve alignment with the objectives of the grants. While the Engage logic model was built cooperatively with grant administrators, it includes some outcomes that are not related to program objectives and for which Program management should not be held accountable for achieving (e.g., HQP training).

[3] 6.56 cents per $1 of grants awarded

SECTION 1: INTRODUCTION

This report presents the findings of an evaluation of the Natural Science and Engineering Research Council's (NSERC) Industry-driven Collaborative Research and Development sub-program. Funding opportunities under this sub-program were evaluated jointly in FY 2015/16, in accordance with the 2009 Treasury Board *Policy on Evaluation*. This evaluation covers three grants that are part of the sub-program: *Collaborative Research and Development (CRD) grants, Engage grants, and Industrial Research Chairs (IRC) grants* which comprise the bulk of the sub-program. The remaining funding opportunities[4] have been excluded from this evaluation based on a recommendation of the evaluation advisory committee because they were deemed too small, or of very narrow scope.

This report provides a brief background of the sub-program, the evaluation, methodological approach, findings by evaluation issue, conclusions, and recommendations.

1.1 The Industry-driven Collaborative Research and Development Sub-Program

The Government of Canada's 2014 Science and Technology Strategy, *Seizing Canada's Moment: Moving Forward in Science, Technology and Innovation* is guided by the core principles of promoting world-leading excellence, focusing on priorities, fostering partnerships[5] and enhancing accountability. It prioritizes business innovation by way of synergies with Canada's research capacities. NSERC uses research partnerships in a number of programs that have a common purpose in promoting closer collaboration between the academic research community and other sectors, including government, not-for-profits, and most notably, Canadian industry. More specifically, the Research Partnerships (RP) Directorate achieves its objectives by supporting research through several sub-programs, including the Industry-driven Collaborative Research and Development sub-program. This sub-program is comprised of a number of grant types, among them the CRD grants, the IRC grants, and the Engage grants.[6] The program logic models are available in Appendix A.

A researcher can hold IRC grants, CRD grants, and Engage grants concurrently, as well as other types of NSERC grants such as Discovery grants.[7]

CRD grants, established in 1983, provide funding for up to 5 years to well-defined projects undertaken as partnerships between university researchers and partners in private industry. The collaborations are intended to be mutually beneficial: Canadian companies are given access to the rich knowledge, expertise, and educational resources available at Canadian postsecondary institutions while university researchers gain valuable hands-on expertise and students are given the opportunity to train in essential skills that will make them valuable to industry. The objectives of the CRD are as follows:

- To give companies operating from a Canadian base access to the unique knowledge, expertise and educational resources at Canadian postsecondary institutions;
- To train students in essential technical skills required by industry; and,
- To offer opportunities for mutually beneficial collaborations that result in industrial and/or economic benefits to Canada.

[4] Funding opportunities not included are Chairs in Design Engineering, Innovation Frontiers, Regional Opportunities, Interactions Grants, and Partnership Workshops. Effective April 1, 2015, the opportunities previously available through the Interaction Grants, Regional Opportunities Fund and Partnership Workshops Grants are now available as Connect Grants.

[5] This evaluation uses three interrelated terms: partnership, collaboration, and networking. While the Engage, CRD, and IRC grants do not use common definitions, these terms are defined as follows in this report. A *partnership* is a relationship between or among separate organizations that commit to work together to achieve shared goals of mutual benefit; partners generally commit in-kind or cash contributions. A *collaboration* is a relationship between or among researchers who make a significant contribution to the intellectual direction or the conduct of research or a research-related activity. A *network* is a collaboration model connecting researchers, HQP, administrators, managers, and directors, across public, academic, private, and not-for-profit sectors and who may geographically span the country.

[6] Natural Science and Engineering Research Council (2006). Results-Based Management and Accountability Framework for the Research Partnerships Programs. Draft.

[7] Discovery Grants support ongoing programs of research (with long-term goals) rather than a single short-term project or collection of projects. These grants assist in promoting and maintaining a diversified base of high-quality research capability in the natural sciences and engineering in Canadian universities; fostering research excellence; and providing a stimulating environment for research training. See http://www.nserc-crsng.gc.ca/Professors-Professeurs/Grants-Subs/DGIGP-PSIGP_eng.asp.

Projects must have defined objectives in the short to medium term, and may consist of separate phases in a program of longer-range research. Projects may range from one year to five years in duration; most awards are for two or three years. Each project is required to have the support of at least one industrial partner. Support from industry is to include:

- Direct contributions to project costs equal to or greater than the amount requested from NSERC (at least half in cash - the remainder can be in-kind);
- Collaboration at all stages of the research project, from proposal development to regular interactions with all those working on the project, and provision of input; and
- Demonstration of clear intent and capacity to make use of the results of the research in Canada.

IRC grants award professorships to individuals who leverage their outstanding stature by integrating an industry-based collaboration at a university. They were established in 1978. The objectives of the IRC are as follows:

- Assist universities in building on existing strengths to achieve the critical mass required for a major research endeavour in natural sciences and engineering of interest to industry;
- Assist in the development of research efforts in fields that have not yet been developed in Canadian universities but for which there is an important industrial need; and
- Provide an enhanced training environment for graduate students and, where appropriate, postdoctoral fellows by exposing them to research challenges unique to industry and the opportunity for significant ongoing interactions with industrial partners.

IRC proposals must be in an area of high priority to both the university and the partner(s).[8]

Grants can support the salary of a chair holder, as well as research tools and instruments, HQP salaries, and general expenses related to their program of research. Universities nominate a chair candidate, but the position is funded jointly between NSERC and industry. The industrial cash commitment should be at least equal to that of NSERC during the same period. There are currently three types of IRC grants:

- **Senior Industrial Research Chairs** for distinguished senior researchers (five-year appointment, renewable);
- **Associate Industrial Research Chairs** for early-stage researchers demonstrating exceptional promise (five-year appointment, renewable once); and
- **Executive Industrial Research Chairs** for outstanding industrial research and development (R&D) professionals (five-year appointment, non-renewable).

Grant duration is five years. Applications for two out of the three grant types are renewable.

Like CRD grants, ***Engage*** grants support well-defined research projects that are partnerships between university researchers and private industry. They are aimed, however, at university researchers and companies who have never worked together before: there can be no existing or past relationship between the person applying for funding and the company whose problem the project intends to address. Launched in 2009, they were designed to overcome challenges identified in launching new collaborations and are used as a means to introduce new industry partners to the benefits of university research, Engage grants are unique from all other NSERC grants for a number of reasons:

- There is no Intellectual Property (IP) agreement – the IP arising from the project is assigned to the company alone.
- The application has a very quick turnaround, averaging at 26 days.
- Applications are not sent for external peer-review. For applicants (researchers) to be eligible, they must demonstrate peer-reviewed support from the previous six years. This is usually shown through a previous application for a grant, often an NSERC Discovery Grant. Decisions are made internally by NSERC staff.
- Proposals to the Engage grant do not need to include training of HQP although, in reality, many do.

The Engage grant provides a maximum of $25,000 to the academic researcher to support a six-month research and development project. The Engage Plus grants can support a project for an additional six months. Eligible projects are

[8] See http://www.nserc-crsng.gc.ca/Professors-Professeurs/CFS-PCP/IRC-PCI_eng.asp

intended to address a company-specific problem; the project must be aimed at generating new knowledge or applying existing knowledge in an innovative way. Funds are intended to cover direct research costs. There is no cash requirement from industrial partners; they are only expected to provide an in-kind contribution reflecting their involvement in the project.

1.2 Funding Statistics

Table 1.1 and Chart 1.1 describe the level of program activity between 2009 and 2014. The number of new grants, the success rate, and the level of total grant expenditures by year and program are displayed. Note that high success rates are due to the fact that applications can be submitted at any time (i.e., proposals are examined on an ongoing basis), industry has already vetted the proposal and found it of high enough quality to support (with cash in the case of CRD and IRCs), program staff review and provide feedback on draft applications and in the case of CRDs, applicants are sometimes given the opportunity to respond to negative peer review evaluations.

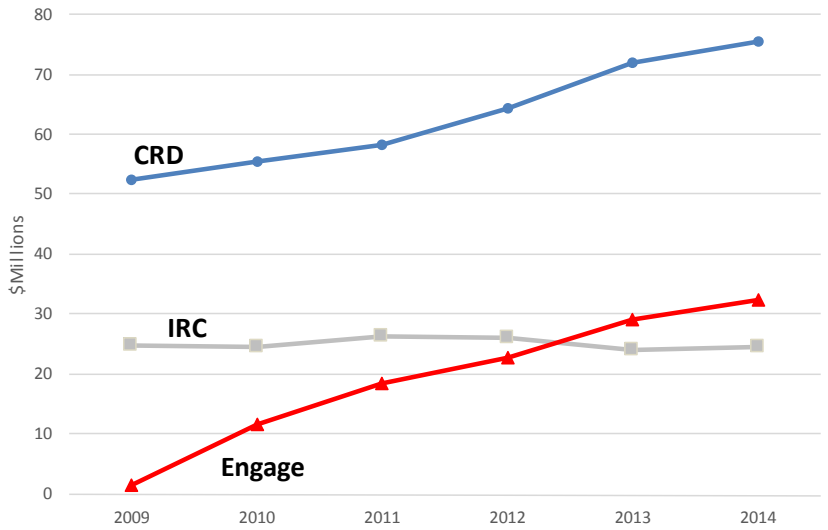
Both CRD grants and Engage grants have seen significant increases in activity from 2009 to 2014. In the case of Engage grants which were initiated in 2009, the number of grants awarded has grown dramatically – surpassing in five years the funding envelope for Industrial Research Chairs. This clearly demonstrates that more Canadian companies out there want to explore working with universities to accomplish their R&D goals. In comparison, IRC activity, be that in terms of chairs or in terms of overall expenditures, has been stable through the period. In 2014, program expenditures for the three grants being evaluated amounted to $132 million (CRD grants, $75.38M or 57% of the sub-program expenditures; IRC grants, $24.41M or 19%; Engage grants, $32.32M or 25%).

TABLE 1.1 – 2009-2014 Grant activity according to administrative files

		Awarded*	Success Rate	Expenditures ($M)
CRD grants	2009	277	84%	52.49
	2010	252	83%	55.51
	2011	314	83%	58.11
	2012	329	80%	64.22
	2013	343	81%	71.95
	2014	376	84%	75.38
IRC grants	2009	23	64%	24.63
	2010	30	81%	24.53
	2011	23	92%	26.40
	2012	25	83%	26.10
	2013	26	84%	24.08
	2014	27	75%	24.41
Engage grants	2009	58	87%	1.37
	2010	509	89%	11.55
	2011	719	89%	18.31
	2012	925	86%	22.78
	2013	1180	87%	29.07
	2014	1310	85%	32.32

* For IRCs this includes renewals for an addition 5-year term.

CHART 1.1 - 2009-2014 Program expenditures according to administrative files



1.3 Evaluation Objectives

The overarching objective of this project was to complete an evaluation of the Industry-driven Collaborative Research and Development sub-program (more specifically CRD grants, Engage grants, and IRC grants) to support the continuous improvement of the funding opportunities, to contribute to informed decision-making, to learn about what works and what does not (and in which circumstances), and comply with the Treasury Board Secretariat *Policy on Evaluation* (2009) and Section 42.1 of the *Financial Administration Act* regarding evaluation coverage. CRD grants were last evaluated in 2010, while IRC grants were last evaluated in 2006. Engage grants were launched five years ago, and have never been evaluated before. In keeping with the *Policy on Evaluation*, the evaluation covers fiscal years 2009/10 through 2013/2014.

The evaluation conforms to the *Policy on Evaluation* and its associated Directive and Standards by addressing these key evaluation issues:

- **Relevance**, the extent to which the sub-program addresses a continued need, is aligned with federal government priorities and departmental strategic outcomes, and is aligned with federal roles and responsibilities:
  - To what extent is there a continued need for the grants?
  - To what extent does federal government have a role in funding industry-driven research and development?
  - To what extent are the objectives of the grants aligned with departmental and government-wide priorities?
- **Performance**, the extent to which the sub-program has achieved its expected outcomes; the Policy on Evaluation identifies three dimensions of performance:
  - **Effectiveness**, the progress toward expected outcomes with reference to performance targets and program reach, program design, including the linkage and contribution of outputs to outcomes:

    Immediate outcomes:

    - To what extent have partnerships and/or collaborations been formed between university researchers and industries?
    - To what extent has the research capacity of researchers been enhanced?
    - To what extent have universities been able to increase their research capacity in areas directly related to the IRC?
    - To what extent have grants led to the enhancement of networks and partnerships between universities and industrial partners?

- To what extent have universities improved their knowledge base and/or technology in industrially relevant areas?

Intermediate outcomes:

- To what extent have long-term relationships (relationships that have continued past the completion of the initial grant) been established between academic researchers and industrial partners?
- To what extent have industrial partners experienced benefits from partnering with university researchers?
- To what extent has involvement in the grants encouraged industry partners to continue with, or expand, their research and development efforts?
- What are the impacts on HQP involved in grants?
- To what extent do HQP involved in grants obtain employment in their field?
- To what extent is knowledge being transferred to Canadian companies and non-partners (e.g., industry, academia, etc.)?
- What factors, internal or external to the grants, contribute to the achievement of outcomes? What factors inhibit it?

- **Efficiency**: the extent to which expected outputs are produced with the least amount of input (resources), and **economy**, the extent to which costs of resources used for the sub-program are minimized while considering both quality and quantity:
  - **Design and delivery**: How was IP managed? Are there any challenges or points of confusion?
  - **Efficiency/Economy:**
  - To what extent are the grants being delivered efficiently? In what ways might efficiency be improved?
  - Is the unit cost of managing the program appropriate?

SECTION 2: APPROACH AND METHODOLOGY

This evaluation is based on a variety of sources of information: a secondary data review; an administrative data review; key informant interviews; case studies; a literature review; and a cost-efficiency analysis. This section provides an overview of these methods as employed in the evaluation.

