Horizons

The 2020-21 Annual Report of the Central Performance and Impact Assessment Unit

Foreword

With the foundational work of the Business Innovation and Growth Support (BIGS) completed, *Horizons*, the CPIAU's 2020-21 key findings report presents initial descriptive and diagnostic analysis of the BIGS program universe. This year's report is data rich, and offers descriptive statistics on BIGS programming, as well as some preliminary insights on the growth of businesses benefiting from federal government programming. It is through an extraordinary collaboration across government, with nineteen departments and agencies contributing data to our national statistical agency, that this information is made available. As we advance in our capacity to analyze it, we will be able to empower decision makers with evidence-based metrics of program performance.

Also presented in this report are several data development and experimentation pilot initiatives., It is now possible to improve the analytical power and rigor by adding more data to the Linkable File Environment (LFE) at Statistics Canada. CPIAU and Statistics Canada have undertaken work that explores integrating metrics on skills, diversity, and innovation and is exploring the possibility of pulling in intellectual property data. The CPIAU is also experimenting with technology to reduce reporting burden while enriching the dataset. The unit is very focused on the application of innovative data use within government.

Statistics Canada has been the CPIAU's major partner in delivering this initiative and creating the resulting data asset. I am pleased to announce that in February 2021, the Program Performance Analysis Initiative (PPAI) Memorandum of Understanding (MoU) was formalized between TBS and Statistics Canada. This deputy-to-deputy agreement supports ongoing collaboration between and the two parties and is guided by the principles of experimentation and open collaboration.

Lastly, I would like to thank the BIGS program community of public servants who support the work of the CPIAU including the data providers that submit BIGS data and the various practitioners that are applying it. We are beginning to see great value being derived from this common data asset. I invite you to reflect on the key findings in this report and to continue to engage with the CPIAU. We look forward to your support and advice as we continue our activities in the coming year.

Assistant Secretary, Expenditure Management Sector

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Section 1: Introduction to the CPIAU

Who We Are

The CPIAU is a data, analysis and research program located within Results Division, Expenditure Management Sector, Treasury Board Secretariat. The unit was created following the 2017-18 Horizontal Innovation Review (the Review) of federal innovation programs which pioneered the use of program administrative data to conduct statistical analysis on the impact of innovation programs. The CPIAU aims to advance the use of statistical methods and analysis to inform program performance, policy design and spending priorities used in the Review. Its mandate is to examine the impact of BIGS programing to help ensure that the government is supporting high-performing businesses. A Government of Canada program is considered a BIGS program if it seeks to improve innovation or growth activities of enterprises[1].

In the long-term, the team will also undertake horizontal assessments of innovation programming on an ongoing basis using data developed in partnership with Statistics Canada (STC). The unit's products can inform departmental policies, processes, program design, delivery and evaluation. Over time, data, research and analysis produced by the CPIAU will shed light on how BIGS programs are associated with economic benefits found at the enterprise-level[2].

What We Do

The CPIAU undertakes and sponsors analytical studies as well as data development and experimentation initiatives to understand the impact of BIGS programs on the firms they serve and the Canadian economy. The results of this work undertaken in the 2020-21 Fiscal Year are highlighted in this report.

Section 2 highlights the collective reach of BIGS programs across Canada through reporting descriptive statistics on the BIGS program universe and enterprises that receive interventions. It also presents analysis that reveals that overall growth for BIGS recipients is positive and heightened depending on the characteristics of the enterprises.

Section 3 describes the major novel research and findings of the CPIAU, its academic sponsored researchers and the BIGS program community. Throughout 2019-20, the CPIAU engaged and sponsored several pilot data development and experimentation activities to create new and robust information for which the CPIAU and BIGS programs can use in their analytical activities. The unit's academic-sponsored researchers contributed new insights to the body of knowledge on the measurement of innovation by summarizing emerging themes and proposing a new framework that estimates the impact of innovation policy on the economy. Finally, a series of summaries of how BIGS departments are using their program administrative data to inform their own program and policy and activities is also provided.

[1] See Annex 1: BIGS Inclusion Criteria which provides a list of BIGS eligible and non-eligible activities.

[2] Enterprise includes for-profit firms, non-profits and post secondary institutions. The CPIAU is most interested in for profit firms. An enterprise comprises one or many firms. Enterprise refers to the highest level of the Business Register statistical hierarchy at Statistics Canada. In alignment with the System of National Accounts, it is defined as an institutional unit that directs and controls the allocation of resources relating to its operations, and for which financial statements are maintained from which international transactions, an international investment position and a financial position for the unit can be derived. Enterprises can be corporations, quasi-corporations, institutions, or unincorporated businesses such as sole proprietors or partnerships. For incorporated enterprises, financial statements can be consolidated. Source: *Statistics Canada: Definitions, data sources and methods: Statistical units*

Governance and Partnerships

The CPIAU's primary partner is STC, who collect and integrate BIGS program administrative data into their Linkable File Environment (LFE), an integrated microdata environment based on the entire universe of Canadian businesses in STC's Business Register. Additional information on the LFE including a list of its survey and administrative data sources and terms of access can be found in Annex 2. BIGS program administrative data[3] linked to the LFE has resulted in the creation of a shared data asset and provides an opportunity for the CPIAU and BIGS departments to engage in rigorous statistical analysis to better understand the impact of enterprise programming on Canadian firms. The data is updated annually through a joint data collection exercise led by CPIAU and STC.

The partners also collaborate on research, analysis, and data development activities as well on the dissemination of statistical products and research findings from the BIGS database including through STC's *The Daily* publication. STC provides access to federal organizations and researchers to the BIGS database through the Business Data Access Centre (BDAC).

As mentioned, the Program Performance Analysis Initiative Memorandum of Understanding is a key piece in the TBS-STC relationship and is guided by the principles of experimentation and open collaboration.

The CPIAU is supported by an interdepartmental Steering Committee, representing the major departments that deliver BIGS programs. This forum (the Committee) informs and receives the CPIAU's findings and recommendations. The key objectives of the Committee are:

- Engaging in substantive discussion to provide advice, debate issues and refine analysis;
- Providing departmental insight and advice on the effective design, delivery, and evaluation of federal business innovation and growth support programs;
- Suggesting, developing, and validating topics for analysis and research;
- Meeting according to a schedule agreed-upon by the Committee; and,
  Receiving the CPIAU's annual report

[3] The CPIAU data model describes BIGS program administrative data as it relates to the policy suite and government activities. See Annex 3 for additional information.

Section 2: Descriptive Analysis of BIGS Programs

The CPIAU highlights the collective reach of BIGS programs across Canada through reporting descriptive statistics on the BIGS universe and enterprises that receive program interventions. Data reported is either presented over time starting from the 2007-2008 fiscal year (FY), the first year BIGS data is available, or for the 2018-19 FY, the most recent year of data that was collected by Statistics Canada in the Fall of 2019[4]. Approximately 64,000 unique recipients receiving BIGS program interventions have been matched to Statistics Canada's Business Register[5] from FY 2007-2008 to 2018-19. In the 2018-19 FY, 18 federal organizations submitted information on more than 120 program streams[6].

Most figures presented on program recipients represent the ultimate beneficiary enterprises that receive BIGS program interventions. There are three categories of ultimate beneficiary enterprises: for-profit, not-for-profit, and post-secondary institutions. The central research focus of the CPIAU is to examine the impact of the BIGS program suite on Canadian enterprises to ensure it is achieving positive outcomes primarily in the for-profit sector.

Section 2.1: The BIGS Program Universe

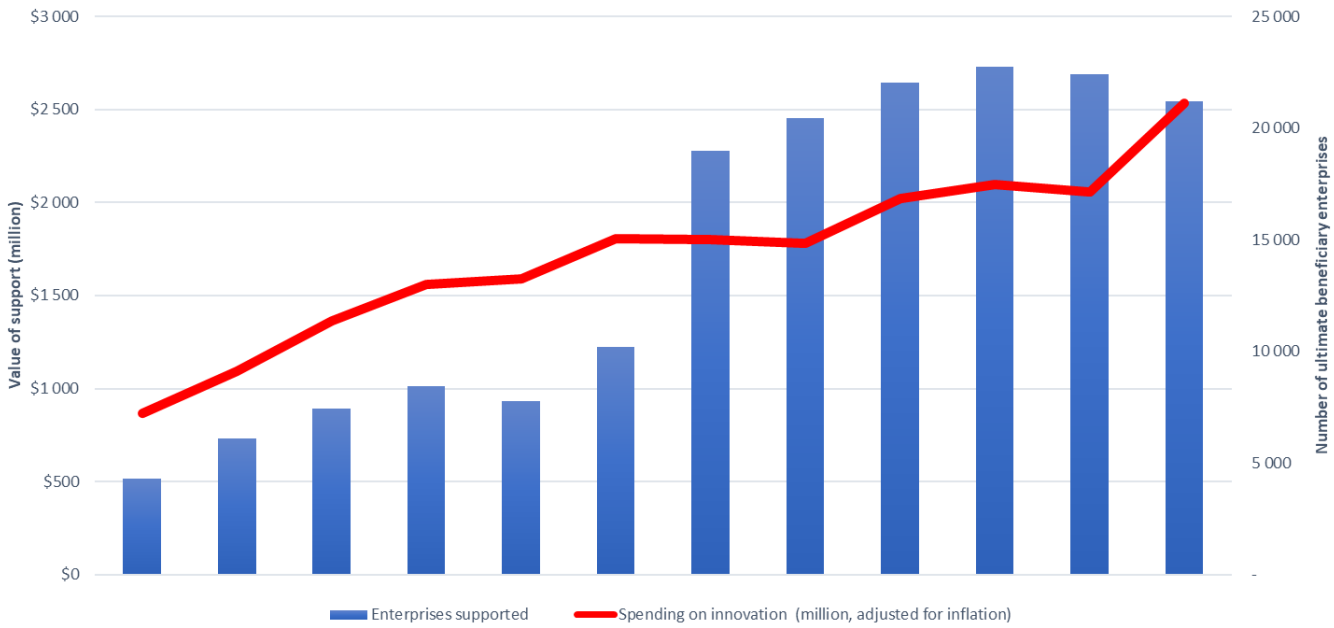
BIGS Program Investment in Canadian Enterprises

The Government of Canada supports and facilitates innovation through a suite of BIGS program streams. Total expenditures to BIGS programs identified in the BIGS administrative data linked to the LFE database was estimated at $18 billion over the 12-year period (from the 2007-08 to 2018-19 fiscal year). As shown in Figure 1, both government investment on business innovation and the number of recipients[7] have increased from the 2007-2008 FY to the 2018-19 FY[8]. In the 2018 to 2019 FY, $2.4

[4] Currently, BIGS program administrative data collected by Statistics Canada lags one year from the FY in which it is collected (i.e., financial administrative data collected in the 2019-20 FY was disbursed in the 2018-19 FY)
[5] The overall database match rate of the records reported by participating departments and agencies matched to Statistics Canada's Business Register was above 95%.
[6] Program streams are the basic BIGS entities that face the public and are the direct link between the Government of Canada's programming and target beneficiary enterprises. The number of program streams here only include those streams with transactions reported by Departments or agencies.
[7] There are some program streams for which the data exist but have not been reported by departments in certain years during the period 2007-2018. The consequence is an underestimation of the employment levels and value of support.
[8] Year-over-year comparisons should be made with caution. as shifts may be the result of changes in departmental financial systems and the unavailability of data rather than changes to the programs. A significant spike in the number of supported enterprises between the 2012-13 and the 2013-2014 FY is mainly due to the significant improvement of data reporting on beneficiaries who received advisory services provided by the National Research

billion value of support was delivered by federal organizations to 21,200 ultimate beneficiary enterprises[9].

Figure 1: Spending over the last 12 years
Both spending and the number of beneficiaries have increased



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable File Environment.
Note: Spending on innovation is adjusted for inflation by using the most recent available Consumer Price Index (i.e. CPI May 2021). Statistics Canada. Table 18-10-0004-01 Consumer Price Index, monthly, not seasonally adjusted

The steady rise in government investment supporting innovation illustrates a shift in Canadian innovation policy towards providing direct financial support to Canadian enterprises. These funds have supported the scale-up and growth of Canada's innovators and entrepreneurs in sectors such as advanced manufacturing and collaborative projects between enterprises and post secondary institutions that focus on areas such as pre-commercialization research and development. The shift is partially a response to selected panels[10] and reports[11] during the period (from FY 2007-08 to 2018-19) that noted the need for Canada to provide additional financial support directly to firms to stimulate innovation. Budget 2017 established Innovation Canada at Industry, Science and Economic Development (ISED)

Council's Industrial Research Assistance Program (IRAP) and Global Affairs Canada's Trade Commissioner Service (TCS) program stream.

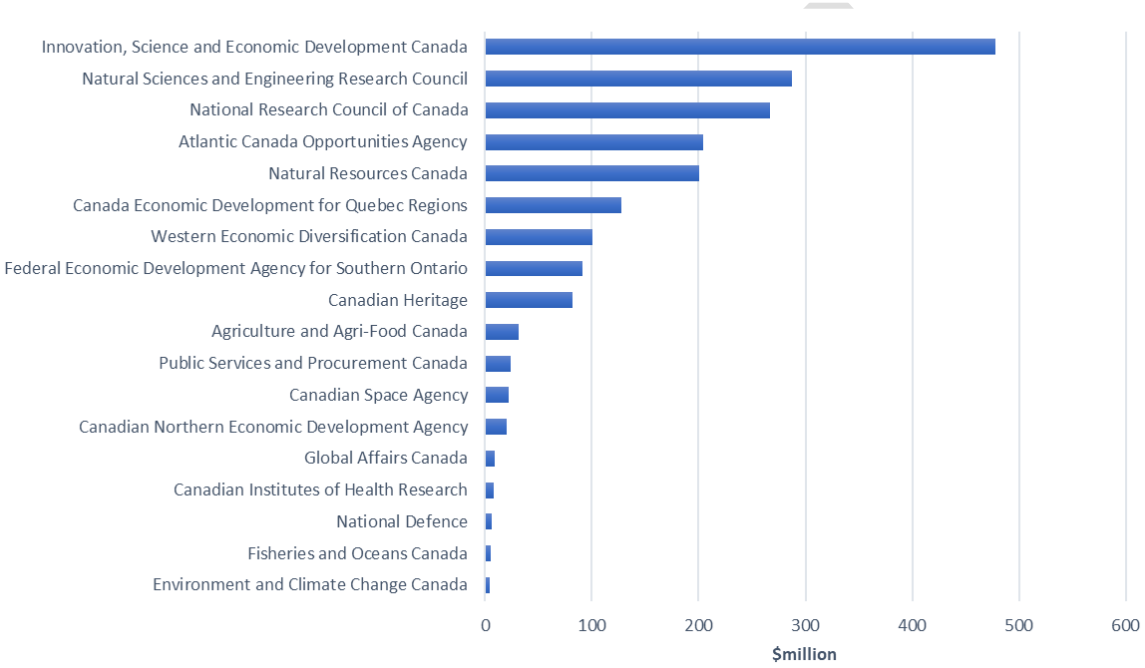
[9] The "ultimate beneficiary enterprises" refer to those enterprises that ultimately received the financial support or in-kind support from the BIGS program.

[10] The 2011 Independent Panel on Federal Support to Research and Development chaired by Tom Jenkins recommended to "redeploy funds from the tax credit to a more complete set of direct support initiatives to help SMES grow into larger competitive firms" (Jenkins, 2011).

[11] The 2014 Report of the Science, Technology and Innovation Council, an Advisory Council to the Government of Canada, noted that in 2013, Canada ranked 4th in indirect government support for Business R&D (ie. tax incentives) while 28th in direct funding out of 38 countries. (Science, Technology and Innovation Council, 2014)

Canada, which is responsible for investing in large-scale financial projects through programs such as the Innovation Supercluster Initiative[12] and the Strategic Innovation Fund[13].

Figure 2: Spending on BIGS program support by federal organization, reported average annual from the 2014-2015 FY to the 2018-2019 FY



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable File Environment and ISED custom table

The average annual value of the support was $1.9 billion for the 5 FYs spanning from the 2014-2015 FY to the 2018-2019 FY. The five BIGS departments and agencies reporting the highest average annual expenditures on business innovation over the period were as follows (Figure 2):

- Innovation, Science and Economic Development Canada (ISED)
- Natural Sciences and Engineering Research Council (NSERC)
- National Research Council Canada (NRC)
- Atlantic Canada Opportunities Agency (ACOA)
- Natural Resources Canada (NRCan)

This reflects Departmental mandates, especially the concentration of BIGS-type programming in Innovation Canada at ISED. In the 2018-19 FY, 148 program streams were identified in the scope of the BIGS programs[14]. The ISED Portfolio[15] was responsible for about two thirds (around 100 ?) of all

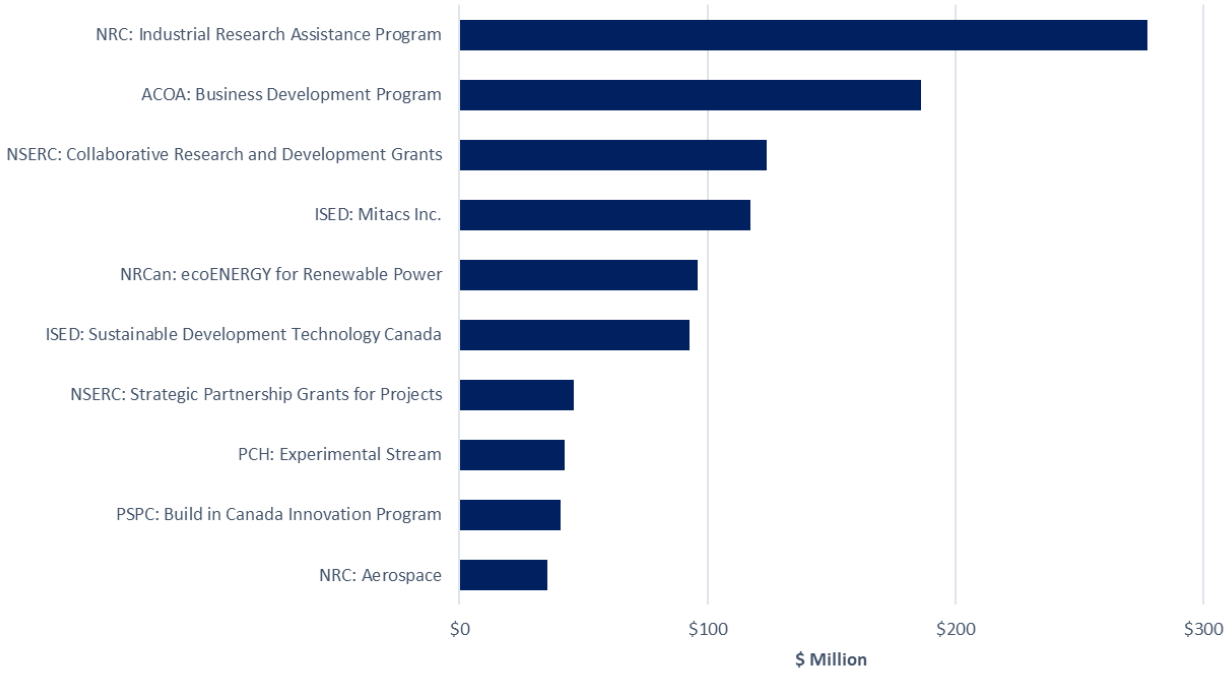
[12] Home - Innovation Superclusters Initiative (ic.gc.ca)
[13] Home - Strategic Innovation Fund
[14] The BIGS program stream inventory for 2018-2019 FY is provided in Annex 4.
[15] Departments within the portfolio of the Minister for Industry that deliver BIGS programming include ISED, NRC, NSERC, the Regional Development Agencies (RDAs), and Canadian Space Agency (CSA).

program streams. Outside of the ISED portfolio, NRCan and Agriculture and Agri-Food Canada (AAFC) accounted for the greatest number of program streams, at 20 and 9, respectively. Through these program streams, BIGS departments and agencies provide funding or in-kind support[16] to enterprises to support their pursuit of innovation and growth objectives. Some program streams provide support to create ecosystem or community activities such as business accelerators, incubators and other networks which can also help enterprises innovate and grow[17].

