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Innovation in New Brunswick

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Innovation in New Brunswick

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Innovation in New Brunswick

Abstract

This report is part of a research project on the linkages between innovation and productivity in New Brunswick, prepared for the Atlantic Institute for Policy Research at the University of New Brunswick. This report examines the innovation situation in New Brunswick by analyzing the levels and trends of seven indicators of innovation: R&D spending, R&D personnel, patents, firm-based innovation statistics, non-residential fixed investment, investment in intellectual property products, and business entry. This report finds that New Brunswick's state of innovation was weak compared to the other provinces, but has improved over time. New Brunswick ranked below the national average for all seven innovation indicators, with especially poor results for business R&D spending and personnel, patents, and firm-level innovation. However, New Brunswick enjoyed an absolute and relative improvement in five of seven indicators: R&D spending, R&D personnel, patents, firm-based innovation statistics, and investment in intellectual property products. Results for only two indicators—non-residential fixed capital investment and number of active businesses—deteriorated.

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Innovation in New Brunswick

Executive Summary

Innovation plays an important role in improving productivity. Strong innovation leads to technological advancement and the creation and diffusion of new knowledge in firms, resulting in higher productivity. As higher productivity leads to economic growth, innovation significantly impacts economic development and living standards.

This report is the first part of a three-report series on the linkages between innovation and productivity in New Brunswick, prepared for the Atlantic Institute for Policy Research at the University of New Brunswick. Part one of this series examines the state of innovation in New Brunswick, while part two examines productivity in the province. Lastly, part three assesses the links between innovation and productivity in New Brunswick and proposes recommendations to improve the province's innovation performance and its impact on productivity.

This report provides a comprehensive overview of the innovation situation in New Brunswick. It examines the following seven indicators of innovation: R&D spending, R&D personnel, patents, firm-based innovation statistics, non-residential fixed investment, investment in intellectual property products, and business entry. For each indicator, we analyze levels and trends in New Brunswick with comparisons to provincial and national data. We conclude that the state of innovation in New Brunswick was weak relative to the other provinces, but has generally improved since 1981.

Overall, New Brunswick ranked low among the provinces and below the national average for all seven innovation indicators. New Brunswick had particularly poor results for business R&D spending and personnel, patents, and firm-level innovation. Despite its weak performance among the provinces, New Brunswick's innovation situation has generally improved over time in absolute terms and relative to the Canadian average. Five of seven indicators enjoyed an improvement: R&D spending, R&D personnel, patents, firm-based innovation statistics, and investment in intellectual property products. Results for only two indicators—non-residential fixed capital investment and number of active businesses—deteriorated.

Levels of Innovation

New Brunswick's current state of innovation ranked among the weakest in Canada across indicators. The following are key statistics in the province's levels of innovation:

- **R&D Spending** – New Brunswick had \$342 million (in current prices) or \$446 per capita in total R&D expenditures in 2017, ranking last among the provinces. New Brunswick had 0.95 per cent R&D intensity, ranking ninth among the provinces. The province relied mostly on the government and higher education sectors to perform R&D. R&D intensity in the business and higher education sectors in New Brunswick both ranked poorly at eighth of the provinces. The government sector fared better, with New Brunswick ranking fifth of the provinces in terms of R&D intensity.
- **R&D Personnel** – New Brunswick had 2,280 R&D personnel in 2013, ranking eighth of the provinces. About 0.64 per cent of New Brunswick’s total employment worked in R&D, which was the lowest share in Canada. All three performer sectors also had low rankings in terms of R&D personnel as a share of total employment. The government and business sectors ranked ninth of the provinces, while the higher education sector ranked eighth.
- **Patents** – In 2016, New Brunswick had 35 patents granted by the USPTO, ranking eighth of the provinces. New Brunswick’s share of total patents granted in Canada was 0.7 per cent.
- **Firm-Based Innovation** – Atlantic Canada, a proxy for New Brunswick, ranked last for all innovation statistics analyzed in this report. Between 2015 and 2017, 69.1 per cent of firms in Atlantic Canada were innovative, the smallest share of all the regions in Canada. Similarly, firms in Atlantic Canada were the least likely compared to those in other regions to implement any type of innovation (product, process, organizational, marketing) or to use any advanced technology. The top reasons for not adopting advanced technologies in Atlantic Canada include the following: advanced technologies were not applicable to business operations; investing in technologies was not necessary for their business; and firms were not convinced of their economic benefit.
- **Non-Residential Investment** – In 2018, New Brunswick’s non-residential investment was \$5.12 billion or 13.8 per cent of nominal GDP, ranking seventh of the provinces. New Brunswick also fared poorly in investment in engineering construction, ranking sixth, and intellectual property products, ranking eighth. In contrast, the province ranked an impressive third in investment in non-residential buildings and machinery and equipment.
- **Investment in Intellectual Property Products (IPP)** – In 2018, New Brunswick’s investment in IPP was \$750 million or 2.0 per cent of nominal GDP. Of the three types, software received the highest investment at \$452 million or 1.22 per cent of nominal

GDP, ranking third. The other two types—mineral exploration and evaluation and research and development—fared significantly worse, both ranking eighth.

- **Business Entry** – In 2017, New Brunswick’s gross entry rate was 12.0 per cent of total active firms, ranking ninth in Canada, while the province’s net entry rate was 0.2 per cent of total active firms, ranking eighth. Seven of fifteen industries in New Brunswick had negative net entry rates. Three industries with a negative net entry rate—manufacturing; professional, scientific, and technical services; and wholesale trade—were part of the Information and Communication Technology sector, which is known to be highly innovative.

Trends in Innovation

Despite current weak levels of innovation, New Brunswick enjoyed significant absolute and relative improvement in most indicators of innovation over time. The following are key trends in innovation indicators:

- **R&D Spending** – New Brunswick’s R&D expenditures increased 144 per cent from \$125 million in 1981 to \$304 million in 2017 (in constant 2012 dollars). This increase was largely driven by significant improvements in the business and higher education sectors (485 per cent and 448 per cent increases, respectively). Total R&D intensity increased 0.41 percentage points from 0.54 per cent of nominal GDP in 1981 to 0.95 per cent in 2017. For all sectors, New Brunswick’s R&D intensity remained below Canada’s by 2018. However, New Brunswick’s total R&D intensity relative to Canada’s increased 10.8 percentage points from 46.4 per cent in 1981 to 57.2 per cent of Canada’s in 2017. Over the period, the business and higher education sectors saw increases of 22.5 percentage points and 35.6 percentage points in R&D intensity relative to Canada’s, respectively, but the government sector experienced a decline of 25.4 percentage points.
- **R&D Personnel** – Between 2000 and 2013, New Brunswick’s total R&D personnel increased 30.3 per cent from 1,750 employees to 2,280 employees. Consistent with R&D spending, the increase in total R&D personnel was concentrated in the business and higher education sectors with increases of 26.3 per cent and 58.3 per cent, respectively. Total R&D personnel as a share of total employment increased 0.12 percentage points from 0.53 per cent in 2000 to 0.64 per cent in 2013. Over the period, total R&D personnel as a share of total employment relative to Canada’s increased 2.5 percentage points from 46.3 per cent of Canada’s in 2000 to 48.9 per cent in 2013. Similarly, the business and higher education sectors experienced improvements of 1.7 percentage points and 6.0 percentage points, respectively, but the government sector saw a significant decrease of 19.1 percentage points.

- **Patents** – The number of patents granted by the USPTO in New Brunswick grew an impressive 483.3 per cent from 6 patents in 1980 to 35 patents in 2016.
- **Firm-Based Innovation** – Among the four regions in Canada, Atlantic Canada experienced the greatest improvement in the share of innovative firms. The share of innovative firms increased by 23.3 percentage points from 45.8 per cent of total firms in the 2010-2012 period to 69.1 per cent in 2015-2017 period.
- **Non-Residential Investment** – Total non-residential investment in New Brunswick increased 62.6 per cent from \$2.76 billion in 1981 to \$4.48 billion (constant 2012 dollars) in 2018; however, non-residential investment as a share of nominal GDP decreased by 6.9 percentage points from 20.7 per cent in 1981 to 13.8 per cent in 2018. Relative to Canada's, total non-residential investment as a share of nominal GDP in the province decreased 15.6 percentage points from 108.2 per cent of Canada's in 1981 to 92.6 per cent of Canada's in 2018. Similarly, investment relative to Canada's in non-residential buildings, engineering construction, and machinery and equipment decreased by 10.5, 19.4, and 3.8 percentage points, respectively. In contrast, investment in intellectual property products relative to Canada's was the only type of investment to increase over the period, growing 11.4 percentage points.
- **Investment in Intellectual Property Products (IPP)** – New Brunswick's investment in IPP increased 216.2 per cent from \$210 million in 1981 to \$664 million (constant 2012 dollars) in 2018. IPP investment as a share of nominal GDP increased 0.92 percentage points from 1.1 per cent in 1981 to 2.0 per cent in 2018. Similarly, investment as a share of nominal GDP in R&D and software increased by 0.04 and 0.94 percentage points, respectively, but investment in mineral exploration declined 0.05 percentage points. Relative to Canada, however, investment as a share of nominal GDP in R&D and software declined 0.56 percentage points and 7.56 percentage points from 1981 to 2018, respectively, but investment in mineral exploration increased by 1.19 percentage points.
- **Business Entry** – The number of businesses in New Brunswick declined by 8.5 per cent from 24,920 businesses in 2002 to 22,790 businesses in 2017. Over the period, the number of businesses in New Brunswick decreased at a rate of 0.59 per cent per year, the worst rate among the provinces.

Barriers to Innovation

New Brunswick faces several barriers to innovation, which likely explain the province's relatively weak level of innovation. These barriers include financial issues, labour shortage issues, and a lack of motivation among firms to innovate. The following are eight key barriers to innovation in New Brunswick:

- Less R&D funding and access to capital compared to other provinces
- Lack of collaboration between R&D performer sectors, particularly between the higher education and business sectors
- Low R&D intensity across business sector industries
- Unfavourable industrial structure in conducting R&D (i.e. The province's economy is not concentrated in typically R&D intensive industries)
- Disinterest among businesses in adopting new technologies
- High costs of purchasing and implementing new technologies in firms
- Uncompetitive business environment, due to high corporate taxes and rising business costs
- Population issues, including out-migration of young educated people and low immigration flows

Given New Brunswick's weak yet improving innovation performance, researchers and policymakers should address these barriers to further enhance the state of innovation in the province.

Innovation in New Brunswick¹

I. Innovation Situation in New Brunswick

Innovation plays an important role in improving productivity. The Oslo Manual by the OECD (2018) defines innovation as any “new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes.”² Innovation activity consists of four types: product (a new or improved good or service), process (a new or improved method of production or delivery), organizational (a new method in business practices), and marketing (a new marketing strategy).³ In effect, strong innovation leads to technological advancement and the creation and diffusion of new knowledge in firms, resulting in higher productivity. As higher productivity leads to economic growth, innovation significantly impacts economic development and living standards. Given the important economic implications of innovation, the state of innovation in Canada and the provinces has been widely studied.⁴

This report, prepared for the Atlantic Institute for Policy Research at the University of New Brunswick, is part one of a series on the linkages between innovation and productivity in New Brunswick. This series consists of three parts. Part one examines the state of innovation in New Brunswick, while part two examines the state of productivity in the province. Finally, part three assesses the link between innovation and productivity in New Brunswick and proposes recommendations to improve the province’s innovation performance and its impact on productivity.

This first part provides a comprehensive overview of the innovation situation in New Brunswick. It examines the following seven indicators of innovation: R&D spending, R&D personnel, patents, firm-based innovation statistics, non-residential investment, investment in intellectual property products, and business entry. For each indicator, we analyze levels and

¹ This report was written by CSLS economist Kimberly Wong under the supervision of Andrew Sharpe, CSLS Executive Director. The author would like to thank Herb Emery for comments. The Centre for the Study of Living Standards also acknowledges the financial support from the JDI Roundtable on Manufacturing Competitiveness in New Brunswick and Atlantic Canada Opportunities Agency support for the Atlantic Institute for Policy Research’s research program on “Innovation as a Driver of Growth of the Regional Economy” at UNB.
Email: kimberlywong056@gmail.com

² See Gault (2013) for more discussion on innovation definitions, indicators, and measurement.

³ The fourth edition of the Oslo Manual characterizes the types of innovation differently from previous editions. It categorizes innovation as two major types (product and business process innovations) and characterizes marketing and organizational innovations as sub-categories. This report, however, refers to the four types of innovation as defined by previous editions. Our analysis is based on data from Statistics Canada, which uses the four types.