2.1 Secondary Data Review

A major component of this study was an extensive analysis of surveys conducted for NSERC for this evaluation and reports filed by recipients through the normal grant management process. In preparation for an assessment of the Strategy for Partnerships and Innovation[9] (SPI) and for the evaluation of industry-driven funding opportunities, the Evaluation Division of NSERC conducted surveys of researchers, partners, and students in 2014. The data included CRD grants with completion dates between July 2010 and July 2013; Engage grants with completion dates between July 2011 to August 2012; IRC grants without renewals with completion dates between July 2007 and July 2011; as well as IRC grants with renewals that are currently funded.

- ***SPI Researcher Survey***, which contains responses from, among others, the three grants relative to this evaluation (only these were included in the analysis).
- ***SPI Partner Survey***, which was conducted concurrently with and in a manner similar to the researcher survey, with partners of the projects used for the SPI researcher survey. Only data relevant to this evaluation were used.
- ***SPI Survey of HQP*** included students (college, Bachelors', Masters', and PhD) and postdoctoral fellows who participated in SPI projects and industry-driven funding opportunities. Full survey administration occurred in the winter of 2015 for the SPI HQP survey. Only data relevant to this evaluation were used.

Also, researchers and partners involved in CRD, IRC, and Engage grants report periodically on the activities and outcomes of their grant. These reports were mined for the purposes of this evaluation:

- ***Final Reports for Researchers***, which contain information from the researchers' perspective on the outcomes and benefits of their participation in the grants. The 40 CRD and 15 IRC Final Reports used in the qualitative analysis include competition years from 2001 to 2013. Engage Final Reports for Researchers contain information from the researchers' perspectives on the process and progress of research projects funded by Engage grants. The 45 Engage Final Reports used in the qualitative analysis include competition years from 2011 to 2014. All available reports were used in the quantitative analysis of final reports; see Table 2.1 for exact numbers.
- ***Engage Final Reports for Partners***, which provided information similar to that supplied by researchers in their Final Reports, but from the partners' point of view.
- ***Engage Impact Survey,*** which takes place 12 months after the grant completion and is concerned with impacts of the research collaboration on the partner's business, use of the research findings, and the relationship with the researcher. It included information from partners who concluded their research in 2009 to 2012.

The sample sizes, numbers of respondents, and margins of error for the secondary data review sources are provided in Table 2.1.

[9] SPI initiatives aim to accelerate research in areas of national importance to Canada and where the country can be a world leader.

TABLE 2.1 – Sample size and responses for surveys and Final Reports

Data Source	Sample	Responses	Response Rate	Margin of Error
SPI Researcher Survey				
CRD grants	602	229	38%	±5.1%
Engage grants	380	146	38%	±6.2%
IRC grants	107	37	35%	±12.9%
SPI Partner Survey				
CRD grants	822	214	26%	±5.3%
Engage grants	469	204	43%	±5.6%
IRC grants	300	91	30%	±9.3%
SPI HQP Survey[10]				
CRD grants	N/A	262	N/A	N/A
Engage grants	N/A	82	N/A	N/A
IRC grants	N/A	183	N/A	N/A
Final Reports for Researchers[11]				
CRD grants	1250	1214	97%	N/A
Engage grants	2893	2534	88%	N/A
IRC grants	25	23	92%	N/A
Engage Grant Final Report for Partners and Impact Survey				
Final Reports for Partners	2895	1960	68%	N/A
Impact Survey	1645	818	50%	±2.4%

Each grant was examined independently of the others; comparisons were also performed between opportunities. Different categories within grants were examined. These groupings were chosen based on the availability of data and on the likelihood of finding relevant differences.[12] The following factors were analyzed:

- short and long CRD grants: CRD grants were split into two categories according to whether they last less than three years or three years or more;
- industry in-kind contribution: below median in-kind contribution vs. median and above in-kind contribution;
- industry cash contribution: below median cash contribution vs. median and above cash contribution;
- IRC grants being new or renewed;
- region of research institution; and,
- level of NSERC funding to research institution.

This segmented analysis uncovered a number of limited differences but few that were recurrent enough to form a pattern. In the findings, we report only instances of differences that were observed repeatedly.

A qualitative analysis of a sample of Final Project Reports from IRC grants, CRD grants and Engage grants was also conducted. The sample included 45 Engage grants, 40 CRD grants (20 shorter grants and 20 longer), and 15 IRC grant Final Reports. Data from open-ended questions in the Final Reports were analyzed based on key outcomes in the evaluation matrix including: development of active, productive partnerships; improvement of research capacity at universities; establishment of ongoing relationships; mobilization and transfer of knowledge;[13] and, training of HQP.

[10] NSERC has no list of HQP involved in grants; therefore, the surveys of HQP used a snowball (reference) approach which is not amenable to establishing the size of the population, the dimension of the sample, and the ensuing response rate.
[11] Final reports are considered census-like; therefore, it is not appropriate to calculate a margin of error on the estimates produced from these sources.
[12] Industrial sector or the company size were not among the factors analyzed.
[13] The vocabulary around knowledge management is not quite consistent in the grant documentation and reporting. The NSERC Strategic Objective no 1 (Canada is a world leader in advancing, connecting and applying new knowledge in natural sciences and engineering) suggests the following vocabulary: *advancing*, knowledge creation/knowledge production; creation or extension of knowledge; *connecting*, diffusion, dissemination, and communication of research results; *applying*, knowledge mobilization (e.g.: prototype development; market studies; IP).

2.2 Key Informant Interviews

Key informant interviews (N=25) were conducted with a variety of key stakeholders to the industry-driven funding opportunities. The distribution of informants is as follows:

- NSERC senior management and program staff (3);
- Unfunded project applicants (2);
- Members of the Advisory Committee on University-Industry Grants (ACUIG) (3);[14]
- Research Vice Presidents of universities that frequently use the grants (6); and,
- Associate IRC Chair holders (11)[15].

The evaluation team compiled a list of potential informants in consultation with the Project Authority. Following interviewee selection, NSERC sent out invitation emails to potential key informants. Shortly after, the evaluation team sent follow-up emails asking key informants about their availability to participate in an interview. If necessary, phone calls were also made to determine availability. Interviews with all key informants except Associate Chairs took approximately 45 minutes to an hour. Interviews with Associate Chairs ranged between 20 and 30 minutes. All interviews were conducted in the respondents' official language of choice. Interviews with program management and staff took place in person, while all others were conducted by telephone. Findings from these interviews were summarized in an Excel-based template, recorded by evaluation question.

2.3 Case Studies

Twelve mini-case studies examined four funded projects from each of the three grants (CRD, IRC, and Engage).

Cases were selected so as to include a range of partnership success. Within each of the funding opportunities, program staff were asked to nominate up to 6 grants, half of which were "very successful in terms of reaching the program objectives" according to researchers' and, when available, partners' reports as well as staff knowledge, and half of which "were not able to reach the program objectives to the extent expected". Within these, Evaluation Division staff and the consultant selected a sample which included a range of disciplines, industries and regions. When cases declined or did not respond, Evaluation Division staff and the consultant selected the most similar backup. Several of the cases identified as having been less successful in fact declined participation or did not respond to the invitation after several reminders: this was the case for three IRC grants, one Engage grant, and two CRD grants. In total, 18 cases were invited and 12 participated; overall, the completed case studies respected the balance between more and less successful grants as planned.

Each of these mini-case studies consisted of:

- a file review of project documentation, including application reviews, progress and final reports submitted by grant holders as well as each of their industrial partners, and correspondence pertaining to various aspects of the grants' implementation. This was supplemented by additional internet research to follow up on the current status of issues mentioned in interviews; and,
- interviews with the grant's principal investigators and main industry partners. In the case of Engage grants, the one partner organization was solicited for an interview. For IRC grants, at least two partners were solicited for interviews, although not all responded. For CRD grants, one or two partners were approached depending on the size of the grant.

[14] ACUIG is a multidisciplinary advisory committee with a mandate to make recommendations to the NSERC President or his delegate on awards to be made under NSERC's University-Industry Programs; the Committee on Research Partnerships on policy modifications to the programs; and staff on changes in administrative procedures. ACUIG makes funding recommendations for CRD proposals requesting in excess of $150,000 but less than $200,000 a year from NSERC taking into consideration the recommendations of external written peer reviews; CRD proposals requesting in excess of $200,000 a year from NSERC taking into consideration the recommendations of a site visit committee; and all new IRC proposals and those renewal Chair applications requesting in excess of $150,000 a year from NSERC. Members of ACUIG are selected on the basis of their personal expertise and are appointed for terms of up to three years. See http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Committees-Comites/UniversityIndustry-UniversitesIndustrie_eng.asp.

[15] Associate IRC Chairs are early-stage researchers who demonstrate exceptional promise. Interviews with Associate IRC Chairs were proposed by Program senior management to explore the impact of IRC grants on their career. Senior Chair holders were interviewed as part of the case studies.

Data from interviews and file review were entered into in an Excel-based template. Qualitative analysis identified prominent cross-case themes for each evaluation question.

2.4 Document Review

A review of the documents was conducted by NSERC to support the analysis of the grants' operating environment, the role of the federal government in R&D, the alignment of the grants to NSERC's strategic outcomes, and the need for industry-driven partnerships.

2.5 Cost-Efficiency Analysis

NSERC conducted a cost-efficiency analysis aimed at assessing the operational efficiency of the sub-program. Operational efficiency is a measure of the unit cost of managing these research grants. Financial data were reviewed to assess the operational efficiency of each funding opportunity in comparison to the RP Directorate and NSERC overall. The data were provided by NSERC-SSHRC's Finance and Awards Administration Division.

The analytical approach used divides expenditures into direct salary, direct non-salary, and indirect costs which are allocated to the most detailed level possible. The methodology uses full cost allocation, which includes indirect costs. Direct salary administrative expenditures include salaries and the costs of the Employee Benefits Plan. Direct non-salary administrative expenditures include costs, such as those associated with transportation, telecommunications, publishing, professional and special services, printing, etc. Indirect administrative expenditures include costs generated by other divisions, such as Corporate Internal Audit and the Common Administrative Services Directorate (CASD).

2.6 Challenges and Limitations

While conducting the data collection for this evaluation, the evaluation team encountered some challenges.

- ***Limited availability of informants***. This evaluation necessitated interviews with key informants who were often busy, making them difficult to reach to schedule interviews. This situation was managed by making prompt and regular contact with individuals to ensure their participation in the research, by being flexible with regards to timing to accommodate respondents' schedules and time zones, and in some cases, by involving NSERC officials in contact attempts.
- ***Reluctance to participate in qualitative data collection:*** It was particularly difficult to obtain input from applicants who had not received funding or who had been involved in less successful projects. Attempts to contact unfunded applicants for interviews were discontinued and resources were reinvested in other lines of evidence. As a consequence, interviews with unfunded applicants were not used as a line of evidence because of insufficient participation; this contributed to the absence of a comparison group in this evaluation. It is acknowledged that these points of view would have been valuable in assessing the possible grants shortcomings. For case studies, several investigators either did not respond or declined to participate. This seemed to be especially true of cases identified by program staff as having been less successful and especially for IRC grants. These cases were replaced by backups, but it remains possible that this reduced the variance of the information collected.
- ***Lack of comparison group***. No comparison groups were available to determine in an independent fashion what the incremental impacts of the funding opportunities were. The original design of the evaluation included interviews with unfunded applicants but, as explained above, this effort was not successful. Throughout this report, impacts of grants are documented via the researchers' and industrial partners' self-assessments and before-after comparisons performed by partners. That being said, the evaluation benefits from the convergent or competing points of view of researchers, partners and students.
- ***Non-random sample of HQP.*** The results from the survey of HQP must be treated with caution, as the sample used was built using a snowball technique, making it a non-random sample possibly not representative of students and fellows trained as part of the Industry-driven grants.

SECTION 3: RELEVANCE

The Industry-driven Collaborative Research and Development sub-program is designed to meet the needs of both industrial partners and academic researchers: projects address real world challenges that are relevant to industry, help build sustainable relationships between the two sectors, and connect people and skills. Each funding opportunity included in the sub-program adopts a different means to achieve common objective: fosters partnerships in natural sciences and engineering that facilitates the transfer of knowledge and skills to the user sector through awards that support research projects and activities intended for socioeconomic impact. The partnerships encouraged and enabled by the sub-program also increase the commercialization of Canada's research through new products, services, and processes for the benefit of all Canadians. The evaluation concludes that the objectives of the sub-program mirror the priorities of both the previous and the current Governments. The sub-program has been shown to be a flexible and effective tool that allows industry access to the 'brain trust' that has been developed in universities across Canada and therefore is a perfect fit within the larger Innovation Agenda.

3.1 Continued Need for the Sub-Program

Canada has one of the most educated work forces in the world. In 2012, Canada had the highest percentage of adults (aged 25-64) who had attained tertiary education among the OECD countries (53% against the OECD average of 32%)[16] and 30% of the labour force filled S&T jobs.[17] In 2014, Canada ranked sixth among the OECD countries with regard to the higher education spending on R&D (HERD) as a percentage of GDP.[18] It also ranks in the top ten countries in regard to the number of publications in Natural Sciences and Engineering.[19]

Despite a healthy research environment and some of the world's most generous incentives to encourage business R&D and innovation provided by both federal and provincial governments, such as the Scientific Research and Experimental Development (SR&ED) tax incentive which amounted to CAD 3.3 billion in 2012 and to 80% of overall public support for business R&D[20], Business enterprise R&D spending (BERD) in Canada steadily decreased. As shown in Chart 3.1, business expenditures on R&D have diminished over the period 2009-2013 as a proportion of GDP. In comparison, federal expenditures on R&D have decreased only slightly, while expenditures in higher education and provincial governments have remained relatively stable (with a spike in higher education expenditures in 2012).