As highlighted in Figure 3 below, ten program streams[18] represented about 44% of all spending during the 2018-2019 FY, led by:

- NRC's Industrial Research Assistance Program (IRAP): $278 million
- ACOA's Business Development Program (BDP): $186 million
- NSERC's Collaborative Research and Development Grants: $124 million

Figure 3: Top 10 BIGS program streams by spending on support, 2018-19 FY



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

[16] In-kind support includes federal delivered advisory services, as well as some of government performed services, such as 'Service Fully Subsidized'. For example, GAC's Trade Commissioner Services provides advisory services, ISED's Centre for Drug Research and Development program stream and Communications Research Centre Canada program stream provides service fully subsidized to recipients.

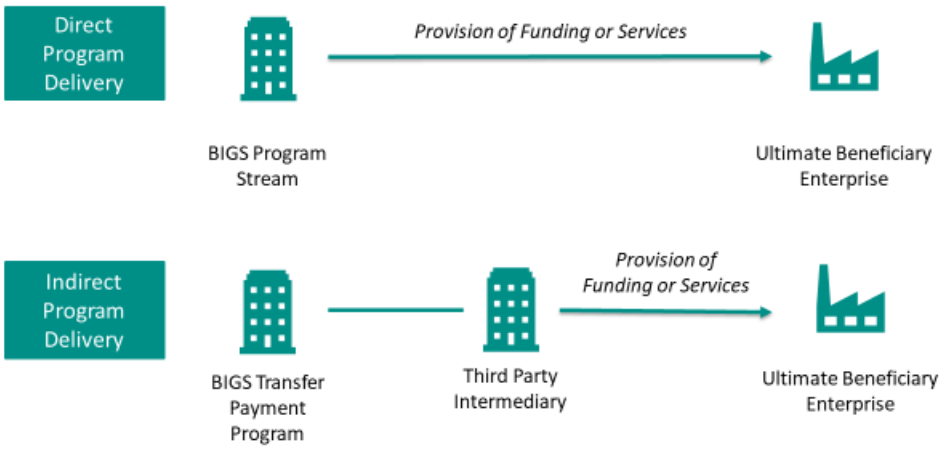
[17] BIGS inclusion criteria are provided in Annex 1.

[18] The spending estimates of a program stream is based on the total value of support received by enterprises that were matched to the Business Register. The value for some program streams is suppressed to meet the confidentiality requirement of the Statistics Act, for example, ISED's Strategic Innovation Fund and Strategic Aerospace and Defence Initiative, Canada Economic Development for Quebec Region's Productivity and Expansion.

BIGS Program Service Models and Intervention Types

BIGS program streams provide funding or in-kind support to ultimate beneficiary enterprises. While many program streams are delivered directly through departments or agencies, in other cases a transfer payment may be delivered via third-party intermediary, typically a not-for-profit organization, which then delivers funding or services to Canadian businesses. Figure 4 below showcases these two program delivery models. Given that third-party intermediaries provide funding or services, the CPIAU also considered intermediaries program streams[19].

Figure 4: Program Delivery Models

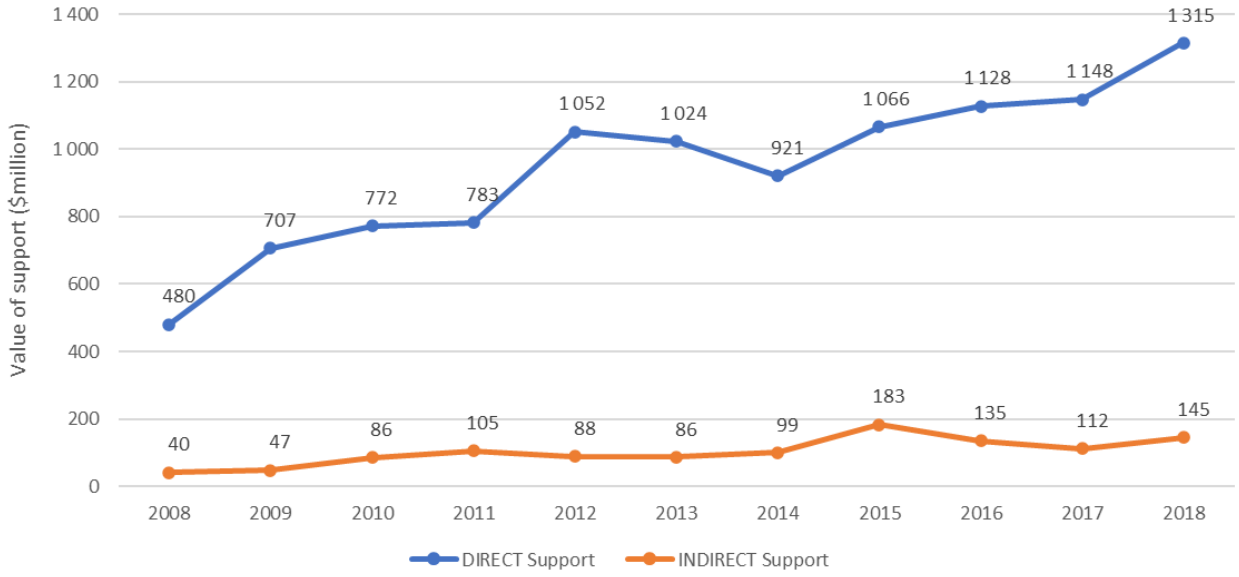


Mixed support delivery models may be employed. For example, NRCan's Green Jobs - Science and Technology Internship Program, Environment and Climate Change Canada (ECCC)'s Science Horizons Youth Internship Program, and the Federal Economic Development Agency for Southern Ontario (FedDev)'s Investing in Business Growth and Productivity[20] provide support through both direct and indirect program delivery models.

That said, most of the financial support is directly delivered by federal organizations to enterprises. NRC provided the largest amount of direct funding over the period of 2018-2019 FY through IRAP and its associated program streams, followed by ISED, NSERC, and ACOA. The total real[21] value of support of $138 million were delivered through intermediaries to 1,600 ultimate beneficiaries who are for-profit with at least one employee in the 2018-19 FY as shown in Figure 5[22].

[19] These are defined as 'third party delivery funding streams.' (Source: CPIAU Glossary)
[20] These programs are identified in a department's or agency's program inventory per the *Departmental Results Framework*.
[21] Real indicates adjusted for inflation.
[22] The number of ultimate beneficiary enterprises receiving funding through third-party intermediaries is significantly underestimated in this report due to existing data gap. The reasons for the data gap are threefold: 1) Departments and agencies did not request intermediaries to report data on ultimate recipients; 2) Department and agencies were not willing to share ultimate recipients data with STC/TBS due to existing data sharing

Figure 5: Real value of support to for-profit ultimate beneficiary enterprise, by delivery model, 2008-09 to 2018-19 FY



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

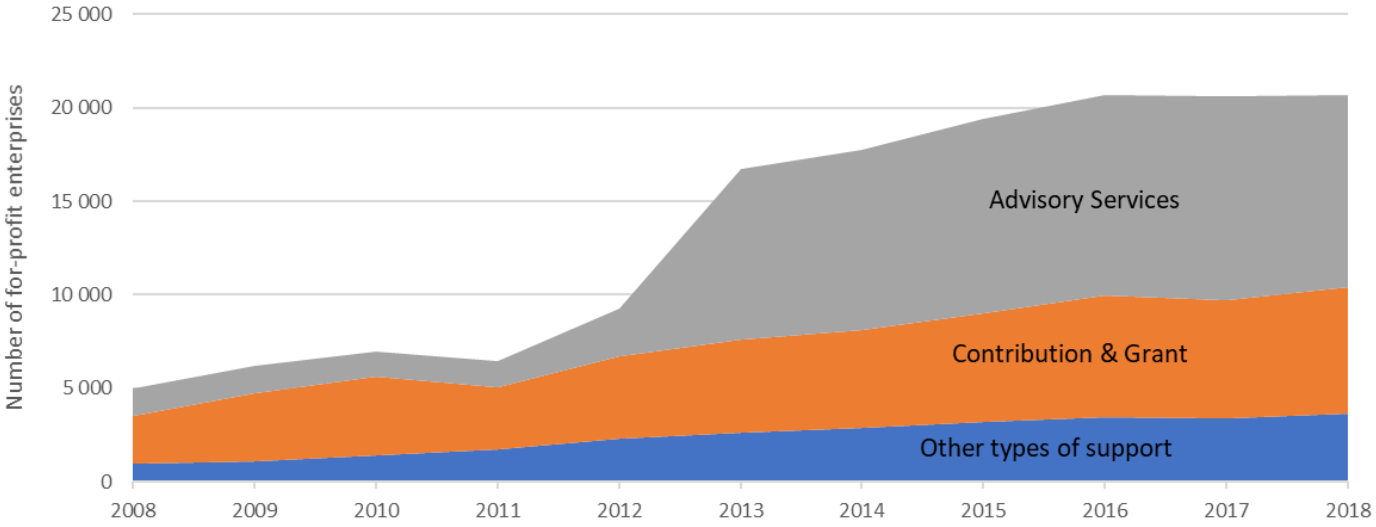
Enterprises received federal support from various funding streams, such as grants and contributions (G&Cs), advisory services, government performed services, targeted procurement, etc. IRAP was the only program stream that reported delivering advisory services in conjunction with funding. During the 2014-15 to 2018-19 period, NRC's IRAP accounted for around 44% of all annual interactions with enterprises, including both funding (e.g., non-repayable contributions) and advisory services.

Figure 6 shows[23] that about one-third of for-profit ultimate beneficiary enterprises received G&Cs and more than half received advisory services since the 2013-14 FY. As discussed previously, the spike on advisory services between 2012-13 and 2013-14 FY is due to improvements in data reporting that were undertaken within the NRC's IRAP and Global Affairs Canada's Trade Commissioner Service program streams, the two biggest program streams that provide advisory services to Canadian enterprises.

agreement between intermediary and ultimate recipients; 3) Intermediaries reported value of support to ultimate recipients over the length of the project (could be multiple years), therefore, departments or agencies can not report transactions to ultimate recipients. Furthermore, there is a special case where an intermediary is supporting another intermediary. For example, FEDDEV's Eastern Ontario Development Program.

[23] The 2007-2008 FY is the first year in the BIGS dataset with multiple data issues, such as incomplete data reported by departments and agencies. As a result, the number of supported enterprises and value of support provided by the BIGS programs are most likely underestimated. In additional, the number of supported enterprises unclassified in 2007-08 is much higher than the following years.

Figure 6: Distribution of BIGS's for-profit ultimate beneficiary enterprises by type of support, 2008-09 to 2018-19 FY



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment
Note: Other types of support contains for-profit enterprises with at least one employee who received government performed services, targeted procurement, enterprises reported as consortium members, enterprises with missing type of support or other.

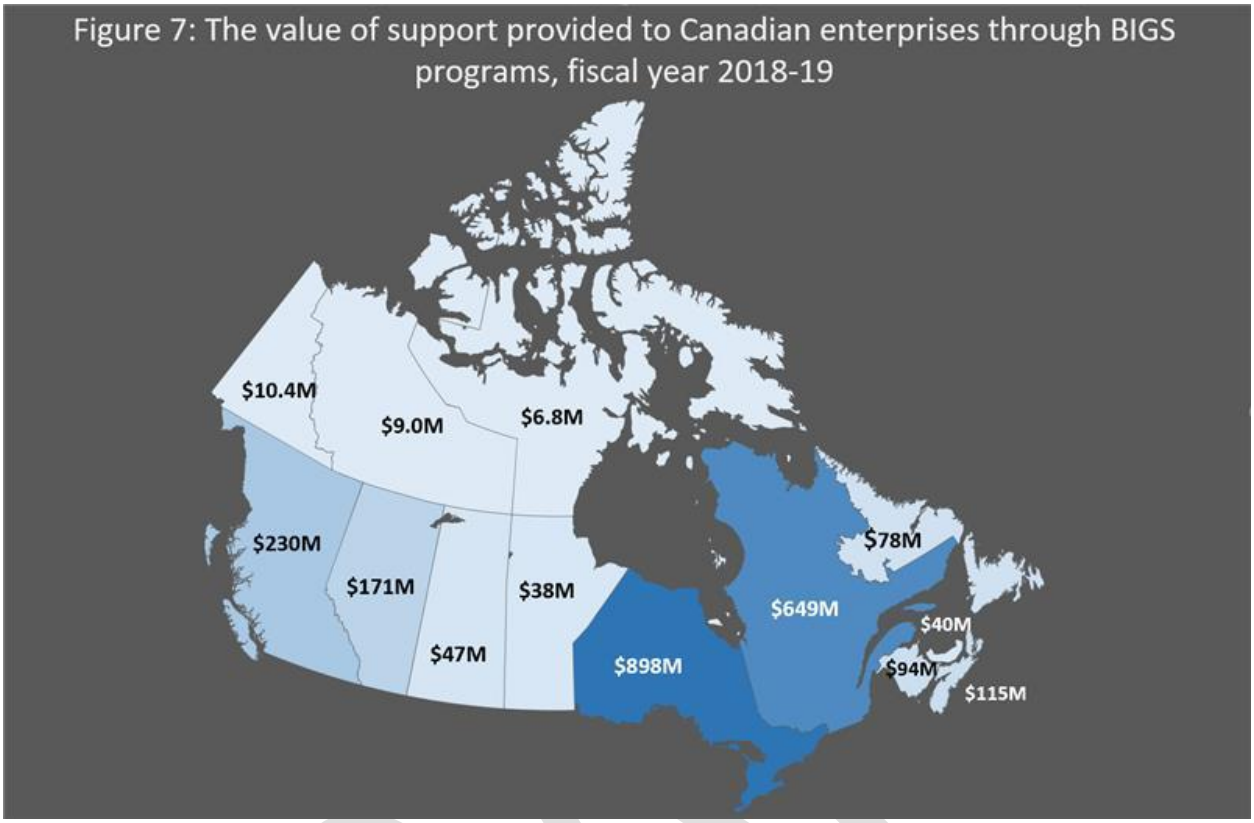
Section 2.2: BIGS Program Recipient Characteristics[24]

Approximately 85% of BIGS Program Support is Distributed in British Columbia, Alberta, Quebec and Ontario

The regional breakdown revealed a higher proportion of recipients and support in Ontario and Quebec. In the 2018-2019 FY, 35% of BIGS supported ultimate beneficiary enterprises were in Ontario (i.e., 7,446 unique enterprises), followed by Quebec at 23%, British Columbia at 16%, and Alberta at 10%. The value of support is also concentrated in the same provinces as shown in the map in figure 7. However, figure 8 illustrates that enterprises in three territories (i.e., Nunavut, Yukon, and Northwest Territories) received highest value of support on average.

