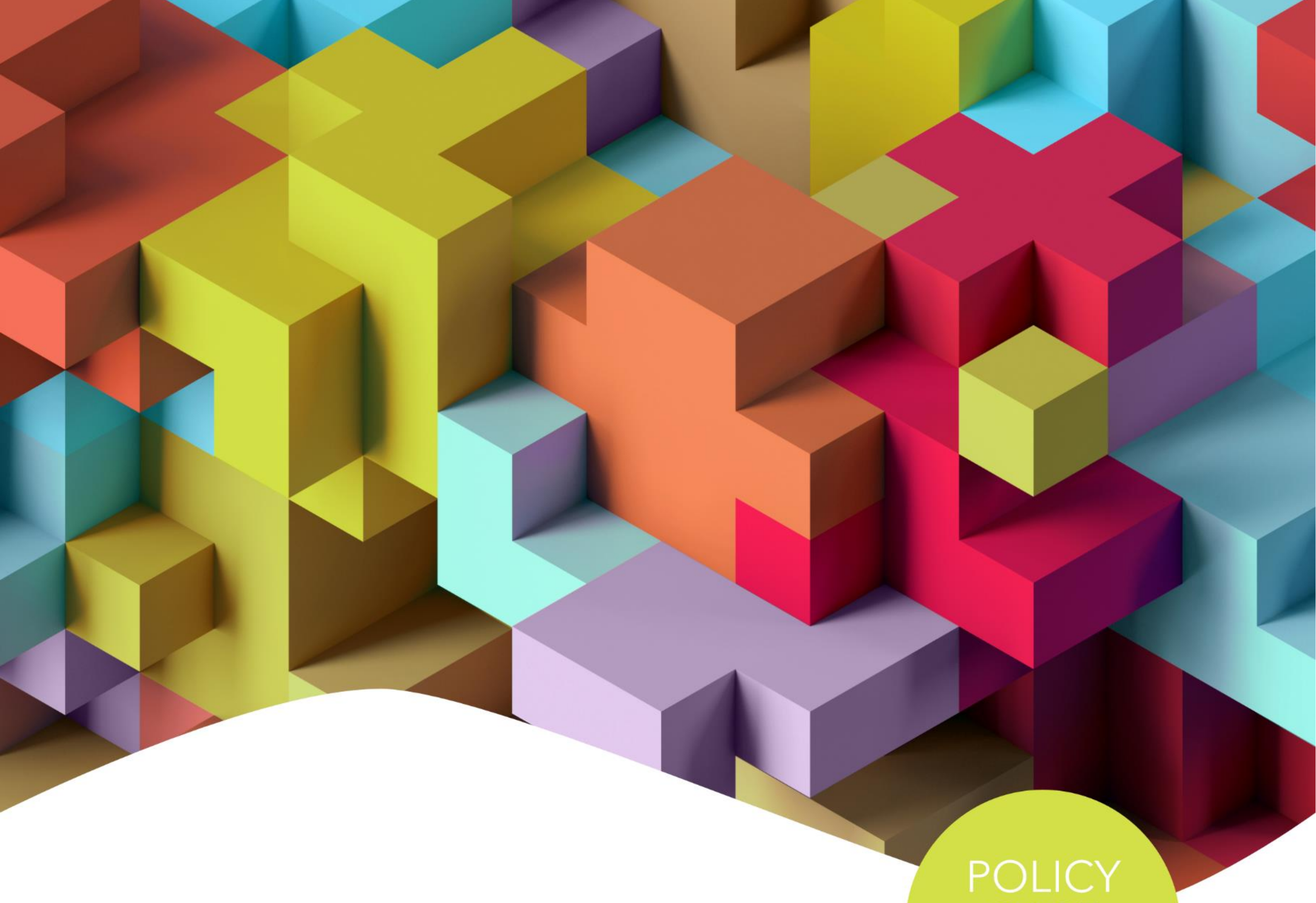

POLICY CASE STUDY

The Technology Access Centre Grants in Canada

Case study contribution to the OECD TIP Knowledge Transfer and Policies project

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Abstract

This case study focuses on the Technology Access Centres (TAC) Grants administered by the Natural Sciences and Engineering Research Council of Canada (NSERC), a federal agency of the Government of Canada that provides funding for research at post-secondary institutions. TAC Grants support the operations of centres established by colleges that enhance the ability of companies, particularly small and medium-sized enterprises (SMEs), to become more productive and innovative by enabling them to readily access college expertise, technology and equipment. This access to college capabilities is intended to enhance the productivity, competitiveness and innovation of the participating SMEs.

The case study begins with a description of Canada's post-secondary education landscape. This provides the context in which the TAC Grant was developed. The majority of the case study focuses on the characteristics of the TAC Grant, including its main features, objectives, and interplay with other knowledge transfer policies and programs. The study concludes by exploring considerations for other countries that may wish to develop a similar initiative.

Executive summary

Canada's post-secondary sector is comprised of both universities and colleges.[1] There are about 96 publicly funded universities and more than 130 publicly funded colleges in Canada, with about 1.31 million students enrolled in universities and about 728 thousand enrolled in colleges.[2] While recent developments in both universities and colleges have expanded their missions, universities and colleges continue to play distinct roles in the research and innovation system and have different approaches to knowledge transfer.

Universities perform much more research than colleges, and there are important differences between the types of research that occur within the two types of post-secondary institutions. Universities tend to focus more on fundamental research, although their role in applied research has grown. Due in part to the historically high level of government funding for university research, universities have also developed strengths in a wide range of areas. In addition, university faculty are employed as both teachers and researchers, and they are usually expected to spend between 20 and 40 percent of their working time conducting research.

Canada's colleges, on the other hand, were not established to be involved in the production and dissemination of research, but rather to provide specialized occupational skills to address regional labour market needs. However, over the past thirty years, colleges have substantially increased the amount of applied research that they perform, and they are carving out a more significant role within the national research and innovation system.