In 2014, Canada ranked 19th among the 34 OECD countries with regard to the business enterprise expenditure on R&D (BERD) as a percentage of GDP.[21] In 2012, it was estimated that businesses in Canada spent 0.88% of GDP on R&D[22] which is well below United States (1.96%), the EU (1.28% as of 2013),[23] and the OECD average (1.63%).[24] It is also a substantial decrease from the 2006 Canadian estimate of 1.11% when Canada ranked 16th.[25] According to the Conference Board of Canada's international ranking, in 2015 Canada earned a "C" on the innovation report card, and ranked 9th out of 16 peer countries. Although it was an improvement over the "D" grade and 13th place ranking received in the previous innovation report card, Canada received a 'D' grade in Patents, Business enterprise R&D, and researchers engaged in R&D.[26]

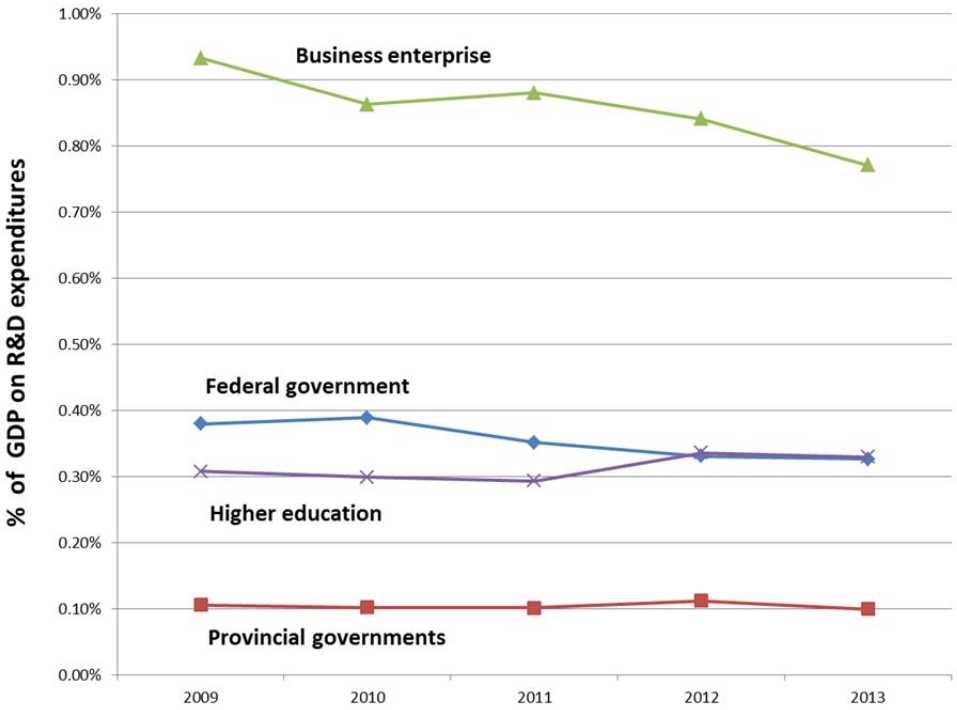
This resonates with the findings of the Panel, chaired by Tom Jenkins, then Executive Chairman of OpenText Corporation, which was charged by the Government of Canada with analyzing federal government business R&D programs and recommending how to adapt its approach to better stimulate the growth of innovative firms. The report states that

[16] OECD (2014), Education at a Glance 2014: OECD Indicators, OECD Publishing.
[17] OECD (2012). OECD Science, Technology and Industry Outlook 2012, OECD Publishing
[18] OECD. Main Science and Technology Indicators. https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB#
[19] Science-Metrix (2013). Natural Sciences and Engineering Research in Canada and in Other Leading Countries—2001-2012.
[20] OECD (2014), OECD Science, Technology and Industry Outlook 2014, OECD Publishing.
[21] OECD. Main Science and Technology Indicators. https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB#
[22] Seizing Canada's Moment: Moving Forward in Science, Technology and Innovation 2014.
[23] http://ec.europa.eu/eurostat/statistics-explained/index.php/R_%26_D_expenditure
[24] Seizing Canada's Moment: Moving Forward in Science, Technology and Innovation 2014
[25] Organisation for Economic Co-operation and Development [OECD] (2008). The Global Competition for Talent: Mobility of the Highly Skilled. Paris, France: OECD.
[26] http://www.conferenceboard.ca/hcp/details/innovation.aspx

business R&D spending, adjusted for inflation, has been declining every year since 2006. "This trend is both surprising and ominous."[27]

The presence of only a few large research companies in Canada may partially account for the low business R&D spending; in 2008, the top ten companies have carried out one-third of all R&D in Canada in the past 20 years.[28] At the same time, large firms account for a smaller share of Canadian BERD than the OECD average and Canadian firms fall below the OECD median in terms of top 500 corporate R&D investors.[29]

CHART 3.1 – Percentage of the Gross Domestic Product on R&D expenditures, by source, for 2009-2013



Sources:
a) Statistics Canada, Gross domestic expenditures on research and development (GERD), by funding sector, (http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/scte01a-eng.htm).
b) Statistics Canada, Gross Domestic Expenditures on Research and Development in Canada (GERD), the Provinces and Territories. Catalogue no. 88-221-X (http://www5.statcan.gc.ca/olc-cel/olc.action?objId=88-221-X&objType=2&lang=en&limit=0).

The Industry-driven Collaborative Research and Development sub-program is designed to meet the needs of both industrial partners and academic researchers: projects address real world challenges that are relevant to industry, help build sustainable relationships between the two sectors, and connect people and skills. Each funding opportunity included in the sub-program adopts a different means to achieve common objective: fosters partnerships in natural sciences and engineering that facilitates the transfer of knowledge and skills to the user sector through awards that support research projects and activities intended for socioeconomic impact. The partnerships encouraged and enabled by the sub-program also increase the commercialization of Canada's research through new products, services, and processes for the benefit of all Canadians. While industry R&D expenditures in Canada decline, the sub-program is attracting increased levels of partner contributions, and the partners tend to maintain or increase their R&D expenditure after the grants. During this period, NSERC implemented the Strategy for Partnerships and Innovation (SPI)[30]. The Industry-driven Collaborative Research and Development sub-program was the most important vehicle in the strategy for funding

[27] Innovation Canada: A Call to Action. Review of Federal Support to Research and Development – Expert Panel Report.
[28] OECD (2008). OECD Science, Technology and Industry Outlook 2008. ISBN 978-92-64-04991-8
[29] OECD (2014), OECD Science, Technology and Industry Outlook 2014, OECD Publishing.
[30] NSERC's Strategy for Partnerships and Innovation is a blueprint to leverage R&D for sustainable national prosperity. The approaches and actions outlined in the Strategy are specifically designed to address existing challenges to effective industry-academic collaboration, and to increase the number and range of companies that are able to benefit from post-secondary research capabilities. Source: http://www.nserc-crsng.gc.ca/_doc/business/SPI_e.pdf

additional industry-academic partnerships. As a result of the strategy implementation, the number of industry partners was doubled and private sector investment in R&D conducted with universities increased.[31]

At the same time, university researchers benefit from establishing and maintaining partnerships between academia and industry by having an opportunity to conduct research and create new knowledge and technology for company-specific needs. Students become exposed to R&D in industrial environment, as well as gain expertise and knowledge required for future employment.

The sub-program addresses the above challenges by fostering partnerships between university researchers and industry, stimulating innovation in the Canadian economy, and encouraging greater science and technology investment by the private sector. It also aims to develop and transfer new knowledge to Canadian based organizations.[32]

- *Engage grants address the initial bump to get businesses interested in R&D.* Engage grants were created as part of SPI. Case studies describe Engage grants as low threshold, easy to access "getting to know you" grants, useful for researchers and the industrial partner to get acquainted. The case studies also document how Engage grants allow industrial partners to assess the capacity of the trainees, at any level from Masters to postdoctoral fellows. Thus, Engage grants serve as pilots for subsequent relationships as well as subsequent research. According to key informants, Engage grants avoid the barriers of industry cash commitments and the risk of disagreements over IP.
- *CRD grants support the cost of conducting research and contribute to addressing knowledge transfer issues.* CRD grants are seen by case study researchers and industrial partners as tackling a discrete problem in greater depth and complexity than Engage grants over a relatively short period of time. However, because CRD grants require a more substantial commitment from industrial partners than Engage grants, they carry a greater business risk but also offer greater reward. NSERC reduces the risk by contributing funding. According to case studies conducted as part of this evaluation, this risk is sometimes managed by carrying out annual renewals where partners decide to stay engaged or leave the partnership.[33] Some of the CRD case study grants had grown into sequential CRD grants to pursue the different steps needed to move technology towards commercialization or through changes needed to regulations or standards for the technology to be adoptable industry-wide.
- *IRC grants support an on-going investment in R&D as well as regular knowledge transfer.* IRC grants are seen by researchers and industrial partners as long-term and relatively open-ended funding, where a number of lines of questioning can be pursued and modified as results emerge. From industry's perspective, IRC grants are useful for ensuring researchers' commitment to addressing longer-term questions that partners know they will face as an industry, and for ensuring that industry commits at least some resources to addressing those in the longer term.

According to key informants, the needs addressed by the funding opportunities are not tackled by other Canadian government programs and little to no duplication of the IRC grants exists within the confines of public funding. They noted that private endowments from companies could possibly play the same role as IRC grants, but that these are uncommon, and that industry partners retain much more control over the research in the context of endowments. Other key informants suggested alternatives to IRC grants tend to be smaller in scale, such as CRD grants, the Ontario Research Fund, or Mitacs. However, the case studies did not unequivocally indicate that there were no alternative sources of funding for the research projects and programs. Researchers indicated that they may have been able to access alternatives in the form of private investment in research, through contracts and/or other arrangements such as paid internships. However, interviewed as part of the case studies were of the view that the IRC grants provided a combination of advantages in terms of finances, duration and flexibility that are unmatched by other programs. Also, the NSERC grants promote collaboration in a way that contracts usually do not. Note that these conclusions stem from the observations of key informants and not from a systematic review of alternatives sources of funding.

[31] NSERC. *Partners in R&D. Celebrating 5 years of success in helping business innovate, connect, collaborate and prosper.* December 2014.
[32] NSERC, Report on Plans and Priorities 2015-16, http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Reports-Rapports/RPP-PPR/2015-2016/index_eng.asp
[33] According to program management, annual progress reports for these grants show that very few industry partners (<5%) leave a CRD grant before it is completed (average duration 3 years).

3.2 Appropriateness of Federal Involvement

The Government of Canada S&T strategy justifies federal government involvement in industry-focused research as one contributor in a large innovation ecosystem of funding and support.

According to the Government of Canada S&T strategy, the role of the federal government in R&D is to encourage private-sector S&T investment, to fund university and college R&D, to undertake science and technology work, and to foster national and international collaborations.[34] NSERC exists to fulfill a central part of that role and supports academic research, promotes collaboration between sectors and develops the next generation of qualified and talented scientists and engineers: "NSERC's role is to make investments in people, discovery and innovation to increase Canada's scientific and technological capabilities for the benefit of all Canadians.."[35]

Key informants saw federal funding of R&D as a critical element of an innovation-based economy. They positioned support for industry-university partnerships as a good incentive for industry to get involved (some key informants indicated that industrial partners would not get involved in research with academics without the funding opportunities and supports provided by these grants). Moreover, according to key informants, providing funding to academic and industrial research can be an effective way to encourage progress on identified federal science and technology priorities. On the whole, the federal government plays a role in a large innovation ecosystem of funding and support. Federal funding is an important contribution but it does not act alone.

In some of the case studies, it was clear that had the grants not been available, the work would not have gone forward. In others, scaled down versions of the same research would have gone forward using provincial funds. In yet others, where industry commitments were very large and where industry was also providing funds for research through contracts and other mechanisms, it did seem possible that the work could have been carried out without the grants.

3.3 Alignment with Government Priorities

The Industry-driven Collaborative Research and Development sub-program is well-aligned with the priorities of both the federal government and NSERC itself.

3.3.1 Federal government priorities

The Industry-driven Collaborative Research and Development sub-program aims to build sustainable relationships between academia and industry in order to spur innovation and "address real-world challenges that are relevant to industry."[36] It also looks to foster research efforts that meet industrial needs in fields that have not yet been developed in Canadian universities.[37] These objectives mirrored the priorities of the previous Government, which was in power during the period covered by the evaluation. The 2015 Economic Action Plan titled *Strong Leadership, A Balanced Budget, Low Tax Plan for Jobs, Growth and Security* described funding priorities as being "refocused to better support collaborative research and development projects that are driven by industry needs."[38] These objectives are also aligned with the priorities of the current Government, including improvement of programs that support innovation, scientific research and entrepreneurship, as well as the development of an Innovation Agenda with intent to expand effective support for the emerging national network for business innovation and cluster support.[39] The Budget 2016 "Growing the Middle Class" defines a new vision for Canada's economy, which is building Canada as a centre of global innovation. This vision encompasses the key ingredients for helping entrepreneurs innovate, such as science and technology, innovation infrastructure, and supportive business environment for commercialization and growth.[40] The Government believes that investing in an appropriate balance between fundamental research to support new discoveries and the commercialization of ideas will lead to sustainable economic growth.[41]

[34] Canada's New Government. *Mobilizing Science and Technology to Canada's Advantage*. Ottawa, 2007.
[35] Natural Sciences and Engineering Research Council of Canada. *Vision*. Retrieved February 2 from http://www.nserc-crsng.gc.ca/NSERC-CRSNG/vision-vision_eng.asp
[36] http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Reports-Rapports/DPR-RMR/2013-2014/index_eng.asp
[37] http://www.nserc-crsng.gc.ca/Professors-Professeurs/CFS-PCP/IRC-PCI_eng.asp
[38] http://www.budget.gc.ca/2015/docs/plan/budget2015-eng.pdf
[39] Liberal Party of Canada. Real Change: A New Plane For A Strong Middle Class, 2015.
[40] Budget 2016. "Growing the Middle Class".
[41] Ministerial Mandate Letters (http://pm.gc.ca/eng/ministerial-mandate-letters)

As part of the objectives of the People program, the sub-program looks to "train students in essential technical skills required by industry."[42] This addressed priorities in the previous Government's 2014 Economic Action Plan *The Road to Balance: Creating Jobs and Opportunities*, which recognized that "the creation of knowledge, application of scientific discoveries and development of highly qualified people bring social and economic benefits to all Canadians."[43] It also spoke to objectives in the S&T Strategy *Moving Forward in Science, Technology and Innovation 2014* that aimed to "encourage more young people to pursue education and choose careers in science, technology, engineering and math disciplines" and ensure that "young Canadians gain the real-life work experiences needed to develop the technological skills increasingly required for jobs." This is also aligned with the current Government's priorities to help Canadian get the skills they need for good quality jobs by strengthening the training system to build human capital that Canadians and employers need[44]. The Budget 2016 "Growing the Middle Class" defines creative and entrepreneurial citizens as a key ingredient for helping entrepreneurs innovate as part of the Government's vision to make Canada a centre of global innovation. This includes industry-relevant education and training opportunities.[45]

3.3.2 NSERC priorities

The sub-program falls under the Innovation Program of the NSERC Program Alignment Architecture.[46] It is designed to fuel innovation in the Canadian economy and encourage private-sector business to invest more into science and technology. [47] Its objectives pertain to university-industry collaboration and industry-relevant innovation, which are critical elements of achieving the outcomes related to impactful and potentially commercialized academic research. Additionally, given that both CRD grants and IRC grants include objectives relating to the training of students, these two grants in particular also reflect the strategic outcome of the People program which refers explicitly to the development of HQP.

