BIGS, innovation, and intellectual properties for small and medium-sized enterprises

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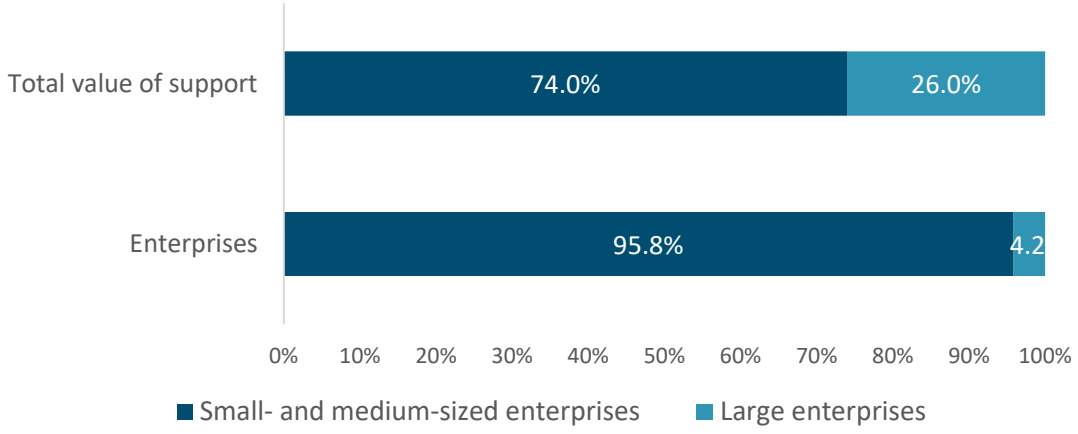
Motivation of the case study

- The majority of enterprises that received federal BIGS support were small and medium sized.
- In 2020, small and medium-sized enterprises (SMEs) constituted 95.8% of the enterprises that received support from a federal BIGS program stream. Additionally, SMEs received around 75% of the total funding distributed through these programs.



Source: BIGS administrative data, 2020

- Limited evidence of the effectiveness of BIGS programs on SMEs businesses.
- This research seeks to address this gap.

Objective and Data Source

Objective:

- This analysis estimates the effect of federal growth and innovation support on the innovation and intellectual property performance of small and medium-sized beneficiary enterprises.

Data Source:

- Statistics Canada's Linkable File Environment (LFE)
- This publication defines a SME as a business establishment with 1 to 499 employees.
- The target population for the survey consisted of private-sector, for-profit SMEs employing between 1 and 499 people and generating $30,000 or more in annual revenues.
- The core target population of over 730,000 SMEs with a random sample size of 17,323 SMEs, and a response rate of 59.7 percent.

Survey on Financing of Small and Medium Enterprises (2017) → BIGS administrative database (2015-2017) → General Index of Financial Information (GIFI) database (2014)

Innovation and intellectual property

Two main questions on innovation and intellectual property rights in the survey:

- ***"In the last three years has your business developed or introduced any of the following innovations? An innovation must be new to your business, but it does not need to be new to your market."***

a) A new or significantly improved good or service

b) A new or significantly improved production process or method

c) A new organizational method in your business practices, workplace organization or external relations

d) A new way of selling your goods or services

- ***"As of (specific date), did your business hold any of the following types of intellectual property…?"***

a) Registered trademarks

b) Patents

c) Registered industrial designs

d) Trade secrets

e) Non-disclosure agreements

Methodologies

- A number of methodologies can be used to estimate the causal impact of government programs such as instrumental variables, difference-in-differences, regression discontinuity designs and matching.
- Researchers make model selection decisions based on the characteristics of their data (e.g., cross-sectional, panel) and the nuances of their research questions (such as the availability of instruments or the presence of cutoff points).
- For this study we choose matching techniques to investigate the impact of Business Innovation Growth Support programs on innovation and intellectual property outcomes for SMEs.

Types of Matching

- **Exact matching:** The most basic type of matching is called "exact" matching. In this method, each treated unit is paired with control units that have the exact same values on all observed characteristics. This creates groups where both treated and control units share identical characteristics.

- **Inexact matching:** Involves pairing treated units with control units that have similar but not necessarily identical values on covariates or characteristics. This technique is often used when exact matching isn't feasible due to the continuous nature of the covariates or when the sample size is limited. (Propensity scores matching, Nearest Neighbor Matching, stratification matching, weighting methods)

- In this case study, we used propensity score matching and a weighting method referred as entropy balancing.

Simple Example

Firm ID	Program Participation	Revenue (in thousands)	Size (number of employees)	Province	Propensity Score
1	1	520	50	Ontario	0.35
2	1	890	58	Saskatchewan	0.45
3	1	620	55	British Columbia	0.7
4	0	510	50	Ontario	0.4
5	0	720	70	Manitoba	0.45
6	0	540	58	Saskatchewan	0.6

- Pair with similar observed characteristics:
  Firm 1 and firm 4
  Firm 2 and firm 6.