⁴ For example, see Gault (2003) for studies on innovation in Canadian industry, Sharpe and Long (2012) for a study on innovation in Canada’s natural resource industries, and Murray (2016) for a report on innovation policies in Canada.

trends in New Brunswick with comparisons to provincial and national data.⁵ Lastly, a summary of findings and literature review on the state of innovation in Atlantic Canada and New Brunswick are presented.

A. R&D Spending

The Frascati Manual (2015) by the OECD defines research and development as “creative and systematic work undertaken in order to increase the stock of knowledge ... and to devise new applications of available knowledge.” Embodying innovation, R&D improves firm productivity.⁶ Higher R&D expenditures lead to the creation and diffusion of new technologies, products, and ideas, which enhances the efficiency of firms. As a result, R&D spending is considered one of the standard measures of innovation. In this subsection, we compare the R&D spending of New Brunswick, the provinces, and Canada. In addition, we examine R&D spending by performer sector, namely government, business, and higher education.⁷

i. Cross-Sectional Analysis by Province

a. R&D Spending per Capita

Chart 1 shows provincial R&D spending per capita (in current dollars) by performer sector in 2017.⁸ Total R&D spending in New Brunswick amounted to \$342 million, equivalent to \$446 per capita. Of all the performer sectors, the province spent the most on the higher education sector at \$187 million or \$244 per capita. New Brunswick spent \$111 million or \$145 per capita on the business sector, while it spent the least on the government sector at \$39 million or \$51 per capita.

⁵ The data used in this report is from Statistics Canada. For the complete dataset used for our analysis, see the database posted with this paper at <http://www.csls.ca/reports/csls2020-08-data.xlsx>.

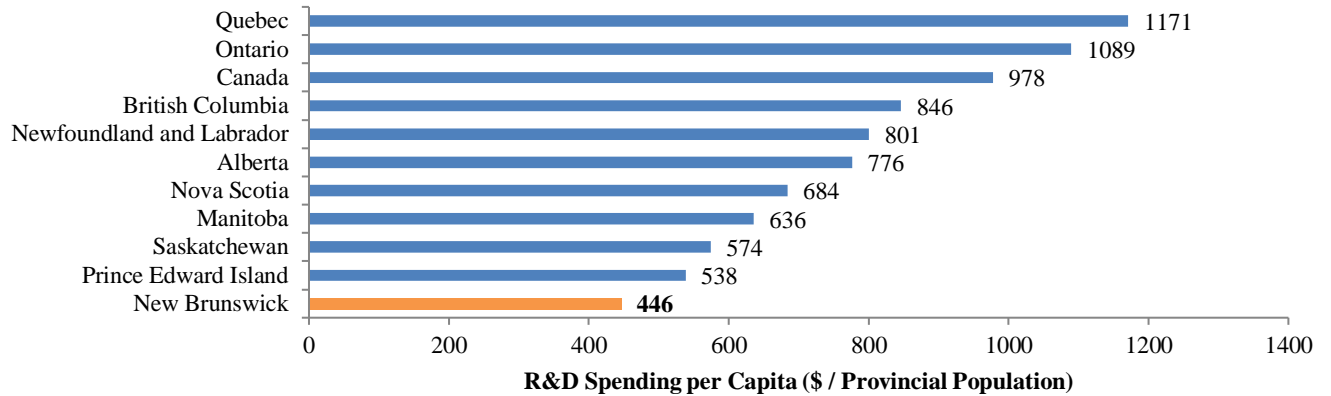
⁶ See Tang and Wang (2019) for a study on the effects of R&D on firm productivity.

⁷ Statistics Canada provides estimates of R&D spending by funder (sources of R&D funding) and performer (receivers of R&D funding) sectors. This report analyzes R&D spending only by the performer sector. In addition, Statistics Canada includes provincial research organizations and private non-profits as performer sectors, but this report does not discuss them, as they constitute only a small share of R&D spending

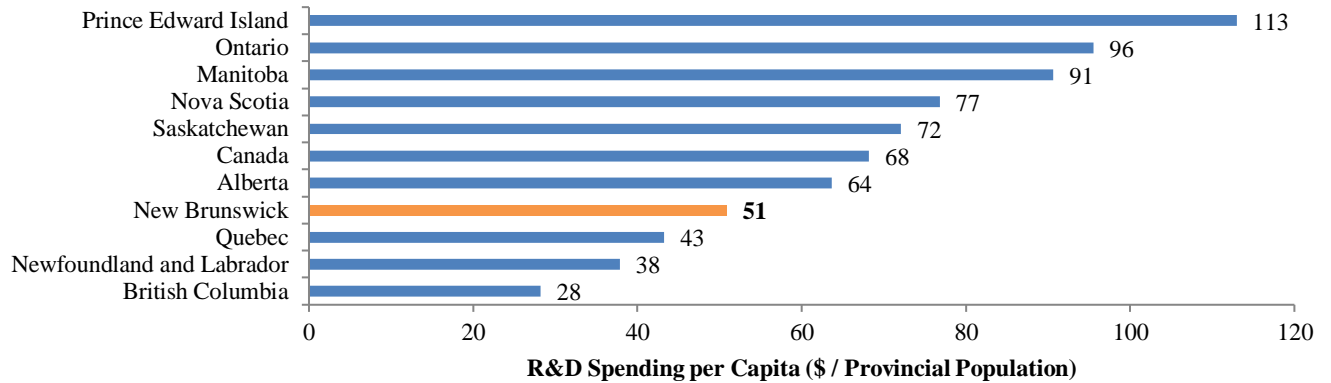
⁸ 2017 is the last year for which provincial data on R&D spending are currently available. Refer to database Table 1 for estimates on R&D spending by performer sector and province.

Chart 1: R&D Spending per Capita by Performer Sector and Province, 2017

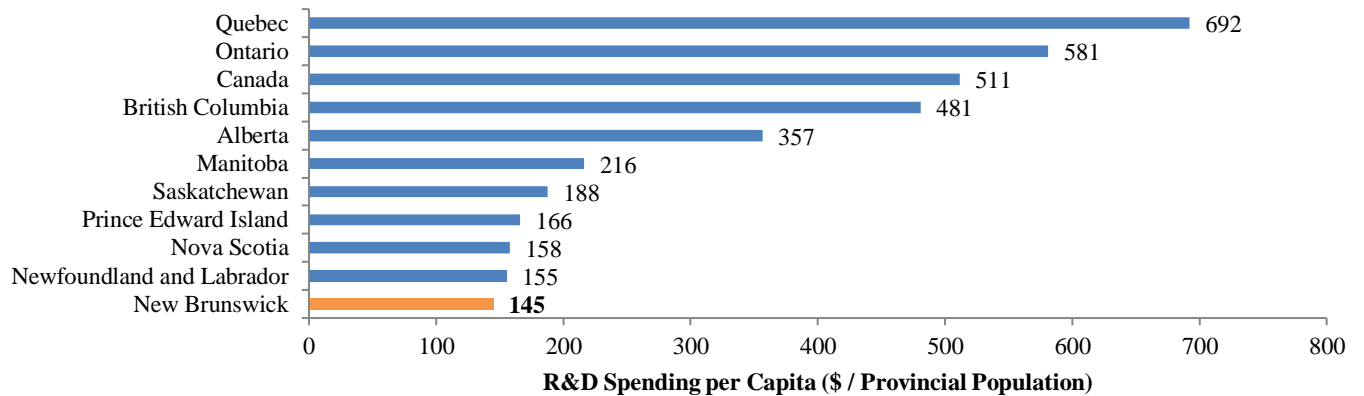
Panel A: Total R&D Spending



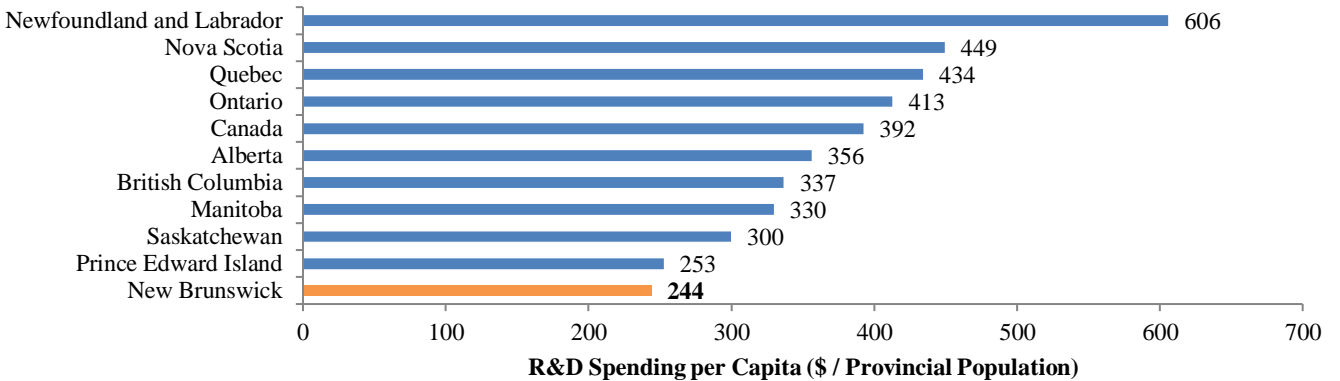
Panel B: Government



Panel C: Business



Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0273-01 & Table 17-10-0005-01

For every performer sector, New Brunswick's R&D spending per capita was low compared to the other provinces (Chart 1). New Brunswick ranked last for total R&D spending per capita, the business sector, and the higher education sector, while the province ranked seventh for the government sector. For each sector, the top-ranking province exceeded New Brunswick by a significant margin. For total R&D spending, Quebec's R&D expenditures per capita were 2.6 times higher than New Brunswick's. Surprisingly, Prince Edward Island and Newfoundland ranked first in the government and higher education sectors, respectively, which indicates that New Brunswick fared poorly even among the Atlantic provinces. Prince Edward Island's R&D spending per capita in government and Newfoundland and Labrador's in higher education were about twice as much as New Brunswick's in both sectors. Most significantly, for the business sector, Quebec's R&D spending per capita was 4.8 times higher than New Brunswick's. It is important to note that, in the business sector, the four Atlantic provinces had the lowest R&D spending per capita.

As noted previously, New Brunswick's R&D spending per capita was lower than Canada's for all performer sectors.⁹ The province had the strongest results in the government and higher education sectors, spending 74.6 per cent and 62.2 per cent of Canada's R&D spending per capita. For the business sector, however, New Brunswick's R&D spending per capita was only 28.3 per cent of Canada's.

⁹ Refer to Appendix Chart 1 for the R&D spending per capita in New Brunswick by performer sector as a share of Canada's in 2017.

b. R&D Intensity

R&D intensity is defined as R&D spending as a share of nominal GDP. Chart 2 compares provincial R&D intensity by performer sector in 2017. New Brunswick spent 0.95 per cent of its nominal GDP on research and development. Consistent with the findings for R&D spending per capita, the province spent the most on the higher education sector at 0.52 per cent of its nominal GDP. The business sector followed with 0.31 per cent of New Brunswick's nominal GDP, while the government sector had the smallest share of spending with 0.11 per cent.

Compared to the other provinces, New Brunswick's total R&D intensity ranked among the lowest (Chart 2). The province, however, fared better in R&D intensity than in R&D spending per capita.¹⁰ New Brunswick had the second lowest total R&D spending, surpassing only Saskatchewan by 0.12 percentage points. Compared to the other Atlantic provinces, New Brunswick's total R&D spending was significantly lower. For example, Prince Edward Island, which had the second lowest R&D spending as a share of nominal GDP among the Atlantic provinces, exceeded New Brunswick's by 0.26 percentage points. Furthermore, Quebec and Ontario, the provinces with the largest economies, spent the most on research and development, exceeding New Brunswick's spending as a share of nominal GDP by 1.37 and 0.90 percentage points, respectively.