TABLE 3.1 –NSERC Programs

The **Innovation program** fosters partnerships in natural sciences and engineering that facilitate the transfer of knowledge and skills to the user sector through awards that support research projects and network activities intended for socioeconomic impact. The partnerships encouraged and enabled by these awards also increase the commercialization of Canada's research through new products, services, and processes for the benefit of all Canadians.
The **People program** supports the attraction, retention and development of highly qualified people in the natural sciences and engineering in Canada through Chairs programs, fellowships, scholarships and stipends.
The **Discovery program** supports the creation of new knowledge and maintenance of a high quality Canadian broad based research capacity in the natural sciences and engineering through grants to researchers.

[42] http://www.nserc-crsng.gc.ca/Professors-Professeurs/RPP-PP/CRD-RDC_eng.asp
[43] http://www.budget.gc.ca/2014/docs/themes/road-voie-eng.html
[44] Ministerial Mandate Letters (http://pm.gc.ca/eng/ministerial-mandate-letters)
[45] Budget 2016. "Growing the Middle Class".
[46] NSERC, Report on Priorities and Plans 2014-2015, http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Reports-Rapports/RPP-PPR/2014-2015/index_eng.asp#s1.2.3
[47] NSERC, Report on Plans and Priorities 2014-15, http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Reports-Rapports/RPP-PPR/2014-2015/index_eng.asp#s2.4

SECTION 4: EFFECTIVENESS

The industry-driven funding opportunities produced the results anticipated. The university-industry partnerships supported by the industry-driven funding opportunities are generally successful at fostering meaningful collaborations that last beyond the funding period. Long-term relationships were typically maintained past the completion of the initial grant. The industry-driven funding opportunities substantially contributed to enhancing the research capacity of researchers and universities involved. Industrial partners reported significant impact from the grants on competitiveness and productivity. Increased market visibility is the most frequently reported type of competitiveness benefit. Knowledge transfer to industrial partners did occur. The grants involved substantial numbers of students and fellows whose involvement was multifaceted. Students and fellows frequently reported developing their skills and gaining experience in diverse areas as a direct result of their participation in the research program. Positive impacts on HQP employment were also documented.

4.1 Differences Among Grants

In this chapter, findings on the effectiveness of the grants are laid out. They are not meant to be interpreted comparatively: we are not attempting to evaluate the relative effectiveness of the different grants. The data have been disaggregated by grant for descriptive purposes; the intent is not to judge grants comparatively as each grant is designed according to different aims on the spectrum of industry-university partnerships. Grants are also of different size, scope, and duration, so that expectations would be different for each of them. Results should be read and interpreted using that lens.

4.2 Importance of the Partner Contribution

By comparing various groups of recipients (see page 7 for details), different elements of the context of the grants were tested for the impact they may have on the achievement of program outcomes; this was done through the analysis of survey data and Final Reports. While some elements of the context have been shown to be related to program impact for specific result indicators (e.g., region), one emerged as clearly more significant than the others: the size of the contribution by the industrial partner(s), be that in money or in-kind, was repeatedly found to be associated with the extent of the program impact – with larger contributions being related to more impact.

These analyses were conducted without statistical control for the possibility that other factors provided stronger explanation of the observed outcomes. In fact, multivariate analyses conducted as part of the SPI assessment concluded that the most important factors affecting outcomes were the extent of the substantive participation of the partner into the research project and the continued collaboration of the partner and university researchers beyond the funded project.

The observed bivariate relationship between the size of the industrial partner's contributions and grant outcomes was not investigated further within this evaluation.

4.3 Achievement of Immediate Outcomes

If they are successful, the industry-driven funding opportunities under study should foster existing collaboration, support the creation of university-industry partnerships, contribute to enhancing the researchers' capacity, and increase the research capacity of universities, particularly through an improved knowledge base and access to technology in industry-relevant areas.

4.3.1 Partnerships between University Researchers and Industries

The university-industry partnerships supported by the industry-driven funding opportunities are generally successful at fostering meaningful collaborations that last beyond the funding period. IRC grants are more likely to produce collaborations beyond the original group than CRD; though they are both effective at doing so. There is evidence that IRCs tend to reinforce existing partnerships rather than create new ones which is not surprising considering the size of the investment by the industry. It has been noted that the relationship between a company and a university can begin by satisfaction in completion of a project funded through a CRD grant

followed by further investment in an IRC based on that success. By design, Engage grants involve new partnerships and, therefore, contribute to bridging the gap between researchers and industry.

As Table 4.1 shows, for all grants, about three-quarters of partners reported further collaboration with the grant researcher as a result of the grant. Moreover, for a quarter of short CRD grants, one third of long CRD grants, and more than one-half of IRC grants, industry collaboration has expanded beyond the original researchers.

Successful Engage and CRD partnerships (i.e., those that attained the project objectives) led to research findings which turned out to be useful to the partner. Instances of discontinuation were found when this condition was not present.

TABLE 4.1 – Further collaboration with researchers

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
% who indicated further collaboration with the same researcher	75%	79%	78%	75%
% who indicated further collaboration with other researcher(s) on the same research subject	26%	32%	57%	—
n for 100%	439	775	23	647

Note: multiple responses were possible; percentages total more than 100%.
Sources: CRD and IRC Final Reports; Engage Impact Survey

Table 4.2 presents additional evidence of the positive impacts of industry-driven funding opportunities on university-industry collaboration. Large majorities of researchers indicated that the grant resulted in increased networking and built collaborative relationships with project partners (from 60% for Engage researchers to 92% for IRC researchers), and that it resulted in improved ability to attract research funding (from 50% for Engage researchers to 97% for IRC researchers). The differences in results are explained by the fact that the Engage grants support the short-term establishment of a collaboration between a researcher and an industrial partner whereas CRD grants support longer partnerships and IRC grants typically involve long-term multi-partner teams.

TABLE 4.2 – Enhancement of networks and collaboration between academia and industry

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
The grant resulted in increased networking and build collaborative relationships with project partners[1]	86%	85%	92%	60%
n for 100%	75	144	38	141
The grant resulted in improved ability to attract research funding[1]	81%	84%	97%	50%
n for 100%	64	128	31	135
The grant increased opportunities for additional research funding				
Moderately (3-5 on a 7-point scale)	37%	32%	24%	49%
Highly (6 or 7 on a 7-point scale)	56%	62%	76%	40%
n for 100%	75	149	38	145

[1] Percentage stating that this "has happened". Sources: SPI Researcher Survey

According to researchers, the grants also increased opportunities for additional research funding in a substantial manner. There is a close relationship between the extent of this impact, on the one hand, and either the duration of the program support of the partnership or the level of funding, on the other hand. Engage grants are half as likely to increase opportunities for additional research funding as IRC grants. Because funding opportunities differ both in length and in level of funding, it is not possible to disentangle these two factors.

Many IRC grants involved intense collaborations that took a variety of forms between researchers and industry, as identified in case studies: the research was programmatic and long term, and there were many individuals involved such as Associate Chairs as well as students at all levels and postdoctoral fellows. Communications between industry representatives and the chairholder's team can even take place many times a day through a variety of means. Associate

Chairs likewise indicated that the scope of the grants had allowed them to develop their partnerships into multifaceted, long-term collaborations between partners and a stable research team on multiple research axes. Indeed, key informants noted that IRC grant partnerships really had to be active and productive even before an IRC grant was awarded: this was seen as a prerequisite for funding.

In Final Reports, CRD and IRC grantees documented how the grants supported the development of active and productive collaborations between academia and industry. The reports revealed that shared goals benefited both researchers and the partners: while researchers were provided with valuable input and feedback at all stages of the research (e.g., advice on research directions and methodology, feedback on articles before submission to academic journals), companies reported increased competitiveness gained through new knowledge and technologies developed through the funded research.

The IRC grant case studies suggest that the grant reinforced or maintained the existing teams and partnerships between universities and industrial partners.[48] In all cases, industrial partners were involved in more than one research arrangement with more than one university. The IRC grants sometimes involved partnership with an entire sector (e.g., manufacturing) rather than a particular company (e.g., an airplane engine maker). Based on a few case studies, it could be tentatively concluded that IRC grants do not lead to novel partnerships between universities and industrial partners, but rather expand (e.g., to more companies within a sector) or deepen (e.g., to more projects within a company) existing ones.[49]

Suggestions to further enhance collaborations and partnerships between universities and industrial partners included: establishing linkages with venture capital companies to understand where that sector's interests lie and ensure there is good alignment with where venture capitalists become interested; and involving not-for-profits in partnerships or as a partnership sector.

Some case study grantees also suggested that NSERC involve technical colleges more actively. According to some case study interviewees, there is resistance to innovation and R&D in the technical training sector, which inhibits the capacity of larger industries to move R&D into practice, particularly in areas involving manufacturing.

4.3.2 Research Capacity of Researchers

The industry-driven funding opportunities have substantially contributed to enhancing the research capacity of researchers involved – through improved access to facilities, expertise, data, equipment, and intelligence as well as additional resources for hiring personnel.

Substantial majorities of researchers report improved access to facilities, expertise, data, and equipment as a result of the various grants: the proportion of researchers varies from 58% for Engage grants to 83% for IRC grants (Table 4.3). Additionally, a large number of researchers indicated that these grants and the associated collaborations helped them gain intelligence on further research directions: from 65% for Engage grants to 91% for IRC grants.

TABLE 4.3 – Enhancement of the research capacity of researchers

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Improved access to facilities, expertise, data, and equipment	66%	81%	83%	58%
n for 100%	51	101	30	96
Intelligence gained on future research directions	83%	80%	91%	65%
n for 100%	69	127	33	127
Sources: SPI Researcher Survey				

[48] Note that case study evidence is available only from IRCs on this issue. This is because the original evaluation design addressed this evaluation question only to IRCs. The question was later widened to include Engage and CRD grants based on the availability of quantitative evidence.
[49] The potential for a near-future IRC application might often be an incentive to start working together before committing to a 5-year grant. The effectiveness of the IRC program to promote new partnerships is therefore difficult to assess, especially based only on a few case studies.

The research capacity of the IRC researchers[50] had been enhanced over the grant period. The following impacts were observed:

- attracting major funds from their industry partners and from other companies and organizations in the same sector for related but different work, often as contract research;
- attracting high quality students, who also sometimes brought their own funding from NSERC or other agencies;
- being supported in preparing applications for and/or winning major infrastructure grants through the Canada Foundation for Innovation (CFI) (and if unsuccessful in those applications to have that equipment, the industry partners purchasing the required equipment);
- hiring an Associate Chair and creating a new faculty position beyond the requirements of the program; in cases observed, that individual went on to achieve tenure and to operate a full laboratory and train students on their own;
- Associate Chairs increasing their productivity well over what it would have been in the absence of the Chair, with an increased team size (more students and collaborators);
- Associate Chairs gaining increased recognition within their university and peer community, contributing to promotions, invitations and opportunities that then in turn increased their visibility and research capacity;
- Associate Chairs developing their capacities as research managers, able to assume leadership of larger research entities.

These impacts are likely not due only to the chair award: by program design, IRC recipients have ongoing success in the entire endeavor and have capacity for success in attracting more funds and resources.

According to case studies, interviews, and Final Reports, IRC chairs typically have some form of advisory committee or review structure that reviews findings on a regular basis and brings in discussion of how the industry's needs are evolving and where the research direction should go in order to meet these; this intelligence weighs on future research direction and constitutes significant value added for researchers. Such intense exchange on industry needs can lead to industry discontinuing their involvement if the research is not responsive to industry direction or if it is responsive increasing their interest and investment even more.

4.3.3 Research Capacity of Universities

The industry-driven funding opportunities exerted positive effects on the research capacity of universities. The grants opened up new opportunities for research beyond the original objectives, influenced the direction to more industrially relevant topics, assisted in attracting better qualified personnel, and generally contributed to the improved knowledge base of universities.

According to large majorities of researchers, the research capacity of universities was enhanced by the various types of grants because the grants opened up new opportunities for research beyond the original objectives and influenced the direction to more industrially relevant topics, and improved the ability of researchers to attract more and better qualified personnel (Table 4.4). Researchers also considered that the grants contributed to the research knowledge base and that the grants led to new or improved methodology or models.

[50] This information is from case studies of IRC grants and interviews with researchers and associate chairs. This evidence is available only from IRCs on this issue.

TABLE 4.4 – Enhancement of the research capacity of universities

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
The grant opened up new opportunities for research beyond the original objectives	91%	94%	83%	85%[1,2]
The grant influenced the direction to more industrially relevant topics	76%	78%	74%	—
n for 100%	439	775	23	147
The grant impacted the ability to attract more qualified personnel	94%[1]	95%[1]	95%[1]	82%[1]
The grant impacted the ability to attract better qualified personnel	89%[1]	94%[1]	92%[1]	77%[1]
n for 100%	75	147-149	38	142-145
The grant contributed to the research knowledge base[3]	100%	99%	100%	70%
n for 100%	76	149	38	143
The grant led to new or improved methodology or models[3]	92%	83%	92%	63%
n for 100%	72	142	36	126

[1] Percentage selecting 3 to 7 on a 7-point scale (moderate or high).
[2] The question is slightly different: "the grant led to new areas of research".
[3] Percentage stating that this "has happened".
Sources: CRD and IRC Final Reports; SPI Researcher Survey

In larger grants studied, including IRC grants but to some extent CRD grants as well, the investigators indicated that universities benefited from the visibility of the research area within the institution and its attendant attractiveness to students, particularly higher-quality students. In fact, the training of HQP that occurred in the context of the grants was considered a key aspect of the universities' improved knowledge base since most of the work in the three grants is carried out by students. While students and fellows are often transient in universities, the supervising professors incorporate the findings into their larger research program that can have many impacts over the tenure of the professor. This provides a level of assurance that the funded research builds university research capacity.

