Estimating the Aggregate Net Present Value of Business Innovation and Growth Support (BIGS) Programs: A Feasibility Study

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Delivering insight through data for a better Canada

Presentation Overview

- Who we are
- Objectives of the project
- Data
- Methodology
- Results

Who we are

- The Centre for Special Business Projects (CSBP) and the TBS are working closely together on various growth and innovation support related programs and initiatives which help to provide comprehensive, evidence-informed advice on innovation programming and policy.

- This StatCan-TBS partnership includes the Business Innovation and Growth Support (BIGS) database, which covers government activities that support business innovation and growth.

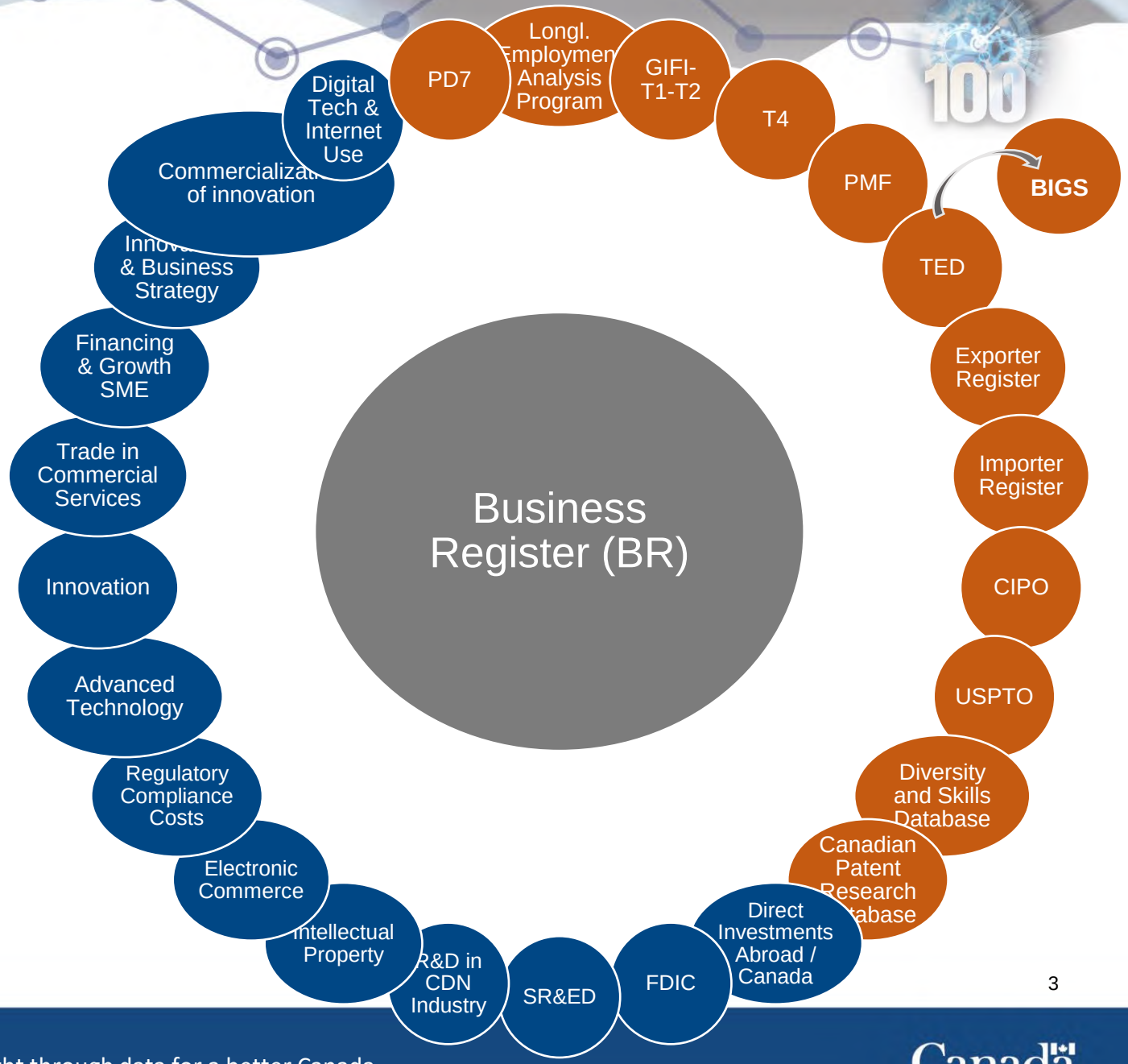
- This statistical program is to contribute to the improvement of performance and impact assessments for growth and innovation-related programs.