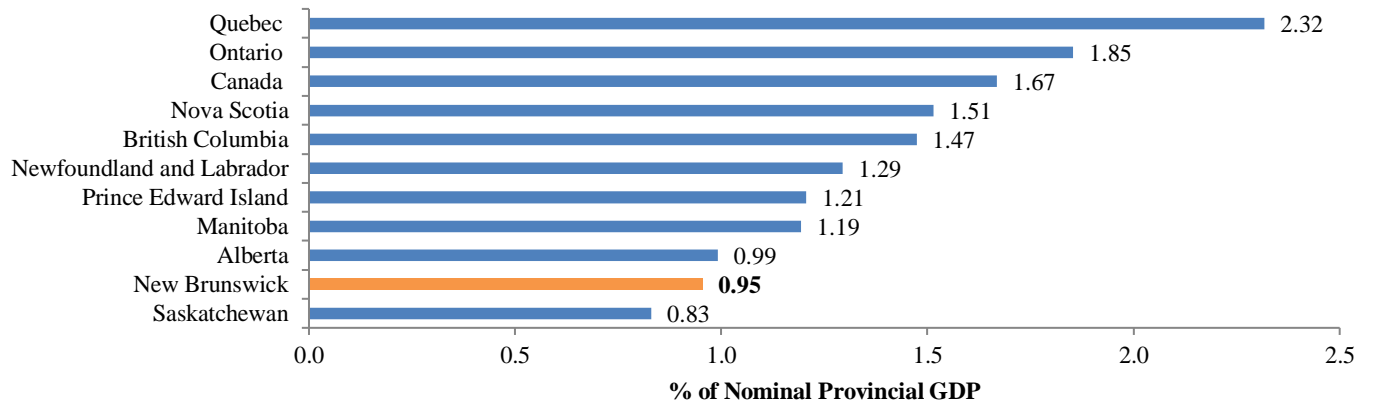
Across performer sectors New Brunswick's R&D spending also consistently ranked low among the provinces (Chart 2). New Brunswick's R&D spending was below the national average for all sectors. For both the business and higher education sectors, New Brunswick ranked seventh of the ten provinces, and ranked among the lowest of the Atlantic provinces. For the business sector, Quebec, which had the highest R&D spending performed by the business sector, exceeded New Brunswick by 1.06 percentage points. The Atlantic provinces apart from New Brunswick had relatively high R&D spending performed by the higher education sector; Nova Scotia ranked first with 0.99 per cent of its nominal GDP, exceeding New Brunswick by 0.47 percentage points. Although New Brunswick was highly reliant on the higher education sector for R&D, it spent significantly less on university-performed R&D compared to most provinces.

The government sector was the exception to New Brunswick's relatively low R&D expenditures. In contrast to the business and higher education sectors, New Brunswick ranked fifth of the ten provinces for R&D spending performed by the government sector. Prince Edward Island ranked first at 0.25 per cent of its nominal GDP, exceeding New Brunswick by 0.14 percentage points.

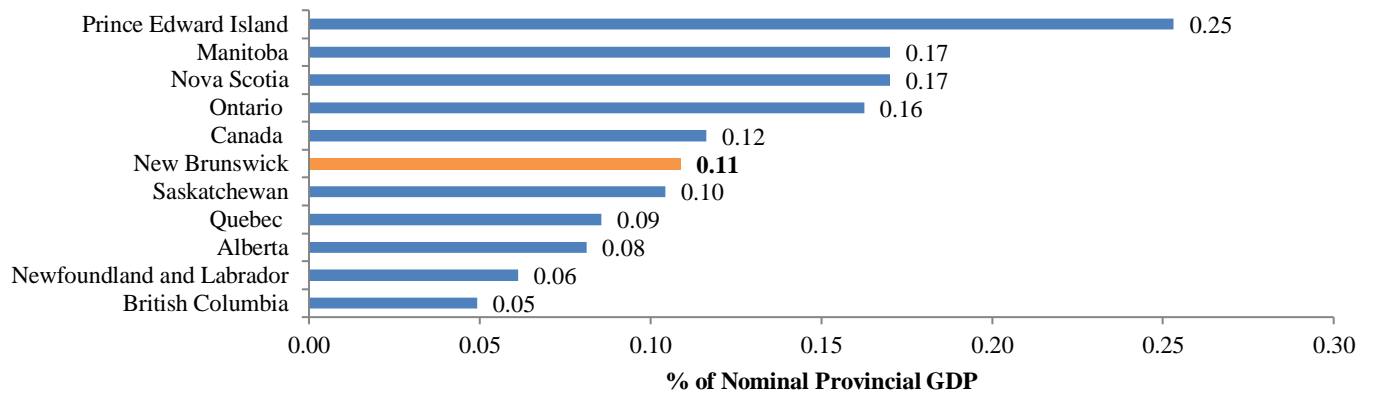
¹⁰ Among the provinces, New Brunswick never ranked last in terms of R&D intensity. This slight improvement in R&D intensity compared to R&D per capita is likely due to the province's relatively low nominal GDP. In 2017, New Brunswick's nominal GDP was 1.7 per cent of Canada's, whereas the province's population was 2.1 per cent of Canada's.

Chart 2: R&D Intensity by Performer Sector and Province, 2017

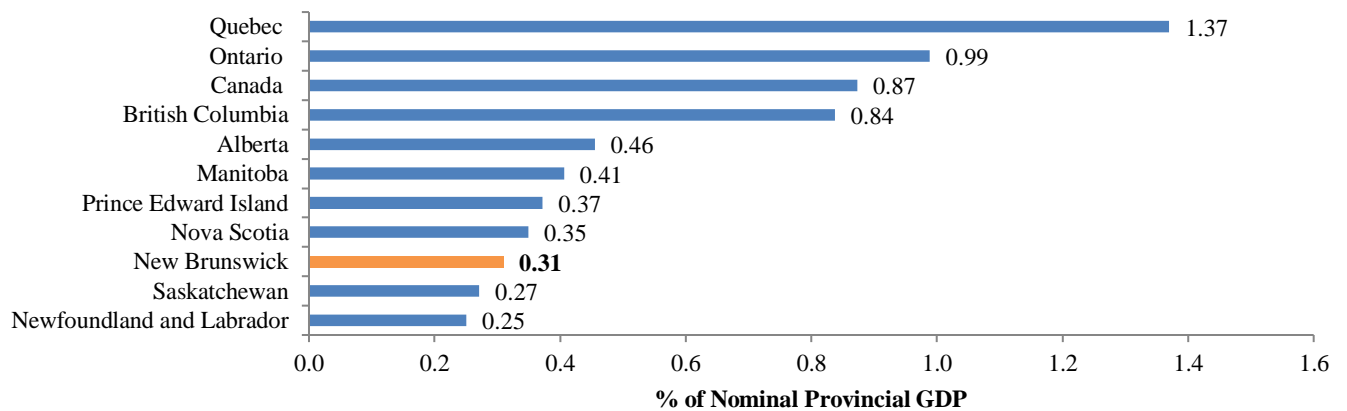
Panel A: Total R&D Spending



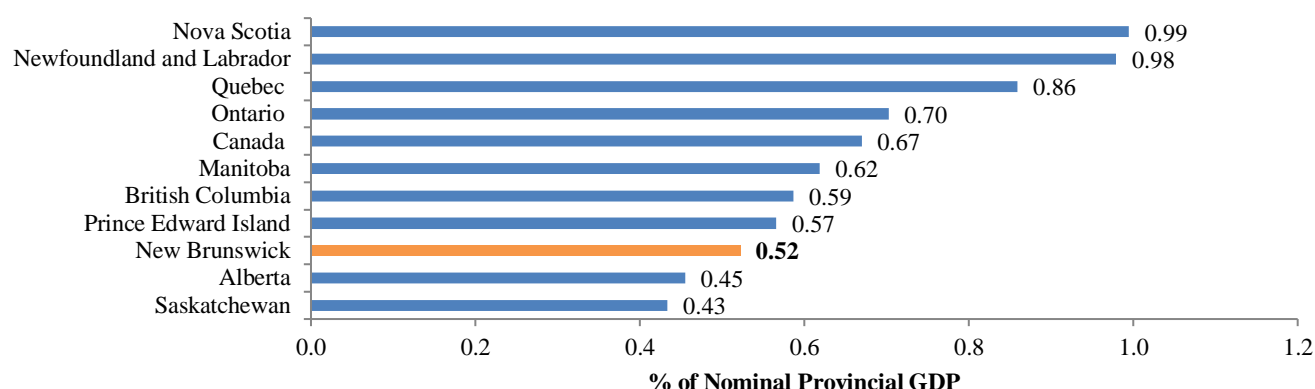
Panel B: Government



Panel C: Business



Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0273-01 and Table 36-10-0222-01

c. Relative Importance of Each Performer Sector to Total R&D Spending

Chart 3 compares the R&D spending by performer sector as a share of total R&D spending by province in 2017. Of the three performer sectors in New Brunswick, higher education had the highest share of total R&D spending for the province, performing 54.7 per cent of New Brunswick's total R&D expenditures.¹¹ The business sector followed with 32.5 per cent of total R&D spending. The government sector ranked last with 11.4 per cent of total R&D spending in New Brunswick.

New Brunswick ranked relatively high for the government and higher education sectors in total R&D spending, surpassing the Canadian average (Chart 3). The province ranked fourth for the government sector and third for the higher education sector. The other Atlantic provinces also had relatively large shares of total R&D spending for these sectors. Prince Edward Island had the largest share of total R&D spending performed by the government sector at 21.0 per cent, exceeding New Brunswick by 9.6 percentage points. For the higher education sector, Newfoundland and Labrador had the largest share at 75.7 per cent, exceeding New Brunswick by 21.0 per cent.

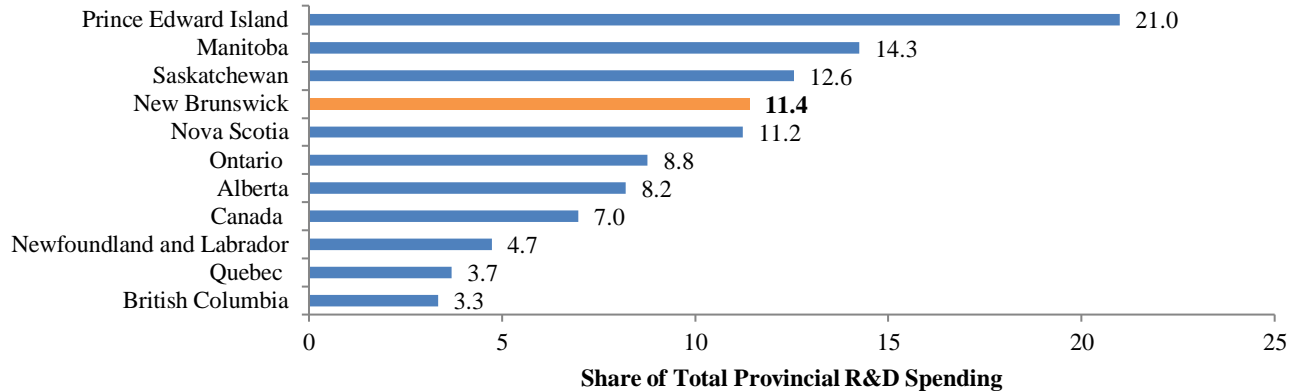
However, the Atlantic provinces had the lowest shares of total R&D spending performed by the business sector (Chart 3). New Brunswick ranked seventh, though it had the highest share of the Atlantic provinces. Most notably, Quebec and Ontario were among the highest for the business sector at 59.1 per cent and 53.3 per cent of total R&D spending, respectively, but ranked among the lowest for the other sectors. The provinces with the highest total R&D spending, thus, concentrated much of those expenditures in the business sector, while the

¹¹ According to the Global Advantage Consulting Group (2019), the University of New Brunswick was responsible for about 70 per cent of the R&D performed by the higher education sector in the province in 2016.

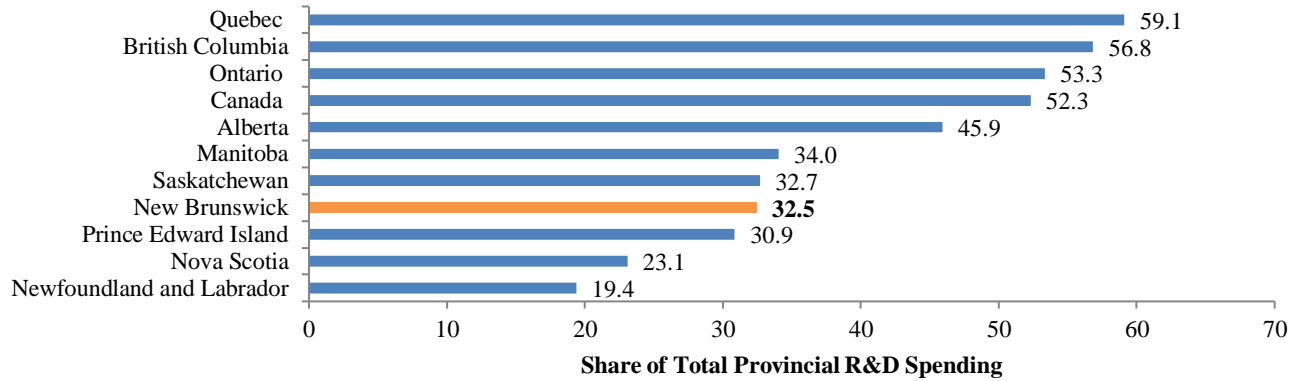
Atlantic provinces spent more of their total R&D expenditures on the government and higher education sectors.