Colleges approach research from a different starting point than universities. The primary purpose of college research is to extend and enhance the mission of employment-related education and regional economic development. Colleges focus on applied research, and can thus serve as a bridge between advanced knowledge and the late-stage development and commercialization that occur in Canadian companies.

1 Colleges in Canada generally offer degrees at the tertiary B level.

2 Statistics Canada, Postsecondary enrolments, by registration status, institution type, sex and student status, Table: 37-10-0018-01

1. Main features of the Technology Access Centre Grants

Canada's federal government has invested in a number of programs that connect industry with research and talent in post-secondary institutions. In the last ten years, more attention has been devoted to the role of colleges in the research and innovation system and the part that college-industry collaboration can play in addressing business R&D and innovation challenges.

Recognizing that the focus of colleges on industry-relevant applied research makes them a particularly attractive partner to small and medium-sized enterprises (SMEs), the Government of Canada supports initiatives to promote collaboration in this space. One such initiative is the Technology Access Centres (TAC) Grant, which is the focus of this case study.

The TAC Grants are delivered through the Natural Sciences and Engineering Research Council of Canada (NSERC)-managed College and Community Innovation (CCI) Program. The objective of the CCI Program is to increase innovation at the community and/or regional level by enabling Canadian colleges to increase their capacity to work with local companies, particularly SMEs. The program supports applied research and collaborations that facilitate commercialization, as well as technology transfer, adaptation and adoption of new technologies.[3] Along with the TAC Grants, there are seven other types of grants offered through the CCI Program:

Engage Grants support short-term applied research projects undertaken by college researchers and their industrial partners. Engage Grants do not exceed C$25,000 over a six month period. These grants are intended to foster the development of new research partnerships by supporting short-term R&D projects aimed at addressing a company-specific problem.

Applied Research and Development (ARD) Grants support short-term, well-defined applied R&D projects undertaken by college researchers and private sector partners. ARD Grants do not exceed C$150,000 annually. Awards are offered for up to three years and private sector involvement in the project is required through direct contribution to project costs.

Applied Research Tools and Instrument (ARTI) Grants support the purchase of applied research equipment costing between C$7,000 and C$150,000. The proposed equipment may be a single item or a collection of items targeted at a particular applied R&D capability. Private sector partners are not necessary to be awarded an ARTI grant.

College and Community Social Innovation Fund (CCSIF) Grants support well-defined and focused social innovation projects undertaken by college researchers with partners from the public, private or not-for-profit sectors. CCSIF Grants do not exceed C$120,000 per year and have a duration of one to two years.

Innovation Links Grants support college-university collaborations in partnership with industry to advance commercialization. Direct project costs are shared by the company partner(s) and the CCI Program. Projects may span up to three years in duration, and

3 Natural Science and Engineering Research Council of Canada. College and Community Innovation Program. http://www.nserc-crsng.gc.ca/Professors-Professeurs/RPP-PP/Info-Info_eng.asp

provide up to C$125,000 per college/university partner. Private sector participation is required through direct contribution to the project costs.

Industrial Research Chairs for Colleges (IRCC) Grants support colleges to develop new or significantly enhance existing applied research efforts and capacity in areas that meet local or regional socio-economic needs. Chair holders are expected to conduct a program of applied research with partner companies. IRCC Grants range from C$100,000 to C$200,000 annually over five years.

Innovation Enhancement (IE) Grants are the largest funding source available through the CCI Program, supporting research costs through three types of grants (Build IE Grants, Entry-Level IE Grants and Extend IE Grants). Build IE Grants provide up to C$400,000 per year, delivered over five years.

Companies must commit cash and in-kind support. Build IE Grants can be developed initially through an Entry-Level IE Grant (up to C$100,000 per year for up to two years), and can be extended for an additional three years through an Extend IE Grant (up to C$300,000 per year for up to three years).

Funding provided through the CCI Program is complemented by funding from the Canada Foundation for Innovation (CFI), which helps colleges build their capacity to support business innovation in Canada by providing them with state-of-the-art, industry-relevant research infrastructure through the College-Industry Innovation Fund (CIIF). The CIIF includes a stream associated with the Build IE Grants, allowing colleges to include a request for research infrastructure in their grant application.

With respect to the subject of this case study, the TAC Grants provide core support to Technology Access Centres (TACs), which provide applied research support to businesses. Canada’s 30 TACs are demand-driven, specialized, applied R&D centres affiliated with publicly-funded colleges, polytechnics, and cégeps[4] (hereafter referred to simply as colleges) located across Canada. Each TAC focuses on strengthening an industrial sector of significance to that region. The TACs are networked with one another, and may refer a company seeking assistance to another TAC if the local TAC’s specialization and the company’s need do not align.

TAC Grants support the management of the TACs, enabling the TACs to draw on the technical capabilities (researchers, faculty, students and equipment) at their host colleges. With support from the TAC Grants, the TACs provide clients and partners from across Canada with access to:

- expertise and experience of **over 1,400** business innovation and applied R&D experts;
- over **2.6 million square feet** of applied research and innovation space; and
- over **C$265 million** worth of highly-specialized equipment and facilities.

This specialized capacity is designed to be complementary to other players in the Canadian research and innovation system such as incubators, accelerators, private research and testing laboratories, universities, and government research laboratories.

Many TACs existed before the launch of the TAC Grants. For example, all of the TACs in Québec existed as provincially-designated *centres collégiaux de transfert de technologie*

4 A cégep is a publicly funded pre-university college in the province of Québec's education system.

(discussed in more detail below) before receiving the TAC designation through a TAC Grant award.

Outside of Québec, the TACs have all evolved from previous multi-year NSERC capacity-building grants (such as IE Grants) held by the host college. Many of these colleges received additional funding support from their host province or other federal programs over the years to assist with capacity development. The TAC Grant bestowed an official designation and additional resources on what was a pre-existing (but unofficial) research centre/group/team with a track record of collaborative applied research projects with local/regional firms.