With IRC grants[51], universities increased their research capacity in areas directly related to the grant. Universities obtained access to industry expertise and infrastructure, as well as HQP training opportunities. Some IRC chair holders have brought international renown to their universities as leaders in their areas of expertise. Some obtained major CFI grants for infrastructure in their area. Some acquired equipment through the IRC grant; the equipment benefited other members of the departments involved. Some would have seen Associate Chairs move to the United States or into industry positions if the chair had not been available.[52]

It was not always clear however that the IRC grant was the main or sole driver of these results. Rather the IRC grant was one of the tools used – a tool of particular interest because of its potential to lead to recruitment of additional faculty. For example, in one case, the industry partner already provided large sums of money into the university through the establishment of a research institute and various other funding mechanisms; the capacity acquired by the university was really linked to the overall partnership and not specifically or in any way uniquely to the IRC Chair. Also, the retention effect on Associate Chairs is not always strong enough as examples were found of Associate Chairs who left to go to the United States because academic opportunities were better for them there.

[51] This information is from case studies of IRC grants. This evidence is available only from IRCs on this issue. This is because the original evaluation design addressed this evaluation question only to IRCs. The question was later widened to include Engage and CRD grants based on the availability of quantitative evidence.
[52] Some did notwithstanding the IRC grants. In two of the case studies of IRC grants that recruited associate chairs, these recruits left to go to the United States because opportunities were better for them there – showing that a positive retention effect can be countered by attractive offers from abroad.

Grants that were large enough to involve longer-term involvement of more senior students and fellows were more likely to result in increased knowledge base: this was the case where the grants led to the hiring of additional faculty or where the grant was related to the acquisition of a major new infrastructure. The only grants in the case studies that did not contribute to the research knowledge base of the organization were those that did not conclude on positive findings (e.g., no usable technological solution) and smaller CRD grants and Engage grants. The researchers nonetheless reported that there had been an indirect benefit of having hired or trained the few students who worked on those grants.

Other benefits to institutions identified in case studies were: improved interdepartmental and interdisciplinary collaboration within the institution; overhead obtained from the grants; and in some cases, new research directions for the investigator or avoided research directions that did not show promise for further research.

4.4 Achievement of Intermediate Outcomes

The industry-driven funding opportunities will be considered a success according to three criteria: contributing to the establishment of long-term relationships between researchers and partners; providing benefits to industrial partners and encouraging them to continue or expand their R&D efforts; and benefiting the HQP involved in grants.

4.4.1 Establishment of Long-Term Relationships between Academic Researchers and Industrial Partners

Long-term relationships, defined as relationships that have continued past the completion of the initial grant, are typically established (Engage) or maintained (CRD and IRC) as part of the industry-driven funding opportunities – less so after the small Engage grants but still leaving the parties intending to continue collaborating. The nature of the long-term relationships is varied and consistent with the interests and resources of the parties.

A majority of partnerships have been maintained after the grant period, using mainly public funds but also contract relationships. As Table 4.5 shows, instances of contract research relationships are about half as frequent as publicly funded ones. One third of Engage researchers documented a publicly funded partnership that extended beyond the grant; this was the case for about one-half of CRD researchers and more than three-quarters of IRC researchers. Researchers and partners in case studies, as well as key informants within institutions, confirmed that relationships are ongoing, either in continued collaboration on follow-up projects or on evolving questions addressed through other grants or projects.

TABLE 4.5 – Incidence of further research activity involving grant partners

Has there been further research activity that involved a partnership as a result of the grant:	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Yes, publicly funded with industrial partner(s)	52%	59%	81%	32%
Yes, contract research with industrial partner(s)	26%	31%	50%	8%
n for 100%	74	145	37	132

Source: SPI Researcher Survey

Regarding Engage grants specifically, the large majority (88%; Engage Final Reports) of researchers reported that they *intend* to continue the collaboration by seeking funding from NSERC. Similarly, a large majority (82%; Engage Final Reports) of partners indicated an *intent* to fund future collaboration through NSERC. A year after the end of the Engage grant, 37% of partners reported having continued to collaborate with the same researcher on the same research problem; 25% had collaborated with the same researcher on different research problem; and 14% had collaborated with other researchers on the same research problem.[53]

The success of the grants at fostering the establishment of long-term relationships is further evidenced by the case studies:[54] Almost all of the 12 case studies have resulted in relationships that are continuing beyond the completion of the grant studied. Final reports also told a story of success at maintaining long-term relationships.

[53] These percentages cannot be added up since they were derived from a multiple-response survey question.
[54] The case studies do not constitute a random and representative sample.

The relationships between researchers and partner companies can continue in various ways, most often through continued work on the original issue (in some cases, the researcher will apply for extensions), or on new research directions (including new NSERC grants). Some final reports referred to a "network" being formed that was expected to last long after the end of the initial projects. A CRD case study showed that continuation of a partnership can take the form of grant-supported HQP being hired or contracted by industry partners. For industry partners, being able to work with researchers who are open-minded and flexible, aware of the interests, contexts and constraints of the particular industry, and easy to work with are key to maintaining long-term relationships.

Regarding CRD grants and IRC grants, many of these relationships were not a first collaboration – they were building on prior grants or contracts. A researcher can also maintain an involvement with the partners through other means such as a research institute that the partner is funding. Furthermore, partnerships can develop in multiple directions, to a point where a single partner company can be engaged in a large number of IRC grants: one university VP gave an example of 12 or 13 IRC grants; one case study industrial partner was supporting eight IRC grants. Such intense involvement of a single partner could be construed as putting research projects at risk (if the partner decided to pull out) but this is not the case because large projects are typically supported by several partners. It was noted that industry can come to view some universities as "preferred partners" in this respect.

4.4.2 Benefits to Industrial Partners Including Impacts on R&D Staffing and Budgets

Industrial partners reported that the grants had significant impacts on competitiveness and productivity. Increased market visibility is the most frequently reported type of competitiveness benefit. About one-half of the partners indicated that their revenues increased since the end of the grant; representing on average an increase of 22 percent over all grant types. When asked how much of the increase could be attributed to the grant, the result is more modest; roughly 5 percent. The survey results indicate that partners who participated in these grants tend to maintain or grow their R&D budgets after their participation. When reported decreases to R&D budgets are factored in against reported increases, the estimated net effect is in the range of a 5 percent increase in R&D budgets. The transfer of knowledge to industrial partners is another benefit that companies can obtain. Evaluation evidence indicated that such transfer does occur, sometimes with a single company and other times to an entire industry. Reports and formal publications were the main mechanisms used in transferring knowledge to industrial partners. Training of HQP was an important motivator for many industry partners to get involved in these types of grants: it is seen as a way to train and to assess potential future employees and, therefore, to contribute to the value proposition. It has been shown that transfer of knowledge through the hiring of university graduates who worked on the project can be very effective. While a number of benefits for industrial partners were identified, it is clear that the desire of industry partners to continue to partner for R&D depends on the economic benefits of research outcomes in which industry-driven funding opportunities factor in along with many other considerations.

Benefits accrued by industry partners were assessed by the partners themselves. Substantial numbers of partners indicated that the grant had an impact on the *competitiveness* or *productivity* of the company, as shown in Table 4.6. These effects were felt by between 37% of Engage partners with regard to productivity and 62% of IRC partners regarding competitiveness. Smaller companies reported statistically more impact on competitiveness in the context of short CRD grants only.

TABLE 4.6 – Perceived impact of grants on partners' competitiveness and productivity

The grant has resulted (or is likely to result) in…	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Impact on competitiveness (e.g., market, sales, profit)	52%	41%	62%	47%
n for 100%	45	135	68	170
Impact on productivity (e.g., output, labour, materials or energy costs, or job quality)	47%	45%	50%	37%
n for 100%	46	118	60	148

Source: SPI Partner Survey

Looking at impacts on *competitiveness* more specifically (Table 4.7), reported specific impacts of grants are modest with between 2% and 14% of partners mentioning them. Increased market visibility is the most frequently reported type of competitiveness benefit. Short CRD grants exerted more influence than other grants.

TABLE 4.7 – Perceived impact of grants on partners' competitiveness (% of partners)

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Accessed new markets	14%	7%	6%	6%
Increased organization's profitability	12%	5%	9%	3%
Allowed organization to maintain its profit margins	12%	3%	13%	2%
Increased market visibility	11%	10%	10%	5%
Increased sales	7%	4%	4%	2%
Increased revenues	3%	5%	5%	2%
Increased market share	3%	7%	10%	3%
n for 100%	45	135	68	170

Source: SPI Partner Survey
Note: Considering the margins of error on small proportions and relatively small sample sizes, the differences observed in this table within each grant are not statistically significant. The data is nonetheless valuable to document the absolute level of perceived impact on partners' competitiveness.

About one-half of partners indicated that their *revenues* increased since the end of the grant (Table 4.8). The average increase in reported revenues was a 20-25% increase for CRD partners and Engage partners, and of 40% for IRC partners. Partners were also asked to estimate the portion of the increase in revenues that was attributable to their participation in the grant research. While the overall increase to revenues (across all grant types) was 22 percent on average, when the portion of the increase attributable to the grant is factored in, the result is more modest; roughly 5 percent.

TABLE 4.8 – Change in partners' revenues since the end of the grant

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
% of partners indicating that revenues have…				
increased since the end of the grant	58%	53%	64%	45%
decreased since the end of the grant	11%	13%	0%	4%
stayed the same since the end of the grant	31%	34%	37%	52%
Average change in revenues since the end of the grant (increases and decreases factored in)	9%	9%	26%	8%
n for 100%	51	109	12	160
Average increase in revenues since the end of the grant	19%	25%	41%	20%
Average increase in revenues since the end of the grant attributable to the grant according to partners[55]	6%	6%	5%	5%
n for 100%	29	57	8	68

Source: SPI Partner Survey

Impacts of grants on industrial processes and practices were more frequent than reported impacts on competitiveness (Table 4.9 compared to Table 4.7). New or improved processes were most frequent while improved flexibility of production and new or improved organizational practices were least frequently stated. Here again, short CRD grants appeared to exert somewhat more impacts on partners than other grants.

[55] Increase in revenues attributable to the grant is calculated by weighting the increase using the extent to which the increase was attributable to the grant as reported by partners (i.e., attribution reported as "Not at all" is weighted to 0 and "To a great extent" weighted to 1).

TABLE 4.9 – Perceived impact of grants on partners' processes and practices (% of partners)

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
New process developed or existing process improved	27%	21%	28%	14%
New or improved standard operating practice	14%	13%	16%	5%
Improved flexibility of production	13%	5%	4%	4%
New or improved system/supporting activity for processes	13%	9%	11%	6%
New or improved organizational practices	8%	5%	5%	4%
n for 100%	58	153	69	149
Source: SPI Partner Survey				

Additional benefits to partners can take the form of on-going R&D. Some positive grant impacts were identified in this regard but they were limited.

The majority of partners indicated that the grant was followed by further partnered research activity, ranging from 58% for short CRD partners to 68% for long CRD partners (Table 4.10). Moreover, in a majority of cases, grants were said to have an impact on the firm's R&D capabilities. Although counterintuitive, short CRD grants appeared to be more frequently associated with increased R&D capacities than long CRD grants or IRC grants; considering their small size, Engage grants also produced a substantial impact on R&D capacity according to partners. Note that differences among these funding opportunities could be due to the type of partners that they attract (e.g., level of preparation, motivations) as well as to their features (e.g., duration, funding level).

TABLE 4.10 – Reported impact of grant on further collaboration with researchers and r&d capabilities (% of partners)

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Incidence of some further partnered research activity as a result of the grant	58%	68%	66%	60%
n for 100%	58	161	76	182
The grant has resulted (or is likely to result) in an impact on research and development capabilities	73%	56%	58%	61%
n for 100%	55	147	67	168
Sources: SPI Partner Survey				

Increased R&D capabilities are likely to translate into increased staff and budget attributed to R&D activity in different forms. The evidence for the effect of the grants on these aspects of R&D capability is mixed.

As Table 4.11 shows, between 20% (IRC) and 40% (Engage and short CRD) of partners indicated that their R&D staff increased since the end of the grant (Table 4.11); between 8% and 22% indicated that it had decreased. While the most frequent response was "no change", more partners were likely to indicate that their R&D budget had increased than had decreased: this change was reported by between 35% of IRC partners and 52% of the Engage partners while between 10% and 29% indicated that their R&D budget had decreased. The IRC partners who reported the decrease in their R&D budgets tended to indicate a larger change in the budget levels than that indicated by IRC partners who reported an increase. This resulted in an average change in R&D budget of -10%. The level of increase was larger than the level of decrease for Engage (average change in R&D budget of 9%) and CRDs (2% for long CRD grants and 3% for short CRD grants). The estimated overall net effect is in the range of a 5 percent increase in R&D budgets.

Care must be exercised in interpreting these results because of the absence of a control group to gauge the change that could have occurred without participation in the grants in a turbulent economic context. The data do not allow attributing a portion of this increase (or decrease) to participation in the grant research.

According to project Final Reports, CRD and IRC knowledge dissemination[56] occurs mainly through reports, formal publications, and the participation of partners in the research (Table 4.12). In the case of Engage grants, the main methods are informal discussions and correspondence and private reports, as well as participation of partners in the research. Final Reports suggest that knowledge from research results is always transferred to partners.