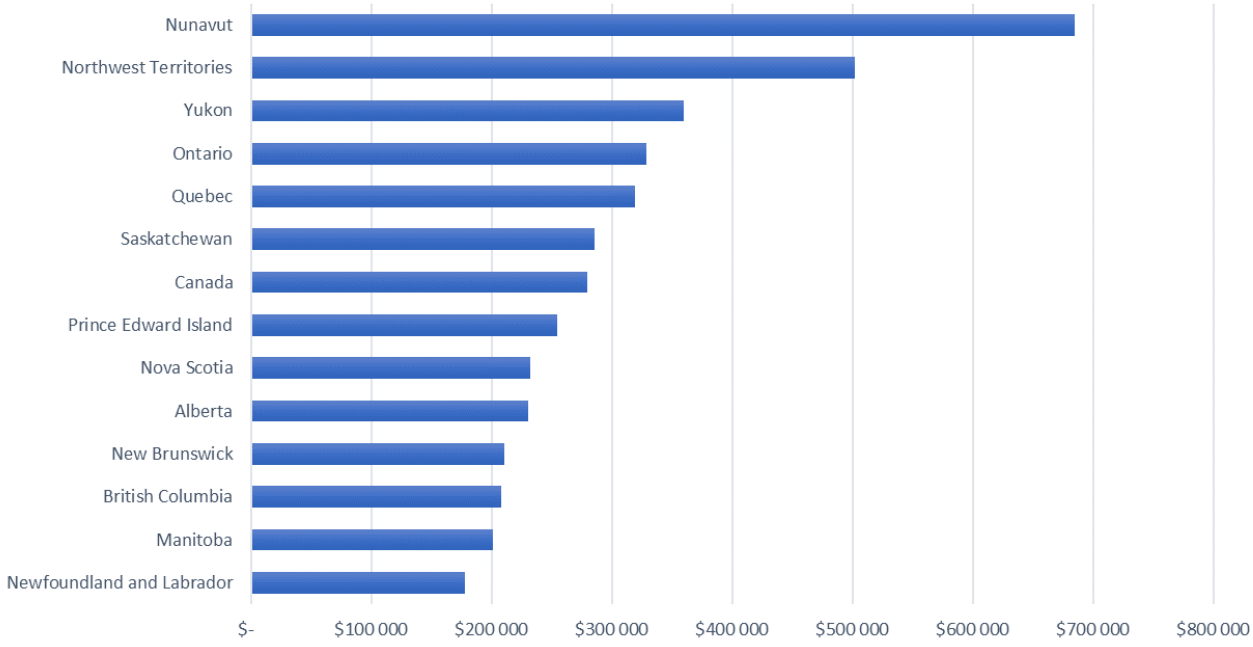
[24] Due to intermediary reporting data gap, a number of ultimate beneficiary enterprises receiving federal support through intermediaries were not captured in the BIGS microdata. As a result, they are not covered in the analysis of the characteristics of ultimate beneficiary enterprises.

Figure 7: The value of support provided to Canadian enterprises through BIGS programs, fiscal year 2018-19



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

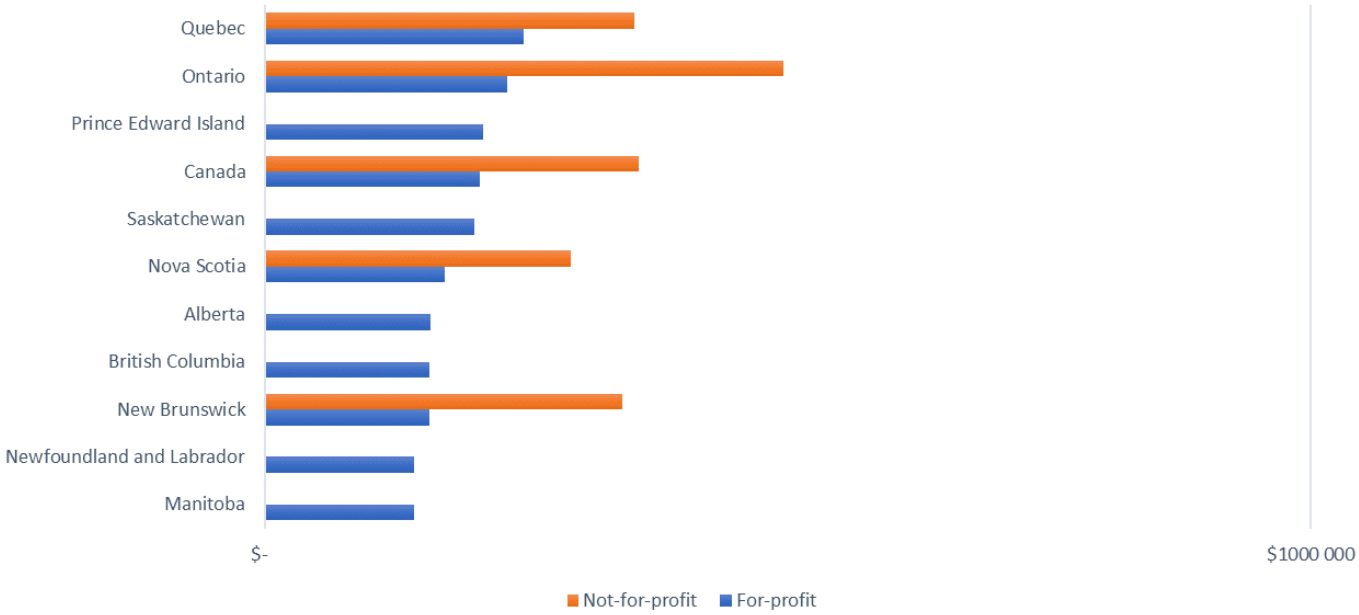
Figure 8: Average value of support received by ultimate beneficiary enterprises, by provinces, 2018-19 FY



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

While the CPIAU's primary focus is on for-profit ultimate beneficiary enterprises[25], not-for-profit enterprises and post-secondary institutions are two other types of ultimate beneficiaries that may receive BIGS program interventions. In the 2018-19 FY, for-profit enterprises received over half (63%) of the total value of support. Post-secondary institutions, accounting for about 2% of all ultimate beneficiaries, received 22% of the total value of support. Their average value of support was around $2.8 million, comparing to $206,000 for funded for-profit enterprises. Not-for-profit enterprises received $358,000 on average. However, the value of support received by the vast majority of ultimate beneficiary enterprises accounts for 10% of less of their annual revenue. Only about 5% of ultimate beneficiary enterprises received value of support that is more than half of their revenue. Figure 9 indicates that average values of support for each type of ultimate beneficiary enterprises vary among Provinces[26].

Figure 9: Average value of support provided in the fiscal year 2018-19, by type of enterprises



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

[25] The majority of BIGS supported ultimate beneficiary enterprises are for-profit (on average, about 85%, over the 12 years data). CPIAU mainly assesses economic impact of BIGS programs on those for-profit enterprises, such as productivity, employment and revenue changes after receiving BIGS support.

[26] In some provinces, the number of ultimate beneficiary enterprises or the value of support were suppressed to meet confidentiality requirement of the *Statistics Act*. Therefore, the average value of support was not reported in figure 10 for some provinces. For example, there were post-secondary institutions in the Western provinces that received funding but these values cannot be released due to confidentiality requirements of the *Statistics Act*.

The Manufacturing Sector Received almost 1/3 of the Total Value of BIGS Support

Ultimate beneficiary enterprises supported by BIGS program streams are concentrated in selected industrial sectors. Over the 12-year period, the professional, scientific and technical services sector and the manufacturing sector accounted for the largest share of total program stream interactions with enterprises[27]. Together, they received almost half of total financial support from business innovation programs. The other two major industry sectors received BIGS support were wholesale trade and Information and cultural industries (Figure 10). Above one-third of total paid employees in Canada worked in these four industrial sectors[28]. The educational services sector accounted for a small proportion of supported beneficiaries (less than 3%), however, they received around 20% of total financial funding.

In the 2018-2019 FY, the manufacturing sector received almost one-third of the total value of federal BIGS support[29] (Figure 11). The average value of support received per enterprises in the manufacturing sector was estimated at $339,000, which is higher than the average across all industry sectors ($279,000)[30]. The second largest share of total BIGS financial support was the educational sector, receiving $531 million but only accounting for 3% of all supported enterprises[31].

[27] The marked increase in the 2013-14 FY, as shown in Figure 11, mainly due to the significant improvement of data reporting on beneficiaries who received advisory services provided by NRC's IRAP and GAC's Trade Commissioner Services.

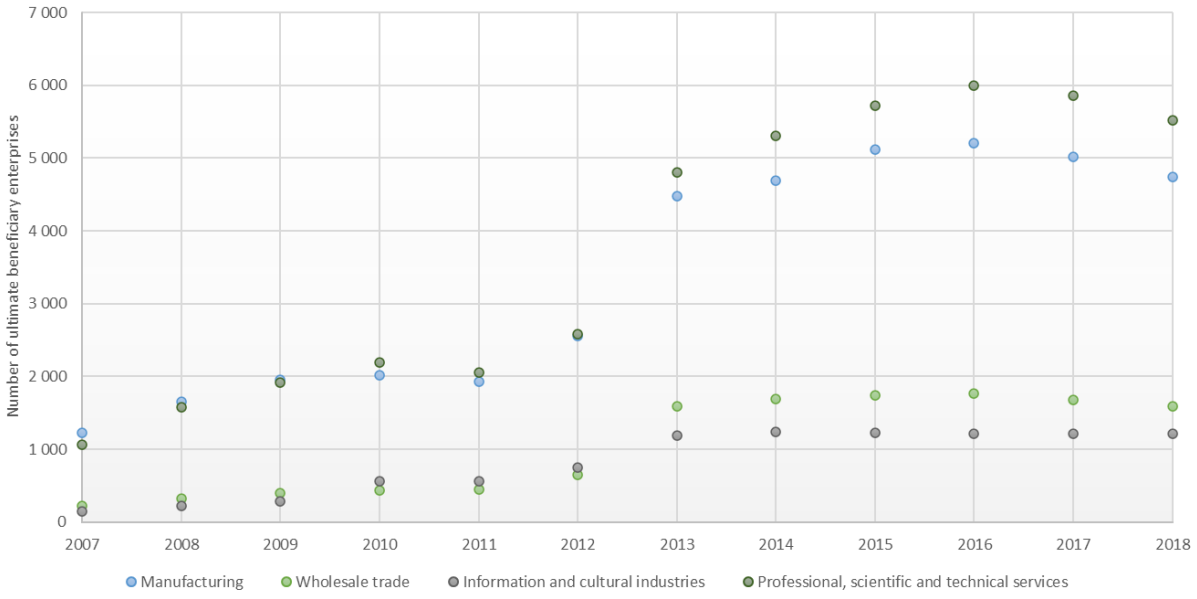
[28] Source: Statistics Canada, the Survey of Employment, Payrolls and Hours which is produced from the combination of the Business Payroll Survey results and the payroll deductions administrative data received from Canada Revenue Agency. It is Canada's only source of detailed information on the total number of paid employees, payrolls, hours and job vacancies at detailed industrial, provincial and territorial levels.

[29] It was reported by Statistics Canada in Daily. The Daily — Business innovation and growth support, 2018 (statcan.gc.ca)

[30] The BIGS database comprises a large number of advisory services as well as enterprises in a consortium with no reported value of support. Some industries may have more enterprises that received services, which could affect the average support per enterprise. Statistics Canada, Daily release.

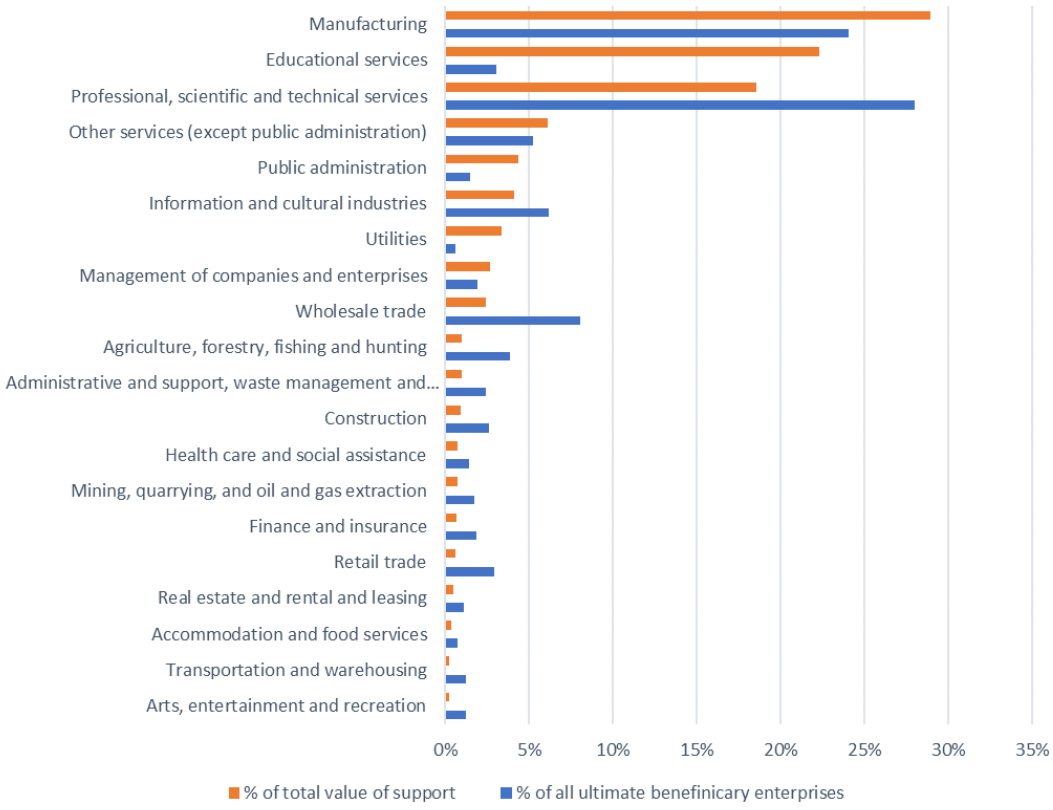
[31] Vast majority of the financial support to the educational sector went to post-secondary institutions.

Figure 10: Number of ultimate beneficiary enterprises by industry sectors, over the 12-year period



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

Figure 11: BIGS program support by industry, 2018-19 FY



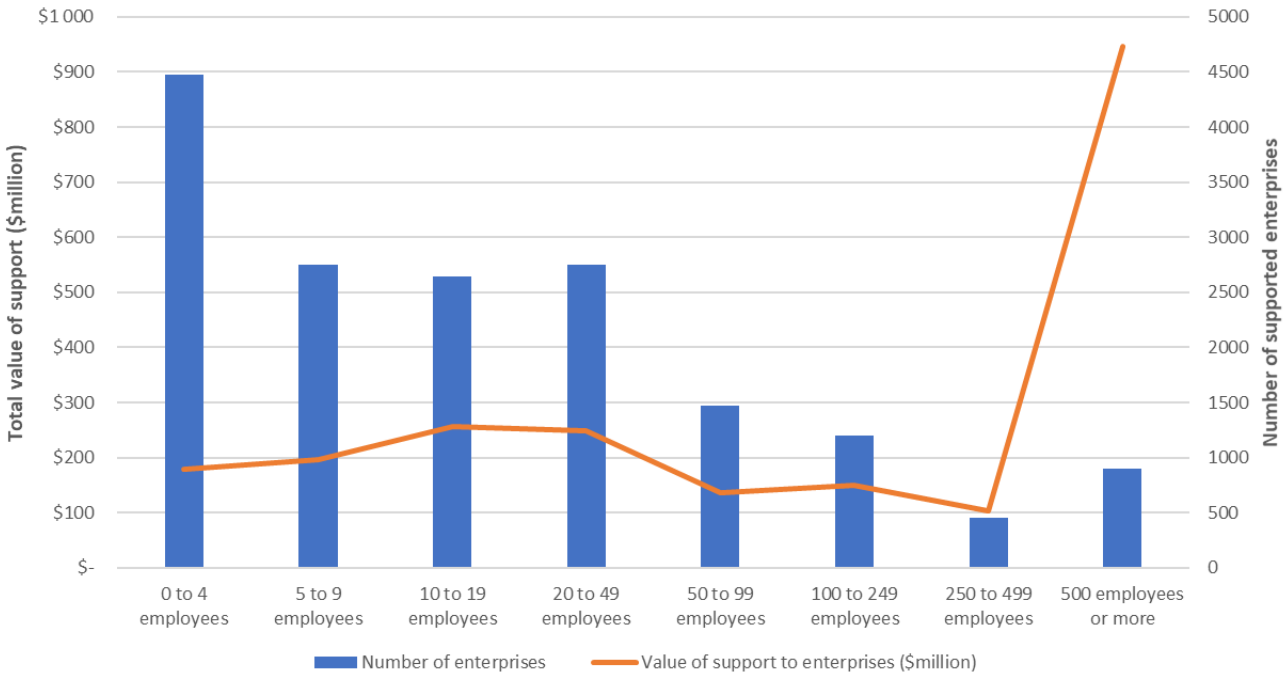
Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

The Distribution of BIGS Program Support Varies by Enterprise Size, Revenue, Age and Type

In the 2018-19 FY, the majority of supported enterprises were small and medium sized[32] enterprises (SMEs), but the average value of support significantly increases with enterprise size as shown in Figure 12. For example, the average value of support received by small enterprises was $156,000 in 2018-19. Medium-sized enterprises received on average $411,000 and large enterprises received $2,483,378[33].

A similar pattern is observed when examining BIGS support by the enterprise's revenue size. Enterprises supported by the BIGS programs are concentrated in those with lower annual revenue, but enterprises with the annual revenue of more than $500 million received the highest average value of support (Figure 13). Over three quarters (78%) of enterprises that received support had annual revenue of less than $10 million in the 2018-19 FY. These enterprises received half of the total value of support.

Figure 12: Vast majority supported enterprises were small and medium sized. However, they received 57% of the total value of support in 2018-19

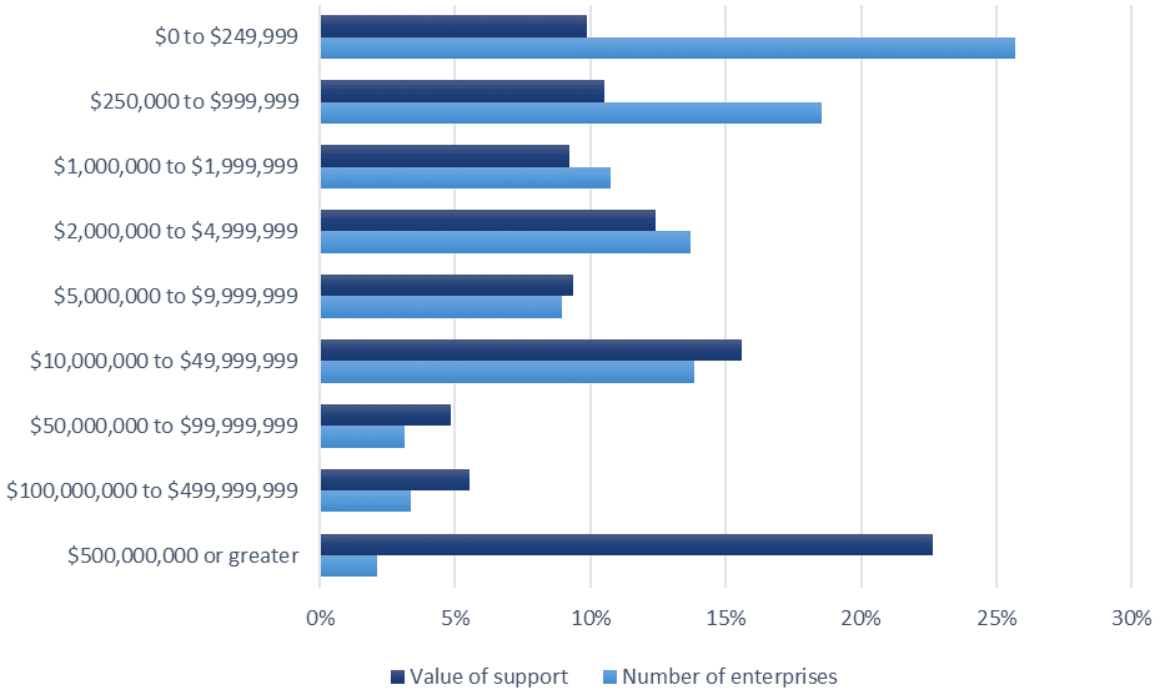


Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

[32] Small-sized enterprises are enterprises with 0-99 employees, medium-sized enterprises are enterprises with 100-499 employees, large-sized enterprises are enterprises with more than 500 employees.