Box 1. Innovation in home building

Projects undertaken at TACs are not just about manufacturing a new widget or optimizing a new piece of software. For instance, Mattamy Homes joined four other Canadian homebuilders in the ecoENERGY Innovation Initiative (ecoEII) – a federal-government-funded demonstration initiative to build 25 Net-Zero Energy Homes (NZEH) across Canada. Mattamy had to construct five Net-Zero homes in Calgary’s challenging climate and they had to be affordable for middle-class Canadians.

To tackle the challenge of showing that high-performance, energy-efficient building is a viable option for large volume home builders, Mattamy worked with the high-energy research team at the **Southern Alberta Institute of Technology’s (SAIT) Green Building Technologies (GBT)** TAC in Calgary. In four years, Mattamy has completed, and sold, four of the five NZEHs, while the fifth NZEH is open to the public as a show home in the northeast Calgary community of Cityscape. This flagship project will pave the way for Mattamy, as well as other production homebuilders, to make net-zero homes available in more communities across Canada.

1.1. TAC Grants main characteristics

Types of support provided: TAC Grants support activities related to a TAC’s activities, including administrative personnel, purchase or rental of equipment or a facility, travel to develop business and deliver services, faculty release costs, equipment maintenance, operating costs and supplies, and advertising and project management.

With a full complement of 30 TACs (5-year renewable grants: 13 in Québec receiving C$100,000/year and 17 in the rest of Canada receiving C$350,000/year[5]), the annual budget for the TAC Grants is C$7.25 million/year. The investment announced in Federal Budget

5 The centres in Québec receive less funding through TAC Grants because, at the time the TAC Grants were being developed, the Government of Québec provided $280,000 per year in direct support to the centres. As a result of the existing direct support, NSERC, in consultation with Réseau Trans-Tech and the Government of Quebec agreed that a federal top-up of C$100,000 would be sufficient.

2018 will bring the annual budget for the TAC Grants to C$13.5 million per year and increase the number of TACs to 58 by 2020-21.

With respect to the TACs themselves, they do not offer any financing for business innovation-related activities. As an innovation service provider, they work with firms on a fee-for-service basis to solve their innovation challenges (via flexible engagements related to the provision of business and technical services, applied research projects, and customized training).

Because the TACs are affiliated with Canadian colleges, they can access a variety of funding support programs beyond the TAC Grants to enable college-industry collaboration, which help offset/de-risk the project cost for the industry partner.

They can also help direct firms to other available firm-specific federal funding programs (e.g., Business Development Bank of Canada).

More specifically, TACs help Canadian businesses—especially SMEs—get their products market-ready and enhance their processes by:

- offering objective advice and specialized technical services, applied research support and advice;
- providing training related to new types of equipment and processes; and
- conducting applied R&D projects focused on company problems.

Target group: TAC Grants are awarded to Canadian colleges that offer programs in line with the research area proposed in the TAC Grant application. The TACs supported by the TAC Grants are intended to provide benefits to a specific industrial sector in their region, though they also provide access to their specialized facilities, equipment, and expertise to firms from across Canada.

As noted above, TACs are particularly well-suited to serve the needs of SMEs with the goal of promoting the adoption and application of novel technologies.

Selection mechanism and criteria: TAC Grant competitions have a two-stage application process; i.e., letters of intent followed by applications from invited applicants. Both stages are reviewed by a panel made up of representatives from industry and academia against the TAC Grant selection criteria. TAC Grant selection criteria are described in Box 2. The TAC Grant competition process takes about 14 months from the launch of the competition to the award decision.

Box 2. TAC selection criteria

1. Value Added

- The value added of the centre to the targeted sector's/region's innovation capacity and the potential for the centre to play a significant role in SME innovation in their region, including potential for synergies between the proposed centre, the host college(s) and other innovation support organizations in the region.
- The incremental value that the TAC Grant would bring to the college's current activities in this area. In particular, for existing centres that already receive other government or college support for the centre’s core operations, the incremental value from the TAC Grant support must have been clearly demonstrated.

2. Organizational Structure

- The organizational structure of the centre; the degree of engagement and support from the college, public, and company stakeholders in the proposed centre; and the centre's integration with the strategic plan of the college.
- Evidence of an accountability framework likely to result in effective leadership and sound financial decision-making.

3. Market Opportunity

- The ability of the centre to attract investment, the potential for private sector revenue for rendered services, and the ability to meet the performance metrics and investment targets identified.

4. Delivery Plan

- Focus, coherence and feasibility of the service delivery plan. This includes the scope of support capabilities and the approach planned for reaching and delivering innovation support to companies in their region.

5. Applied Research Competence

- The current strength of the expertise (both human and technical) and the anticipated quality and quantity of expertise and support capabilities to be offered by the centre in support of SME innovation needs.

Date of launch: The TAC Grants pilot launched in summer 2010 further to an announcement in the 2010 Federal Budget, which doubled funding for the CCI Program from C$15 million annually to C$30 million annually. The first nine TAC Grant awards were made on May 8, 2012. The five competitions to date have created 30 TACs at 27 colleges[6]. The 2018 Federal Budget provided additional annual funding to the CCI Program, allowing at least two new TAC Grant competitions that will award 16 new centres with the TAC designation in 2019-20, and an additional 12 in 2020-21.

Government body or agency in charge: As part of the CCI Program, the TAC Grants are managed by NSERC in collaboration with the Canadian Institutes of Health Research (CIHR) and the Social Sciences and Humanities Research Council of Canada (SSHRC) which are federal agencies of the Government of Canada that provide research funding.

2. Development of the TAC Grants

2.1. Rationale for TAC Grants implementation and tailored application

The TAC Grants were created to increase the innovation capacity of regions across Canada and to leverage the strong applied research base at colleges developed through previous government funding.