TABLE 4.11 – Change in partners' R&D staff and budget after the end of the grant

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
% of partners indicating that R&D staff have…				
increased since the end of the grant	40%	28%	20%	40%
decreased since the end of the grant	20%	17%	22%	8%
stayed the same since the end of the grant	40%	56%	57%	52%
Average change in R&D staff since the end of the grant (after coding categories as percentages)	4%	1%	-2%	8%
n for 100%	59	142	15	177
% of partners indicating that R&D budget has…				
increased since the end of the grant	48%	39%	35%	52%
decreased since the end of the grant	17%	18%	29%	10%
stayed the same since the end of the grant	35%	43%	36%	39%
Average change in R&D budget since the end of the grant (after coding categories as percentages)	3%	2%	-10%	9%
n for 100%	52	133	16	172
Source: SPI Partner Survey				

TABLE 4.12 – Knowledge Transfer methods used

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Through reports provided to the partners	81%	83%	78%	
Through formal publications	73%	86%	96%	
As a result of the partners participating in the research	54%	69%	78%	
Through patents	9%	11%	4%	
Through licensing arrangements	3%	9%	13%	
The research results have not been transferred to the partner	1%	1%	0%	
Other	10%	13%	9%	26%
Through informal discussions and correspondence				81%
Through reports that will be used internally				71%
As a result of direct participation in research activities				43%
n for 100%	439	775	23	2534
Source: Project Final Reports				

Researchers indicated that refereed publications are still the preferred method used to disseminate knowledge: more than 90% of CRD and IRC researchers noted this whereas it was the case for 43% of Engage researchers (Table 4.13). Refereed publications were also used often to publish results jointly with the partners (albeit less so with Engage grants which work on a much shorter time frame than CRD grants and IRC grants, and possibly because the Engage research concerns are oriented toward a short-term solution for a particular company). Non-refereed publications (e.g., technical reports, white papers) were most commonly used by IRC researchers (92%) and researchers involved in long CRD grants (67%). Shorter time frames were less supportive of this type of publication (56% for short CRD researchers and 23% for

[56] It is acknowledged that the use of the expressions "knowledge transfer" and "knowledge dissemination" is not entirely consistent in this report or in connection with the literature. The reporting is constrained by the wording of the original questionnaires.

Engage researchers). Other types of mobilization methods included non-disclosure and network agreements, patents, licences, and social media; IRC researchers were more engaged in these types of methods than researchers supported by other types of grants.

TABLE 4.13 – Knowledge dissemination and mobilization methods used

Please indicate how the results of the grant have been mobilized:	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Refereed publications	91%	93%	100%	43%
Non-refereed publications	56%	67%	92%	23%
Joint refereed publication by academic and private sector researchers	51%	54%	68%	17%
Execution of non-disclosure or confidentiality agreements	18%	23%	43%	16%
Patent issued	10%	14%	38%	2%
Social media	8%	6%	19%	2%
Network agreement regarding IP / commercialization	5%	17%	38%	7%
Licence issued	1%	7%	19%	1%
Copyright registered and/or trademark issued	1%	1%	8%	2%
n for 100%	76	149	38	147
Source: SPI Researcher Survey				

Table 4.14 presents the average level of written production for CRD grants and IRC grants. Short CRD grants produced an average of 10 documents compared to 29 for long CRD grants and 143 for IRC grants. In all cases, conference presentations and posters represented about 50% of all written production.

TABLE 4.14 – Dissemination methods used (Mean)

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Refereed journal articles submitted	1.2	2.7	13.7	N/A
Refereed journal articles accepted or published	1.8	5.8	35.6	N/A
Conference presentations/posters	5.0	13.9	70.9	N/A
Other (technical reports, non-refereed articles, etc.)	2.4	7.0	23.2	N/A
TOTAL	10.4	29.3	143.4	N/A
n for all respondents	439	775	23	N/A
Source: Project Final Reports				

The type of knowledge transfer to Canadian companies depended on the arrangements within each of the cases studied. Seven of the 12 cases involved specific solutions that were being transferred to a particular company for their advantage. Even in the case of three of the IRC grants, the knowledge sharing was restricted to one company or its joint venture spin-offs involving the researcher.

Some chairs dealt with consortia of companies which supported the research for collective benefits. This shared funding model gave consortium members access and first right of refusal to knowledge and IP. These consortia tended to be industry-wide and therefore permitted a good deal of sharing among competitors, as well as with and among suppliers and consultants that are also part of that same industrial sector. In the industry consortium model, knowledge is shared through annual or biannual research and development days; these often involve an opportunity for students to make presentations or present posters. These large consortia also operate access-protected websites where research results and databases can be accessed by consortium members who pay essentially a subscription as their contribution to the grant.

A number of other benefits for industry partners of taking part in industry-driven funding opportunities were identified. Nine of the case study grants reported very positive results and benefits for the industry partners involved including reaching commercialization, creating resources and knowledge that are of use for the partners as they pursue

improvements in their operations, and industry-wide application of findings for economic benefit in terms of costs avoided or efficiencies.[57] For example, some industries involved are heavily regulated (e.g., nuclear energy production and aerospace) and successful R&D facilitates regulatory approval (e.g., safety standards in manufacturing) because university-driven research adds credibility and strength in facing regulators.

It is important to note that such impacts on industry are not generated entirely and incrementally by the grants. In many case studies, if not most, and particularly those that are clearly success stories, the researcher came to academia from industry. In these cases, the grant itself was a continuation of the previous valuing and engagement in R&D in a different arrangement. The incremental value of the public investment that the grant represents must be adjusted to take these preceding circumstances into consideration.

The desire of industry partners to continue to engage in R&D (whether on the same project or on other work) depends on the economic benefits of research outcomes (based on case studies); if the industry-driven funding opportunities find a niche in that reasoning, they contribute to a positive outcome. The continued involvement depends on the likelihood that industry partners will see a benefit to their value proposition, which in turn depends at least in part on the extent to which the researcher understands that value proposition – which sometimes requires rethinking the end game. For example, in one case, the CRD grant application indicated that a "by-product" of the technology demonstration would be dispensed with, as it was of no value; when the partner came on board, it quickly realized that this by-product could be a central part of its value proposition for investing in the research. The research team re-oriented their thinking to accommodate this, and the partnership has been extremely successful. Thus, the case studies indicate that involvement in the grants encourages industry partners to continue with, or expand, their research and development efforts when the industry partner and the researcher can negotiate a space of common value.

In none of the cases studied did the grant result in improved perception of R&D among industrial partners: they had all come into the partnership already valuing R&D or at least understanding that there could be benefit in it for them. Although sometimes results around a specific question were disappointing, that did not call into question partners' views on the potential benefit of R&D.

4.4.3 Benefits for HQP

The industry-driven funding opportunities involved substantial numbers of students and fellows in applied industrial research and their involvement was multifaceted, including interacting with industry partners and presenting results. Students and fellows frequently reported developing their skills and gaining experience in diverse areas as a direct result of their participation in the research program. Positive impacts on HQP employment were also documented.

Over the course of entire grants, which range from 6 months to several years, CRD, IRC, and Engage grants involved a substantial number of students and fellows (per researcher surveys and final reports). According to final reports, it is estimated that during the period from 2009 to 2016, over 11,400 students and postdocs received training through CRD projects; more than 800 through IRC projects[58]; and 9,300 through Engage projects (from 2010 to 2015).[59]

As Table 4.15 shows, on average, an Engage project involved 2.7 students or fellows, from all levels of higher education. Projects funded through short CRD grants, which are substantially longer than Engage grants, saw the involvement of 6.2 students and fellows, followed by projects funded through long CRD grants (10.4) and IRC grants (37.1). The difference in grant duration must be noted: whereas Engage grants are 6 months long, short CRD grants are 1 to 2 years, and long CRD grants and IRC grants can last as long as 5 years. IRC grants can be renewed for an additional 5-year term.

[57] The case studies do not constitute a random and representative sample.
[58] This does not include the on-going and extended IRC grants and comprises only completed IRC projects for which final reports were received (N=39).
[59] These data are the most up to date but they exceed the period documented elsewhere in this report.

TABLE 4.15 – Average number of HQP involved in projects

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Undergraduate	2.21	3.29	12.23	0.87
Master's	2.18	3.07	9.68	0.79
Doctoral	1.06	2.43	9.35	0.60
Postdoc	0.78	1.56	5.85	0.46
TOTAL	6.23	10.35	37.11	2.72
n for 100%	53-55	97-105	27-29	101-113
Source: SPI Researcher Survey				

Training of HQP was an important motivator for many industry partners to get involved in these types of grants (case studies): it is seen as a way to train and to assess potential future employees and, therefore, to contribute to the value proposition discussed in the previous section. Also, researchers are very much motivated by the ability to fund their students and to give them some industrial experience. Associate Chairs uniformly reported that one impact of the grant had been an increase in their capacity to attract more and better students, because they were able to offer them industrial experience.

The involvement of HQP with partners was multifaceted (survey of HQP and final reports). Table 4.16 describes the frequency at which HQP were involved in various research activities based on their own account. Key activities were presenting research results, discussing the project directly with the partner, and submitting results to the partner organizations for review. Somewhat less frequent were attendance at regular meetings with the partner, working regularly in the partner facilities, and producing joint presentations.

TABLE 4.16 – Reported involvement of HQP with partner organizations

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Presented research results to partner(s)	77%	86%	90%	87%
Discussed the project directly with the partner(s) to obtain input	72%	77%	74%	83%
Submitted written material/results to individuals from partner organizations for review	63%	69%	67%	79%
Attended regular project meetings with the partner organization(s)	42%	50%	41%	60%
Regularly worked in the facilities of partner organization(s)	40%	28%	26%	26%
Produced joint presentations (at conferences, workshops, etc.) with individuals from partner organization(s)	33%	44%	42%	20%
Produced joint publications with individuals from partner organization(s)	33%	38%	32%	17%
Attended guest lectures by individuals from partner organization(s)	28%	29%	25%	5%
One or more partner(s) jointly supervised my thesis project with my university supervisor	19%	18%	18%	18%
Other	2%	11%	11%	8%
n for 100%	43	199	175	77

Source: SPI HQP Survey
Note: The results shown in the table must be treated with caution, as the sample used for the survey of HQP was built using a snowball technique, making it a non-random sample possibly not representative of students and fellows trained as part of the Industry-driven grants.

Students and fellows frequently reported developing their skills and gaining experience in diverse areas as a direct result of their participation in the research program. Table 4.17 demonstrates that substantial majorities of HQP reported

improvements in a variety of areas, from knowledge of their discipline to project management. Several technical skills and knowledge and/or technology transfer and mobilization were less frequently cited than others. The lower percentages of skill improvement reported by Engage grant HQP are not surprising given the short duration of the projects and the lower emphasis on HQP training in Engage applications.

TABLE 4.17 – Reported HQP skill improvement as a result of participating in a grant

To what extent do you feel that your skills and level of experience improved as a direct result of participating in this (type of grant) project? (entries are % selecting 6 or 7 on a 7-point scale)	**Short CRD Grants**	**Long CRD Grants**	**IRC Grants**	**Engage Grants**
Knowledge of the discipline	85%	79%	83%	66%
Analytical techniques/experimental methods	82%	80%	78%	67%
Report writing and publications	81%	73%	75%	54%
Competence in data collection	79%	70%	67%	57%
Critical and creative thinking	78%	74%	67%	55%
Team/group work	*76%*	*68%*	*65%*	*65%*
Competence in research development and design	71%	67%	66%	58%
Technical skills, expertise and/or know-how relevant to the private sector	66%	67%	63%	56%
Research and project management	65%	60%	67%	63%
Ability to conduct research to address private sector problems	64%	71%	66%	61%
Communication and interpersonal skills	*63%*	*64%*	*64%*	*58%*
Interdisciplinary research	57%	56%	53%	47%
Leadership	*57%*	*57%*	*52%*	*46%*
Knowledge and/or technology transfer/mobilization	49%	48%	56%	43%
Networking skills	*41%*	*44%*	*43%*	*35%*
IP protection/management	*38%*	*36%*	*27%*	*22%*
Supervision/management of other employees	*33%*	*35%*	*33%*	*31%*
Financial management	*21%*	*14%*	*16%*	*11%*
Entrepreneurship and business management	*21%*	*13%*	*12%*	*13%*
n for 100%	39-49	160-213	145-183	54-82
Note: Non-technical skills are in italics Source: SPI HQP Survey				

Industrial partners concurred that HQP who were involved in these grants were better prepared than students who did not participate in such projects (Table 4.18): close to two-thirds of partners were of the view that, upon hiring, HQP who participated in the grants required less training than those who did not. HQP themselves were almost unanimous in reporting that the experience they gained in their participation in the grants improved their career prospects (Table 4.19).

TABLE 4.18 – Industrial partner's assessment of HQP training

Did the students who participated in (grant) and who were hired by your company require more, less, or the same amount of training than other students who did not participate in the project?	**Short CRD Grants**	**Long CRD Grants**	**IRC Grants**	**Engage Grants**
Required less training	64%	62%	57%	64%
n for 100%	16	34	26	18
Source: SPI Partner Survey				

TABLE 4.19 – Reported HQP career impact

To what extent do you disagree or agree that the experience you gained during your participation in this (grant) project: (% agree)	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Improved your career prospects	87%	90%	92%	88%
n for 100%	47	206	179	77
Source: SPI HQP Survey				

Positive impacts on HQP employment were also documented. Hiring of students and fellows involved in industry-driven projects was relatively frequent (surveys of research and industrial partners, case studies). As Table 4.20 shows, from one-quarter to one-third of CRD and IRC partners indicated that they completed such hiring, and 11% of Engage partners stated the same. The average number of students and fellows hired by industry is elusive: because they have different time perspectives[60] and sources of information, partners and researchers report different figures. According to researchers, the average Engage grant leads to the hiring by industry (not just the partners) of 0.7 HQP whereas short CRD grants lead to 2.2, long CRD grants, 4.2, and IRC grants, 12.4. Information obtained from partners averages fewer hirings except for Engage grants where the partner average is higher.

TABLE 4.20 – Partner hiring of students and fellows involved in grants

	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
% of partner organizations who hired any of the students who participated in the grant (according to partners)	29%	25%	36%	11%
n for 100%	64	162	76	181
Average # of students and fellows who participated in the grant who have since been hired by industry (according to researchers) (median)	2.2 (2.0)	4.2 (3.0)	12.4 (6.6)	0.7 (0.5)
n for all respondents	154	137	37	125
Average # of students and fellows who participated in the grant who have since been hired by industry (according to partners) (median)	1.8 (1.0)	1.8 (1.0)	3.9 (2.0)	1.8 (1.0)
n for all respondents	16-17	33-37	23-26	15-17
Sources: SPI Partner Survey, SPI Researcher Survey				

Some Engage and CRD cases studied involved students going on to successful careers in the same or very closely related sectors spurred at least in part by their involvement. Some of the smaller grants, however, did not result in any direct hires: either because the grant did not produce useful results or because the company was not in a position, or was too small, to expand.