[33] The average value of support per enterprise in enterprise size category is expressed as the value of support in an enterprise size category divided by the number of enterprises who received value of support greater than $0 in the same category. For example, average value of support per small-sized enterprises = total value of support received by small-sized enterprises / number of small-sized enterprises receiving at least $1 funding from BIGS program streams. The average values of support for small-, medium-, and large-sized enterprises are different from the estimates containing in the Daily release of "Business innovation and growth support, 2018" by Statistics Canada. Average value of support in Daily for small-sized enterprises = total value of support received by small-sized ultimate beneficiary enterprises / number of entire small-sized ultimate beneficiary enterprises. The enterprises received advisory services or other in-kind support were included in Statistics Canada's calculation.

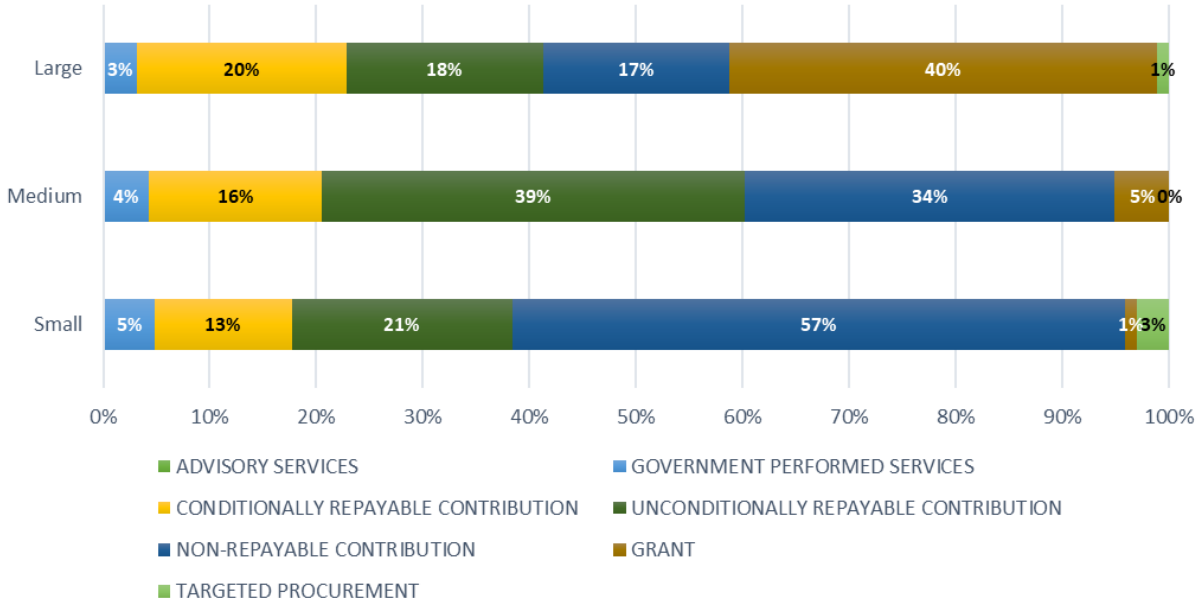
Figure 13: BIGS support by enterprises' revenue size, in 2018-19



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

On average, SMEs received funding mainly through contributions, while large-sized enterprises received 40% of federal support through grants over the 5-year period from the 2014-2015 FY to the 2018-2019 FY as shown in Figure 14. The use of grants is concentrated in larger enterprises. Grants do not have reporting requirements and in many cases are larger in financial value and disbursed by smaller boutique style BIGS programs. The sample size of these more narrowly subscribed BIGS programs means that descriptive statistics are unlikely to be released from Statistics Canada given the confidentiality requirements of *the Statistics Act*. Following this, the performance of these programs will have to be assessed using other methods than the ones undertaken by the CPIAU.

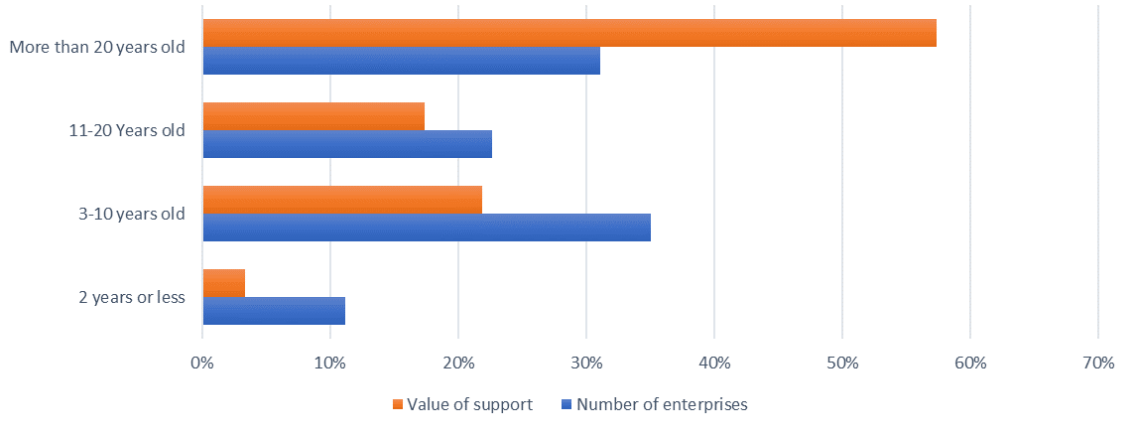
Figure 14: The value of support by enterprises size and by type of support, 5-year average value of support from the 2014-2015 fiscal year to the 2018-2019 fiscal year



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

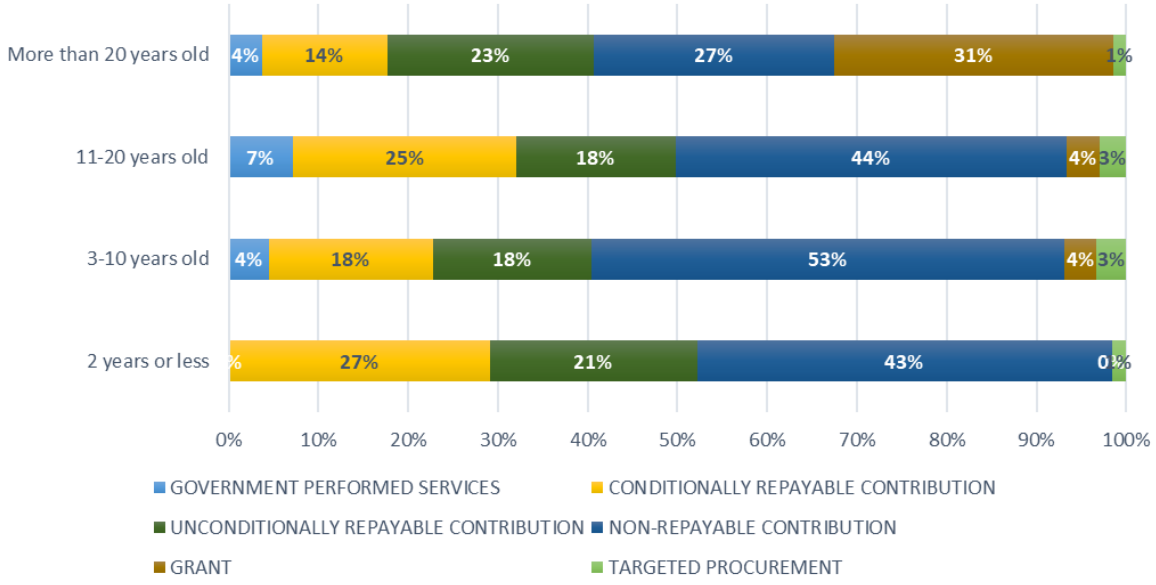
The value of support provided by BIGS programs are more concentrated in older, mature enterprises. Enterprises more than 20 years old accounted for 57% of total value of support in the 2018-2019 FY. In contrast, those less than 2 years old only received 3% of support as illustrated in figure 15. Well-established enterprises (more than 20 years old) received funding through both grants and contributions, while younger enterprises counted more on contributions provided by federal support as shown in figure 16.

Figure 15: Ultimate beneficiary enterprises by the age of enterprises, 2018-2019 FY



Source: Derived from the custom tables produced by Statistics Canada for ISED

Figure 16: The value of support by enterprises age and by type of support, 5-year average value of support from the 2014-2015 FY to the 2018-2019 FY



Source: Derived from the custom tables produced by Statistics Canada for ISED

Larger Enterprises Receive Multiple BIGS Program Streams' Interventions

Enterprises may receive funding or services from multiple program streams. In the 2018-19 FY, majority of for-profit enterprises received support from a single program stream, and the majority of them are SMEs. In contrast, more than half of post-secondary institutions interacted with multiple program streams as shown in Figure 17. About one quarter of large-sized enterprises received support from more than three BIGS program streams in the 2018-2019 FY as illustrated in figure 18. Figure 19 indicates that enterprises in manufacturing and professional, scientific and technical services more likely interacted with multiple BIGS program streams. Additional analysis could be undertaken to examine whether these enterprises received support from multiple program streams with similar or different objectives, delivered by the same or different federal organizations.

Figure 17: Over half of post-secondary institutions supported by multiple program streams, 2018-19

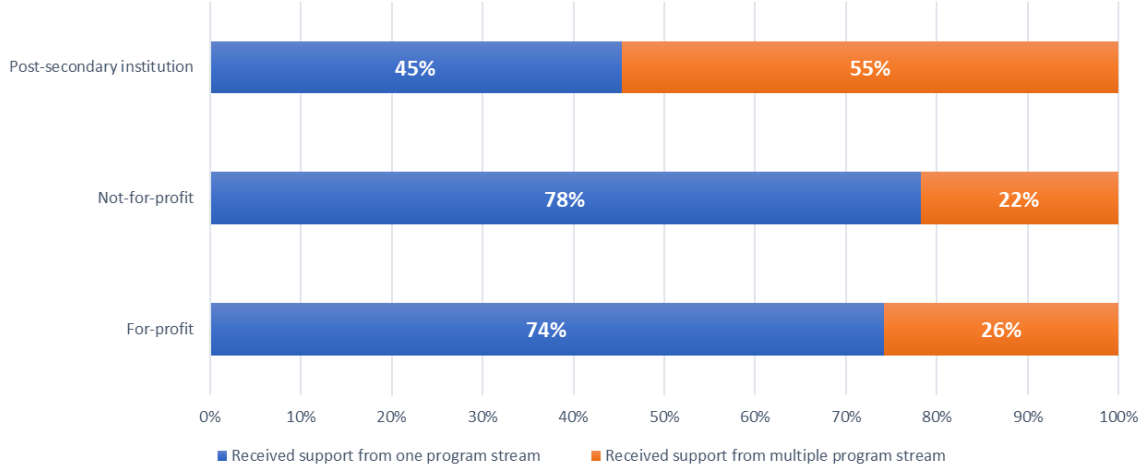
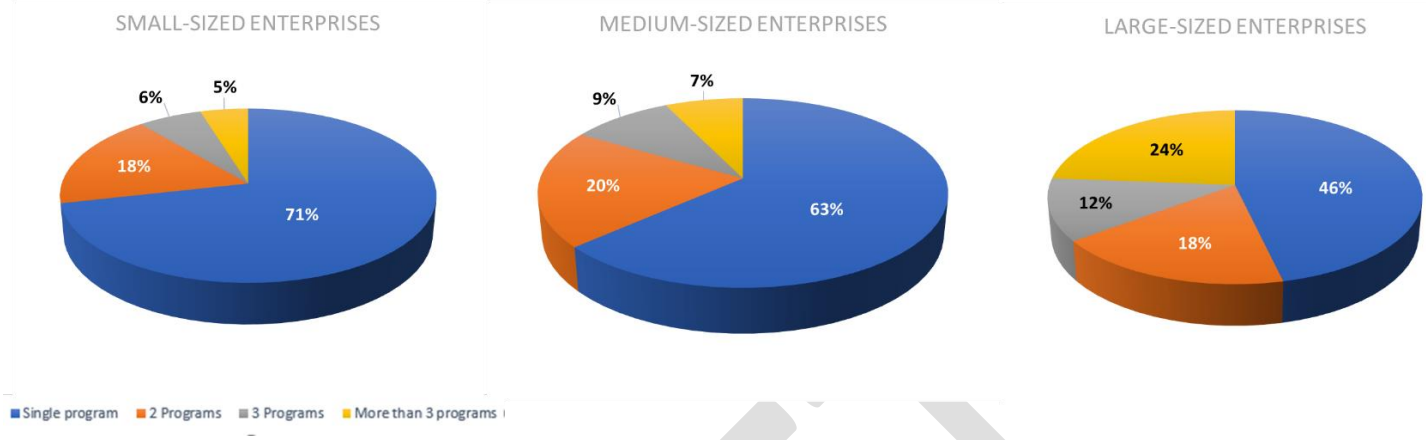
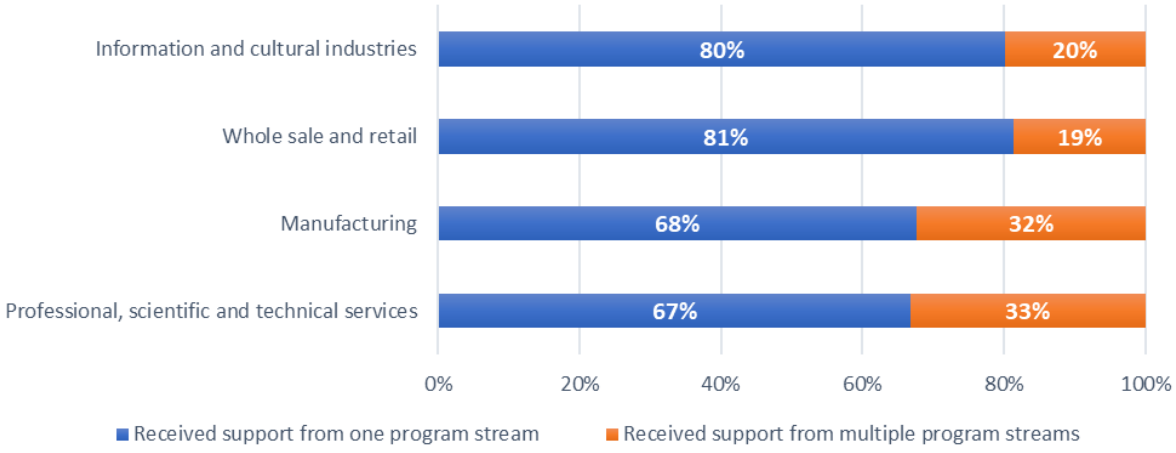


Figure 18: Majority of SME entreprises interacted with a single program streams, 2018-19



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

Figure 19: About one-third of enterprises in manufacturing and Profession, Scientific and Technical Services receiving support from multiple program streams, 2018-19



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

Section 2.3: Does BIGS Programming Drive Growth?

This past fiscal year the CPIAU undertook a literature review of international BIGS programs that have undertaken quasi-experimental econometrics evaluations to see if enterprises that receive support from international BIGS programs achieve better results than those that do not. A summary of the literature review is presented in Annex 5[34]. The major finding of this work is that, in these foreign nations,

[34] The literature review also examines the common methods, data sources and firm-level indicators used in the quantitative assessment of international BIGS programs.

enterprises that were smaller, younger, and received support from one or more international BIGS program interventions experienced the strongest outcomes following the program intervention.

Following from the results previously presented on ultimate beneficiary enterprises and the findings of the international literature review, the CPIAU has begun exploring how enterprises in Canada perform with respect to employment[35], revenue[36], and productivity[37] using median growth rates[38] three years following the receipt of a BIGS program intervention.

Compound Annual Growth Rate (CAGR) was used to estimate the change of a supported firm's employment and revenue over a 3-year period after the year of funding. Then the median growth rate was identified in the middle of CAGR distribution. The CAGR smooths out the volatility of periodic performance of firms. The specific characteristics of BIGS for-profit ultimate beneficiary enterprises with at least one employee studied were the enterprise size, lifecycle stage, and enterprises receiving support from a single program stream versus multiple program streams.

All enterprises[39] that received BIGS support over the period of 2010-11 to 2015-16 achieved an employment growth rate at a range of 1.8% to 3.1%, revenue growth rate at a range of 5.2% to 5.8%, and median three-year change in productivity ($value-added/per employee) between the year of support and three years after support at a range of $4,500 to $8,700. While these results are encouraging, further study is required to compare these results with enterprises that did not receive support from BIGS programs.

Figures 20-21 below reveals that smaller and younger firms achieved higher growth compared to the median supported BIGS firms. Firms receiving support from multiple program streams experienced stronger relative performance across three indicators. Overall, firms receiving support in the 2015-16 fiscal year achieved 3% employment growth and 6% revenue growth after three years (i.e., the 2015-16 to the 2018-19 fiscal year). The median of value-add per employee increased $5,74 three years after receiving BIGS program support. Relative to the median growth rate for overall firms' performance,

[35] Employment growth is calculated using the Compound Annual Growth Rate formula: (Employment year of support + 3/Employment year of support)1/3-1. Employment growth is calculated only for enterprises with positive employment in the year of support and three years later. Employment in this study is the average employment over the year from the PD7 (payroll deductions) file.