According to a 2010 discussion paper by NSERC:

6 As each TAC specializes in a particular industrial sector, colleges may have multiple TACs that focus on different industries.

There are perhaps 3,000 companies that currently conduct collaborative R&D with universities and 3,500 that work with Canada's colleges and polytechnics.

The clear majority of the 20,000 companies in Canada that conduct R&D do not directly work with universities and colleges. Most of these companies are small (less than 50 people) and, on average, invest less than C$250,000 per year in research and development. These companies generally conduct innovation projects that aim at incremental improvements to existing products or processes; are executed in weeks, and are exploited commercially (rather than published). A significant proportion of these companies conduct research episodically; meaning they are unlikely to have full-time R&D staff (i.e., approximately 50 percent conduct research for one or two years out of every seven years, and only 10 percent conducted R&D on a continuous basis).

The SME's focus on market responsiveness is not aligned with the effort to build long-term research relationships; they don't have money or expertise to negotiate project collaborations and can rarely afford long-term research. Returns on investments from innovation projects are typically expected within 12 to 18 months. The innovation needs of this type of company are not well addressed by university structures and approaches.[7]

Many SMEs are focused on keeping their existing production line profitable and are busy trying to fill current orders, for their current products, from their current clients. This creates challenges for making the innovation-related investments required to develop new products.

While Canada's universities have a variety of technical capabilities that complement federal financial support for SMEs, the defining characteristics of universities (long training cycles, an information-sharing culture and a knowledge creation drive) can limit the ability of companies to access these specialized and high-value capabilities. Recognizing this gap in innovation support for SMEs, NSERC envisioned the creation of a strong network of innovation intermediaries ready to assist these companies.

As mentioned above, compared to Canada's very long-standing tradition of world-class university research, the emergence of college applied research in Canada is still a relatively recent phenomenon, dating back to the late 1990s and early 2000s. In the early 2000s, college applied research operated very lean, partnering on modest applied research projects to solve industry-identified problems, in the rapid timelines industry needed. Slowly but surely, colleges built a modest track record of successful engagements and began establishing dedicated applied research offices, similar in concept to the technology transfer offices in universities.

In 2004, NSERC used funds from its existing budget to launch an innovative pilot program exclusively for colleges (i.e., the CCI Program), providing six colleges with grants of C$100,000 per year over three years to develop applied research capacity through projects with industry partners.

Following a Government of Canada announcement in Federal Budget 2007, the CCI Program pilot was made permanent in 2008. Over the years, complementary supports from the CFI and SSHRC have evolved into a federal suite of programs to support a strong college applied research network across the country.

TAC Grants support TACs across Canada that cater to local and regional needs of a specific industrial sector, but also support technology and capabilities that are in demand across the

7 Natural Sciences and Engineering Research Council of Canada, Technology Access Centres – A Discussion Paper. http://www.nserc-crsng.gc.ca/Professors-Professeurs/RPP-PP/TACDocument-ECATDocument_eng.asp

country. The individual TACs are afforded the flexibility to respond to local needs as they see fit (e.g. realities of rural and remote areas, different sized companies, different industrial sectors, etc.).

2.2. Previous inspiring experiences for TAC Grants implementation

The TAC Grant is largely based on the very successful 35-year-old Québec *centres collégiaux de transfert de technologie*—or CCTT—model. Under this model, the Government of Québec provides stable, predictable funding to maintain and expand the applied research capacity that a college has built in a specific discipline of economic significance in a defined geographic region. The first CCTTs started in 1983 and there are now 59 CCTTs throughout Québec, each with a unique mandate. In the 1980s, a similar model was implemented in France through the creation of a network of about 200 *centres régionaux d'innovation et de transfert de technologie* (CRITTs). The TAC Grant was also influenced by Canada's National Research Council (NRC) institutes, which were developed in the 1980s and 1990s as attempts to seed innovation clusters across Canada through the development of facilities that were geographically accessible to SMEs.

3. Interactions with policy mix

3.1. Previous policy mix gaps

TAC Grants respond to the challenge of supporting innovation by SMEs and scaling small innovative companies into companies that compete in global markets. Prior to the development of the TAC Grant, colleges supported innovation through their applied research offices. The TAC Grant has enabled colleges to develop centres that differ from the pre-existing applied research offices insofar as the applied research offices tend to be project-focused across a variety of research disciplines and assign faculty as-needed to act as researchers for the duration of the project before sending them back to their core teaching duties. TACs, on the other hand, have dedicated R&D staff as well as a mandate to offer objective advice and specialized technical services. They provide training related to new types of equipment and processes and conduct technological diffusion and community outreach focused on a narrow specialization.

TACs also connect companies to additional sources of assistance, testing, and expertise, and they help companies navigate the landscape of the more than 1,000 provincial and federal government R&D support programs. In addition, TACs have the equipment and expertise that other service providers often do not have. Much of their equipment is unique to their province, unique to Canada and sometimes one of only a few pieces in the world. The complementary capabilities of Canada's TACs significantly enhance those of universities, private laboratories, government institutes, incubators, accelerators and other colleges in their region.

By design, TACs do not compete with services provided by the private sector. TACs have an important role in referring clients to private sector suppliers of innovation support services, such as independent laboratories and testing firms. In 2016-17, the TACs spent over C$300,000 to subcontract routine testing from independent laboratories. In cases where private sector suppliers are unable to provide the service required, TACs can fill the gap. TACs can also involve consultants and service providers as part of technology projects.

Box 3. Attracting international investments

While TACs help Canadian SMEs get products and processes to market and gain exposure to business opportunities around the world, TACs also provide a soft-landing for international firms wishing to enter the Canadian market with their own new-to-Canada, or even new-to-world, innovation.