- The NPV project was conducted as part of this StatCan-TBS partnership.

Who we are

The Linkable File Environment (LFE)

- Covers all Canadian businesses
- Over 30 linked data sources
- Analytical opportunities
  - Customized tabulations
  - Program impact evaluation
  - Business performance analysis
  - Supply chain analysis



Objectives of the project

1) To conduct a statistical analysis of the business archetypes developed by EY Consulting (formerly named Ernst & Young)

2) To develop a method to estimate the net present value (NPV) of the funding cost to the government and financial value to program users

Main objective of EY (2020) *NPV Impact Modeling for Government Subsidies*:

- To develop a valuation model to estimate the after-tax net present value (NPV) impact of government subsidies to businesses

Data sources

Period under study: Fiscal years going from 2012-2013 to 2019-2020

Microdata used in this analysis:

1. Business Innovation and Growth Support (BIGS)

2. General Index of Financial Information (GIFI), which includes financial statement information used to file the T2 corporation income tax return

3. Linkable File Environment (LFE) microdata files at the enterprise level

Objective 1:

To conduct a statistical analysis of the business archetypes developed by EY

Background on EY's business archetypes

EY (2020) *NPV Impact Modeling for Government Subsidies*

- Three theoretical business archetypes to provide numerical examples of their cost and benefits evaluation models
  - Small manufacturers
  - Large manufacturers
  - Technology start-ups

- Examples of questions stemming from EY's study
  - What type of business is most likely to receive grants?
  - Do SMEs and large enterprises receive the same types of support?

- Do these theoretical archetypes exist in practice?
  - Use of BIGS database and LFE to conduct a statistical analysis to test EY business archetypes

Methodology to test EY's business archetypes

- Principal Component Analysis (PCA)
  - Factor analysis method
  - Reduce the number of variables while minimizing loss of information

- PCA conducted on 136 BIGS program streams available the 2019-2020 fiscal year

- Expected results
  - Factors would group correlated variables for each business archetype

Variables included in the PCA

- **Business size**
  - Small (< 100 employees)
  - Medium (100-499 employees)
  - Large (> 500 employees)
- **Industry (NAICS code)**
- **Type of program support**
  - Advisory services
  - Non-repayable contributions
  - Conditionally repayable contributions
  - Unconditionally repayable
  - Government performed services
  - Grants
  - Targeted procurements
  - Other types of support
- **Technology intensity (OECD classification)**
  - Low tech
  - Mid-low tech
  - Mid tech
  - Mid-high tech
  - High tech
- **Financial performance**
  - Total revenues
  - Total expenses
  - Wages and salaries
  - After-tax net income
- **Capital structure**
  - Total assets
  - Total liabilities
- **Business age**

Tests and statistics performed in the PCA

- Bartlett's test of sphericity
  - Test of correlations among the variables to validate if the PCA can be performed
  - Minimum threshold: p-value < 0.05

- Kaiser-Meyer-Ohlin (KMO) statistic
  - Measure of sampling adequacy of the relationships between variables
  - Minimum threshold: KMO > 0.5

- Cronbach's alpha
  - Coefficient of factors' internal consistency

Results of the PCA

- Bartlett's test of sphericity
  - p-value < 0.05
  - Indicates presence of correlation between variables
- KMO statistic
  - Extremely low (KMO = 0.05) below the minimum threshold of 0.5
  - Further analysis not warranted
- PCA conducted on a single program stream (Industrial Research Assistance Program (IRAP))
  - To reduce heterogeneity
  - Higher KMO (0.33) but also below the minimum threshold of 0.5
- Further research could explore other BIGS program streams, individually or in groups, to test business archetypes with different data structure

Objective 2:

To develop a method to estimate the net present value (NPV) of the funding cost to the government and financial value to program users

Method to estimate the NPV of one BIGS program stream

Over 120 BIGS program streams

- Focus on one program stream: Industrial Research Assistance Program (IRAP)

IRAP (2012-2013 to 2019-2020):

- $1.8 billion
  - Non-repayable contributions[1]
- More than 3,100 recipients each year
- Represents 11% of all BIGS program streams

1. IRAP also provides support in the form of *Advisory services*, for which no value is attributed as these services are not cost-recovered

Methodology: Background

EY (2020) *NPV Impact Modeling for Government Subsidies*

- Models focus on financial aspects at the micro-level
  - Data used at the project and business level

- Opportunity to adapt EY models at the macro-level
  - Leverage BIGS database and LFE
  - Compare value of two groups: recipients and other similar businesses
  - Compare trends on how these two groups evolve through time