[36] Revenue growth is calculated using the Compound Annual Growth Rate formula: (Revenue year of support + 3/Revenue year of support)1/3-1. Revenue growth is calculated only for enterprises with positive revenue in the year of support and three years later. Revenue in this table is line 8299 from the General Index of Financial Information (GIFI).

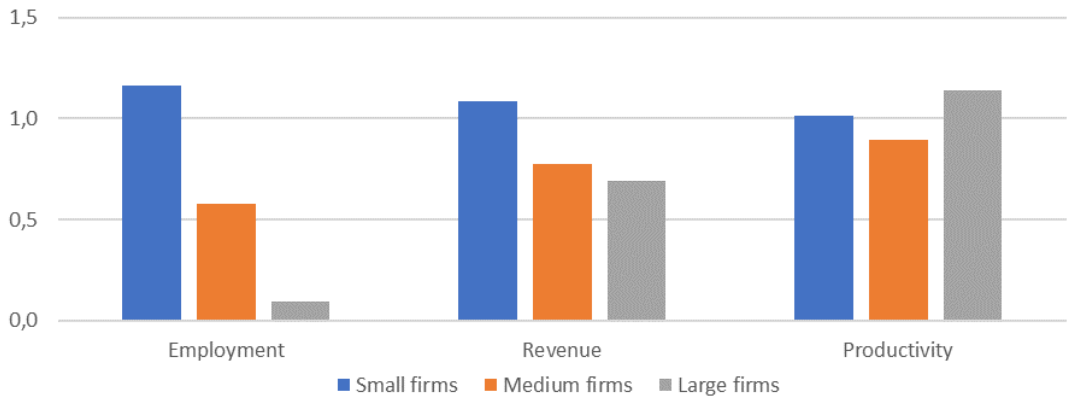
[37] The three-year change in productivity of an enterprise is its value-added per employee three years after the year of support minus value-added per employee in the year of support. Value-added is net income before tax (GIFI line 9970) plus PD7 (payroll deduction file) annual pay. Productivity is value-added divided by the average number of employees during the year according to PD7 payroll deduction files. Change in productivity is calculated only for enterprises with non-zero income and non-zero employment in the year of support and three years later.

[38] Median is a common descriptor used to express a "middle" value in a set of data. This "middle" value is also known as the central tendency. Median gives a better representation of the majority of the values in the data set than average, since "average" can be significantly influenced by a few extreme values.

[39] Here, firms refer to for-profit ultimate beneficiary enterprises with at least one employee.

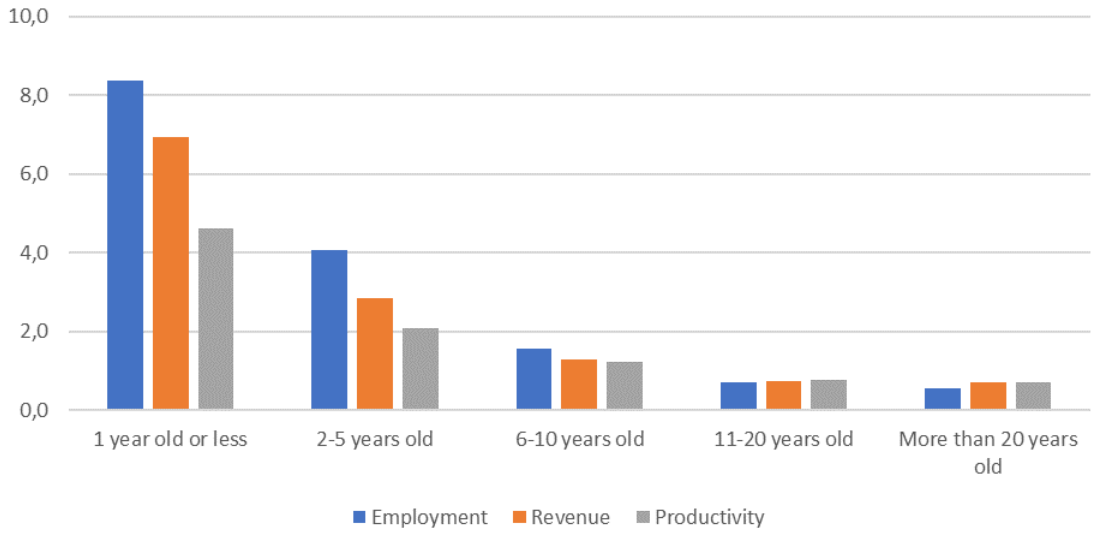
small-sized firms showed stronger employment (1.16[40]) and revenue growth (1.09) after three years of support as shown in Figure 20. Smaller firms did not have as strong performance in productivity in comparison to large-sized firms, but younger enterprises (less than 5 years old) do show much higher growth rates across all growth indicators compared to the median BIGS supported firm as shown in figure 21.

Figure 20: Firms' performance three years after receving support in the 2015-16 fiscal year, by firm size



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

Figure 21: Firms' performance three years after receiving BIGS support in the 2015-16 fiscal year, by firm age



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

[40] Relative growth to overall median = median growth for any given category / Overall median growth

The marginal benefit of a BIGS program may be greater for smaller and younger enterprises compared to larger and older ones. A smaller and younger enterprise is more likely to be financially constrained[41], less likely to take risks and therefore may benefit more from funding to pursue research and development. Smaller and younger enterprises may be less likely to develop general growth strategies or take steps to export to new markets due to limited time and resources and the support of advisory services programs can help them develop strategies to grow. Smaller and younger enterprises may benefit more from participating in consortium projects funded by network and collaboration programs where they are learning how to innovate from their more experienced enterprises and post-secondary institutions.

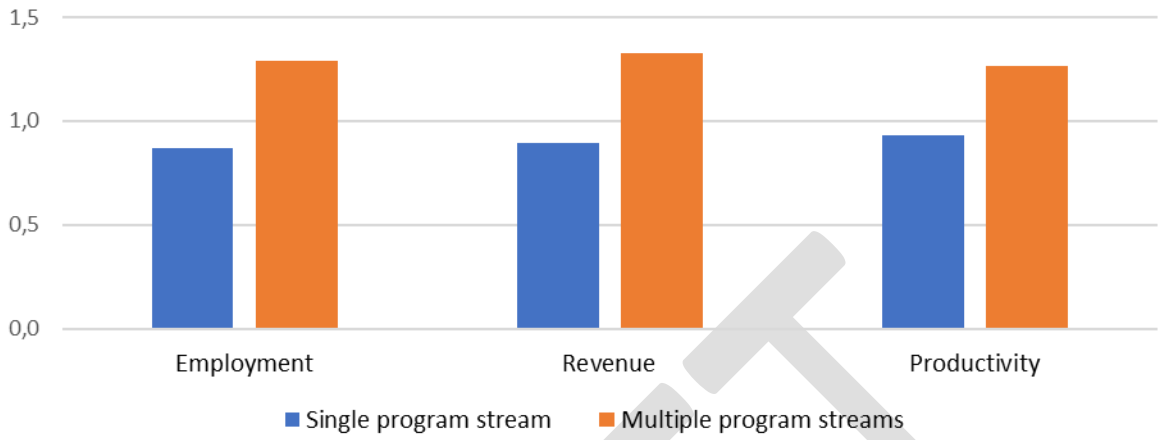
While these results do provide useful information on the relationship between BIGS programs and the performance of smaller and younger enterprises receiving their interventions, they do not robustly estimate the causal impact of BIGS programs. Younger enterprises are far more likely to start their businesses with a smaller number of employees, lower revenue, and less productivity. The observed stronger performance in these growth indicators illustrated in figures 20-21 may simply illustrate that smaller and younger enterprises' ability to grow since they are starting off at lower absolute levels to begin with.

More analysis using quasi-experimental econometrics methods and counterfactuals is required to robustly determine if it is BIGS programs that have contributed to the positive outcomes observed for the supported enterprises. Section 3 describes these methods in more detail and how they can be used to assess the causal impact of a BIGS program.

The CPIAU is uniquely positioned to assess the performance of these enterprises given its mandate to assess the horizontal performance of the BIGS program universe. Figure 22 shows that accessing support from multiple program streams may have led to improved revenue, employment and productivity growth. Some international literature suggests that enterprises may have a higher probability of being innovative and that experiencing multiple forms of government support may lead to improved outcomes[42]. Further studies could consider assessing program impact through a more wholesome lens such as examining whether accessing additional funding leads to changes that are additive, multiplicative, or diminishing returns, by holding all other factors equal and constant.

[41] Becker, B. (2015) "Public R&D policies and private R&D investment: A survey of the empirical evidence"
[42] Additional information can be found in Annex 5.

Figure 22: Firms' performance three years after receiving BIGS support in the 2015-16 fiscal year, by number of program intervention



Source: Derived from Statistics Canada's BIGS administrative microdata linked to the Linkable Files Environment

Section 3: Novel Research and Findings

The CPIAU both undertakes and sponsors analytical studies as well as data development and experimentation initiatives to measure the impact of BIGS programs on the Canadian economy. In the 2020-21 FY, the CPIAU sponsored academic researchers to contribute new insights to the body of knowledge on the measurement of innovation. The main findings presented here describe emerging themes using common measurement methods and a new measurement framework that looks at the widespread impact of innovation policy on the economy.

Data development and experimentation initiatives are undertaken to create robust information that the CPIAU and BIGS programs can use in their research and analysis activities. For example, this year CPIAU and Statistics Canada embarked on a data experimentation project that led to the creation of the Diversity and Skills Database (DSD), a comprehensive dataset of firm-level variables characterizing business owners and their workforce in diversity and skills. To better improve the assessment of how BIGS programs contribute to the production of innovation using intellectual property (IP) rights as an indicator, the CPIAU and Statistics Canada discussed the feasibility of linking selected data from the Canadian Intellectual Property Office (CIPO) into the LFE. As a result of these efforts, patent data, one indicator of the production of IP, will be linked to the LFE later in the 2021-22 Fiscal Year. The CPIAU also commenced two data experimentation initiatives internally to examine the possibility of generating new data assets while simultaneously reducing administrative burden on BIGS data providers.

The novel research and findings presented here illustrate the CPIAU's contributions to advancing the evidence-based policy discourse on BIGS programs. These findings build on *Foundations,* the CPIAU's inaugural annual report which presents the following results

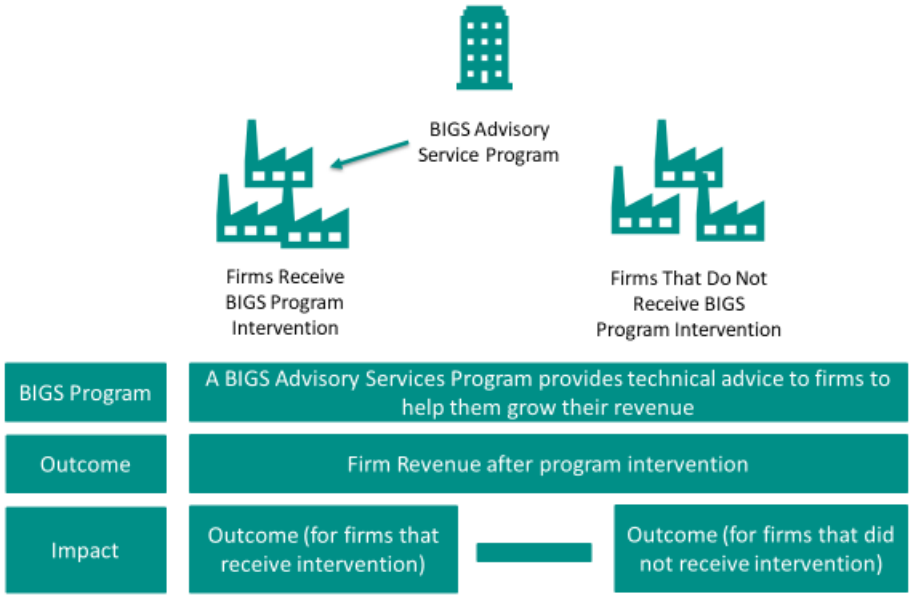
- the need to ensure administrative data structures are linked within the policy suite to advance the exchange of project performance data across government;
- smaller BIGS programs require specialized analysis as sample sizes are too small for horizontal reporting; and,
- performance measurement challenges are broad across the BIGS program suite and linked data provides the ability to generate horizontal indicators to analyze programs with similar state outcomes.

Also presented in this section is a series of summaries on how selected BIGS departments are using their program administrative data linked to the LFE to inform their program and policy activities. This analysis was made possible through the joint CPIA-Statistics Canada data collection exercise. For future CPIAU annual reports, these summaries will be added to a new annex, which will provide a list of departmental research projects that use the BIGS data asset.

Defining and Advancing Quasi-Experimental Impact Assessment Methods

Program administrative data linked to the LFE provides an opportunity to conduct quasi-experimental assessments, a form of quantitative impact assessment, to better understand how BIGS programs contribute to a change in outcomes for the firms they serve. Quasi-experimental approaches estimate the causal impact of a policy or program through comparing the outcomes of firms that receive a BIGS program intervention to a counterfactual comparison group of firms that did not receive the intervention but are as similar as possible to the firms that did receive the BIGS program intervention. A practical example is provided in Figure 23.

Figure 23: Outcome vs Impact



Quasi-experimental approaches can play an important role in ensuring programs are running effectively and deliver value-for-money. They are meant to complement qualitative evaluative methods. BIGS programs with relatively small number of recipients are likely to be too small for quasi-experimental methods to show robust results. In Annex 6, the CPIAU provides a link to a set of guidelines for BIGS

programs on the selection of appropriate quasi-experimental methods for current BIGS program schemes.

The CPIAU and Statistics Canada co-created a virtual course on the complete universe of quantitative impact assessment titled "The Evaluator's Guide to the Quantitative Impact Assessment Galaxy" to assist evaluators in further understanding and applying the results of quantitative impact studies in their work. The course was delivered virtually in September 2020 and evaluators from 13 BIGS departments attended. In addition to reviewing the course contents, participants discussed other topics such as the importance of working with programs to improve the availability and quality of data as well as how to access relevant and timely data for impact assessment purposes. The course was well received by participants with one evaluator noting, "there is a need for evaluators—including myself— to develop competencies in this area. This course is a good step towards this end."

The course provides three lectures including overviews of quantitative impact assessment approaches, randomized control trials, and common quantitative impact assessments, including quasi-experimental approaches. Links to the course videos and presentation can be viewed on the CPIAU's GCCollab page.

Section 3.1: Research and Analysis

Crowding in or Crowding Out –Analysis of Government Support

In the past year, Dr. Claudia De Fuentes at Saint Mary's University commenced a research study, *Crowding-in or Crowding Out? Analysis of Innovation Government Support for Firms Located in Canada* that aims to investigate the performance of Canadian firms that received program interventions from selected BIGS program streams. This is the first time an academic researcher will assess firm level performance using BIGS data. Figure 3 describes the departments and program streams included in the study. The program streams investigated in Figure 24 encompass a wide array of program interventions designed to stimulate innovation and spur economic growth.

In January 2021, as part of the CPIAU Speaker Series, Professor De Fuentes and her research team provided an overview of her study and summaries of her systematic literature review as well as findings from work examining the subsidy allocation process of how firms select and allocate funds to firms. The latter two summaries will be published as white papers as part of this project. The literature review portion of the presentation provided an overview of the main quasi-experimental methods of analysis being used to conduct impact assessment in innovation studies and how her original research will contribute to the body of knowledge on innovation studies. The subsidy allocation portion of the presentation gave an overview of how BIGS programs select firms to receive their interventions, including eligibility and allocation criteria.

Figure 25 provides an overview of the key themes, questions, findings and insights for future work as identified in De Fuentes' two white papers. The CPIAU provided comments and feedback to Dr. De Fuentes and her team which were incorporated into both documents. Examining the effect of government support on firm performance and identifying how programs can complement each other are two major themes the CPIAU conducted its own internal analysis on in Section 2. As the CPIAU

continues its ongoing analysis, future work will take into account some of key insights provided by De Fuentes such as identifying differences and specificities in regard to the type of innovation support provided, including but not limited to direct support for R&D, advisory services, and support for networks and collaboration, and the characteristics of firms receiving interventions. Future CPIAU analysis could also examine whether there are Matthew effects for BIGS program users, which refers to an increased likelihood that previous program users receive BIGS program funding.

Figure 24: Program Streams Under Study

Department	Program Stream	Sub Program Stream
Atlantic Canada Opportunities Agency	Business Development Program	
Canadian Northern Economic Development Agency	Strategic Investments in Northern Economic Development	
National Science and Engineering Research Council	College and Community Innovation Program Innovation Enhancement Grants Industry-driven Collaborative Research and Development Applied Research and Development Grants	
National Research Council	Industrial Assistance Research Program	Technology Innovation Contribution to Firms Contribution to Organizations
Global Affairs Canada	Going Global CanExport Innovation	

Figure 25: Key Themes, Questions, Findings and Insights for Future Work

Themes	Central Question(s)	Findings	Key Insights for Future Work
Input Additionality	Does the provision of public support to innovation stimulate additional private firm-level investment?	Current results are not conclusive with some studies claiming that public support for innovation stimulates additional investment for innovation from the firm (i.e., crowds-in) while other studies state public support offsets	There is a need to: - Identify differences and specificities in terms of the type of the innovation support; and, - Assess the connection between

		private investment in innovation (i.e., crowds-out)	public support, different characteristics of firms receiving the intervention (i.e., firm heterogeneity) and innovation dynamics
Output Additionality	What is the effect of government support on firm performance?	Current results are not conclusive with some studies suggesting output additionality is present with R&D expenditures, value-added productivity, employment and wages being higher for firms receiving innovation program interventions, while other studies do not find statistically significant effects	Like input additionality, it is necessary to identify differences regarding the type of support provided and characteristics of firms receiving the intervention The availability of longitudinal panel data and firm level variables that provide information on business capabilities, innovation intensity, output and firm performance is required to conduct analysis examining output additionality
Policy Complementarity	How can direct (provision of loans, grants and subsidies) and indirect (tax incentives) public support programs complement each other? How do supply and demand side instruments contribute to the innovation system?	Most analysis has focused on the effect of direct and indirect support and many have found policy complementarity between instruments as firms more often achieve better outcomes when receiving multiple instruments as opposed to a single instrument. While many of the studies coincide that more than one innovation policy instrument is necessary to boost innovation, some evidence suggests an indiscriminate addition of instrument can cause crowding out effects.	Considering the various characteristics of the innovation instruments and how they interact with different kinds of firms is important when assessing policy complementarity.
Subsidy Allocation and the Matthew Effect	What is the process by which government agencies select and	Selected evidence suggests firm selection is mainly determined by prior grants, high quality interventions and	Future research should seek to identify whether the Matthew effect is virtuous or vicious for firms that have

	allocate funds to specific firms? Is the Matthew effect, which refers to an increased likelihood of firms receiving public funds based on having previously received public funds, present?	minority state-ownership for Chinese firms (Boeing 2016) A seminal piece by Antonelli and Crespi (2013) elaborates a crucial distinction between vicious Matthew-effects and virtuous Matthew-effects. Vicious Matthew-effects include cases where public support is consistently directed towards repeat program users even when these firms have reduced their commitments to research after receiving support. Virtuous Matthew-effects sees public support continuously be directed to firms that have been able to use previous subsidies to increase innovation activities.	previously received program support.