On Prince Edward Island (PEI), **Canada's Smartest Kitchen**, a globally-recognized TAC dedicated to food product development, is collaborating with European food packaging and design experts *Food Atelier & DeDutch* in order to pilot a new packaging innovation project. The project's goals are to expose PEI companies to leading-edge packaging concepts and to provide them with modernized solutions to their unique packaging needs through detailed market research and product design. The pilot project has allowed emerging and established food businesses to build international relationships and enhance their company profile through specialized packaging. The project has also resulted in new client opportunities for local and regional packaging suppliers who are engaged by the participating partners to develop the prototypes and finished concepts.

The TACs expect this type of service offering to grow, as attracting high-quality, innovative foreign investment into Canada is important to governments.

3.2. Expected interactions and policy instruments in line with TAC Grants' objectives

The TAC Grants, and the centres they support, interact with a number other federal policies and programs in Canada, including college research programs (e.g. CCI Program) and industry R&D assistance programs. These interactions are explored in detail below.

The College and Community Innovation (CCI) Program

Almost every centre supported by a TAC Grant can trace its roots back to a previous multi-year grant from the CCI Program, which allowed it to build up significant capacity in a specific area of applied research through dozens of collaborative projects with industry partners. While the TAC Grant only provides funding for operations and staff, the other types of grants under the CCI Program (other than ARTI) provide funding for research projects and activities.

TAC-affiliated colleges are welcome to apply for any of the project-specific grants offered through the CCI Program, as well as some multi-year grants. A survey of the last five years of awards under the CCI Program shows that TAC-affiliated colleges are more successful in these grant competitions than colleges without a TAC.

Colleges with a TAC Grant in a specific domain are not allowed to apply for an IE Grant or another TAC Grant if there would be overlap in their broad research areas.[8] Colleges can

8 IE Grants support the growth of capacity in an applied research area at colleges while TAC Grants are intended to further advance and maintain the activities in the applied research area developed through the IE Grants.

apply for more than one TAC Grant; however, it must be clearly demonstrated that the application falls within a new applied research area.

National Research Council (NRC) Research Facilities

The NRC offers Canadian businesses access to specialized research equipment as well as experts to optimize its use. This includes aerospace engineering and manufacturing, astronomy, high-throughput DNA sequencing, photonics, biotechnology and nanotechnology – to name just a few. Access to these facilities allows businesses of all sizes to pursue R&D opportunities in Canada, while lowering the associated risks and accelerating product development.

The centres funded by TAC Grants complement the NRC research facilities, as the TACs are smaller scale, more local and focus on demand-driven mid-TRL[9] projects that are closer to market. The TACs are owned by a local college and feature strong local participation on their management board. The NRC research facilities have core R&D capabilities that compare with other research institutes internationally and are controlled centrally. They have a national responsibility within their technical/sector domain.

NRC Industrial Research Assistance Program (NRC-IRAP)

NRC-IRAP provides funding support to carefully screened firms that want to grow through innovation. NRC-IRAP has a large network of Industrial Technology Advisors (ITAs) around the country to assist their client firms. The TACs plug into this network as service providers to whom ITAs can direct their clients. This requires an awareness of the TAC's equipment, expertise, facilities, capacity and service offerings on the part of the ITA. Since there are many innovation service providers in the ecosystem, it is incumbent on the TAC to build these relationships, including with the ITAs, and keep them up-to-date.

Regional Development Agencies

The Government of Canada has six Regional Development Agencies (RDAs) located across the country with mandates to enhance capacity for innovation, entrepreneurship and collaboration within their respective geographical regions. The RDAs are well acquainted with the centres supported by TAC Grants and their host colleges given that the TACs and colleges are important providers of skills training, applied R&D support, and technology demonstration in the region. Since the TAC Grants fund centres that support the industrial sectors of importance to a region, officials from the local RDA and TAC know each other well, as they are both assisting the same private sector clients with different resources.

In some cases, an RDA will provide financial support to a TAC for the acquisition of an expensive piece of equipment for the purpose of demonstrating to local firms the productivity and competiveness gains that can be achieved from purchasing similar equipment. In addition, RDAs provide direct financial support to firms, which the firms may choose to spend on R&D services in the region. Often, if the firm’s project is mid-to-late TRL and innovation related, the firm will use the funding to collaborate with a TAC. The firm pays fee-for-service at the TAC, and the RDA funding helps leverage the firm's existing resources to de-risk the investment and solve its innovation challenge.

9 Technology readiness level (TRL) is a method of estimating technology maturity.

Box 4. Multi-partner R&D projects

In 2007, a competition was launched in Québec by l'Institut du transport avancé du Québec (ITAQ) and le Centre des matériaux composites du Québec (CDCQ), to design an advanced urban school bus concept. The Advanced Urban School Bus (AUA in Québec) was envisioned to be environmentally friendly, viable and profitable.

The **Innovative Vehicle Institute (IVI),** a Sainte-Jérôme, Québec-based TAC specializing in electric and autonomous vehicles, partnered with École Polytechnique de Montreal, HEC Montreal and the Industrial Design School of the University of Montreal to produce a prototype concept for the competition. Several multidisciplinary teams from across the institutions (integration, design, structural, mechanical engineering, manufacturing, and finance) worked for almost nine months to design a virtual prototype.

Compared to traditional urban school buses, the team’s final AUA concept reduced the number of parts required for the bus and therefore the assembly costs. The modern design also incorporated the flexibility of composite materials, which reduced the vehicle’s weight by 23 percent compared to a conventional school bus. The new body design allowed for flexibility of interior design and the composite materials allowed for a longer lifespan. Coupled with an electric-gasoline hybrid drivetrain, the concept reduced fuel consumption by 33 percent and significantly reduced greenhouse gas (GHG) emissions.

Sainte-Jérôme-based school bus manufacturer Autobus Lion saw the results of the competition at the public presentation, and in late 2008, acquired the rights to use the concept. However, Autobus Lion wanted to move from a hybrid powertrain model, to a fully-electric school bus. A new-to-Canada innovation.