Chart 3: R&D Spending in Canada by Performer Sector as a Share of Total R&D Spending by Province, 2017

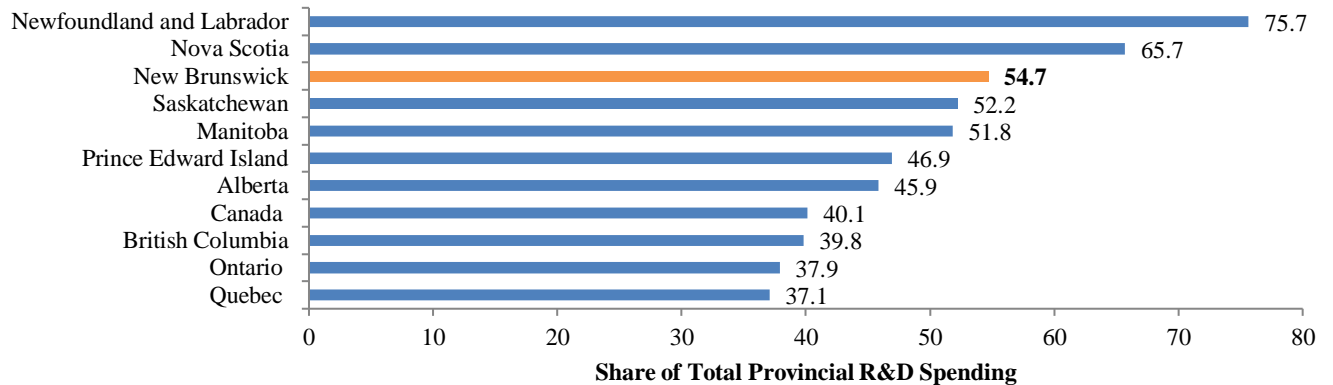
Panel A: Government



Panel B: Business



Panel C: Higher Education



Source: Statistics Canada, Table 27-10-0273-01

ii. Cross-Sectional Analysis by Industry in New Brunswick and Canada

The previous subsections confirmed New Brunswick's weak performance in R&D spending compared to the other provinces. This subsection attempts to explain New Brunswick's low R&D spending. Two reasons could account for these low R&D expenditures. First, New Brunswick could have low R&D intensity across all industries relative to Canada. Second, New Brunswick's industrial structure may not be conducive to R&D; the province may have few industries that are typically R&D intensive. To determine the factors behind New Brunswick's weak R&D spending, this subsection first provides an overview of R&D expenditures, value added, and R&D intensity by industry in Canada and New Brunswick. Finally, we assess the two possible reasons.

Table 1 shows Canada's business R&D expenditures by industry in 2016 (in current dollars).¹² In Canada, the information and communications technology (ICT) sector comprised \$6.9 billion or 38 per cent of its total R&D expenditures.¹³ In the ICT sector, services-producing ICT had a larger share of R&D spending than manufacturing ICT (34.1 per cent vs. 3.6 per cent). Following the ICT sector, the non-ICT services-producing and manufacturing sectors had the largest shares of spending. These three sectors—ICT, non-ICT services-producing industries, and non-ICT manufacturing—comprised 94.5 per cent of total business R&D spending.

Table 1 also shows New Brunswick's business R&D expenditures by industry in 2016 (in current dollars).¹⁴ The business sector spent the most on the services-producing industries at \$93 million or 69.9 per cent of total business R&D spending.¹⁵ The ICT sector comprised \$78 million or 58.6 per cent of its total business R&D expenditures. Of the sectors listed, New Brunswick had the smallest shares of R&D spending in construction (0.0 per cent of total business R&D spending) and utilities (0.8 per cent of total business R&D spending).

¹² Refer to database Table 3 for estimates on R&D expenditures and value added by industry in Canada and New Brunswick.

¹³ The North American Industry Classification System (NAICS) does not include a separate industry for the ICT sector. The ICT sector is a composite of several NAICS industries. Statistics Canada Table 27-10-0333-01 and Table 27-10-0341-01 define the ICT sector as ICT-related industries from the manufacturing and services-producing businesses sectors.

¹⁴ Data on R&D expenditures by province was restricted for several industries between 2014 and 2017. We included an additional sector, "Other sectors", by subtracting the R&D expenditures of utilities, construction, and services-producing industries from total business R&D expenditures in New Brunswick. We also included "Other sectors" for Canada for comparison. We chose the reference year 2016, as data for nominal value added by province and industry is only available up to 2016.

¹⁵ Note that there is overlap between the services-producing industries and the ICT sector (i.e. Services-producing industries include those in the ICT sector, and the ICT sector includes services-producing industries).

Table 1: Business R&D Expenditures by Industry in Canada and New Brunswick, 2016**Panel A: Canada**

| Industry | Current dollars (Millions) | Shares of R&D |
|---|---------------------------------------|--------------------------|
| Agriculture, forestry, fishing and hunting | 155 | 0.008 |
| Mining, quarrying, and oil and gas extraction | 830 | 0.044 |
| Utilities | 386 | 0.021 |
| Construction | 96 | 0.005 |
| Manufacturing (total = non-ICT + ICT) | 6,680 | 0.357 |
| Manufacturing (non-ICT) | 6,023 | 0.322 |
| Services-producing industries (total = non-ICT + ICT) | 10,576 | 0.565 |
| Services-producing industries (non-ICT) | 4,355 | 0.233 |
| Other sectors (including agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; and total manufacturing) | 7,665 | 0.409 |
| Information and communication technology (ICT) sector | 6,878 | 0.367 |
| Information and communication technology - Manufacturing | 657 | 0.035 |
| Information and communication technology - Services- producing industries | 6,221 | 0.332 |
| Total business sector industries | 18,723 | 1.00 |

Panel B: New Brunswick

| Industry | Current dollars (Millions) | Shares of R&D |
|---|---------------------------------------|--------------------------|
| Utilities | 1 | 0.008 |
| Construction | 0 | 0.00 |
| Services-producing industries | 93 | 0.699 |
| Other sectors (including agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; and total manufacturing) | 39 | 0.293 |
| Information and communication technology (ICT) sector | 78 | 0.586 |
| Total business sector industries | 133 | 1.00 |

Source: Statistics Canada, Table 27-10-0333-01 & Table 27-10-0341-01

Table 2 shows Canada's and New Brunswick's nominal value added in the business sector in 2016. Canada and New Brunswick had similar shares of value added in most industries. Canada had its highest value added in the non-ICT services-producing sector at \$800 billion or 58.3 per cent of its total value added. Following this industry, non-ICT manufacturing (14.4 per cent of total value added) and construction (10.5 per cent of total value added) had the largest shares. Similarly, New Brunswick's non-ICT services-producing sector had the largest share at 58.4 per cent of total value added, followed by non-ICT manufacturing (15.4 per cent of total value added) and construction (9.8 per cent of total value added). Both had small shares in the ICT sector: Canada with 5.6 per cent of total value added, and New Brunswick with 5.1 per cent of total value added.

Major differences in shares of value added were concentrated in natural resource industries. Canada had its smallest share in agriculture, forestry, fishing, and hunting at 2.7 per

cent of total value added, which was half of New Brunswick's share in this industry. Similarly, New Brunswick had its smallest share in mining, quarrying, and oil and gas extraction at 1.5 per cent of total value added, whereas Canada's share was 5.5 per cent of total value added.

Table 2: Nominal Value Added (VA) in Canada and New Brunswick, 2016

Panel A: Absolute Values

| Industry | Canada | New Brunswick |
|--|----------------------------|---------------|
| | Current Dollars (Millions) | |
| Agriculture, forestry, fishing and hunting | 36,805 | 1,081 |
| Mining, quarrying, and oil and gas extraction | 76,103 | 294 |
| Utilities | 40,899 | 908 |
| Construction | 144,018 | 1,970 |
| Manufacturing (total = non-ICT + ICT) | 201,058 | 3,119 |
| Manufacturing (non-ICT) | 197,670 | 3,111 |
| Services-producing industries (total = non-ICT + ICT) | 873,727 | 12,816 |
| Services-producing industries (non-ICT) | 800,861 | 11,786 |
| Other sectors (including agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; and total manufacturing) | 313,965 | 4,494 |
| Information and communication technology (ICT) sector | 76,253 | 1,039 |
| Information and communication technology - Manufacturing | 3,388 | 8.6 |
| Information and communication technology - Services-producing industries | 72,866 | 1,030 |
| Total business sector industries | 1,372,610 | 20,188 |

Panel B: Shares of VA

| Industry | Canada | New Brunswick |
|--|---|---------------|
| | VA in Industry / Total Business Sector VA | |
| Agriculture, forestry, fishing and hunting | 0.027 | 0.054 |
| Mining, quarrying, and oil and gas extraction | 0.055 | 0.015 |
| Utilities | 0.030 | 0.045 |
| Construction | 0.105 | 0.098 |
| Manufacturing (total = non-ICT + ICT) | 0.146 | 0.155 |
| Manufacturing (non-ICT) | 0.144 | 0.154 |
| Services-producing industries (total = non-ICT + ICT) | 0.637 | 0.635 |
| Services-producing industries (non-ICT) | 0.583 | 0.584 |
| Other sectors (including agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; and total manufacturing) | 0.229 | 0.223 |
| Information and communication technology (ICT) sector | 0.056 | 0.051 |
| Information and communication technology - Manufacturing | 0.002 | 0.00042 |
| Information and communication technology - Services-producing industries | 0.0531 | 0.0510 |
| Total business sector industries | 1.00 | 1.00 |

Source: Statistics Canada, Table 36-10-0480-01

Table 3 shows Canada's R&D intensity by industry in 2016. In Canada, for total business sector industries, 1.3 per cent of total value added was spent on R&D. The most R&D intensive sector was the ICT sector at 9.0 per cent of value added; manufacturing ICT was particularly R&D intensive at 19.4 per cent of value added. Following the ICT sector, non-ICT services-producing ICT had a R&D intensity of 3.3 per cent of value added. The least R&D intensive sector was the construction sector at 0.07 per cent of value added.

Table 3 also shows New Brunswick's R&D intensity in 2016. The province's total R&D intensity in the business sector was 0.66 per cent of its total value added, approximately half of Canada's. Similar to Canada, the ICT sector was most R&D intensive in New Brunswick at 7.5 per cent of value added. Services-producing industries and other sectors followed with 0.73 per cent and 0.60 per cent of total value added, respectively. New Brunswick's R&D intensity was below the Canadian average for all industries for which data is available.

Table 3: R&D intensity in Canada and New Brunswick, 2016

Panel A: Canada

| Industry | R&D Spending by Industry / VA by Industry |
|--|--|
| Agriculture, forestry, fishing and hunting | 0.0042 |
| Mining, quarrying, and oil and gas extraction | 0.0109 |
| Utilities | 0.0094 |
| Construction | 0.0007 |
| Manufacturing (total = non-ICT + ICT) | 0.0332 |
| Manufacturing (non-ICT) | 0.0305 |
| Services-producing industries (total = non-ICT + ICT) | 0.0121 |
| Services-producing industries (non-ICT) | 0.0054 |
| Other sectors (including agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; and total manufacturing) | 0.0244 |
| Information and communication technology (ICT) sector | 0.0902 |
| Information and communication technology - Manufacturing | 0.1939 |
| Information and communication technology - Services-producing industries | 0.0854 |
| Total business sector industries | 0.0136 |

Panel B: New Brunswick

| Industry | R&D Spending by Industry / VA by Industry |
|--|--|
| Utilities | 0.0011 |
| Construction | 0.00 |
| Services-producing industries | 0.0073 |
| Other sectors (including agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; and total manufacturing) | 0.0060 |
| Information and communication technology (ICT) sector | 0.0751 |
| Total business sector industries | 0.0066 |

Source: Calculated from Tables 1 & 2

As data on R&D expenditures for New Brunswick are restricted for several industries, we calculate these data by assuming that New Brunswick and Canada have the same R&D intensity in each sector (Table 4). These estimates also indicate whether low R&D intensity in New Brunswick compared to Canada could explain the province's low R&D spending. New Brunswick's total business R&D expenditures are estimated to be \$273.4 million. The province would have spent most of its R&D expenditures in the ICT sector (\$93.7 million), particularly services-producing ICT (\$88.0 million).

As discussed previously in Table 1, the business sector in New Brunswick spent \$133 million on R&D in 2016. Therefore, the estimated value of \$273.4 million, assuming that New Brunswick and Canada had the same R&D intensity in each industry, was twice the actual value in 2016. Estimates for the R&D intensive sectors were significantly larger than their respective true values. For examples, the estimated value for the ICT sector was 20.1 per cent higher than the actual value of \$78 million in 2016. These large discrepancies suggest that significant differences in R&D intensity between New Brunswick and Canada could explain New Brunswick's weak performance in business R&D spending.