Methodology: Benefits to Recipients

Compare value of two groups of businesses

1) Treatment group
   - Recipients of IRAP support in a given reference year

2) Control group
   - Businesses similar to IRAP recipients
   - Have not received support from any BIGS program stream
   - Defined by propensity score matching (PSM) method

Methodology: Benefits to Recipients

Propensity Score Matching (PSM)

- Matching observations in treatment and control groups
- Propensity score represents the probability of assignment to treatment based on a model of observed covariates
- Nearest neighboor (1:1), without replacement
- Logistic regression model for propensity score:

Exact match

- Province of operation
- 2-digit NAICS code
- Canada or foreign
- Non-profit status

Non-exact match

- Legal constitution
- Multi-province
- Multi-sector
- Structural complexity
- Engage in R&D expenses
- Business age

Financial variables, 2-year pre-treatment average

- Revenue (log)
- Expenses (log)
- Assets (log)
- Liabilities (log)
- Net income (log)
- Employment (log)

Methodology: Benefits to Recipients

Compare IRAP recipients and control group through time

- Time window to measure treatment effect
  - Project-specific
  - Assumed to be medium-term
  - IRAP support assumed to have an impact on profitability in year *t+3*
- 3-year window allows to study 5 cohorts between 2012-13 and 2019-20

Cohorts references names and years

	Fiscal year of funding	**Final year**
Reference name	t	t+3
Cohort 2012-13	2012-13	2015-16
Cohort 2013-14	2013-14	2016-17
Cohort 2014-15	2014-15	2017-18
Cohort 2015-16	2015-16	2018-19
Cohort 2016-17	2016-17	2019-20

Note: Alternative time windows of 1-year and 5-year also included in the report

Methodology: Benefits to Recipients

Estimation of net present value of IRAP program effects

$$NPV\_PE = ((NetInc_{IRAP\,t+3} - NetInc_{ctrl_{t+3}}) - (NetInc_{IRAP\,t} - NetInc_{Ctrl_t})) * (1+r)^T$$

NPV_PE	Net present value of estimated IRAP program effects;
$NetInc_{IRAP\,t+3}$	Net income after tax of IRAP recipients in year *t+3*;
$NetInc_{ctrl_{t+3}}$	Net income after tax of control group in year *t+3*;
$NetInc_{IRAP_t}$	Net income after tax of IRAP recipients in the cohort base year;
$NetInc_{ctrl_t}$	Net income after tax of control group in the cohort base year.
r	Discount rate
T	Number of periods

Methodology: Benefits to Recipients

Estimation of net present value of IRAP program effects

Summary, NPV IRAP Program Effects

Group	Fiscal year of funding	Final year	Difference
Treatment	$IRAP_t$	$IRAP_{t+3}$	$IRAP_{t+3} – IRAP_t$
Control	$Ctrl_t$	$Ctrl_{t+3}$	$Ctrl_{t+3} - Ctrl_t$
Difference	$IRAP_t - Ctrl_t$	$IRAP_{t+3} – Ctrl_{t+3}$	Direct program effects

Time differences
(Final year – Funding year)

Group differences
(Treatment – Control)

- If program stream effect > 0, recipient businesses improved profitability **more** than similar non-recipient businesses 3 years after funding
- If program stream effect < 0, recipient businesses improved profitability **less** than similar non-recipient businesses 3 years after funding

Methodology: Benefits to Recipients

Estimation of net present value of benefits to recipients

$$NPV\_Benefit = NPV\_PE + \sum_{t=1}^{T}(Direct\_cost_t - Repayment_t) * (1 + r)^T$$

$NPV\_Benefit$	Net present value of of benefits to recipients;
NPV_PE	Net present value of estimated IRAP program effects;
$Direct\_cost_t$	Value of support provided by IRAP in year t;
$Repayment_t$	Value of repayments made to IRAP in year t.
r	Discount rate
T	Number of periods

Methodology: Cost of Funding

Estimation of net present value of IRAP cost of funding

$$NPV\_Cost = \sum_{t=1}^{T}\left(Direct\_cost_t + Admin\_cost_t - Repayment_t\right) * (1+r)^T$$

NPV_Cost	Net present value of IRAP costs;
$Direct\_cost_t$	Value of support provided by IRAP in year t;
$Admin\_cost_t$	Value of annual administrative costs;
$Repayment_t$	Value of repayments (if applicable) made in year t;
r	Discount rate;
T	Number of periods.