The next step for Autobus Lion was to find the right team of experts to take the concept from hybrid prototype to fully-electric scale production model, which meant a visit to IVI. A fully electric school bus is one thing, but a fully electric, certified-for-use in 50 states and 13 provinces and territories to transport school children is another. This involved mandatory analysis of, and adherence to, North American school bus standards for the integration of composite materials and more efficient technologies, in addition to the steps of engineering, prototyping, design, product development, certification and testing.

Over the course of the engagement, IVI engineers tackled numerous challenges and designed a very large rechargeable energy storage system for the bus and adapted it to Québec's climate. In 2015, six fully electric prototype vehicles were designed, and since 2017, Autobus Lion has been in the manufacturing stage with 20 buses built and sold.

Additional measures taken to ensure the success of the TAC Grant program

In 2015, with funding from NSERC, the centres supported by TAC Grants established a formal, member-led network as a two-year pilot project with a dedicated secretariat, which aimed to leverage lessons learned as a basis for supporting excellence in applied research at Canadian colleges. Since 2016, this network has been known as Tech-Access Canada. In February 2018, the network was made permanent with ongoing funding from NSERC.

The 2015 pilot proposal identified that the TAC community faced common challenges with respect to delivering applied research and innovation services to industry partners. The identified challenges became Tech-Access Canada's strategic objectives, which aimed to enhance the members' collective ability to:

- Network and continue to share knowledge and best practices;
- Collaborate around developing business services and standards;
- Sustain the TACs through meaningful community exchange; and
- Promote their value proposition to industry across the country.

One of the core strategic objectives for the pilot was to build and foster stronger relationships between the TACs and NRC-IRAP. After very positive initial discussions, in September 2016, Tech-Access Canada signed a six-month agreement with NRC-IRAP to launch a pilot for an Interactive Visits program with nine Ontario TACs and NRC-IRAP-client SMEs. Interactive Visits provide NRC-IRAP clients with an introductory 20-hour visit with an Ontario TAC to solve an innovation challenge, and act as an introductory engagement with a TAC. Since 2016, the pilot project has received renewed funding from NRC-IRAP on five occasions and is working on expanding to TACs across the country.

Over the course of the pilot, 96 NRC-IRAP clients were referred to a TAC for an Interactive Visit. Seventy-eight clients moved beyond initial scoping and proceeded with a Visit, a flow-through rate of 81 percent. For the other 19 percent, the Visit did not proceed for a variety of reasons. In some cases, the timelines did not work for the firm or the TAC; in others, the TACs did not have the capability or capacity to assist, so they referred the firm to another service provider.

Thirty-two Interactive Visits led to a follow-on R&D collaboration between the client and TAC within 12 months, a conversion rate of 41 percent. In the first 15 months of the pilot, C$838,565 was invested by clients in follow-on R&D projects at the nine Ontario TACs.

Recognizing that the CCI Program has consistently demonstrated strong positive outcomes for colleges, industry, and student trainees, Canada's 2018 Federal Budget proposed to provide C$140 million over five years (starting in 2018–19) to increase support for collaborative innovation projects through the CCI Program. As noted above, this funding will, in part, support an increase in the number of TAC Grants thereby growing the number of supported centres.

Alignment of the TAC Grants with the national context

Industry context: Despite representing 97.9 percent of all employer businesses between 2011 and 2013, small businesses accounted for about 27 percent of total R&D spending over the same period.[10] The SMEs that conduct R&D tend to do so episodically, undertaking an R&D project, on average, once or twice within a seven year period.[11] TAC Grants enable the creation of centres at colleges that help to de-risk R&D and support greater innovation by SMEs.

10 Innovation, Science and Economic Development Canada, Key Small Business Statistics June 2016. https://www.ic.gc.ca/eic/site/061.nsf/vwapj/ksbs-psrpe_june-juin_2016_eng.pdf/$file/ksbs-psrpe_june-juin_2016_eng.pdf

11 Natural Sciences and Engineering Research Council of Canada, Technology Access Centres – A Discussion Paper. http://www.nserc-crsng.gc.ca/Professors-Professeurs/RPP-PP/TACDocument-ECATDocument_eng.asp

Collaborating with a TAC enables Canadian SMEs to access the resources they need to innovate. Since TACs are designed to be a safe space for innovation, they can demonstrate the impact of a new technology, process or piece of equipment to a local firm and demystify how investing in that new technology will have a positive impact on their operations. For a small firm, the prospect of investing C$75,000 in a new technology can be intimidating. An objective assessment and demonstration of the technology by a TAC, as well as training on how to integrate the new technology into their operations and optimize its performance, can make the difference between significantly improving productivity and simply maintaining the status quo.

For firms, there are several ways to engage with a TAC, each of which can be custom-tailored to meet the needs of the client. These engagements are:

- **Fee-for-service arrangements**, which can entail specific technical and business services, training on new equipment and technologies, as well as collaborative applied research projects.
- **Leveraged applied research projects**, which help partners to stretch their R&D investment further by accessing provincial or federal R&D support programs designed to de-risk the innovation investment.
- **Capstone projects**, which involve an interdisciplinary team of college student researchers in the last year of their undergraduate program (under the supervision of an instructor) working to solve the industry partner's problem.
- **Industry association-sponsored applied research**, which involves an industry association, representing private firms of all sizes in a sector, engaging the services of a TAC to tackle an innovation challenge that affects all of its members.

Box 5. Industry association-sponsored applied research

An excellent example of industry association-sponsored applied research involves several provincial beekeeper associations and the **National Bee Diagnostic Centre (NBDC)**, a TAC in Grande Prairie, Alberta, providing critical diagnostic services to commercial beekeepers and apiary researchers. As the majority of Canada's commercial beekeepers are sole proprietors or micro-sized enterprises, their provincial associations engage the NBDC to evaluate the health of the honey bee stock through samples provided from member hives. The NBDC establishes baselines of pests, parasites and diseases affecting the beekeeping industry in Canada and also develops strategies to mitigate their effects. Given the plight of Canada's bees in recent years, this engagement model has significant societal and financial benefits for commercial beekeepers, with trickle down effects for the Canadian agriculture sector.