Table 4: Estimated R&D Expenditures in New Brunswick by Industry, 2016

| Sector | Current Dollars (Millions) |
|--|----------------------------|
| Agriculture, forestry, fishing and hunting | 4.6 |
| Mining, quarrying, and oil and gas extraction | 3.2 |
| Utilities | 8.6 |
| Construction | 1.3 |
| Manufacturing (total) | 103.6 |
| Manufacturing (non-ICT) | 94.8 |
| Services-producing industries (total) | 155.1 |
| Services-producing industries (non-ICT) | 64.1 |
| Other sectors (including agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; and total manufacturing) | 109.7 |
| Information and communication technology (ICT) sector | 93.7 |
| Information and communication technology - Manufacturing | 1.7 |
| Information and communication technology - Services-producing industries | 88.0 |
| Total business sector industries | 273.4 |

Note: Estimates were calculated by multiplying New Brunswick's value added by Canada's R&D intensity [R&D (NB) = VA (NB) * R&D / VA (CAN)]

As Canada and New Brunswick have similar shares of value added across two-digit level industries, differences in industrial structure between Canada and New Brunswick appear unlikely to account for New Brunswick's low business R&D expenditures at this level of disaggregation. However, Canada and New Brunswick have different shares of value added for

more specific industries at the three- and four-digit level—many of which are highly R&D intensive industries (Table 5). The manufacturing sector accounted for 32.9 per cent of Canada’s business R&D spending in 2018. The most R&D intensive industries at the third-digit level in this sector were computer and electronic product manufacturing (19.1 per cent R&D intensity), machinery manufacturing (0.05 R&D per VA), transportation equipment manufacturing (4.5 per cent R&D intensity), and chemical manufacturing (3.9 per cent R&D intensity). In Canada, these four industries accounted for 23.7 per cent of its total business R&D and 72.2 per cent of its R&D spending in manufacturing. In each of these industries, New Brunswick’s shares of nominal value added in 2016 were much lower than Canada’s, which suggests significant differences in industrial structure. In Canada, the four R&D intensive industries in the manufacturing sector comprised 5.3 per cent of nominal value added in the business sector; New Brunswick’s nominal value added was only one-sixth of Canada’s.

Similarly, Canada and New Brunswick have different shares of value added in the most R&D intensive industries in the services-producing sector. Canada’s services-producing industries were important contributors of R&D, representing 60.2 per cent of total business R&D spending in 2018. In particular, three industries constituted 92.2 per cent of R&D spending in the services-producing businesses sector: professional, scientific, and technical services; information and cultural industries; and wholesale trade. However, consistent with the results in the manufacturing sector, these industries are less significant in New Brunswick than in Canada. In 2016, these three industries constituted 19.6 per cent of business sector value added in Canada, whereas they comprised 14.4 per cent of value added in New Brunswick. The province’s economy is, therefore, not concentrated in R&D intensive industries. These findings suggest that New Brunswick’s industrial structure was a major factor in the province’s underperformance in R&D.

Table 5: R&D Spending in Canada (2018) and Nominal Value Added in Canada and New Brunswick (2016)

| Sectors | Canada | | | | New Brunswick |
|--|---------------------|--------------------|-------------------|---------|-------------------|
| | R&D (Millions) 2018 | Shares of R&D 2018 | Shares of VA 2016 | R&D/VA | Shares of VA 2016 |
| Total business sector industries | 17,692 | 1.00 | 1.00 | 0.01289 | 1.00 |
| Agriculture, forestry, fishing and hunting | 179 | 0.0101 | 0.0268 | 0.00486 | 0.0536 |
| Mining and oil and gas extraction | 629 | 0.0356 | 0.0554 | 0.00827 | 0.0145 |
| Utilities | 318 | 0.0180 | 0.0298 | 0.00778 | 0.0450 |
| Construction | 94 | 0.0053 | 0.1049 | 0.00065 | 0.0976 |
| Manufacturing (Total) | 5,813 | 0.3286 | 0.1465 | 0.02891 | 0.1545 |
| Manufacturing (Non-ICT) | 5,110 | 0.2888 | 0.1440 | 0.02585 | 0.1541 |
| Food manufacturing | 168 | 0.0095 | 0.0185 | 0.00661 | 0.0392 |

| Sectors | Canada | | | | New Brunswick |
|---|---------------------|--------------------|-------------------|---------|-------------------|
| | R&D (Millions) 2018 | Shares of R&D 2018 | Shares of VA 2016 | R&D/VA | Shares of VA 2016 |
| Wood product manufacturing | 72 | 0.0041 | 0.0073 | 0.00721 | 0.0198 |
| Paper manufacturing | 150 | 0.0085 | 0.0063 | 0.01743 | 0.0246 |
| Printing and related support activities | 54 | 0.0031 | 0.0032 | 0.01234 | 0.0005 |
| Chemical manufacturing | 800 | 0.0452 | 0.0148 | 0.03928 | 0.0015 |
| Pharmaceutical and medicine manufacturing | 478 | 0.0270 | 0.0040 | 0.08775 | 0.00 |
| All other chemical manufacturing | 323 | 0.0183 | 0.0109 | 0.02165 | 0.0015 |
| Plastic product manufacturing | 158 | 0.0089 | 0.0063 | 0.01820 | 0.0044 |
| Non-metallic mineral product manufacturing | 41 | 0.0023 | 0.0045 | 0.00667 | 0.0036 |
| Primary metal manufacturing | 174 | 0.0098 | 0.0081 | 0.01563 | 0.0017 |
| Fabricated metal product manufacturing | 193 | 0.0109 | 0.0111 | 0.01264 | 0.0077 |
| Machinery manufacturing | 744 | 0.0421 | 0.0104 | 0.05236 | 0.0038 |
| Computer and electronic product manufacturing | 1,191 | 0.0673 | 0.0045 | 0.19079 | 0.0011 |
| Computer and peripheral equipment manufacturing | 78 | 0.0044 | 0.0002 | 0.24822 | 0.000 |
| Communications equipment manufacturing | 309 | 0.0175 | 0.0011 | 0.20204 | 0.000006 |
| Transportation equipment manufacturing | 1,464 | 0.0827 | 0.0237 | 0.04500 | 0.0022 |
| Motor vehicle, motor vehicle body and trailer and motor vehicle parts manufacturing | 330 | 0.0187 | 0.0147 | 0.01632 | 0.0008 |
| Aerospace product and parts manufacturing | 863 | 0.0488 | 0.0066 | 0.09554 | 0.0003 |
| Service-producing businesses (Total) | 10,656 | 0.6023 | 0.6365 | 0.01220 | 0.6348 |
| Service-producing businesses (Non-ICT) | 4,408 | 0.2492 | 0.5835 | 0.00550 | 0.5838 |
| Wholesale trade | 1,730 | 0.0978 | 0.0730 | 0.01727 | 0.0501 |
| Retail trade | 84 | 0.0047 | 0.0714 | 0.00086 | 0.0942 |

| Sectors | Canada | | | | New Brunswick |
|--|---------------------|--------------------|-------------------|---------|-------------------|
| | R&D (Millions) 2018 | Shares of R&D 2018 | Shares of VA 2016 | R&D/VA | Shares of VA 2016 |
| Information and cultural industries | 2,264 | 0.1280 | 0.0412 | 0.04004 | 0.0423 |
| Software publishers | 972 | 0.0549 | 0.0048 | 0.14631 | 0.0013 |
| Telecommunications and data processing, hosting, and related services | 1,037 | 0.0586 | 0.0272 | 0.02780 | 0.0368 |
| Finance, insurance and real estate and rental and leasing | 300 | 0.0170 | 0.1555 | 0.00141 | 0.1318 |
| Professional, scientific and technical services | 5,832 | 0.3296 | 0.0816 | 0.05209 | 0.0514 |
| Architectural, engineering and related services | 457 | 0.0258 | 0.0167 | 0.01988 | 0.0121 |
| Scientific research and development services | 1,811 | 0.1024 | 0.0039 | 0.34108 | 0.0012 |
| Computer systems design and related services | 3,276 | 0.1852 | 0.0211 | 0.11327 | 0.0129 |
| Administrative and support, waste management and remediation services | 93 | 0.0053 | 0.0401 | 0.00169 | 0.0626 |
| ICT Sector | 6,951 | 0.3929 | 0.0556 | 0.09116 | 0.0515 |
| ICT - Manufacturing | 703 | 0.0397 | 0.0025 | 0.20751 | 0.0004 |
| ICT - Services-producing Industries | 6,248 | 0.3532 | 0.0531 | 0.08575 | 0.0510 |
| Other industries (Including agriculture, forestry, fishing, and hunting; mining and oil and gas extraction; and manufacturing) | 6,624 | 0.3744 | 0.2287 | 0.02110 | 0.2226 |

Source: Statistics Canada, Table 27-10-0333-01 & Table 36-10-0480-01

iii. Trends in New Brunswick

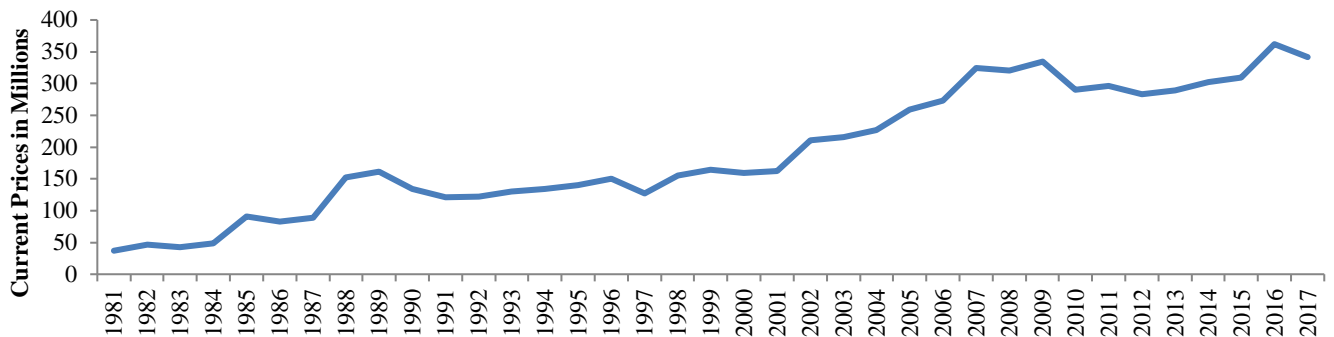
a. R&D Spending

In New Brunswick, R&D spending in current dollars for all performer sectors increased from 1981 to 2017 (Chart 4). Total R&D spending increased from \$37 million to \$342 million (in current prices) in 2017. In constant 2012 prices, total R&D spending grew 143.6 per cent from \$125 million in 1981 to \$304 million in 2017 (Chart 5).¹⁶ Similarly, in current prices, government R&D spending rose from \$22 million in 1981 to \$39 million in 2017, and higher education R&D spending rose from \$9 million in 1981 to \$187 million in 2017.

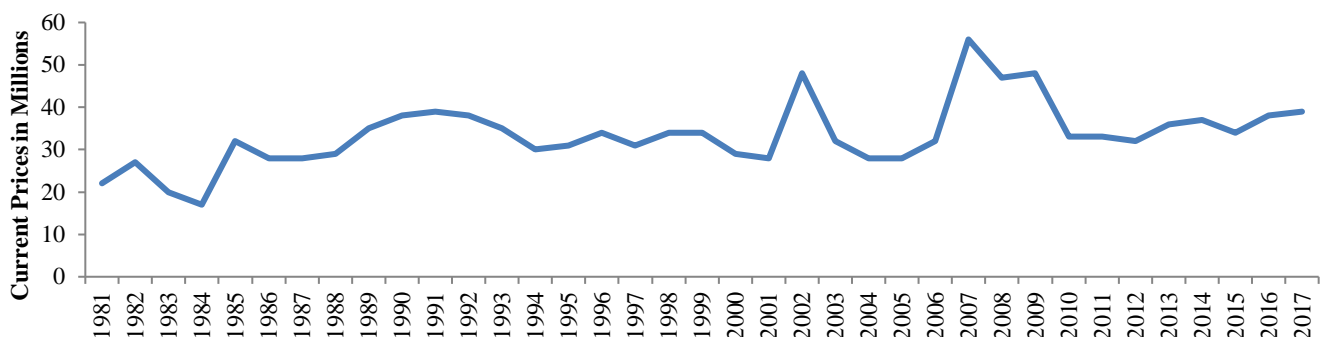
The business sector also saw a substantial increase, rising from \$5 million to \$111 million in 2017, but experienced more volatility compared to the other sectors; in particular, business R&D spending rose from 1981 to 1989 but decreased sharply until 1995.