Methodology: Other Parameters

Administrative costs

- Base scenario: 5% of direct costs
- Alternative scenario: 10% of direct costs

Discount rate

- Reflection of risk (project-specific)
- Three scenarios
  1. 2% (10-year GoC bond yield between 2012-13 and 2019-20)
  2. 5% (median)
  3. 8% (suggested by TBS Cost-Benefit Analysis Guide (TBS, 2007))

Results: PSM

- Approximately 50% of recipient businesses are matched
  - Many observations dropped because missing values (especially net income)

- Non-parametric statistical tests to compare samples
  - Before matching: Wilcoxon rank sum test

    34/35 with $p < 0.05$

  - After matching: Wilcoxon signed rank test

    9/35 with $p < 0.05$

Results: Cost of Funding

NPV direct cost, admin cost, and total cost, by fiscal year

Program stream	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	TOTAL
IRAP	Millions of 2019 dollars								
Direct costs	207	240	207	222	244	188	283	334	1,923
Administrative costs (5%)	10	12	10	11	12	9	14	17	96
Total costs	217	252	217	233	256	197	297	351	2,019

NPV direct cost, admin cost, and total cost, by cohort

Program stream	Cohort 2012-13	Cohort 2013-14	Cohort 2014-15	Cohort 2015-16	Cohort 2016-17	TOTAL
IRAP	Millions of 2019 dollars					
Direct costs	89	106	84	86	96	461
Administrative costs (5%)	4	5	4	4	5	23
Total costs	94	111	88	91	101	484

Results: Benefits to Recipients

NPV, difference in net income for IRAP recipients and control group, by cohort

Cohorts	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Difference (*t+3 - t*)
					Millions of 2019 dollars				
Cohort 2012-13	-265	-312	202	-263					2
Cohort 2013-14		-699	-684	383	-536				163
Cohort 2014-15			-367	-308	-686	-270			97
Cohort 2015-16				-920	-797	-192	-1,360		-439
Cohort 2016-17					-190	-407	-3,321	-1,062	-872

1. Shaded values are not used in the estimation of benefits from BIGS program streams, but are presented for informative purposes.

Program effect on profitability, compared to control group

Results: Benefits to Recipients

NPV, total support, program effect, and total benefits, by cohort

	Cohort 2012-13	Cohort 2013-14	Cohort 2014-15	Cohort 2015-16	Cohort 2016-17
	Millions of 2019 dollars				
Total support received	89	106	84	86	96
Program effect	2	163	97	-439	-872
Total benefits	**91**	**269**	**181**	**-353**	**-776**

- 3/5 cohorts positive total direct benefits
  - IRAP recipients improved net income **more** than control group 3 years after funding
- 2/5 cohorts negative total direct benefits
  - IRAP recipients improved net income **less** than control group 3 years after funding

Results: Summary

NPV total net costs, total direct benefits, benefit-cost ratio, by cohort

	Cohort 2012-13	Cohort 2013-14	Cohort 2014-15	Cohort 2015-16	Cohort 2016-17
	Millions of 2019 dollars				
Total net costs	94	111	88	91	101
Total direct benefits	91	269	181	-353	-776
Benefit-cost ratio	1.0	2.4	2.1	-3.9	-7.7

- Results are ambiguous
  - NPV cost between $91 million and $111 million
  - NPV benefits between -$776 million and $269 million
  - Benefit-cost ratio between -7.7 and 2.4

- Main benefits from IRAP perhaps not reflected by medium-term profitability

Limitations

- Benefits of program support estimated by change in profitability
  - Program effects could be more important on other outcomes of interest
    - e.g., employment, productivity, investments, market development
  - Net income is volatile and estimated direct effects sensitive to outliers
  - Vary depending on timeframe assumption of post-program effect (1-year, 3-year, 5-year)

- Missing values
  - High proportion of IRAP recipients do not consistently report *Net income* in GIFI
  - PSM drops observations with missing values

Conclusion

- Feasibility study provides initial insight into cost and benefits evaluation of BIGS program streams using PSM with administrative data
  - Method can be used to replicate with other program streams or outcomes of interest

- Challenges faced
  - Defining time window for treatment effect (specific to project and program stream)
  - Assumption of treatment homogeneity
  - Missing data (observations are dropped if missing data)
  - Methodology does not allow to obtain the statistical significance (p-value) of estimated effects

Areas for future research

- Method developed in this study would allow assessing impacts on other outcomes of interest
  - e.g., employment, productivity, investments, market development

- Difference-in-differences model to include additional covariates to control for exogenous shocks

- Dynamic model to assess increasing and decreasing effects during post-program period
  - Sun & Abraham's (2021) model allows accounting for heterogeneity of program support
    - (e.g., $10k grant vs $1 million grant)
    - allows to create groups within model with respect to treatment heterogeneity
  - Callaway & Sant'Anna's (2021) model allows to group cohorts within model

Thank you

Questions?

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