Examining the subsidy allocation process by which government agencies select and allocate funds to specific firms is an emerging area of inquiry in innovation literature. De Fuentes' second white paper analyzes how funding is granted and how the availability of data regarding public support to innovation can provide a better understanding of how programs are implemented. She notes that central questions surrounding the subsidy allocation process are whether it is the role of government is to pick firms or industries and what are the specific elements within application guidelines that may lead specific firms to receive interventions. Her preliminary findings suggest that even though government programs seek to foster an innovation environment, in many cases, the process excludes other potential beneficiaries from the process.

In the 2021-22 Fiscal Year, Dr. De Fuentes will undertake applied econometric analysis using the BIGS program streams administrative data linked to the LFE. The results of this work are expected to provide grounded evidence on the impact of firm level decisions to invest in innovation and the effects of government support across time on the performance of Canadian firms. This research will be made publicly available and presented at national and international conferences

Measurement of Complementarities and Spillovers in Technological Innovation

The CPIAU is committed to advancing other measurement methodologies beyond quasi-experimental methods to better understand how BIGS programs influence the innovation process. The CPIAU supported Dr. Kenneth Carlaw at University of British Columbia, Okanagan, to develop a methodological and conceptual measurement framework based on structural evolutionary (SE) economic growth theory. His forthcoming theoretical piece, *The Measurement of Complementarities and Spillovers in*

Technological Innovation, creates a foundation for an alternative way to measure innovation than the common approaches currently applied today.

SE theory contends that when firms innovate, they do so in an environment of pervasive uncertainty and this uncertain environment presents challenges for directly measuring the causal impact of a program or policy. A distinguishing feature of the proposed framework based on SE theory is that it seeks to measure the impact of innovation programs and policy broadly in contrast to the common approach of investigating whether a single program intervention had an impact on specific outcomes that has been described in this report to this point. While both the narrow and broad approaches ask, "did a detectable and worthwhile change occur?" the broad approach questions if the policy or program results in a change in technology or in technology's facilitating structure[43] that policymakers wish to change and that would not have occurred otherwise.

SE theory also notes that technological changes do not occur in isolation but rather in a dynamic process. Technological ideas interact with and complement other technological ideas. These technological complementarities can occur on a vertical scale where one technology enables the development of subsequent technologies or can occur on a horizontal scale where a technology is created and is applied in other technologies. Technological complementarities create spillovers[44] which provide other innovative agents the opportunity to exploit previously created technological knowledge. The proposed measurement framework argues that it is the set of spillovers deriving from technological complementarities that innovation policy seeks to influence and that should be measured to understand technological change and the influence public policy has on the process of change.

Spillovers, by their nature, are hard to measure as it involves directly tracing the evolution of a dynamic process of technological invention, efficiency, application, and diffusion. One application of the proposed framework currently in its early stages of development is to empirically trace technology directly and assess the role that public sector investment has had on the evolution of technology by tracing the co-evolution of its financing between the public and private sectors. This would provide a more comprehensive picture of the impact that policy has on spillovers.

In contrast to BIGS data, which is strictly quantitative, this methodological approach would use information from both qualitative and quantitative data collection techniques. This approach complements existing quantitative impact assessment approaches, which focus on how BIGS program intervention may impact various forms and levels of indicators, by drawing attention to the possible ways to measure the spillovers associated with changes in technological complementarities induced by policy interventions. The foundational framework established will be used to guide further novel techniques of measurement. Technological complementarity tracing is one example of a broader measurement approach that need to be further developed and more closely compared to existing measurement techniques.

[43] Technology is defined here as the set of ideas specifying all activities that create economic, not strictly a physical embodiment in capital goods. The facilitation structure defined here is the set of realisations of technological knowledge ie. the actual physical objects, people, structures, and organisational forms, in which technological knowledge is embodied.

[44] An example of a vertical complementarity spillover is the relationship between electricity and the computer as the latter could not exist without the former being developed. An example of a horizontal complementary spillover is the relationship between refrigeration, transportation technologies and electricity given refrigeration is a technological component used in the blueprint of transportation trucks.

Section 3.2: Data Development and Experimentation

Demonstrating the Potential for Automated Data Collection Using Application Programming Interfaces

Since the CPIAU's inception in 2018, BIGS departments have provided their program administrative data through manually entering all required data into a data collection template and submitting the template to Statistics Canada. The data includes basic information around the financial support businesses receive from BIGS programs, including the value of support, type of support and basic firm characteristics such as name and location. Statistics Canada then reconciles, validates, and edits the data when required to improve its quality which often involves following-up with BIGS departments. The CPIAU recognizes that the manual provision of this administrative data creates respondent burden for BIGS departments.

In late Fiscal Year 2019-20, the CPIAU commenced in a data experimentation exercise to address a potential path to reduce respondent burden and improve data quality. Through leveraging the Government of Canada's API Store, the CPIAU sponsored an Application Programming Interfaces (API) Proof of Concept which sought to create a database and interface system whereby a BIGS department could successfully upload their program administrative data using an API, a set of programming computer code that requests and transmits data between two software systems using specified instructions. The Innovation Canada program at Innovation, Science and Economic Development (ISED) also participated in the Proof of Concept and agreed to provide their previous year's data to accelerate the validation process. ISED's Results and Delivery Unit, the Trade Commissioner Service at Global Affairs Canada and TBS Open Data Group all participated as observers in the exercise.

The results of the Proof of Concept exercise, which concluded in the early 2020-21 Fiscal Year, demonstrated that a database to database transfer could be completed using APIs. This indicates the possibility of moving from a manual data collection towards an automated one using APIs. Automated data collection would greatly reduce the burden placed on BIGS departments in providing their data and responding to validation requests. There are other benefits to adopting this technology. Data could be visualized in real time into a dashboard or microdata sets for reporting purposes. Program administrative data could be shared between departments for other horizontal data collection exercises with departments still maintaining control over who has access to what data.

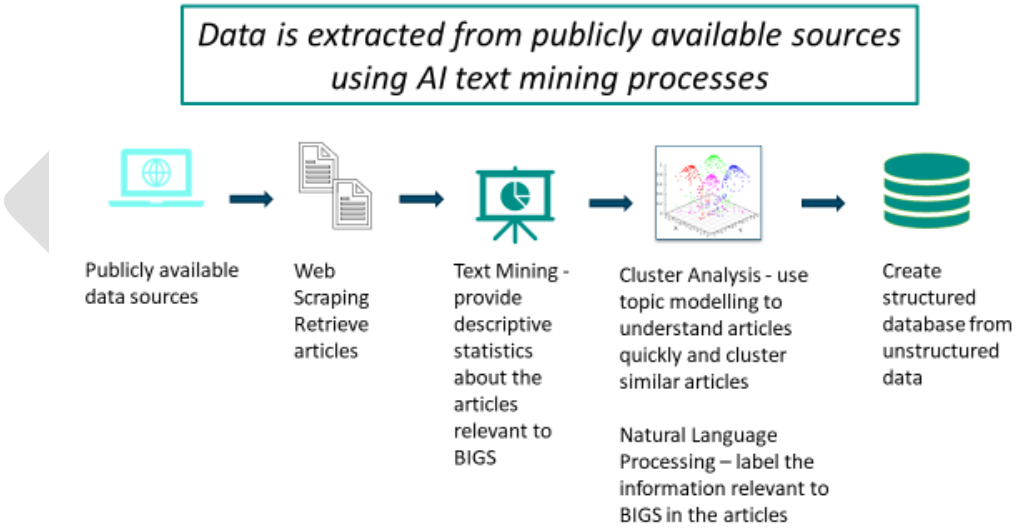
Automated data collection using APIs requires effective data governance. The CPIAU intends to study what data governance requirements in areas such as data storage, operations, and security would be required to effectively establish a data collection system using APIs. In addition, the CPIAU will be conducting a full-fledged pilot involving end-to-end data transfer using APIs during a future administrative data collection exercise to assess how data collection would work in an applied exercise

Gathering Program Stream Information in an Artificial Intelligence Pilot

As previously discussed, program streams are BIGS program entities that face the public and are announced by parliamentarians. A Canadian firm should be able to find a program stream that meets its needs using a basic Internet search. The CPIAU uses program streams as its common unit of observation given that program streams are the direct link between the Government of Canada's BIGS programs and target beneficiaries, including for-profit enterprises, not-for-profit enterprises, and post-secondary institutions. In the initial PIF data collection exercise conducted in the Fall 2018, the CPIAU asked BIGS departments to provide descriptive information on program streams as well as other more detailed information around target recipients and intermediaries. This information is valuable as it helps the CPIAU build a better understanding of the federal support ecosystem to businesses.

Considering the administrative burden placed on departments in providing this information, the CPIAU sought to look for other ways to gather this information through data experimentation. Much of the program stream information the CPIAU is interested in is available through publicly available data sources[45] such as news releases and backgrounders from Canada.ca. The CPIAU undertook an experimental pilot project and designed an artificial intelligence (AI) process to extract and process text from news release items, analyze the text using an algorithm and then extract relevant information. Figure 26 provides a more detailed overview of the data extraction process.

Figure 26: Artificial Intelligence Data Extraction Process



[45] Other publicly available data sources include proactive disclosure data available through the open government portal and departmental plans.

This data experimentation pilot successfully demonstrated how to create a structured dataset from unstructured information, which would create multiple benefits for the CPIAU[46]. The CPIAU continues to experiment with different AI techniques and examine the potential integration of other information sources such as department's Program Information Profiles, open.canada.ca, and publications.gc.ca to improve this new dataset. The AI techniques applied in this exercise could also be used in future CPIAU work to create a classification system on program indicators and themes.

Integrating Skills, Diversity, and Innovation Metrics

BIGS program administrative data linked to the LFE provides an opportunity to report on firm descriptive indicators such as firm age, size, and location. Up to this point, little information on the characteristics of people within firms has been used in the BIGS program performance measurement and evaluation activities. Filling this data gap would allow for improved measurement of internal business capabilities that may influence business innovation outcomes such as the business experience and expertise of owners or the technical know-how and labour market experience of workers within a firm. Data on personal characteristics of firm owners and workers can also be valuable as it offers the opportunity for BIGS programs to undertake Gender Based Plus Analysis.

CPIAU partnered with Statistics Canada to develop a first-of-its-kind Diversity and Skills Database (DSD), a comprehensive set of firm-level diversity and skills variables characterizing business owners and their workforce. This was made possible through the linkages of various tax return[47] sources within the Canadian Employer-Employee Dynamics Database (CEEDD). With respect to business ownership, variables indicating owner gender, age, immigrant status, previous labour market experience and previous business experience are included in the DSD. Characteristics of a firm's workforce including their percentage of female versus male workers, percentage of immigrant workers, including how recent the immigrants are to Canada, age percentages, and percentage of workers with previous labour market experience are also contained in the DSD.

In addition to the creation of this database, Statistics Canada also created a methodological report and data dictionary. In FY 2021-22, it will produce an analytical study containing descriptive statistical tabulations using the diversity and skills characteristics in the DSD comparing BIGS program beneficiaries to non-BIGS beneficiaries. The DSD will also be transferred to the LFE so that BIGS departments and academic researchers can use these data for their own analytical activities.

Although it is possible to assess BIGS program performance with respect to firm-level outcomes such as revenue and employment growth using the LFE, it is currently not possible to assess other indicators that illustrate the production of innovation such as intellectual property (IP) rights. IP rights ensure that innovators are protected when they create something new to improve existing products, processes, and services. Some examples of IP rights are patents, trademarks and industrial design. The Canadian Intellectual Property Office (CIPO), a special operating agency of ISED, delivers IP services in Canada and receives applications for IP in the form of patents,

[46] The dataset would address existing data gaps around program streams, be used as a reference point for the CPIAU to help identify in-scope BIGS programs, update the BIGS program inventory, follow the evolution of program streams over time, and validate and enrich collected administrative data.

[47] These sources include the Business Owner Module (BOM), the Workplace Module (WM) and the National Accounts Longitudinal Microdata File (NALMF), T1 personal Master File (T1PMF), T1 Financial Declaration (T1FD) and Sch50, T4.

trademarks, and industrial design from Canadian firms. It also maintains statistics on these IP rights and the firms that file them which can include firms from other countries. Additional information can be found in Figure 27.

Figure 27: Common IP Rights

IP Right	Description	Statistics[48]
Patent	Firms can file patents with CIPO which provide a time-limited, legally protected, and exclusive right to make, use and sell and an invention.	In 2018, patent filings at CIPO totaled 36,162 applications, of which 4,348 (12%) were from Canadian firms.
Trademark	Trademarks protect the words, sounds, designs or combination of these which businesses use to distinguish their goods and services amongst consumers.	In 2018, CIPO received 63,059 trademark applications, of which 27,321 (43%) were from Canadian residents.
Industrial Design	Industrial design protects the appearance of a product. Visual features of shape, configuration and pattern can provide IP holders a competitive edge in the marketplace.	In 2018, CIPO received 6,568 applications, of which 760 (12%) were from Canadians.

CPIAU, Statistics Canada and CIPO discussed the feasibility of linking these statistics on these IP rights into the LFE so that BIGS programs can analyze the relationship between their programs' activities and firm's registration of IP rights. As a result of this discussion, patent data from CIPO will be linked to the LFE later in the 2021-22 Fiscal Year. CPIAU intends to continue discussions with Statistics Canada and CIPO regarding integrating trademark and industrial design indicators into the LFE.

Section 3.3: Data Applications in BIGS Departments

Assessing the Impact of Business Innovation and Growth Support on Employment and Revenue of Manufacturing Enterprises, 1 to 3 After Receipt of Support

Statistics Canada undertook and published a horizontal study, *The Impact of Business Innovation and Growth Support on Employment and Revenue of Manufacturing Enterprises, 1 to 3 Years After Receipt of Support*, to better understanding the impact of all BIGS programs streams that provided support to manufacturing firms between 2007 and 2017. Few studies have examined the impact of support on manufacturing businesses despite the important role the sector has in an innovative economy. Manufacturing firms are primarily engaged in the chemical, mechanical or physical transformation of materials or substances into new products[49]. In 2017, the manufacturing sector accounted for almost

[48] Statistics come from the *IP Canada Report 2019*

[49] Statistics Canada. (2018). North American Industry Classification System (NAICS) Canada 2017 Version 3.0. Statistics Canada Catalog no. 12-501-X. Ottawa: Statistics Canada.

one-quarter (24.4%) of all enterprises receiving BIGS support and received almost one-third (32.1%) of the total value of support[50].

The study specifically examines whether the employment and revenue of BIGS program beneficiaries in the manufacturing sector improved after receiving program support. Using a propensity score matching methodological approach, the findings suggest that enterprises that received federal support for growth and innovation experienced stronger employment and revenue growth relative to non-beneficiary enterprises. Over the three years following receipt of support, employment growth for beneficiary enterprises averaged 1.8 percent per year for the three years following receipt of support while, on average, enterprises that did not receive support experienced employment declines. Over the same period, the average annual revenue growth of beneficiary enterprises was higher than that of non-beneficiary enterprises by 4.6 percentage points.

Using BIGS Indicators in Departmental Results Reporting

BIGS programs must submit Departmental Plans (DPs) to Parliament that describe departmental priorities, strategic outcomes, programs, expected results and associated resource requirements, covering a three-year period beginning with the year indicated in the title of the report. Departmental Results Reports (DRRs) are department and agency accounts of actual performance for the most recently completed fiscal year against the plans, priorities and expected results set out in respective DPs and are also submitted to Parliament.

In its 2020-21 DP, ISED nested two performance indicators around revenue and R&D growth of

ISED-supported firms for 2016-2018 that are reported using BIGS data linked to the LFE under two departmental results. Additional details are provided in Figure 28. While the specific data was not reported in ISED's 2020-21 DP, a data strategy is being developed to track the indicators with a target to be set in ISED's next DP.

Figure 28: ISED's 2020-21 Departmental Plan

Departmental Result	Performance Indicator
Canadian businesses invest more in R&D	Value of Business Expenditure in R&D by firms receiving ISED program funding
Canadian companies are globally competitive and achieve high growth	Revenue growth rate of firms supported by ISED programs

ISED intends to use BIGS data showing the value of R&D and revenue growth in its 2020-21 DRR. BIGS data could be applied in other DP/DRR exercises to showcase previous years support for BIGS supported firms and how it maps back to departmental results. The one caveat is BIGS program recipient size needs to be large enough as otherwise STC may be unable to release data to the public so that the privacy of the firms involved is protected.