Chart 4: R&D Spending by Performer Sector in New Brunswick, Current Dollars, 1981-2017

Panel A: Total R&D Spending

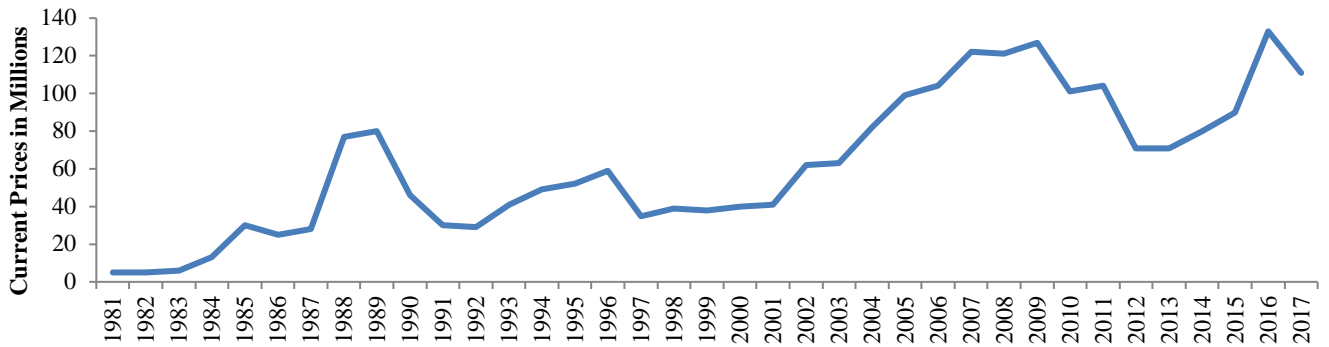


Panel B: Government

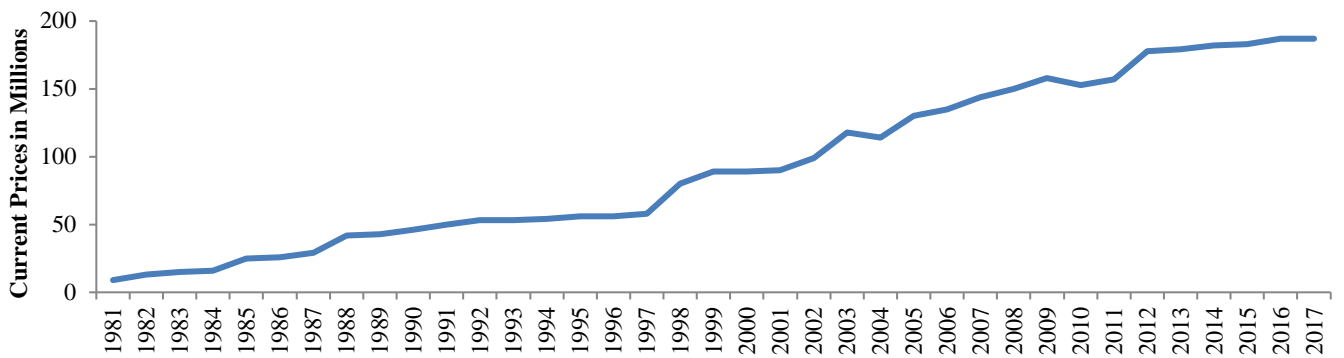


¹⁶ Refer to database Table 2 for absolute R&D spending over time by performer sector in current and constant 2012 prices.

Panel C: Business

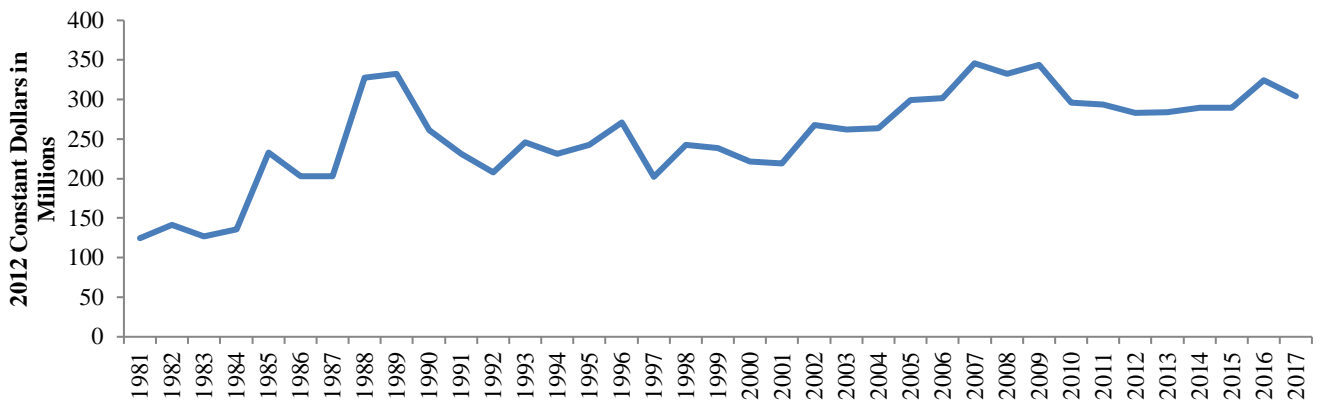


Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0273-01

Chart 5: Total R&D Spending by Performer Sector in New Brunswick, Constant 2012 Dollars, 1981-2017



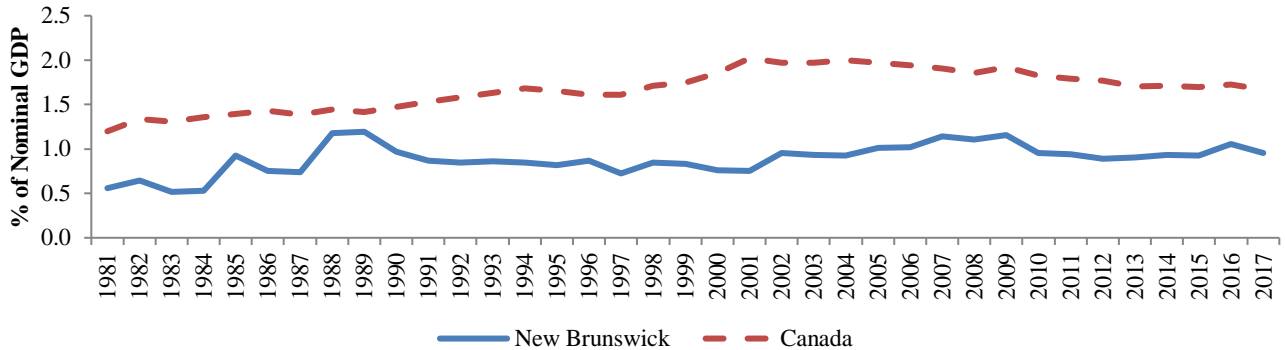
Source: Statistics Canada, Table 27-10-0273-01 & Table 36-10-0098-01

b. R&D Intensity

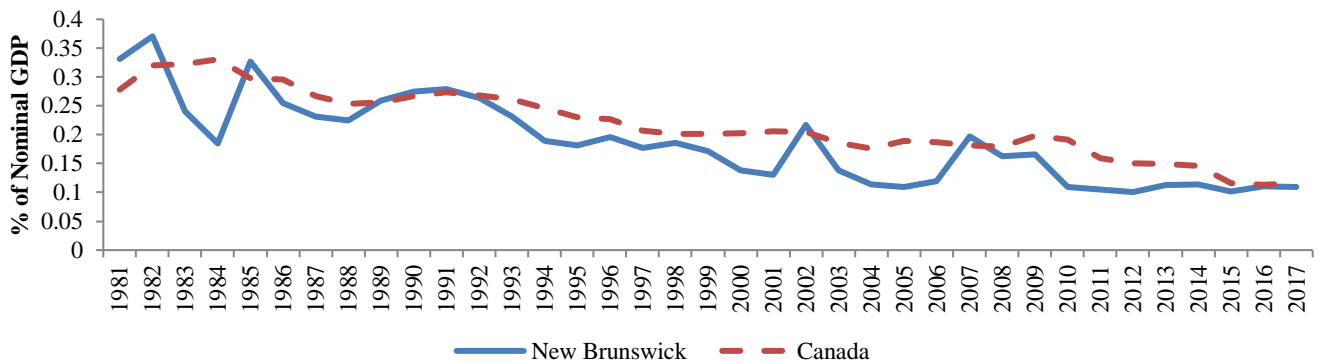
New Brunswick's R&D intensity increased between 1981 and 2017 across most performer sectors (Chart 6).¹⁷ Total R&D intensity increased by 0.41 percentage points from 0.54 per cent of nominal GDP in 1981 to 0.95 per cent in 2017. R&D spending performed by the higher education sector increased by 0.38 percentage points from 0.14 per cent of nominal GDP in 1981 to 0.52 per cent in 2017, while R&D spending performed by the business sector grew by 0.23 percentage points from 0.08 per cent of nominal GDP in 1981 to 0.31 per cent in 2017. However, the government sector saw a decline over the period; R&D spending performed by this sector decreased by 0.22 percentage points from 0.33 per cent of nominal GDP in 1981 to 0.11 per cent in 2017.

Chart 6: R&D Intensity by Performer Sector in Canada and New Brunswick, 1981-2017

Panel A: Total R&D Spending

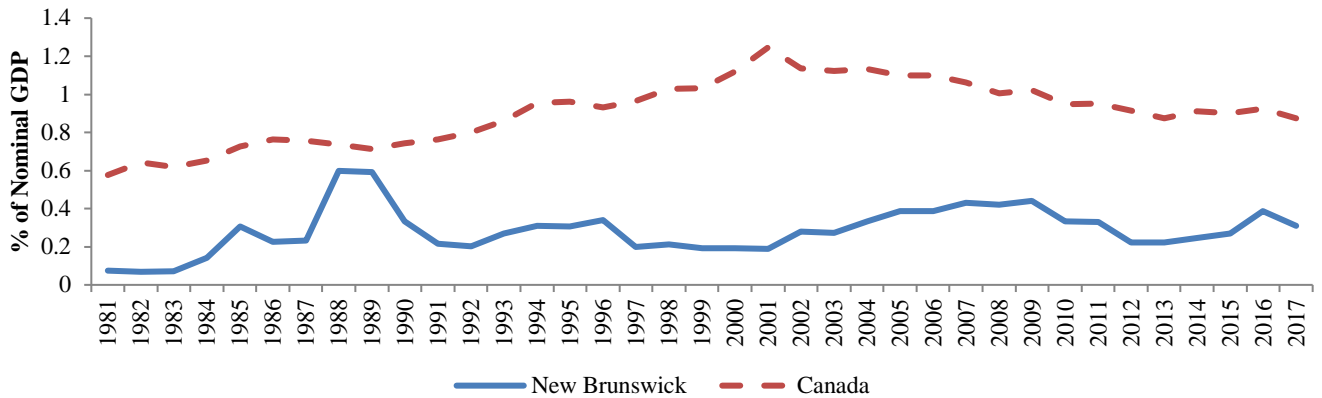


Panel B: Government

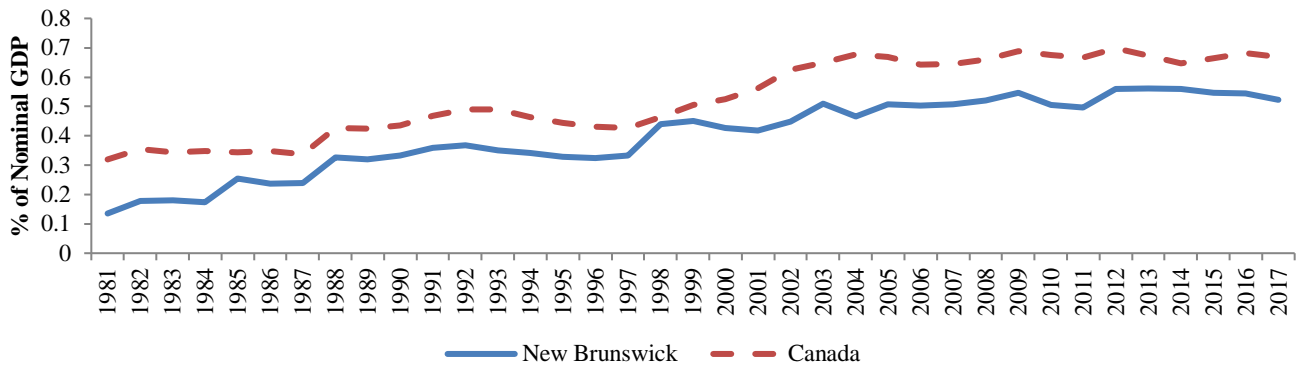


¹⁷ Note that due to inflation and economic growth, R&D intensity is a better measure of R&D trends than absolute R&D spending.