What is the estimate of ATT using exact matching?

Treated (P = 1)	Control (P = 0)	Estimate: Y1 - Y0
Firm 1 (Y1=520)	Firm 4 (Y0=510)	520 - 510 = 10
Firm 2 (Y1=890)	Firm 6 (Y0=540)	890 - 540 = 350

Average ATT = (10 + 350) / 2 = 360 / 2 = 180

This positive value suggests that, on average, participating in the program is associated with an increase in revenue of 180 compared to non-participation.

What is the estimate of ATT using Nearest Neighbor matching?

Treated Firm (P = 1)	Propensity Score (P = 1)	Nearest Neighbor (P = 0)	Propensity Score (P = 0)	Estimate: Y1 - Y0
Firm 1 (Y1=520)	0.35	Firm 4 (Y0=510)	0.4	520 - 510 = 10
Firm 2 (Y1=890)	0.45	Firm 5 (Y0=720)	0.45	890 - 720 = 170
Firm 3 (Y1=620)	0.7	Firm 6 (Y0=540)	0.6	620 - 540 = 80

Average ATT = (10 + 170 + 80) / 3 = 260 / 3 ≈ 86.67

This positive value suggests that, on average, participating in the program is associated with an increase in revenue of 86.67 compared to non-participation.

Methodology 1 (Propensity score matching)

Propensity score matching: match treated and untreated observations on the estimated probability of being treated (propensity score).

Steps in PSM:

- Step 1: use probit model to estimate BIGS participations as a function of observable characteristics and generate propensity score.

$$BIGS_i = X_i\beta + Z_i\delta + \lambda_p + \xi_i + u_i \qquad (1)$$

$\boldsymbol{X_i}$=Firm age, rural indicator, ln(revenue), ln(employment), ln (debt ratio), ln (labor productivity).

$\boldsymbol{Z_i}$= Primary decisions makers age, education and year of experience.

$\boldsymbol{\lambda_p}$= Province fixed effect

$\boldsymbol{\xi_i}$=Industry fixed effect

- Step 2: Match pairs using 1-1 nearest neighbors and estimate the average treatment on the treated:

$$E(\alpha_{TT}) = E(Y^T \mid S = 1,\ X) - E(Y^c \mid S = 0, X) \qquad (2)$$

Balance diagnostics after propensity score matching

	Before matching			After matching		
	BIGS recipients	NON-BIGS recipients	P-value	BIGS recipients	NON-BIGS recipients	P-value
Observations	467	4,860		467	467	
Primary decision maker characteristics:						
Age:						
Younger than 30 years	0.2%	0.7%	0.202	0.2%	0.0%	0.318
30 to 39 years	4.1%	8.9%	0.000	4.1%	3.0%	0.376
40 to 49 years	22.9%	22.8%	0.939	22.9%	25.7%	0.322
50 to 64 years	60.0%	52.9%	0.003	60.0%	59.3%	0.842
Older than 65 years	12.8%	14.8%	0.256	12.8%	12.0%	0.692
Education:						
Less than high school diploma	2.4%	6.6%	0.000	2.4%	1.3%	0.221
High school diploma	8.1%	22.8%	0.000	8.1%	5.6%	0.12
College / cégep / trade school diploma	18.2%	30.8%	0.000	18.2%	19.7%	0.559
Bachelor's degree	42.6%	28.5%	0.000	42.6%	46.9%	0.189
Graduate degree	28.7%	11.3%	0.000	28.7%	26.6%	0.465
Experience						
Less than 5 years	2.6%	3.0%	0.581	2.6%	1.7%	0.366
5 to 10 years	10.9%	15.2%	0.013	10.9%	10.5%	0.833
More than 10 years	86.5%	81.8%	0.011	86.5%	87.8%	0.558
Firm characteristics:						
Business age	27.65	23.75	0.000	27.65	26.84	0.535
rural	16.7%	20.5%	0.049	16.7%	12.6%	0.079
ln (labor productivity, 2014)	11.94	11.38	0.000	11.94	11.88	0.622
ln (debt ratio, 2014)	0.538	0.537	0.952	0.538	0.519	0.378
ln(total assets, 2014)	15.67	13.47	0.000	15.67	15.71	0.838
ln(R&D expenditure, 2014)	5.45	0.432	0.000	5.45	5.04	0.307
ln (average employees, 2014)	3.84	2.36	0.000	3.84	3.93	0.316
ln (revenue, 2014)	15.94	13.98	0.000	15.94	15.95	0.99
Industry controls			Yes			
Province controls			Yes			

PSM results for Innovation outcomes

Average treatment effects on the treated (ATT) of BIGS on innovations

VARIABLES	(1) Innovation	(2) Good or service	(3) Production or method	(4) Organizational method	(5) New way of selling
BIGS	0.0664**	0.0835**	0.0578	0.00857	0.0128
	(0.0327)	(0.0378)	(0.0396)	(0.0411)	(0.0346)
Observations	5,327	5,327	5,327	5,327	5,327