[50] Statistics Canada. (2020). Table 33-10-0221-01. Enterprises (ultimate beneficiary) with business innovation and growth support by industry and year. https://www150.statcan.gc.ca/t1/tbl1/fr/tv.action?pid=3310022101

Identifying Historical Trends and Funding Gaps within Innovation Canada

ISED's Innovation Canada (ICS) provides a wide range of programs and services designed to help firms innovate, create jobs, and grow the Canadian economy. To better understand program overlaps, gaps and opportunities for improvement for government support for ICS programs as well, its Data and Performance Directorate started an analytical study examining the characteristics of firms receiving government support. To undertake this analysis, ICS commissioned a series of tables from Statistics Canada that look at the number of ultimate beneficiary enterprises that received BIGS program stream interventions from 2013-2018 as well as the value of support received. These tables are similar to much of the data reported in Section 2. The main research questions of the study are:

- To examine the similarities (e.g. region, sector, size, revenue and funding value) amongst firms being supported by ICS and BIGS programs and the likelihood of government providing funding to firms with these criteria; and,
- To study if there are any sectors or firms of specific sizes that have historically been provided less or more program funding or services from ICS and BIGS programs.

Identifying if there are specific types of firms and sectors that have historically not received funding or services will help Innovation Canada determine if there are opportunities to spark innovation through providing resources to previously underserved firms. Results of the study are expected in the 2021-22 Fiscal Year and will be included as part of a larger Innovation Canada research report. In addition, ISED will also explore the user journey of government supported firms and how they receive support from different government programs over time. This would provide useful information for assessing the needs of a company and proposing tailored referral services through ICS's Accelerated Growth Service, an ICS program that helps growth-oriented Canadian businesses expand by helping them access the key government services they need to grow including financing, exporting, and business advice.

Assessment of the Economic Impact of the Western Innovation Initiative

To better understand the impact of Western Diversification (WD)'s Western Innovation Initiative (WINN) over time, Statistics Canada carried out a research study examining the impact of WINN on firms performance using program administrative data linked to the LFE for the years 2013 to 2019. WINN was a five-year federal initiative that offered repayable contributions for small and medium-sized enterprises (SMEs) with operations in Western Canada, to help move their new and innovative technologies from the later stages of research and development to the marketplace.

Using a propensity score analysis and difference in difference methodologies this study found that the WINN program has positive effects on some financial variables for enterprises that receive funding in both the short and medium-term. Dependant on the study year, the WINN program had short-term effects on revenue, as well as the growth rates of salaries and wages and debt ratio. In the medium-term, evidence suggests there are positive effects on sales of goods and services and the growth rate of revenue.

Undertaking longitudinal analysis is a new area of inquiry made possible through using BIGS data. The conclusions of this study were included as part of a larger longitudinal study written at WD that will be provided to WD's Performance Measurement and Evaluation Committee for approval in FY 2021-22 and will be subsequently published online.

Assessing the Impact of the Atlantic Canada Opportunity Agency's Financial Support Programs on Small and Medium Sized Businesses

ACOA commissioned a research project with Statistics Canada, using the BIGS dataset, to assess the impact of ACOA's financial support programs to SMEs in the Atlantic provinces on businesses' revenues, employment, productivity, salaries, and wages covering the 2007-2018 period. The report found that support to business had a positive and statistically significant impact on business performance of SMEs in the Atlantic Provinces.

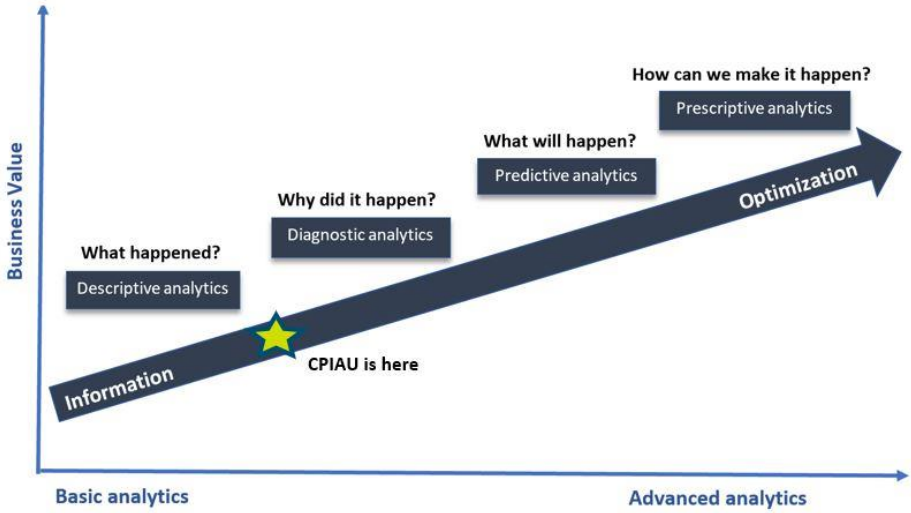
Customized Statistical Tables for the Industrial Research Assistance Program

In March 2021, the National Research Council received statistical tables from Statistics Canada presenting data from 2009 to 2017 on firms receiving financial and advisory services interventions from the Industrial Research Assistance Program and those not receiving these interventions (to be used as a control group). Many of these statistical tables present descriptive information such as the age and size of firms as well as examine employment and revenue growth similar to section 2. Other tables provide more detailed information specific to IRAP supported firms in key R&D sectors such as aerospace, life sciences and energy.

Given the volume of the data received, IRAP is in the process of determining what methodologies to use for measurement and analysis purposes. The data will be used to further explore the impact that IRAP has on SMEs growth. One area for future exploration is to analyze the degree to which IRAP supported firms receive funds from both public and private sources.

What's Next

The figure presented below is an organizational maturity model[51] showcasing the various stages of data maturity. At this time, BIGS data supports questions such as "what happened" and "why did it happen" to Canadian enterprises receiving BIGS program interventions. In the 2021-22 FY, Academics across Canada as well as economists and data scientists within the Federal Government will complete impact assessment studies to better understand the impact of BIGS programs on enterprise-level outcomes of Canadian businesses. These results will be presented in next year's report and will help move our analytical capacity along the analytics maturity model continuum.



The CPIAU will also continue its data development and experimentation pilot activities. There remains great potential to derive and integrate other sources of data, particularly data held in unstructured formats, to fuel new insights into both BIGS policy and program performance. The analytical study containing descriptive statistical tabulations on skills and diversity metrics of BIGS enterprise owners and workers will also be completed next year. These metrics will be transferred to the LFE so BIGS departments and academic researchers can use them in their research and analysis activities.

Finally, it is evident the BIGS data asset is being used in many functions across the Government of Canada's BIGS program community. The CPIAU is proposing to create a strategic research network to better promote research collaboration across the community and to inform the CPIAU's research agenda. A key focus of this group early on will be to establish central research questions that the entire BIGS program community focuses on exploring together. This group will help coordinate departmental research agendas which will help reduce duplication and share best practices to ensure the most rigorous methodologies are applied consistently across the government.

[51] This analytics ascendancy model has been derived from Gartner (March 2012)

Annex 1 – BIGS Inclusion Criteria

INNOVATIVE ACTIVITES OF ENTERPRISES		
Activity Definition	**Eligible Activities**	**Ineligible Activities**
Product (good or service) innovation.	Significant improvements to product's characteristics or specifications such as new functions, quality, durability, efficiency, convenience, user-friendliness or design features.	Minor aesthetic changes such as changes in a product's colour or minor change in shape or minor software updates (e.g., bug fixes, etc.). Routine including seasonal changes or updates such as in clothing fashions, foods, beverages or ornamentation. Resale of new goods purchased from other businesses.
Production of goods or services (activities that transform inputs into goods or services)	Research and experimental development (R&D) (e.g., basic research, applied research and experimental development of R&D carried out or paid for by a firm). Engineering, design and other creative work (i.e., engineering and related testing, design and other creative work, analysis and certification activities to support production, except if minor changes).	Routine engineering processes such as day-to-day production or quality control for existing processes. Simple capital replacement or extension such as purchasing of identical or nearly identical replacement or repairs (See Business Growth Activities for more information).
Distribution and logistics (transportation and service delivery, warehousing, order processing).	Implementation of new processes and technologies to improve distribution and logistics functions, for example using integrated Internet of Things (IoT) systems where devices and objects have networking capabilities to exchange information on equipment maintenance, warehouse stock-levels, new orders and returns or exchanges.	Simple capital replacement or extension such as purchasing of identical or nearly identical replacements or repairs. (See Business Growth Activities for more information).
Marketing and sales (marketing and advertising activities, pricing strategies and methods, sales and after sales activities).	Innovative products' marketing activities such as preliminary market research, market testing, launch advertising,	Routine marketing and advertising processes such as seasonal sales campaigns and market research for new sites,

	development of pricing mechanisms, product placement methods and after-sales support strategies. Innovative business processes' marketing activities such as promoting environmental benefits, improved product quality and business practices (e.g., workforce inclusivity, regulatory compliance, ethical production, etc.). Marketing and brand promotion for existing products where the marketing practice is new for the product.	locations or demographics for existing products.
Information and communication systems (provision and maintenance of hardware and software, data processing and databases, web-hosting).	New or improved information communication systems activities such as business intelligence or cloud-based computing systems, big-data analytics, encryption or advanced authentication systems, blockchain technology, etc.	Routine changes or updates such as software updates or debugging.
Administration and management (strategic and business management, corporate governance, accounting, financial and insurance activities, procurement, human resource management, supply chain management).	Employee training in the use or implementation of new or improved products or business processes, new software logistical systems, new equipment, or new or improved features or benefits. Intellectual property (IP) (ex. application of IP rights, licensing-in or licensing-out IP rights).	Employee training for general skills upgrading, on existing products or business processes or language training. (See Business Growth Activities for more information.)
Product and business process development (activities to scope, identify, develop or adapt products or a firm's business processes).	Product and business processes activities include production trials to optimize efficiency of new processes; creating of prototypes for temporary commercial or regulatory needs; and planning and designing procedures, technical specifications for new or improved products or business processes.	Standard or routine product and business process updates.

GROWTH ACTIVITES OF ENTERPRISES		
Activity Definition	**Eligible Activities**	**Ineligible Activities**
Follow-on activities (marketing, training, after-sales services, etc.) for post-implementation of new or improved products or business processes.	Follow-on marketing activities that promote new or improved products' (or business processes) sales such as customized advertising campaigns, exhibiting at trade fairs, participating in international trade junkets and other market exploration activities, or adopting new distribution channels. Follow-on training activities to promote user adoption which can include in-house training of employees, users' demonstrations or onsite training or posting of user self-learning resources and guides. After-sales services that improve the utility of the new or improved products (or business processes) for users such as installation and setup, updating and maintenance services, warranty and return schemes and user assistance and communication services.	Routine updates to business tools such as websites and product catalogues.
Physical capital investment expected to increase production and lead to growth (revenues or employment).	Purchases of additional and identical or nearly identical machinery and equipment.	Repairs of machinery and equipment. In exceptional circumstances such as unstable supply chains or disaster recovery, repairs to machinery and equipment may be considered eligible under business growth.
Participation in market expansion activities including global market development activities intended to increase growth in exports and revenues.	Sponsorship of participation in interprovincial or international trade missions and other market expansion and development activities.	
Investment in human capital including employee skills upgrading, language	Employee training for general skills upgrading, on existing products or business	In cases of short supply in the domestic labour market, human capital attraction activities such

training, entrepreneurship and other human resource attraction, development and retention activities expected to increase workforce effectiveness.	processes or language training. Participation in job-training programs (new Canadians), student placements, workforce interchanges (within and outside the country), entrepreneurship development and other human capital capacity building activities that target specific populations such as women, Indigenous peoples, visible minorities and the LGBTQ2 communities.	as acquisition of foreign workers may be eligible under business growth.

ECO-SYSTEM OR COMMUNITY ACTIVITIES FOR BUSINESS INNOVATION AND GROWTH		
Activity Definition	**Eligible Activities**	**Ineligible Activities**
New or improved place-based infrastructure investments that improve the quality of life for workers or that attract new businesses to the community.	Sponsoring the development of new or significantly improving existing place-based infrastructure that enhances the appeal of the community for new business investment or local business expansion.	Routine or regular maintenance of physical infrastructure generally undertaken by municipal, regional or provincial governments such as repaving streets, fixing potholes, inspecting community facilities, replacing park equipment or building schools.
Community-based programs or networks that encourage or accelerate commercialization of new knowledge (intellectual property) and business development.	Participation in business accelerators, incubators, science parks and other non-profit community-based business accelerators, incubators, science parks and networks intended to promote commercialization of intellectual property and support business growth (start-ups, spin-offs, etc.).	Private venture capital solely operated business accelerators, incubators or other ventures.

Annex 2 – LFE Data Sources and Terms of Access

LFE Data Sources (Administrative Data)

- Business Register (BR)—2000-2018 (SDDS1105)
- Longitudinal Employment Analysis Program (LEAP) - 2000-2015 (SDDS 8013)
- General Index of Financial Information (GIFI - T1) Unincorporated Businesses -2005-2018
- General Index of Financial Information (GIFI -T2) Incorporated Businesses - 2000-2018
- Statement of Remuneration Paid (T4)– 2000-2017
- Payroll Deductions Account (PD7) - 2001- 2018
- Exporter Register – 2010- 2018 (SDDS 2201)
- Importer Register – 2012, 2015 - 2018 (SDDS 2201)
- Patents (Canadian Intellectual Property office) – 2001- 2006
- United States Patent Office (USPTO) Canadian Enterprises only - 2000- 2011
- BIGS (Business Innovation and Growth Support) database - 2007-2017
- Schedule 32 – 2000 – 2017

LFE Data Sources (Survey Data)

- Annual Survey of Research and Development in Canadian Industry (RDCI) - 2000-2017 (SDDS 4201)
- Canadian Direct Investment Abroad (CDIA) 2000-2013 (SDDS 1537)
- Foreign Direct Investment in Canada (FDIC) - 2000-2013 (SDDS 1537)
- Trade in Commercial Services (TICS) 2000-2014 (SDDS 1536)
- Survey of Innovation and Business Strategy (SIBS) 2009, 2012, 2017 (SDDS 5171)
- Surveys of Innovation (INNO) 2003, 2005, (SDDS 4218)
- Survey of Electronic Commerce Technology (SECT) 2000-2007 (SDDS 4432)
- Survey of Advanced Technology (SAT) 2007, 2014 (SDDS 4223)
- Survey of Commercialization of Innovation (COI) - 2007 (SDDS 5140)
- Survey on Financing and Growth of Small and Medium Enterprises (SFSME) – 2004, 2007, 2011, 2014, 2017 (SDDS 2941)
- Survey of Intellectual Property Management (SIPM) - 2010 (SDDS 5183)
- Survey of Digital Technology and Internet Use (SDTIU), 2012, 2013 (SDDS 4225)
- Census of Agriculture – 2016
- Survey of Regulatory Compliance Costs (RCC) – 2011 (SDDS 5093)

LFE Data Sources (Upcoming)

- Survey on Cybersecurity
- Canadian Defence, Aerospace and Marine Industries Survey, 2016
- Survey of innovation and Business Strategy (SIBS), 2019
- Survey of Digital Technology Internet Use (SDTIU), 2019
- Survey of Regulatory Compliance Costs (RCC), 2016
- Intellectual Property Awareness and Usage Survey (IPAUS), 2019

Terms of Access to LFE Data

Terms of Access to the BIGS Research Database at Enterprise Level Linked to LFE:

The data for this program is acquired under section 13 of the Statistics Act, while their confidentiality is protected under subsection 17 (2) of the Act. All micro data access at Statistics Canada require a valid 'deemed employee status' under subsection 17 (1).

Direct Access to the BIGS Research Database at Enterprise Level (2007-2017):

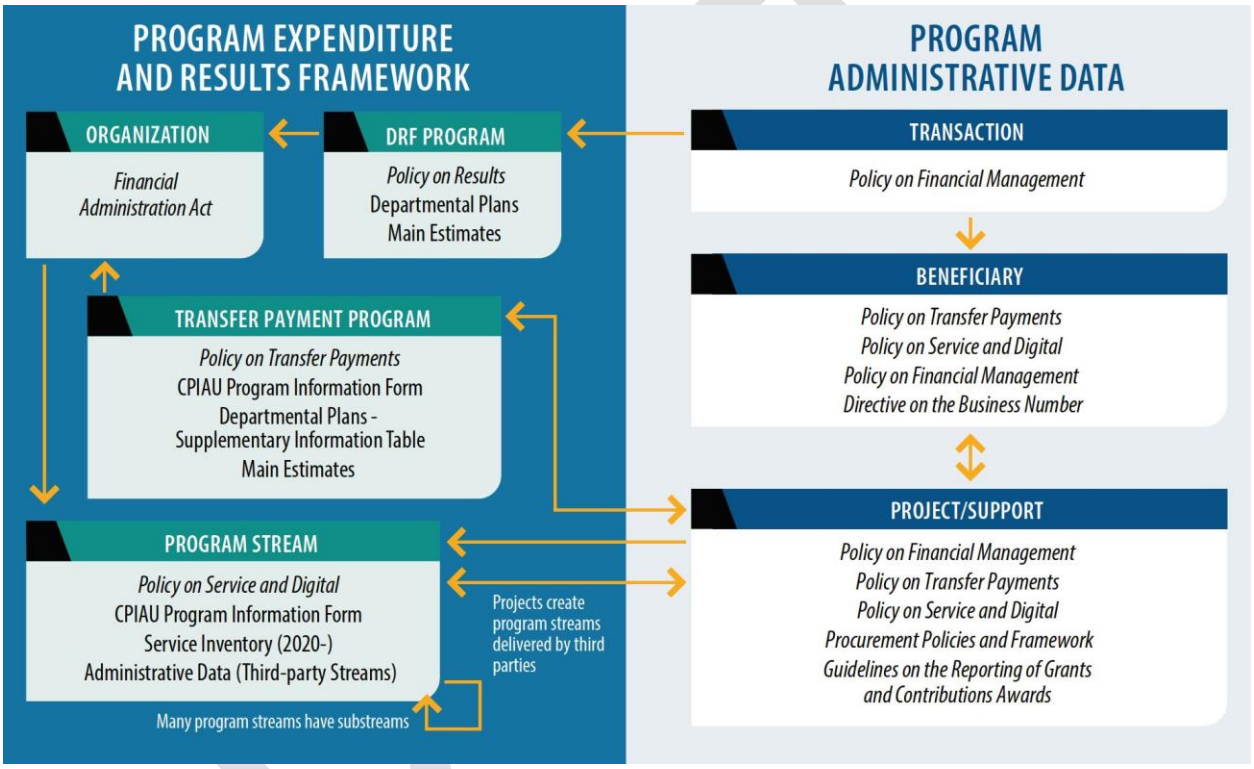
- For the benefit of third-party researchers, STC will provide notice of the annual data collection processes, and availability of microdata on its website as an annual collection activity, and as a data source in the LFE
- The BIGS research database linked to LFE is available:
    - at the Business Data Access Centre (BDAC) for research purposes (Econometric analysis only).
    - at the Centre for Special Business Projects (CSBP) if the purpose of the work is the production of a descriptive report (Tabulations; Graphs). CSBP offers a collaborative mode of access where the tables are produced by CSBP staff following the researcher's specifications and the researcher produces a report on site at CSBP.
- Researchers wishing to access data must submit a formal research proposal and be able to cover all project costs.