Panel C: Business



Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0273-01, Table 36-10-0222-01, & Table 36-10-0104-01

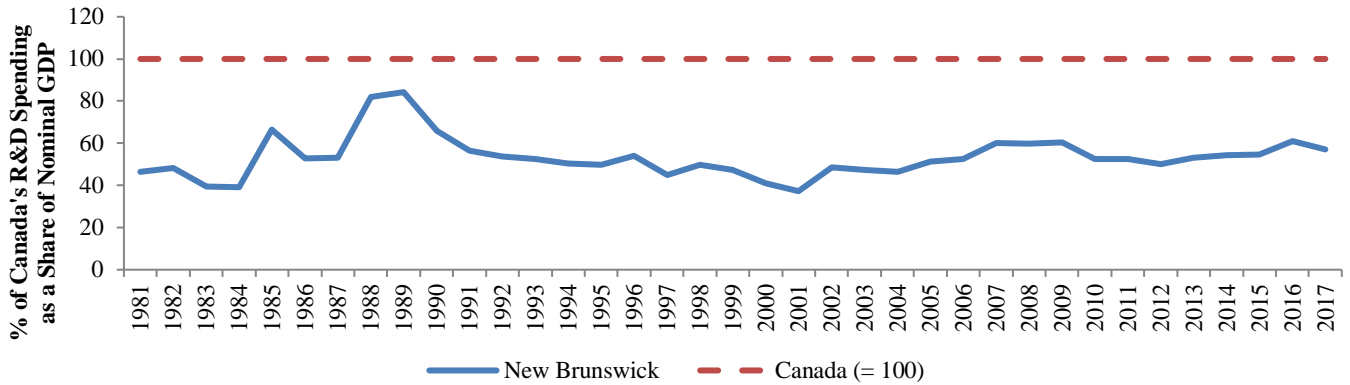
c. R&D Intensity Relative to Canada’s

Although New Brunswick’s upward trend in R&D intensity is encouraging, it is important to consider how the province’s R&D intensity compared to the national average over time. Chart 7 shows New Brunswick’s R&D intensity relative to Canada’s from 1981 to 2017. New Brunswick’s R&D intensity was almost always below Canada’s for each performer sector for the entire period, except the government sector in eight years. By 2017, New Brunswick’s R&D intensity in all performer sectors remained below Canada’s. The government sector had the highest relative R&D spending in New Brunswick at 93.5 per cent of Canada’s, while the higher education sector followed with 77.9 per cent of Canada’s. The business sector had the lowest relative R&D spending in New Brunswick at 35.5 per cent of Canada’s, which may have driven the province’s low total R&D intensity relative to Canada’s at 57.2 per cent.

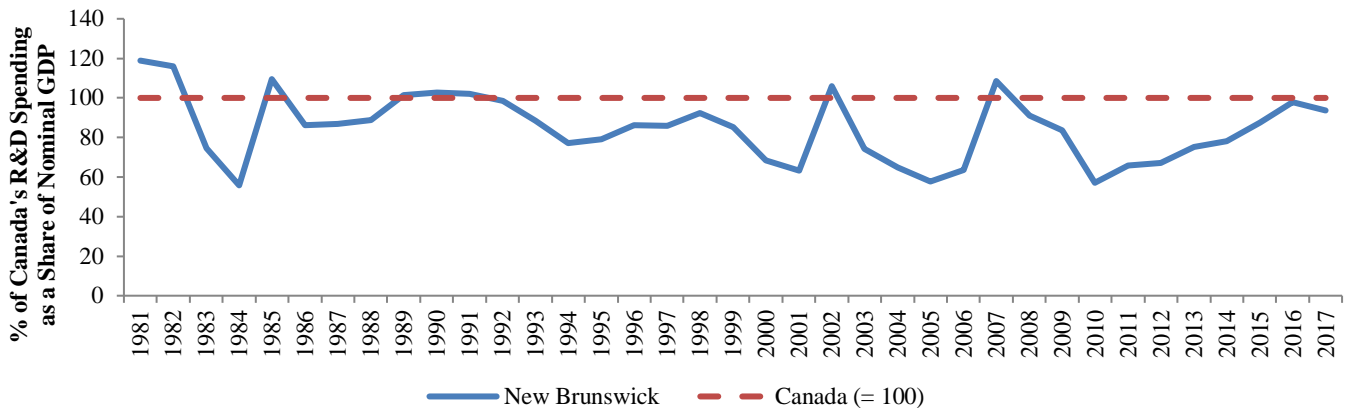
As noted previously, the province’s business R&D spending saw a notable increase in the 1980s. R&D intensity relative to Canada also increased during this period, peaking at 83.4 per cent in 1989. This increase in business R&D in the 1980s is likely linked with the height of

NBTel, the province’s major telecommunications corporation at the time.¹⁸ However, between 1990 and 2018, the province’s R&D intensity relative to Canada’s never again came close to its peak level, averaging only 30.4 per cent of Canada’s. Additional research is required to determine why the province was unable to maintain its progress in business R&D from the 1980s.

Chart 7: R&D Intensity by Performer Sector in New Brunswick Relative to Canada’s, 1981-2017
Panel A: Total R&D Spending

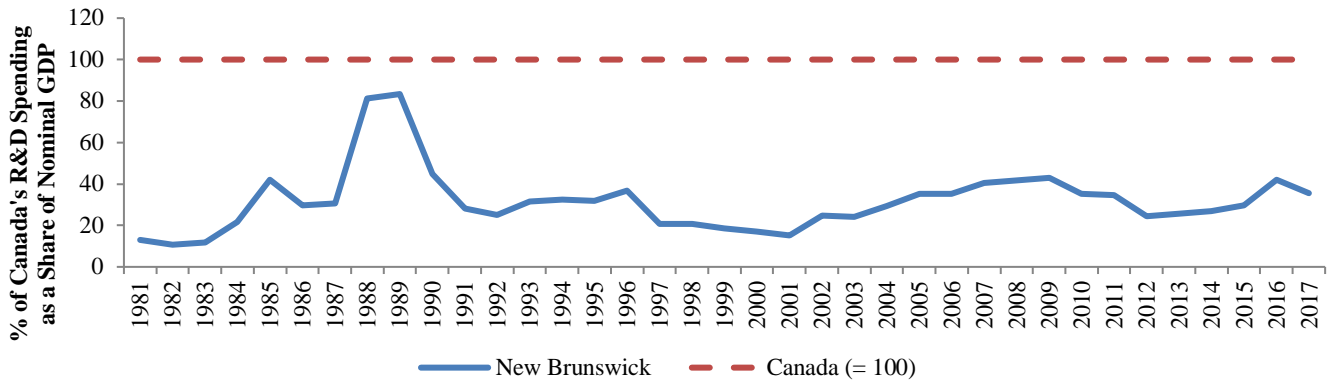


Panel B: Government

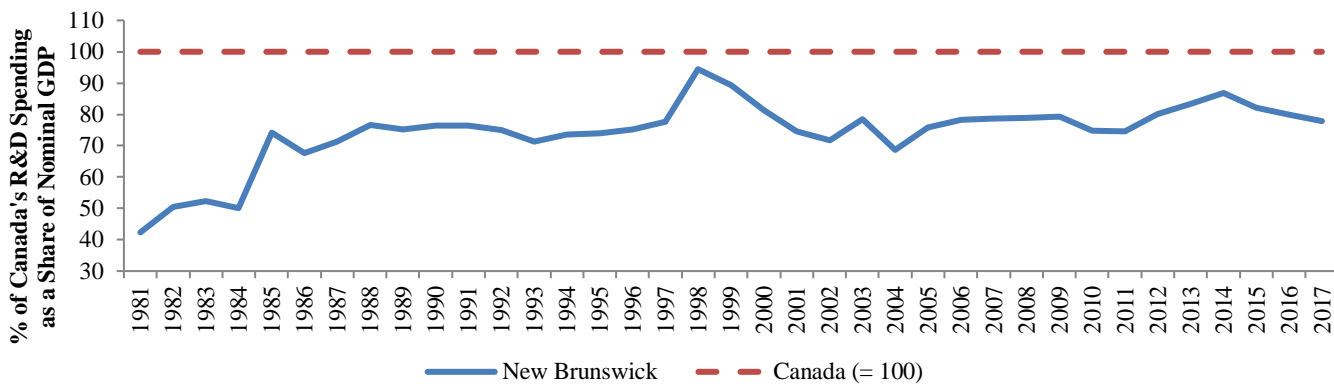


¹⁸ NBTel was a major driver of innovation and entrepreneurship in New Brunswick until it was merged with Bell in 2006 (Emery, 2020a., “From living lab to living museum”).

Panel C: Business



Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0273-01, Table 36-10-0222-01, & Table 36-10-0104-01

While New Brunswick’s R&D intensity for all performer sectors remained lower than Canada’s by the end of the period, the province’s R&D intensity relative to Canada’s did increase from 1981 to 2017 for the total, business, and higher education sectors (Chart 7). Total R&D spending in New Brunswick relative to Canada’s increased by 10.8 percentage points from 46.4 per cent of Canada’s in 1981 to 57.2 per cent in 2017. After peaking in 1989 at 83.4 per cent of Canada’s, relative R&D spending performed by the business sector in New Brunswick declined to 35.5 per cent in 2017, which exceeded the level in 1981 by 22.5 percentage points. New Brunswick’s relative R&D spending performed by the higher education sector increased even more substantially over this period. R&D spending in the higher education sector in New Brunswick relative to Canada’s increased by 35.6 percentage points from 42.3 per cent of Canada’s in 1981 to 77.9 per cent in 2017.

In contrast, New Brunswick’s relative R&D spending in the government sector declined from 1981 to 2017. In 1981, relative R&D spending was 118.9 per cent of Canada’s, which was the highest in the period. By 2017, New Brunswick’s relative R&D spending for the government sector was 93.5 per cent of Canada’s, marking a 25.4 percentage-point decrease from the beginning of the period.

New Brunswick was not a major player in Canada's R&D spending in 2017. New Brunswick's total R&D spending comprised only 0.96 per cent of Canada's.¹⁹ This share was less than half of the province's share of the national population in 2017 at 2.1 per cent. Of the performer sectors, New Brunswick's R&D spending performed by the government sector had the largest share at 1.57 per cent of Canada's. The higher education sector followed with 1.30 per cent of Canada's. New Brunswick's R&D spending performed by the business sector had the smallest share at 0.59 per cent of Canada's, which is consistent with the province's lowest relative R&D spending in this sector.

New Brunswick's R&D spending as a share of Canada's generally increased over the period. For total R&D spending, New Brunswick's share of Canada's increased by 0.12 percentage point from 0.84 per cent of Canada's in 1981 to 0.96 per cent in 2017. The higher education sector had the largest increase at 0.54 percentage point from 0.76 per cent of Canada's in 1981 to 1.3 per cent in 2017. New Brunswick's R&D spending performed by the business sector as a share of Canada's also increased, though less substantially by 0.36 percentage point from 0.24 per cent in 1981 to 0.59 per cent in 2017. This level in 2017 was much lower than New Brunswick's peak share in 1989 at 1.67 per cent of Canada's. In contrast to the other sectors, the government sector declined by 0.58 percentage point from 2.15 per cent of Canada's in 1981 to 1.57 per cent in 2017. These trends for each sector are consistent with the trends for New Brunswick's R&D spending relative to Canada's.

¹⁹ Refer to Appendix Chart 2 for New Brunswick's R&D spending as a share of Canada's from 1981 to 2017.