4.5 Factors Contributing to or Inhibiting the Achievement of Program Outcomes

Table 4.21 summarizes the factors contributing to or inhibiting positive outcomes from the grants, as identified through this evaluation. Some of these factors are under the grant control but others are not. References in the table are not necessarily tied to grant requirements (e.g., Engage does not require student involvement) but they can be related to the logic models or the theories of change.

[60] Researchers can add up hirings to industry (partners and other companies) over several years. Partners see only their own hirings but may refer to more than one grant and may not separate different types of funders (e.g., NSERC, Mitacs). Partner results are based on small samples.

TABLE 4.21 – Summary of Factors Contributing to or Inhibiting Positive Outcomes from the Grants

Factors Contributing	Factors Inhibiting
Partner's contribution One elements of context is clearly more significant than the others in contributing to the success of partnerships: the size of the contribution by the industrial partner(s), be that in money or in-kind: larger contributions being related to more impact.	
Partners' prior experience with research There is a variety of industrial partners, from a small manufacturing company without experience in research to the R&D arm of a large, highly research-engaged organization such as research institute of a provincial hydroelectric utility. Therefore, researcher-industry relationships cannot be conceived in a monolithic or homogeneous fashion. Partners with prior experience in research have more grounded expectations and practice whereas a company with little exposure to R&D has no basis for realistic expectations about research.	**Partners' prior experience with research** Lack of industry understanding of research and unrealistic expectations on their part limit grant outcomes.
Researcher's background Success was more likely when the researcher came from industry or had a background in industry, understood the nature of the industry's interests in R&D, and was able to create a common value space.	**Researcher's background** Lack of faculty experience and understanding of industry was identified as a barrier.
Partnership model The consortium model where multiple companies or even consortia of companies contribute a relatively small amount to pay their part of the grant has been effective in protecting the grant from industry downturn and in ensuring the dissemination of results.	**Partnership model** Collaborations based on few partners may be at risk if the relationship disintegrates or if the research findings do not amount to a good business case for partners.
Sustained contact Close, regular, structured contact between the university and industry teams, ideally with students regularly present at the industry sites, is facilitative of good working relationships and progress in the research.	**Sustained contact** The absence of structured contact is detrimental to the success of the research partnership.
Involvement of the end user A success factor in two particularly successful grants was involvement of the customer – that is, not only the industrial partner helping to develop a new technology application, but the commercial sector who would actually be customers for the product once it was developed. This helped achieve another facilitative factor: researcher responsiveness to changing industry dynamics.	
HQP training Opportunities for HQP training and the excellence of students were cited by almost all case study respondents as having been instrumental in the success of the grants that were successful.	**HQP training** Difficulty in finding students was cited as a problem in several of the case study grants, particularly for the short-term grants such as Engage grants because they needed to be able to commit funding to senior trainees (PhD students in particular) over a longer period. In two of the cases, one Engage grant and one CRD grant, the work was severely compromised by student-related factors: in one case the departure of a student and in the other the failure to recruit an appropriate student until the very end of the grant. Difficulty hiring students due to timing of approvals was also cited as an inhibiting factor, as students could accept positions elsewhere in the meantime.
	Economic climate The volatility of the economy was cited as affecting industry capacity to engage in research.
	Academic motivations Some case study researchers indicated that their colleagues were reluctant to get involved with industry because they felt they would not get credit for their work and would have to cede intellectual property. Concurrently, key informants indicated that researchers who collaborate with industry are not given enough credit for their accomplishments in industry: neither the university nor NSERC places much emphasis on products that are common in researcher-industry collaboration such as technical reports and software. This is particularly challenging for young academics who lack tenure.

SECTION 5: DESIGN AND DELIVERY

This section answers two evaluation questions dealing with the design and delivery of the sub-program. It discusses the management of IP and features of the grants that affect the likelihood of application.

5.1 Management of Intellectual Property

In general, Canadian companies find it challenging to create mutually beneficial university-industry partnership agreements and manage IP.[61] However, partners indicated in the SPI survey that the three grants did not raise insurmountable IP management issues (see Table 5.1): about three-quarters of partners in each grant stated that IP issues either facilitated or did not inhibit their participation in the grant. The Engage grants were conceived with the approach that fore-ground IP must be assigned to the partner. Key informants noted that this provides clarity for partners, and reduces times to start the projects.

TABLE 5.1 – Extent to which IP issues inhibited or facilitated participation in the grant

To what extent did the following factors inhibit OR facilitate your organization's ability to participate in (type of grant)? - Intellectual Property (IP)	Short CRD Grants	Long CRD Grants	IRC Grants	Engage Grants
Inhibited	28%	24%	23%	15%
Neither inhibited nor facilitated	44%	55%	54%	37%
Facilitated	28%	22%	24%	48%
n for 100%	58	158	78	175
Source: SPI Partner Survey				

According to key informant and case study interviews, IP arrangements varied widely across types of projects and the nature of the PI being produced (e.g., technologies, databases, software, techniques). Within the limits of a non-random sample, in most of the case studies, including all of the IRC grants – who are of course led by seasoned researchers and experienced partners – the IP arrangements were satisfactory. This seemed particularly to be the case where the researchers themselves were not particularly interested in obtaining rights or patents for themselves, but rather finding ways to ensure that their students could benefit from their participation in the grants. This included ensuring that students were included in ownership of or rights to any discoveries made under the grant, as well as building in opportunities for students to produce peer-reviewed presentations and reports, even when the researcher had agreed to withhold publication until partners' interests had been realized. A successful example of this was seen in those IRC grants that hold an annual research day for all parties, in which student presentations and posters are given a valued place. NSERC's supports such as the IP management templates were cited as helpful to the successful negotiation of IP partnership arrangements. In some cases, publication was delayed until industry benefit was achieved.

In addition, but in a way that does not amount to a significant problem for the grants funded, the case studies indicated that there is wide variability and lack of standard practice in IP management across institutions.[62] Moreover, in several case studies, university IP offices were seen as encumbering. They were said to have caused delays and frustrations, and in some instances that researchers were aware of or had been involved in, led to industry-university partnerships not being undertaken even though the researchers and the companies were willing. The perspective of several of the industry partners was that universities were greedy and also overly optimistic or unrealistic about the likelihood that any one piece of research would produce anything of commercial interest, especially in the short term. The most successful partnerships seem to have circumvented this by using blanket IP agreements with sub-agreements for specific projects or products where commercial interest was plausible, and simply by learning from experience in working out the arrangements. Examples were also seen of researchers with highly successful records of industrial collaboration, in

[61] Parliament of Canada. The Canadian Intellectual Property Regime. http://www.parl.gc.ca/HousePublications/Publication.aspx?DocId=6038442&Language=E&File=57#13

[62] This reflects observations from *The Canadian Intellectual Property Regime* that post-secondary institutions do not have a consistent, standardized IP ownership policy across institutions.

moving into deanship or similar positions of influence, working to reform institutional IP policy to be more facilitative of industry engagement with academia.

5.2 Program Features that Facilitate or Inhibit Application

Above and beyond the contextual factors such as industry economic outlook that affect interest in collaborative research, key informant interviews suggested that researchers' application for Engage grants was facilitated and inhibited by some features of the program. Information of this nature was not identified from CRD and IRC which are well established grants with a long history of adjusting their application procedures.

For Engage projects, research partners and key informants were in agreement that applying to the program was made more attractive by the relatively short time between the funding application and the decision as well as by the simplicity of the application process. Those researchers who had been involved in Engage grants praised this program for its accessibility and fit with the capacities and stakes of industrial partners.

Engage grant case studies documented very high satisfaction with the efficiency of Engage grants, as did other case studies where Engage grants had been used. The Engage grant process was described as rapid and simple to access. Staff members indicated that the design of the Engage grant has been responsive to a need for an efficient process: the program processes have adapted to simplify recommendation processes and to reduce the bureaucratic sign-offs. Consistency in program management has been supported by biweekly evaluation meetings and the compilation of program guideline interpretations in a repository of precedents.

For IRC grants and CRD grants, the most cited inhibiting factor to applications was the requirement to find partner(s) willing to make a cash contribution. According to key informants, Engage grant applications were inhibited by the short duration of the funding which may only allow grantees to start addressing a problem without reaching a solution; while the initial and rapid analysis of a particular problem is the essence of Engage grants, these short grants can be complemented with an Engage Plus grant.

5.3 Performance Measurement

The grants have a history of conducting performance measurement. Researchers and partners are requested to file final reports to describe project accomplishments and outcomes for various stakeholders. The data gathered in an on-going fashion by the grants has proven valuable to the evaluation and discussions with program staff have shown that the data is used in regular program management.

Interviews and discussions with program staff indicated that there is still work to do to increase the use of common metrics to measure grant performance, considering that the grant logics share many outcomes. A working group has been set up with an objective to develop more common metrics.

SECTION 6: EFFICIENCY AND ECONOMY

6.1 Cost-Efficiency of the Management of the Funding Opportunities

Over the period of 2010-2011 to 2013-2014, the average administrative cost ratio was 8.17 cents for every $1 of CRD grants (which was slightly higher than the overall ratio for the RP Directorate) and 6.73 cents for every $1 of IRC grants (which was in line with the ratio for the RP Directorate). The average administrative cost ratio for Engage grants was slightly higher at 10.18 cents for every $1 of awarded grants. This is due to the higher administrative costs in the beginning of the program. Over the evaluation period, Engage administrative costs dropped by almost one-half and are currently in line with the costs of the other industry-driven grants.

A common measure of operational efficiency of grant programs is to assess the ratio of operating expenditures[63] to the total amount of grant funds awarded. This ratio represents the cost of administering $1 of grant funds awarded. The evaluation also factored in the number of awards (both new and ongoing) and the average grant size.

As Table 6.1 shows, the ratio of operating expenditures over the four-year period (from Fiscal Year 2010-11 to 2013-14) was 8.17 cents for every $1 of awarded CRD grants and 6.73 cents for every $1 of IRC grants. These ratios were slightly higher than that incurred by NSERC overall (4.99 cents). The overall ratio of all expenditures incurred by the Research Partnerships Directorate (6.56 cents per $1 of grants awarded) was roughly in line with the IRC ratio and slightly lower than the CRD ratio.

TABLE 6.1 – Ratios of operating expenditures, 2010-2011 to 2013-2014

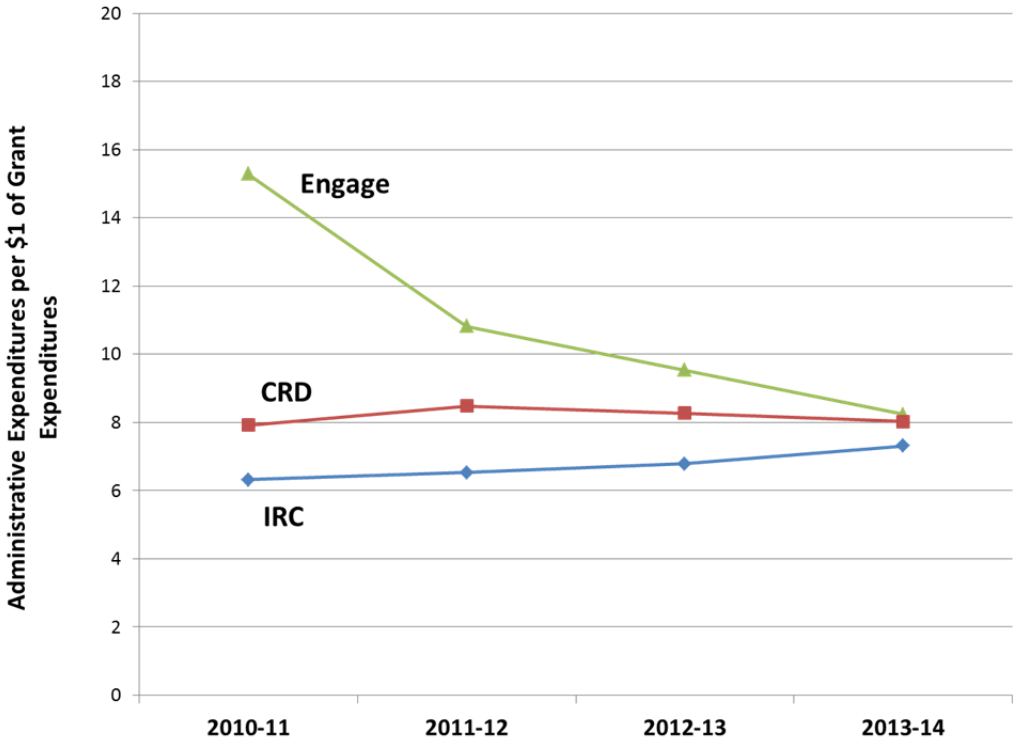
Funding Opportunity	Administrative Expenditures	Grant Expenditures	Total Administrative and Grant Expenditures	Administrative Expenditures per $1 of Grant Expenditures	Number of awards (new and ongoing)	Average grant size
CRD	$20,418,912	$249,864,592	$270,283,504	8.17¢	3,275	$76,295
IRC	$6,805,957	$101,115,450	$107,921,407	6.73¢	978*	$103,390*
Engage	$8,315,328	$81,715,040	$90,030,368	10.18¢	3,334	$24,510

* Includes both IRC Project and IRC Salary grants
Source: NSERC, Cost-Efficiency Technical Report

The ratio for Engage grants was higher than that for CRD and IRC grants and totaled 10.18 cents for every $1 of awarded grants. The higher administrative cost for Engage was incurred in the beginning of the program (administrative costs are often higher at the initial stage of a new grant). Between 2010-2011 and 2013-2014, the Engage administrative costs dropped by almost one-half, whereas the CRD costs have been relatively stable and the IRC costs increased by approximately 15% (Chart 6.1). The Engage costs are currently in line with the costs of the other industry-driven grants despite the internalization of the review process.

[63] Operating expenditures include both direct and indirect costs of administering the program. Direct costs are comprised of salary and non-salary costs, which are related primarily to the adjudication of the award. Non-salary costs also include a share of the costs related to corporate representation and general administration of the Research Grants and Scholarships Directorate. Other direct costs associated with administering the program, such as post-award management (which is a centralized function carried out by the Finance division) and indirect costs, such as common administrative services for NSERC (e.g., finance, human resources and IT) have also been included in the total calculation of costs and were estimated using the ratio of total Discovery Grant awards to total NSERC grant funds.