The Statistical Information Stored in the BIGS Operational Database is not Linked to LFE.

- The information in the BIGS operational database is not available to external researchers, because of STC confidentiality concerns. It is accessible only by CSBP employees and deemed employees for validation purposes.
- When feasible, special aggregated tabulations based on the BIGS operational database could be extracted by CSBP on demand, and Statistics Canada will inform and coordinate with the CPIAU (cost recovery services)
- Statistics Canada will review all outputs at their completion to ensure that the results are in line with the project scope and that data confidentiality is maintained

Annex 3 – BIGS Data Model

To decipher and electronically capture the complexity of the program universe, the CPIAU developed a data model that describes BIGS program data as it relates to the policy suite and government activities involved in delivering and monitoring programs. This data model served as a first attempt to map the multi-directional pathways between expenditure entities and actual entities receiving support, whether financial or otherwise, to eventually trace the flow of support to and from beneficiaries, enabling the capture and analysis of firm-level outcomes. The data model dovetails with the current policy suite and attempts to lay the building blocks to uncover further data granularity, as is required to perform impact assessment as prescribed by Budget 2018.



Annex 4 – BIGS Program Stream Inventory

Department	BIGS Program Stream — Sub-Program Stream (if applicable)
Agriculture and Agri-Food Canada	Agricultural Greenhouse Gases Program AgriScience Program AgriInnovate Program Agricultural Clean Technology Program AgriMarketing Program: Small and Medium-sized Entreprise Component AgriProcessing Initiative AgriInnovation Program - Stream B: Commercialization AgriInnovation Program - Stream C: Enabling Commercialization
Atlantic Canada Opportunities Agency	Atlantic Innovation Fund Business Development Program Community Futures Program Regional Growth Through Innovation - Business Scale-up and Productivity Regional Growth Through Innovation - Regional Innovation Ecosystems Canada Coal Transition Initiative Women Entrepreneurship Fund Women Entrepreneurship Strategy - Ecosystem Fund
Canada Economic Development for Quebec Regions	New Business Development and Start-Ups Innovation and Technology Transfer Commercialization and Exports Innovative and Inclusive Economic Ecosystems Community Futures Program Productivity, Digitalization and Expnasion Network Structuring Regional Growth Through Innovation, Business Scale-up and Productivity – Innovation and Technology Transfer Regional Growth Through Innovation, Business Scale-up and Productivity – Regional Innovation Ecosystem Women Entrepreneurship Fund Women Entrepreneurship Strategy - Ecosystem Fund
Canada Institutes of Health Research	eHealth Innovations Partnership Program Industry-Partnered Collaborative Research
Canadian Heritage	Support for Publishers – Publishing Support Support for Publishers – Business Development Support Business Innovation Music Entrepreneur Component – Aid to Canadian Sound Recording Firms Music Entrepreneur Component – Aid to Canadian Music Publishing Firms

	Music Entrepreneur Component – Aid to National Service Organizations New Musical Works Experimental Stream
Canadian Northern Economic Development Agency	Entrepreneurship and Business Development Strategic Investments in Northern Economic Development Regional Growth Through Innovation - Business Scale-up and Productivity Regional Growth Through Innovation - Regional Innovation Ecosystems Women Entrepreneurship Fund Women Entrepreneurship Strategy - Ecosystem Fund
Canadian Space Agency	Earth Observation Application Development Program Space Technology Development Program
Department of National Defence	Innovation for Defence, Excellence and Security Defence Innovation Research Program
Environment and Climate Change Canada	Science Horizons Youth Internship Program Low Carbon Economy Challenge – Champions Stream Low Carbon Economy Challenge – Partnerships Stream
Employment and Social Development Canada	*Temporary Foreign Worker Program – Global Talent Stream
Federal Economic Development Agency for Southern Ontario	Advanced Manufacturing Fund – For Profit Organization Advanced Manufacturing Fund – Not-For-Profit Organization Eastern Ontario Development Program – Business Development and Community Innovation Eastern Ontario Development Program – Collaborative Economic Development Investing in Business Growth and Productivity – Small and Medium Sized Enterprise Investing in Business Growth and Productivity – Not-For-Profit Organization Investing in Business Innovation – Early-Stage Companies Investing in Business Innovation – Angel Investor Networks Investing in Business Innovation – Not-For-Profit Organization Investing in Regional Diversification Investing in Commercialization Partnerships – Not-For-Profit Organization Investing in Commercialization Partnerships – Post-Secondary Institution Community Futures Program Regional Growth Through Innovation - Business Scale-up and Productivity Regional Growth Through Innovation - Regional Innovation Ecosystems Community Economic Development and Diversification
Department of Fisheries and Oceans	British Columbia Salmon Restoration and Innovation Fund Aquaculture Collaborative Research and Development Program

	Fisheries and Aquaculture Clean Technology Adoption Program Atlantic Fisheries Fund – Canadian Fish and Seafood and Opportunities Fund
Global Affairs Canada	Trade Commissioner Service CanExport Canadian Technology Accelerators Going Global Innovation Canadian International Innovation Program
Innovation, Science and Economic Development Canada	Accelerated Growth Service Automotive Innovation Fund Automotive Supplier Innovation Fund Canada Business Network Canada Small Business Financing Program CANARIE Inc. – Digital Accelerator for Innovation Research Centre for Drug Research and Development Clean Growth Hub FedNor Community Futures Program FedNor Regional Growth Through Innovation - Business Scale-up and Productivity FedNor Regional Growth Through Innovation - Regional Innovation Ecosystems FedNor Regional Growth Through Innovation - Targeted Manufacturing Initiative for Northern Ontario FedNor Women Entrepreneurship Fund FedNor Women Entrepreneurship Strategy - Ecosystem Fund Futurpreneur Canada Genome Canada – Translation Mitacs Inc. – Accelerate Mitacs Inc. – Globalink Mitacs Inc. – Elevate Stem Cell Network – Clinical Trials Research Agreement Stem Cell Network – Disease Team Research Agreement Stem Cell Network – Impact Research Agreement -Clinical Accelerators Stem Cell Network – Impact Research Agreement -Clinical Translation Stem Cell Network – Impact Research Agreement Commercialization Stem Cell Network – Impact Research Agreement -Public Policy Stem Cell Network – Impact Research Agreement -Translational Strategic Aerospace and Defence Initiative Strategic Innovation Fund – Stream 1: Research and Development and Commercialization Strategic Innovation Fund – Stream 2: Firm Expansion and Growth Strategic Innovation Fund – Stream 3: Investment Attraction and Reinvestment

	Strategic Innovation Fund – Stream 4: Collaborative technology development and demonstration Strategic Innovation Fund – Stream 5: National Ecosystems Strategic Innovation Fund – Steel and Aluminum Sustainable Development Technology Canada – Sustainable Development Tech Fund Sustainable Development Technology Canada – NextGen Biofuels Fund Technology Demonstration Program Northern Ontario Development Program – Business Growth and Competitiveness Northern Ontario Development Program – Innovation Northern Ontario Development Program – Targeted Manufacturing Initiative for Northern Ontario Northern Ontario Development Program –Youth Internships Northern Ontario Development Program –Community Economic Development Priority Northern Ontario Development Program—Community Investment Initiative for Northern Ontario Economic Development Initiative Innovation Superclusters Initiative Communications Research Centre Canada Technology Partnerships Canada
National Research Council of Canada	Aerospace Aquatic and Crop Resource Development Automotive and Surface Transportation Canada Accelerator and Incubator Collaborative Science, Technology and Innovation Program Construction Energy, Mining and Environment Human Health Therapeutics Industrial Research Assistance Program – Contributions to Firms Industrial Research Assistance Program –Contributions to Organizations Industrial Research Assistance Program – EUREKA Industrial Research Assistance Program – Youth Employment Program Industrial Research Assistance Program – Youth Employment Program Green Information and Communication Technologies – Digital Technologies Information and Communication Technologies – Advanced Electronics and Photonics Medical Devices Ocean, Coastal, and River Engineering
Natural Resources Canada	Mining Innovation GeoConnections Program

	Clean Energy for Rural and Remote Communities Program – Demonstration Clean Energy for Rural and Remote Communities Program – Deployment Clean Energy for Rural and Remote Communities Program – Bioheat Clean Growth in the Natural Resource Sectors Innovation Program Green Jobs - Science and Technology Internship Program Clean Technology Challenges Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative Forest Innovation Program Investments in Forest Industry Transformation Energy Innovation Program Smart Grid Infrastructure Demonstrations Program Buildings Infrastructure Program Oil and Gas Clean Tech Program Oil Spill Response Science Program Program of Energy, Research & Development Pan North American Renewable Electricity Integration Studies Emerging Renewables Power Program Smart Grid Deployment Program ecoENERGY for Renewable Power Energy Efficiency Program Electric Vehicle Infrastructure Demonstration Program
Natural Sciences and Engineering Research Council	Applied Research and Development Grants Business-Led Networks of Centres of Excellence Centres of Excellence for Commercialization and Research Collaborative Research and Development Grants College-University Idea to Innovation Grants Connect Grants Engage Grants Experience Awards Industrial Research Chairs Innovation Enhancement Grants Strategic Partnership Grants for Networks Strategic Partnership Grants for Projects Technology Access Centres Grants University Idea to Innovation Grants
Public Services and Procurement Canada	Build in Canada Innovation Program
Western Economic Diversification Canada	Canadian Coal Transition Initiative Community Futures Program Regional Growth Through Innovation - Business Scale-up and Productivity Regional Growth Through Innovation - Regional Innovation Ecosystems

	Western Diversification Program Western Innovation Initiative Women Entrepreneurship Fund Women Entrepreneurship Strategy - Ecosystem Fund Women's Entreprise Initiative

Annex 5 – Impact Assessment in International BIGS Programs Literature Review Summary

The CPIAU undertook a literature review to better understand if enterprises receiving support from similar programs in other countries[52] achieve better results than those that do not. The review also examined if there are common econometric methods, data sources and firm-level indicators used in the assessment of enterprise performance. Given the wide variety of direct program interventions designed to stimulate innovation, the scope of the review focused on programs providing direct financial support for research and development (R&D); general advisory services and export promotion advisory services; and support for networks and collaboration. These program intervention themes are similar to the four flagship innovation program platforms[53] announced in Budget 2018 following the completion of the Horizontal Innovation Review.

Similar methods and data sources are commonly used in the quantitative assessment of similar programs in other countries. The econometric method most commonly employed is the creation of a counterfactual group using propensity score matching in combination with a difference-in-difference estimator[54]. The most found data source to assess performance is to link program monitoring data to national statistical agencies or to other databases.

The chart on the following page shows that common performance indicators are found when assessing BIGS program performance across all program intervention themes. When a box is colored in teal, this indicates that at least one international program evaluation in the chosen intervention them assessed the performance of firms using that indicator. For example, in the box in the first row and fourth column that contains direct R&D and Exports indicates that at least one direct R&D evaluation examined if enterprises improved its export performance. Other key highlights of this figure illustrate that:

- Across every BIGS program intervention theme there is at least one study that examined the impact of BIGS program on revenue and employment;
- Outside of the networks and collaboration BIGS programs interventions, the other three program intervention themes examined the impact of productivity and exports;
- Survival rates, and value added, the difference between the sales price and the production cost, are other common variables found in advisory services programs, including those that just deliver export promotion services; and,
- Performance indicators in the other category are less commonly found include capital expenditures or variables that can be found in the Oslo Manuel like process/product innovations.

[52] Program evaluations from Australia, Denmark, Finland, Japan, Norway, and the United Kingdom were reviewed.
[53] The four platforms are the National Research Council's Industrial Research Assistance Program, ISED's Strategic Innovation Fund, GAC's Trade Commissioner Services, and the Regional Development Agencies.
[54] The objective of propensity score matching is to compare the compare the performance of BIGS treated firms relative to a benchmark group that closely resemble the characteristics of BIGS treated firm users. The difference-in-differences estimator used in combination with the propensity score matching intends to control for growth differences between treated and non-treated firms that were present before BIGS program support.

Performance Indicators in International BIGS Program Evaluations

	Revenue	Employment	Productivity	Exports	Survival Rates	Value Added	Other*
Direct R&D	■	■	■	■			■
Advisory Services	■	■	■	■	■	■	■
Export Promotion Services	■	■	■	■	■	■	
Networks & Collaboration	■	■					■

In many cases, the program evaluations applied econometric methods and found that enterprises achieved positive results in the above indicators compared to a counterfactual group of enterprises that did not receive program interventions. In some cases, the magnitude and statistical significance of the results were smaller when more robust methodologies were applied such as propensity score matching and difference-in-differences. Some studies found less evidence that the program showed a causal change in enterprise level outcomes. One evaluation segmented the sample to sub-groups of firms and then found that supported firms in specific locations of the country were found to have greater revenue results. Another study noted that while it did not find positive level enterprise results it may be a result of data limitations since the dataset was smaller and it was not linked to a national statistical agency.

Across all program intervention types, the effects of the program on enterprise level outcomes were most pronounced when the firms receiving the program intervention were smaller and younger. Smaller and younger firms can benefit from these types of programs for various reasons. For programs providing direct financial support for R&D, smaller and younger firms are more likely to be financially constrained[55] and less likely to take risks without the benefit of a subsidy to pursue research and development. Advisory service programs can help programs plan for and execute new strategies, and export promotion advisory service programs can help firms overcome entry barriers to foreign markets. Finally, network and advisory service programs help smaller and younger firms learn from more established firms and universities through participating in consortium projects.

Some evidence also examined the policy mix where firms may receive more than one BIGS program intervention. One study found that enterprises that receive direct financial support for R&D and collaborate with universities achieve stronger results in various innovation indicators compared to firms that only receive the financial support for R&D. Another study found that enterprises receiving advisory services support and a R&D tax incentive achieve higher growth rates compared to firms only receiving

[55] Becker, Ibid.

the R&D tax incentive.

The full results of this literature review will be included in the forthcoming CPIAU paper that will examine the impact of BIGS programs on smaller and younger firms through applying econometric techniques in the next fiscal year.

Annex 6 – Previous CPIAU Sponsored Research Studies

Innovation Support Measures, Evaluation Approaches and Application Guidelines and Horizontal Innovation and Clean Technology Review – Assessment and Next Steps in Impact Assessment (Jibril & Roper, 2019) Of these two reports, the first provides guidance on the appropriate impact assessment techniques to apply in consideration of diverse program beneficiary characteristics. Specifically, it identifies when it is possible and appropriate to use a randomized control trial or a quasi-experimental method, and when the only available option is qualitative assessment. Program design features, assessment timing, heterogeneity of beneficiaries, clustering opportunities, and consideration of rare populations are all factors identified in selecting the best assessment method. The report applies this methodology to 23 of the largest programs in the BIGS program suite and recommends one or more methods for assessing each program. Other BIGS programs are then ranked according to relative tenability for impact assessment using quasi-experimental methods. The second report provides a neutral review of the application of a pilot study using propensity score matching to assess BIGS program impacts, including recommendations for future research.

Impact Assessment for Innovation Policy Programs in Canada (De Fuentes, 2019) focuses on BIGS programs supporting clean technologies, global networks, high tech start-ups and university-industry collaboration. The study describes methodologies used by select Government of Canada programs in evaluation reports, identifies econometric models employed to evaluate the impact of innovation policies and identifies the variables frequently used (necessary) for impact assessment studies. The study also identifies the programs and granting offices which have been in operation for at least five years in the BIGS program suite. The study suggests focusing impact assessment efforts on programs which distribute grants since adjudication is competitive and peer reviewed, grants represent the most important type of support in terms of value for firms and finally, the need for data before and after the grant was awarded is necessary to perform dynamic analysis (available for grants). The study identifies eleven innovation programs, as potential impact assessment candidates. Further, the study identifies best practices for impact assessment and the use of counterfactuals including data on “firms that applied for the policy program but were not successful.”

Towards a Unified Framework for Evaluating Government Programs (Plesca, 2019) and Evaluating the Federal Government Support for Innovation and Clean Technology (Plesca, 2019) are two separate reports, the former begins with a literature review that describes the relationship between productivity and individual skills, training and education, and the role of government in building human capital. It then discusses the assessment methods that can be used to measure the effects of government programs that aim to improve human capital and highlights the need for high-quality data to enable the use of more advanced assessment methods. The latter report provides a detailed description of the suite of program streams included in the Horizontal Innovation Review, including ways that they may be grouped. It discusses methodologies for measuring the various outcomes that these programs aim to achieve, and how to evaluate a program’s effects on both its beneficiary enterprises and the workers associated with those enterprises.

An application of machine learning to identify nascent high-growth firms (Macdonald and Houle, 2020) the CPIAU partnered with Statistics Canada’s Economic Analysis Division to experiment with supervised machine learning to predict high growth firm populations. This study sought to answer the question: can

machine learning and tax filing data be useful in predicting high growth firms[56] and found that for employment, the best performing machine learning model was the neural net, with overall accuracy for predicting both high-growth and non-high growth firms of 71%. For revenue, the study found that the best performing machine learning model was a randomized forest, with overall accuracy for predicting both high-growth and non-high growth firms of 70%.

[56] High growth firms have: an average annual compound growth rate of at least 20% between 2012 and 2015; at least 10 employees in 2015; growth is considered in terms of employment and revenue