Regardless of the research arrangement, TACs are not interested in an ownership stake in intellectual property (IP), not wanting to encumber a start-up or small firm trying to grow. Rather, TACs allow their clients to retain IP ownership and help them develop and exploit their IP so they are better prepared to compete in the global marketplace.

While TACs are IP-friendly for industry, there is a caveat. As TACs are supported with public funding, they must act as responsible stewards of public finances. If the industry partner on a project is not willing to invest cash and significant in-kind contributions on a collaborative project, the TAC will retain the IP and grant the company a license to commercially exploit it, resulting in royalties paid back to the TAC, which are then reinvested in strengthening the TAC's expertise, facilities and equipment. However, companies usually take control of the IP and licenses are a rare occurrence.

Box 6. Industry retention of IP rights

One such example of industry-friendly IP-in-action is the development of a high-performance emergency brake pad for the Canadian windmill industry. The project started in 2010 when an entrepreneur from the Gaspé region of Québec visited the **Québec Metallurgy Center (CMQ)** in Trois-Rivieres, QC, a TAC helping Canadian manufacturing companies specialized in metal processing. The entrepreneur wanted to build high-performing, low-cost emergency brake pads for windmills (a first for Canada). With over 5,000 windmills in Canada and the growing market for windmill maintenance in Québec, those parts also presented a unique opportunity for economic development in the Gaspé region with the ultimate goal of opening a production facility in the region.

The collaboration, supported by Québec's Ministry of Economic Development, started with a complete reverse engineering of conventional emergency brake pad components from Europe. The goal was to determine the optimal process for fabricating higher performing brake pads from different metals, at a lower cost than the European substitute. With CMQ-developed prototypes, the client was able test the product in Germany. With promising results and slight modifications and revisions to the prototypes from CMQ, the client was able to secure an NRC-IRAP grant to further develop the technology and get to market.

In this project, the company retained all rights to commercially exploit the IP. In 2017, the firm *Plaquette de frein haute performance B et B* opened their pilot plant in Gaspé, initially hired six local people and started production on a *Made-in-Canada* product that performs better than the European alterative, at a lower price point.

Research system context: TACs complement important elements of Canada's research system, including other federal and provincial investments in research and innovation as well as research outputs from universities. Hands-on applied research experience available in TACs provides college students, as well as university graduate students, PhDs, and post-doctoral fellows[12], with a tangible opportunity to apply the theory they have acquired. Working as part of a TAC team allows highly-qualified personnel, from all academic backgrounds, a unique and valuable opportunity to participate in applied research projects, providing them with real-life perspectives on the business and innovation challenges faced by a variety of Canadian firms of all sizes, significantly enhancing their innovation skills.

12 Even though TACs are based at colleges, given the nature of the advanced technologies the TACs are working with to solve the innovation challenges of their clients, some projects involve graduate students, PhDs, and post-doctoral fellows with academic expertise in these novel, cutting edge technologies.

Box 7. College-University collaboration

College in Peterborough, Ontario, a TAC offering research and commercialization services to the water and wastewater industry, partnered with Trent University and Peterborough-based industry partner Noble Purification to complete a large-scale biofiltration prototype to treat wastewater using euglena, an algae-like organism. The project collects wastewater effluents from various industries and uses the power of algae blooms to remove hazardous contaminants from municipal and industrial wastewaters. Partnering with Trent University and gaining access to three graduate students accelerated Fleming College's testing of euglena as a viable solution for contaminant removal. The goal of this project is to translate applied research into commercially viable techniques for Noble Purification through pilot demonstrations. The proximity of the two academic partners facilitated cross training of lab techniques. With the assistance of the Peterborough Innovation Cluster, a local incubator/accelerator/amplifier, the collaboration between the university and the TAC has brought Noble Purification's innovation closer to market.

In 2017, the **Centre for Advancement of Water and Wastewater Technologies (CAWT)** at Fleming

Policy context: TAC Grants are part of a broader suite of grants managed by NSERC through the aforementioned CCI Program. These grants build on one another to assist colleges with the continued development of their R&D capacity to increase business innovation at the community and/or regional level. These grants have the ability to address the different funding requirements of colleges based on their size, the length of time they have been conducting applied R&D, and the specific discipline area or activities undertaken. The CCI Program falls within a broader suite of partnership programming offered by the federal granting agencies to support collaboration and knowledge transfer between post-secondary institutions and the private sector.

Along with the programming offered by the federal granting agencies, there are a number of other initiatives of the Government of Canada that promote collaboration and knowledge transfer. Examples include the aforementioned NRC-IRAP and RDAs. Other recent initiatives include the Innovation Superclusters Initiative (ISI) and the Strategic Innovation Fund (SIF).

ISI, which was announced in Federal Budget 2017, is a C$950 million initiative that brings together SMEs and post-secondary institutions (along with larger, established firms) to spur innovation, generate new companies, and commercialize new products and processes. Federal Budget 2017 also announced C$1.26 billion over five years for SIF, which supports public-private collaborations in developing and demonstrating new technologies (among other objectives). Both ISI and SIF are part of the Government of Canada's *Innovation and Skills Plan*, a multi-year strategy to enhance Canada's innovative capacity and talent development. The *Innovation and Skills Plan* includes the target to double the percentage of companies engaged in collaborations with post-secondary institutions by 2025 (over the 2014 level).

4. Impacts

4.1. TAC Grants impact evaluation

In 2018, NSERC undertook an evaluation of the CCI Program. While the evaluation did not focus specifically on TAC Grants, it found that the overall suite of grants offered through the CCI Program is enhancing the capacity of colleges to carry out applied R&D. The evaluation found that SMEs are increasingly engaging Canadian colleges to undertake applied R&D. Between 2010-11 and 2016-17, 958 partners were involved in one or more applied R&D activity funded by a CCI Program grant[13]. Ninety percent of these were companies and other industry partners.