CHART 6.1 – Annual ratios of operating expenditures, 2010-2011 to 2013-2014



6.2 Qualitative Feedback on Efficiency

In interviews, IRC staff recognized a need to modernize and automate their grant administration. Also, reporting by Chairs requires getting industrial comments which is made difficult by partners' busy schedules and competing priorities.

Most university VPs did not report major issues, but a few criticized the annual financial reporting requirement. University research services tend to be mired in red tape and backlog which can be confusing to researchers and partners.

SECTION 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Relevance. The Industry-driven Collaborative Research and Development sub-program is designed to meet the needs of both industrial partners and academic researchers: projects address real world challenges that are relevant to industry, help build sustainable relationships between the two sectors, and connect people and skills. Each funding opportunity included in the sub-program adopts a different means to achieve common objective: fosters partnerships in natural sciences and engineering that facilitates the transfer of knowledge and skills to the user sector through awards that support research projects and activities intended for socioeconomic impact. The partnerships encouraged and enabled by the sub-program also increase the commercialization of Canada's research through new products, services, and processes for the benefit of all Canadians. While industry R&D expenditures in Canada decline, these grants are attracting increased levels of partner contributions, and the partners tend to maintain or increase their R&D expenditure after the grants. At the same time, university researchers benefit from establishing and maintaining partnerships between academia and industry by having an opportunity to conduct research and create new knowledge and technology for company-specific needs. Students become exposed to R&D in industrial environment, as well as gain expertise and knowledge required for future employment.

The sub-program is well-aligned with the priorities of the federal government and NSERC. The 2014 Government of Canada S&T strategy "Seizing Canada's Moment: Moving Forward in Science, Technology and Innovation" encouraged partnerships and justified federal government involvement in industry-focused research as one contributor in a large innovation ecosystem of funding and support. In the recent years, the Federal Government continued to play an important role in encouraging collaborations since the level of private investment in R&D in Canada has decreased.

The sub-program objectives also mirror the priorities of the current government, which focuses on improvement of programs that support innovation, scientific research and entrepreneurship, as well as the development of an Innovation Agenda with intent to expand effective support for the emerging national network for business innovation and cluster support. The Government believes that investing in an appropriate balance between fundamental research to support new discoveries and the commercialization of ideas will lead to sustainable economic growth. The sub-program has been shown to be a flexible and effective tool that allows industry access to the 'brain trust' that has been developed in universities across Canada and therefore is a perfect fit within the larger Innovation Agenda.

Performance. The university-industry partnerships supported by the industry-driven funding opportunities are generally successful at fostering meaningful collaborations that last beyond the funding period. IRC grants are more likely to produce collaborations beyond the original group than CRD; though they are both effective at doing so. There is evidence that IRCs tend to reinforce existing partnerships rather than create new ones which is not surprising considering the size of the investment by the industry. It has been noted that the relationship between a company and a university can begin by satisfaction in completion of a project funded through a CRD grant followed by further investment in an IRC based on that success. By design, Engage grants involve new partnerships and, therefore, contribute to bridging the gap between researchers and industry.

Long-term relationships, defined as relationships that have continued past the completion of the initial grant, are typically established as part of the industry-driven funding opportunities – less so after the small Engage grants but still leaving the parties intending to continue collaborating. The nature of the long-term relationships is varied and consistent with the interests and resources of the parties.

The industry-driven funding opportunities have substantially contributed to enhancing the research capacity of researchers involved – through improved access to facilities, expertise, data, equipment, and intelligence on future research directions as well as additional resources for hiring personnel. They have also had positive effects on the research capacity of universities. The grants opened up new opportunities for research beyond the original objectives, influenced the direction to more industrially relevant topics, assisted in attracting better qualified personnel, and generally contributed to the improved knowledge base of universities.

As part of the evidence gathered, industrial partners reported that the grants had significant impacts on competitiveness and productivity. Increased market visibility is the most frequently reported type of impact on competitiveness, followed

by access to new markets. About one-half of the partners indicated that their revenues increased since the end of the grant; representing on average an increase of 22 percent over all grant types. When asked how much of the change could be attributed to the grant, the result is more modest; roughly 5%. The survey results indicate that partners who participated in these grants tend to maintain or grow their R&D budgets after their participation. When reported decreases to R&D budgets are factored in against reported increases, the estimated net effect is in the range of a 5 percent increase in R&D budgets.

The transfer of knowledge to industrial partners is another benefit that companies can obtain, and was a motivating factor at the outset for three-quarters of partners. Evaluation evidence indicated that such transfer does occur, sometimes with a single company and other times to an entire industry. Almost 85 percent of partners surveyed indicated that the skill and knowledge base of the organization had been, or was likely to be enhanced as a result of the grant. Reports provided to partners and formal publications were the main mechanisms used in transferring knowledge to industrial partners.

The industry-driven funding opportunities involved substantial numbers of students and fellows in applied industrial research and their involvement was multifaceted, including interacting with industry partners and presenting results. Students and fellows frequently reported developing their skills and gaining experience in diverse areas as a direct result of their participation in the research program. Positive impacts on HQP employment were also documented. Training of HQP was an important motivator for many industry partners to get involved in these types of grants: it is seen as a way to train and to assess potential future employees and, therefore, to contribute to the value proposition. It has been shown that transfer of knowledge through the hiring of university graduates who worked on the project can be very effective.

While a number of other benefits for industrial partners were identified, it is clear that the desire of industry partners to continue to partner for R&D depends on the economic benefits of research outcomes in which the grants are one factor among many others.

Efficiency. Over the period of 2010-2011 to 2013-2014, the average administrative cost ratio was 8.17 cents for every $1 of CRD grants (which was slightly higher than the overall ratio for the RP Directorate) and 6.73 cents for every $1 of IRC grants (which was in line with the ratio for the RP Directorate). The average administrative cost ratio for Engage grants was slightly higher at 10.18 cents for every $1 of awarded grants. This is due to the higher administrative costs in the beginning of the program. Launched in 2009, Engage is a new funding opportunity and administrative costs are often higher at the initial stage. Over the evaluation period, Engage administrative costs dropped by almost one-half and are currently in line with the cost of the other Industry-driven grants.

7.2 Recommendations

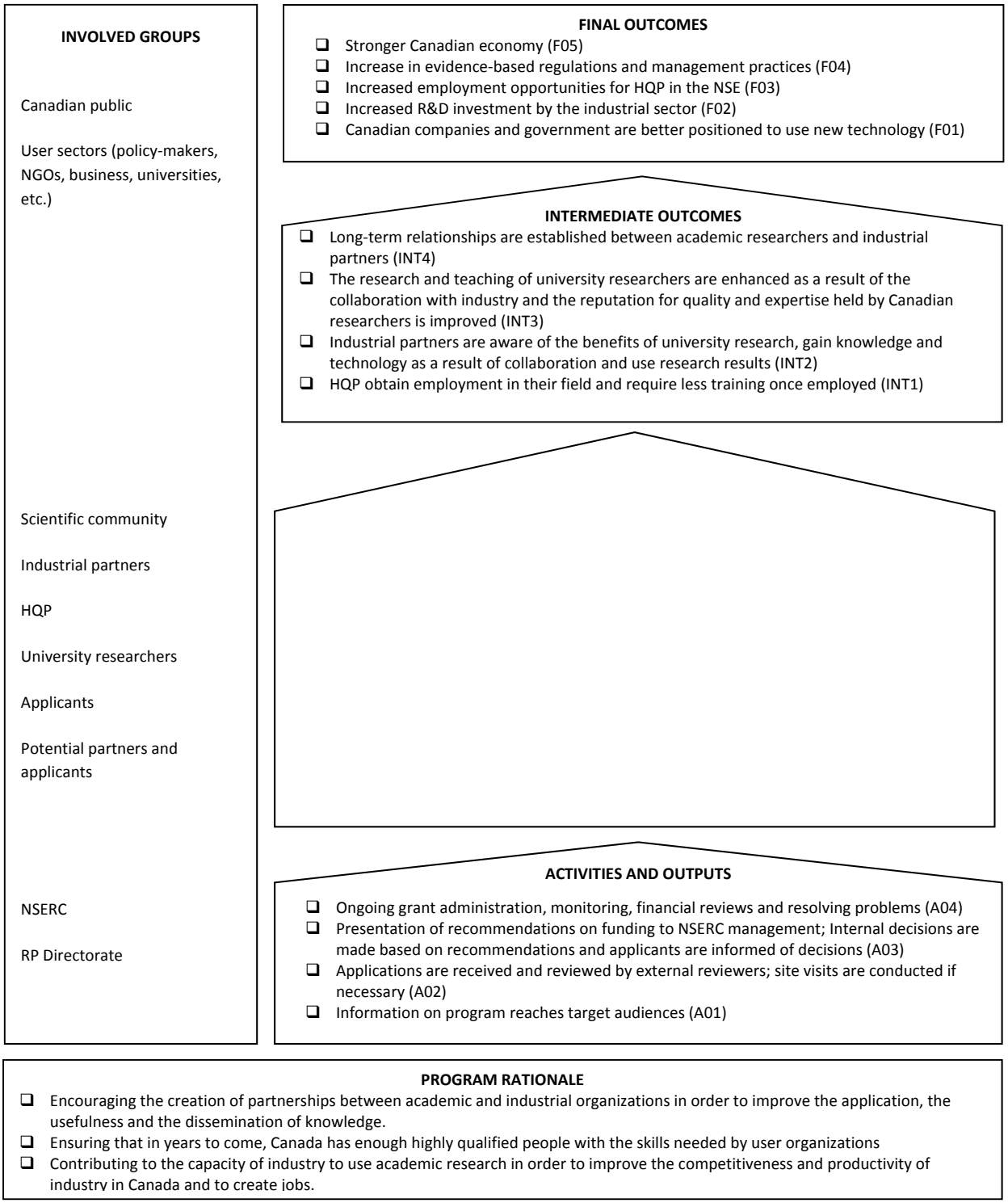
Recommendation #1. Maintain the Industry-Driven funding opportunities. The grants support the role of NSERC in contributing to the Canadian ecosystem of innovation by encouraging research collaborations between industry and universities and are well aligned with government priorities. They are designed to meet the needs of both industrial partners and academic researchers, in which each funding opportunity adopts different means to achieve common objective: fosters partnerships in natural sciences and engineering and facilitate the transfer of knowledge and skills to the user sector. Program management has demonstrated that it is equipped to address the changing landscape of university-industry collaboration via incremental changes to the programs.

Recommendation #2. Continue efforts to develop common metrics for the measurement of impacts on industry and consider homogenizing vocabulary among grants. All three grants have very evolved performance measurement systems that have contributed to the on-going management of the program, as well as to this evaluation. These systems could be improved by increasing the use of common measurements to assess impacts on industry. Additionally, some terminology would benefit from more homogeneity across the grants use, such as the notions of partnership, collaboration, and networking as well as the various activities associated with knowledge (creation, dissemination, exchange, translation, mobilisation, etc.).

Recommendation #3. Consider revising the Engage logic model to improve alignment with the objectives of the grants. While the Engage logic model was built cooperatively with grant administrators, it includes some outcomes that are not related to program objectives and for achieving which the Program management cannot be held accountable (e.g., HQP training).

APPENDIX A: Logic Models

CRD Grants Logic Model



Engage Grants Logic Model

INVOLVED GROUPS

Canadian public

User sectors (policy-makers, NGOs, business, universities, etc.)

Scientific community

Industrial partners

HQP

University researchers

Applicants

Potential partners and applicants

NSERC

RP Directorate

FINAL OUTCOMES

- Stronger Canadian economy (F05)
- Increase in evidence-based regulations and management practices (F04)
- Increased employment opportunities for HQP in the Natural Sciences and Engineering (F03)
- Increased R&D investment by the industrial sector (F02)
- Canadian companies and government are better positioned to use new technology (F01)

ACTIVITIES AND OUTPUTS

- Ongoing grant administration, monitoring, financial reviews and resolving problems (A04)
- Presentation of recommendations on funding by staff reviewers to NSERC management; Internal decisions are made based on recommendations and applicants are informed of decisions (A03)
- Information on program reaches target audiences (A01)

PROGRAM RATIONALE

- Encouraging the creation of partnerships between academic and industrial organizations who have never worked together before in order to improve the application, the usefulness and the dissemination of knowledge.
- Ensuring that in years to come, Canada has enough highly qualified people with the skills needed by user organizations
- Contributing to the capacity of industry to use academic research in order to improve the competitiveness and productivity of industry in Canada and to create jobs.

IRC Grants Logic Model

INVOLVED GROUPS

Canadian public

User sectors (policy-makers, NGOs, business, universities, etc.)

Scientific community

Industrial partners

HQP

University researchers

Reviewers

Applicants

Potential partners and applicants

NSERC

RP Directorate

FINAL OUTCOMES

- Improved industrial performance in the domestic and international marketplace
- Increased R&D investment by the industrial sector
- Increased employment opportunities for HQP in the Natural Sciences and Engineering
- Stronger Canadian Economy / Enhanced economic benefits for Canadians

INTERMEDIATE OUTCOMES

- Enhanced partner use of research results (i.e., new / improved products / processors, policy development, etc.)
- Transfer of knowledge / technology to Canadian companies and government
- Transfer of knowledge from partners to researchers/academia
- Increase in evidence-based regulations and management practices
- HQP obtain employment in their field and require less training once employed

IMMEDIATE OUTCOMES

During Award:

- Enhanced research capacity of the Industrial Research Chair holder
- Enhanced University research capacity in an area directly related to the IRC
- Enhanced networks / partnerships (universities and partners)
- Improved knowledge and / or technology in industrially relevant area
- Increased pool of HQP with research expertise relevant to the industrial sector

ACTIVITIES AND OUTPUTS

- Communicate IRC program information
- Review and Select Applications
- Administer and Manage Grant and Renewal Process
- Communication materials and information website
- Proposals, applications, recommendations, decisions, peer review, site visits, site visit committee, ACUIG, partnerships (university industry)
- Funding Industrial Research Chair holders