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

PSM results for intellectual property outcomes

Average treatment effects on the treated (ATT) of BIGS on intellectual property

VARIABLES	(1) IP	(2) Trademark	(3) Patent	(4) Industrial design	(5) Trade secrets	(6) Non-disclosure
BIGS	0.0964***	0.103**	0.0771**	0.0428*	0.0707**	0.103***
	(0.0317)	(0.0417)	(0.0345)	(0.0249)	(0.0321)	(0.0374)
Observations	5,327	5,327	5,327	5,327	5,327	5,327

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Methodology 2 (Entropy balancing)

Entropy balancing (Heinmueller, 2012): This method achieves the covariate balance through reweighting of the covariate distributions to satisfy a set of specified moment conditions.

- Step 1: entropy balancing method identifies weights which satisfy balance conditions for the sample mean and variance.

- Step 2: The entropy balancing weight are then applied in a probit regression which is specified by.

$$I_i = \delta BIGS_i + X_i\emptyset + Z_i\partial + \lambda_p + \xi_i + e_i \qquad (3)$$

Balance diagnostics after entropy balancing

	Treatment		Control unmatched		Control matched	
Characteristics	mean	variance	mean	variance	mean	variance
Primary decision maker characteristics:						
Age:						
30 to 39 years	7.2%	6.7%	11.8%	10.4%	7.2%	6.7%
40 to 49 years	25.4%	19.0%	24.4%	18.4%	25.4%	18.9%
50 to 64 years	54.8%	24.8%	50.1%	25.0%	54.7%	24.8%
Older than 65 years	12.0%	10.6%	12.8%	11.1%	12.0%	10.6%
Education:						
High school diploma	9.6%	8.7%	24.4%	18.4%	9.6%	8.7%
College / cégep / trade school diploma	18.6%	15.2%	32.2%	21.8%	18.6%	15.1%
Bachelor's degree	46.1%	24.9%	25.8%	19.1%	46.0%	24.9%
Graduate degree	24.0%	18.3%	10.8%	9.6%	24.0%	18.2%
Experience						
5 to 10 years	13.4%	11.6%	19.7%	15.8%	13.4%	11.6%
More than 10 years	85.6%	12.4%	77.1%	17.7%	85.5%	12.4%
Firm characteristics:						
Business age	19.93	210	18.99	214.3	19.92	209.9
rural	13.8%	11.9%	17.5%	14.4%	13.8%	11.9%
ln (labor productivity, 2014)	11.78	4.258	11.27	6.494	11.78	4.256
ln (debt ratio, 2014)	0.6097	0.2906	0.543	0.1688	0.6094	0.2904
ln(total assets, 2014)	14.34	7.826	12.74	9.234	14.33	7.822
ln(R&D expenditure, 2014)	4.551	34.47	0.1994	2.267	4.549	34.45
ln (average employees, 2014)	2.733	1.552	1.789	0.911	2.731	1.551
ln (revenue, 2014)	14.72	2.88	13.29	2.3	14.71	2.878
Observations	470		5414		5414	

EB results for innovation outcomes

Post-EB probit estimates of average marginal effects of BIGS on innovation
(average treatment effects on the treated)

VARIABLES	(1) Innovation	(2) Good or service	(3) Production or method	(4) Organizational method	(5) New way of selling
BIGS2015_2017	0.181***	0.173***	0.0811	0.0487	0.0746
	(0.0481)	(0.0522)	(0.0556)	(0.0551)	(0.0491)
Observations	5,327	5,327	5,327	5,327	5,327

All probit models control for primary decision maker characteristics, firm characteristics, industries, and province. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

EB results for intellectual property outcomes

Post-EB probit estimates of average marginal effects of BIGS on intellectual property (average treatment effects on the treated)

VARIABLES	(1) Intellectual Property	(2) Trademark	(3) Patent	(4) Industrial design	(5) Trade secrets	(6) Non-disclosure
BIGS2015_2017	0.156***	0.172***	0.0648*	0.0112	0.0339	0.132**
	(0.0490)	(0.0495)	(0.0343)	(0.0221)	(0.0503)	(0.0517)
Observations	5,327	5,327	5,327	5,327	5,327	5,327

All probit models control for primary decision maker characteristics, firm characteristics, industries, and provinces. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Conclusion

Key finding:

- After controlling for a rich set of observed characteristics, we found that SMEs who have used BIGS were generally more likely to innovate and implement an intellectual property. However, the impact varied depending on the nature of innovation and the type of intellectual property involved.

Limitation:

- The study cannot confirm causality of the result given that the methodology used doesn't control for unobserved factors.

Future research:

- Use alternative strategies to better capture unobserved heterogeneity.
- Future research could also investigate the impact of more specific BIGS programs on innovation and intellectual properties.

THANK YOU!
MERCI!

QUESTIONS?

For more information, please contact

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