The evaluation also found that the increased participation in R&D by Canadian colleges is enriching the curriculum of colleges and the learning experiences of students. As faculty members are increasingly participating in R&D projects, the new knowledge and experience is shared with students through course materials. Students also benefit by being directly involved in projects funded through the CCI Program, which provide them the opportunity to apply their classroom learning to a “real world” environment. This improves their potential for employment once they graduate from college. Some projects supported by the CCI Program have led to increased revenues and a larger workforce for participating companies. For example, with respect to the centres funded by TAC Grants, almost a third (29 percent) of their surveyed clients (who had completed an applied R&D or technical and business service project) indicated that their revenue increased.[14]

Although an evaluation has not been undertaken on the TAC Grants specifically, Tech-Access Canada has sought to quantify the business innovation capacity of the TAC network. Tech-Access Canada also collects annual performance indicators and applied research metrics from the individual TACs. Metrics used by Tech-Access Canada are divided into three categories—capacity, activity, and results—are as follows:

Capacity

- Number of TACs operating across Canada.
- Number of business innovation and applied R&D experts available at TACs.
- Amount of dedicated innovation and applied research space (square feet) available at TACs.
- Dollar value of the highly-specialized equipment and facilities at TACs.

Activity

- Number of unique areas of innovation expertise at the TACs.
- Number of unique business and technical services, applied research, training, and technology diffusion offerings at the TACs.

13 Only three of the CCI Program grants were included in the evaluation: TAC Grants; IRCC Grants; and ARD Grants.

14 Natural Sciences and Engineering Research Council of Canada, Evaluation of the College and Community Innovation Program and SSHRC’s Community & College Social Innovation Fund, September 2018.

- Number of companies served (annually) by the TACs.
- Percentage of companies served annually who were Small-and-Medium-Sized Enterprises (SMEs).
- Number of other clients assisted (annually) by the TACs, such as universities, colleges, and government and private labs.
- Amount of cash revenue from companies served by the TACs for business innovation and applied research activity.
- Amount of cash revenue to the TACs from other sources for business innovation and applied research activity.

Results

- Number of specialized technical service engagements provided to clients by the TACs.
- Number of collaborative applied research projects between TACs and external partners.
- Number of new products, processes, or services moved to market faster with the assistance of the TACs.
- Number of improved products, processes, or services moved to market faster with the assistance of the TACs.
- Number of training contracts provided to clients by the TACs.
- Count of person-hours of training received by clients.
- Number of students involved in TAC-delivered services.
- Count of hours of innovation skills acquisition by students.

Data collected by Tech-Access Canada from 2016-17 show that Canada’s TACs provided 5,661 specialized technical service engagements to clients and partnered on 1,197 collaborative applied research projects, solving a company-identified problem. The engagements resulted in 793 new or improved products and processes.

In addition, in the same year, Canada's TACs leveraged over C$36 million worth of business innovation investment from external collaborators, C$20.2 million of which came from companies served. This represents a multiplier effect of almost five times the Government of Canada's 2016-17 investment of C$7.25 million to support the core operation of the TACs.

While the quantitative aggregate data show the strength of the TAC network as a whole, Tech-Access Canada is also able to collect many individual stories, one of which is highlighted in Box 8.

Box 8. Leverage impacts of TACs

An excellent example of a TAC's leverage impact, both direct and indirect, comes from Shawinigan, Québec. Nemaska Lithium partnered with le Centre National en électrochimie et en Technologies Environnementales (**CNETE**), a TAC specializing in fermentation processes and extraction, and purification and concentration techniques, to develop a competitive new process for extracting valuable compounds from ore. CNETE, with support from the CFI and NSERC, tested and validated a process that the company had developed to produce lithium hydroxide and lithium carbonate without the use of costly soda ash. The resulting high-quality lithium hydroxide and lithium carbonate will be used for hybrid and electric car batteries for companies like Panasonic and Tesla.

While the success of Nemaska Lithium's research partnership with CNETE will result in additional research projects over the next five years, it has also solidified the company's decision to build a test plant in Shawinigan to scale up its production. Construction on the pilot plant started in September 2015, the same month that Nemaska announced it would also build its C$300 million main processing plant in Shawinigan with construction set to begin in 2018. This example helps illustrate the spillover impact that the very modest financial investments in TACs are having.

5. Implications

5.1. Broader implications

While small businesses make up about 98 percent of companies in Canada, only about a third of small businesses invest in research and development. As a result, there is considerable potential to strengthen their innovation capacity and productivity.

Canada's college sector is particularly well-positioned to help small businesses succeed. Comparatively speaking, Canada has an extremely strong publicly-funded college system with significant investments dating back over 60 years. More than 130 publicly-funded colleges operate with campuses across the country with strong links to local industry.

Recognizing the potential for colleges to support innovation, beginning in the early 2000s, the federal government took a strong leadership role in formalizing college applied research with pan-Canadian support crystalized in the CCI Program. Project-based awards helped colleges build applied research capacity in a specific domain, heavily focused on technology. Then, in 2011, the federal government created the competitive TAC Grant to maintain and mobilize this college applied research capacity across the country.

The TAC Grant has succeeded to a significant degree because:

- It builds on the applied R&D capacity of Canada's colleges, which has been developed over the past decade through the support of other grants provided through the CCI Program.
- It supports centres located across Canada that focus on the local/regional innovation system.
- It aims to enhance the ability of companies, particularly SMEs, to become more productive and innovative by addressing industry-defined opportunities and challenges.
- It complements other instruments and organizations that support knowledge transfer, such as the NRC research facilities, NRC-IRAP, and the RDAs.
- It enables teachers and students to participate in applied R&D projects to address specific industry challenges, thereby enhancing the educational experience and developing the next generation of talent in demand by companies.