B. R&D Personnel

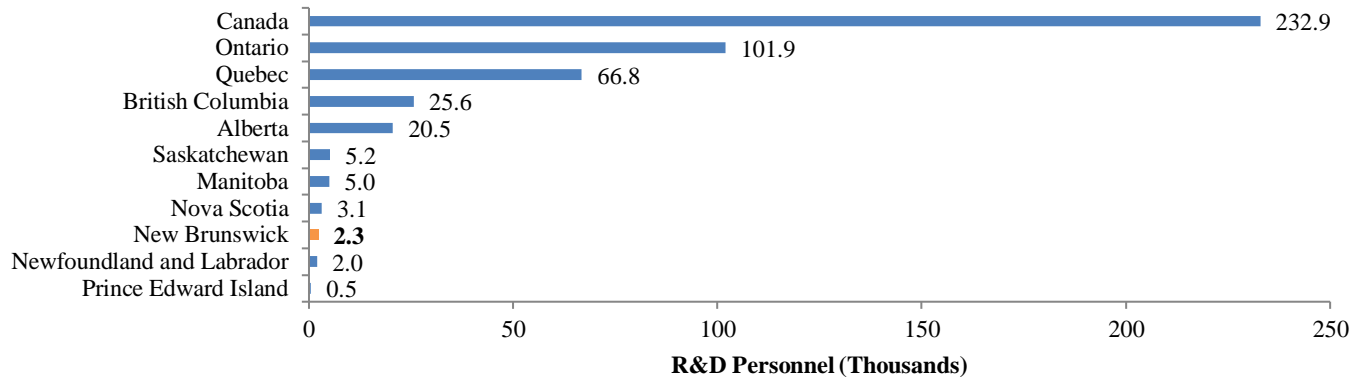
i. Cross-Sectional Analysis by Province

a. R&D Personnel

R&D personnel is another standard indicator of innovation. Statistics Canada (2013) defines R&D personnel as researchers, technicians, and support staff working in research and development. Chart 8 shows the R&D personnel in Canada by performer sector in each province in 2013.²⁰ New Brunswick had 2,280 personnel working in R&D. Most of the province's R&D personnel worked in the higher education sector (1,330 employees). New Brunswick's business sector had 720 R&D personnel, while the government sector had the least with 240 R&D employees.²¹

Chart 8: R&D Personnel by Performer Sector and Province, 2013

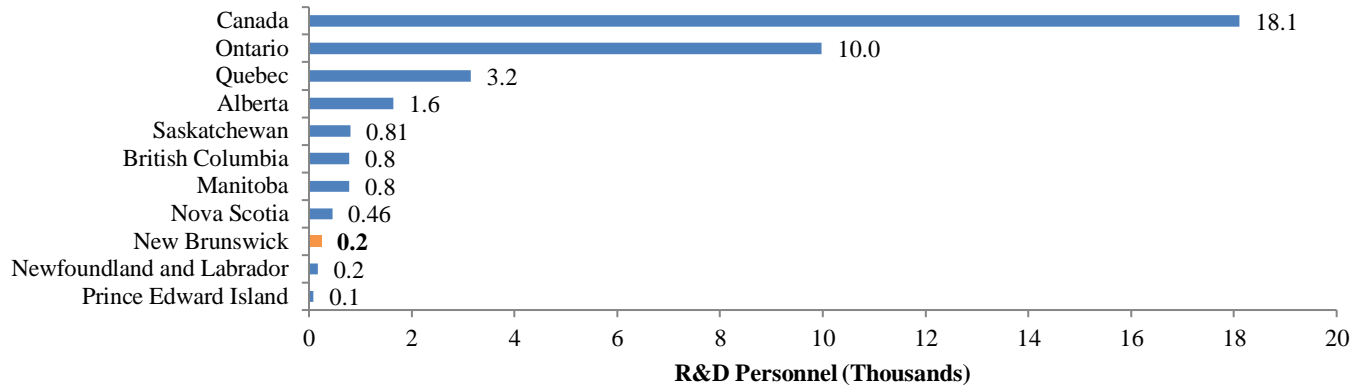
Panel A: Total R&D Personnel



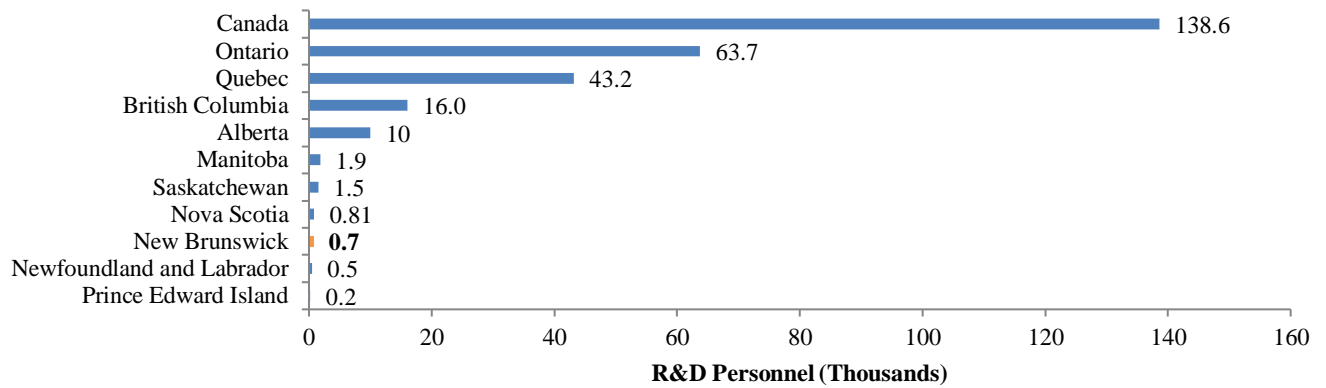
²⁰ Statistics Canada only provides provincial level data up to the reference year 2013. Due to a redesign in the database, data for R&D personnel are no longer available by province. Recent R&D personnel data up to 2019 is only available for Canada.

²¹ New Brunswick spent \$126,754 (in current dollars) of R&D spending per R&D employee in 2013. The province spent the most on the government and higher education sectors with \$150,000 per person and \$134,586 per person, respectively. It spent the least on the business sector at \$98,611 per person. Refer to Appendix Chart 3 for R&D spending per R&D employee by performer sector and province in 2013.

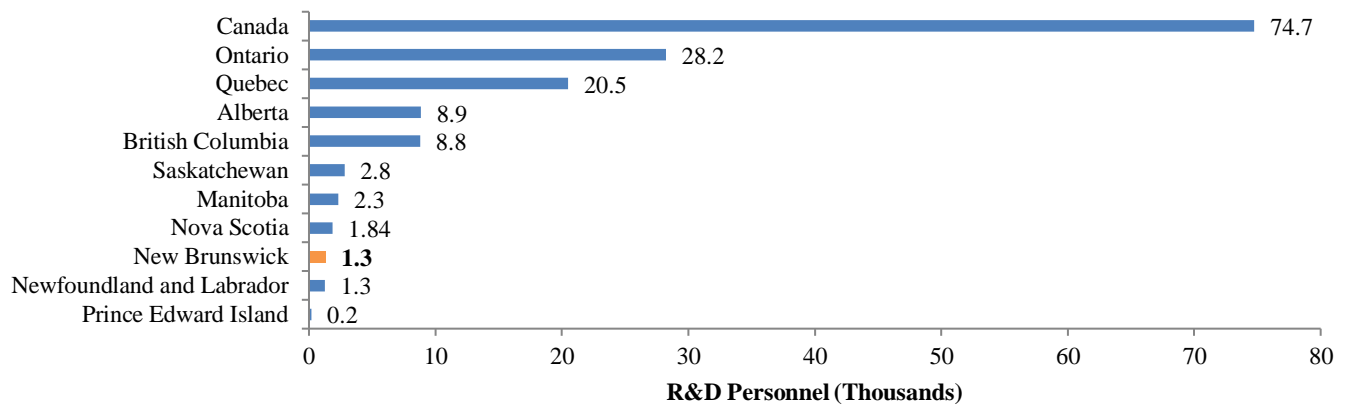
Panel B: Government



Panel C: Business



Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0023-01

New Brunswick’s R&D personnel, and the Atlantic provinces in general, had few R&D personnel relative to the other provinces (Chart 8). New Brunswick ranked eighth for every performer sector, due to its relatively small population. The province’s R&D personnel in every sector only exceeded those of Newfoundland and Labrador and Prince Edward Island.

b. R&D Personnel as a Share of Total Employment

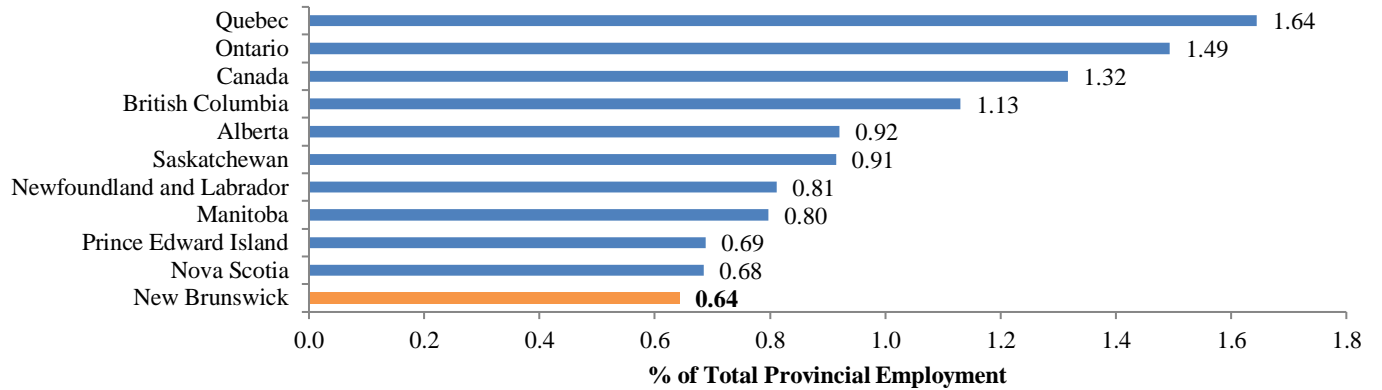
Chart 9 compares the number of R&D personnel as a share of total employment by performer sector in every province in 2013. New Brunswick had 0.64 per cent of its total employment working in R&D. The province had its largest share of employees in the higher education sector at 0.38 per cent of its total employment, followed by the business sector at 0.20 per cent and government at 0.07 per cent.

For total R&D personnel, New Brunswick had the lowest share among the provinces (Chart 9). The other Atlantic provinces also had relatively low shares of total R&D personnel. Quebec and Ontario ranked the highest with 1.64 per cent and 1.49 per cent of their total employment, respectively, exceeding New Brunswick by 1.0 and 0.85 percentage points, respectively. The Western Provinces followed Quebec and Ontario, but fared better than the Atlantic provinces.

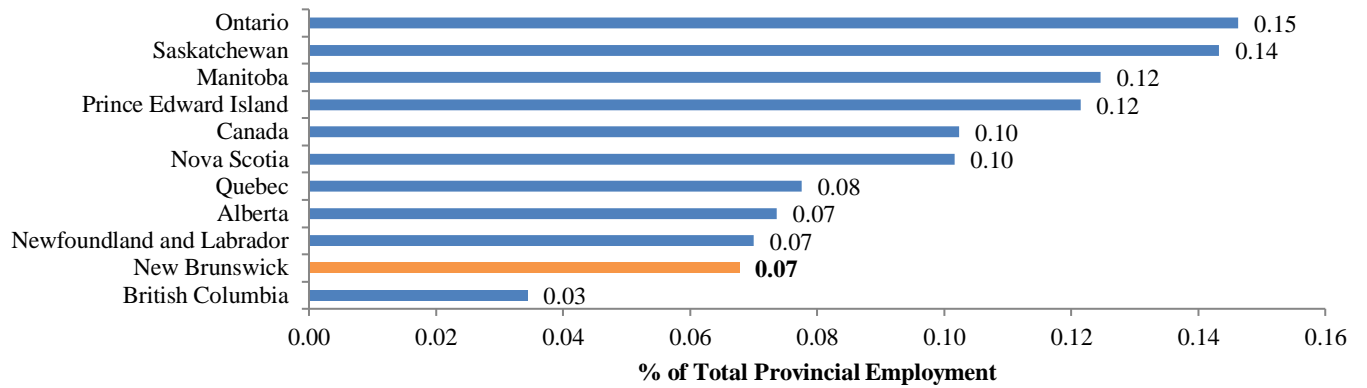
Among the three performer sectors New Brunswick's number of R&D personnel as a share of total employment also ranked low (Chart 9). For the higher education sector, New Brunswick ranked eighth of the ten provinces, and was the second lowest of the Atlantic provinces. Newfoundland and Labrador ranked first in the higher education sector with 0.53 per cent of its total employed as R&D personnel, exceeding New Brunswick by 0.15 percentage points. For the business sector, New Brunswick fared relatively worse, ranking ninth among the provinces and exceeding only Nova Scotia by 0.02 percentage points. Quebec, which had the highest share of R&D personnel in the business sector, topped New Brunswick by 0.86 percentage points. Finally, New Brunswick ranked ninth among the provinces in the government sector, and fared the worst among the Atlantic provinces. New Brunswick's R&D personnel in the government sector as a share of total employment was 0.08 percentage points lower than Ontario, the highest ranked province with 0.15 per cent of its total employment as R&D personnel in the government sector.

Chart 9: R&D Personnel by Performer Sector as a Share of Total Employment by Province, 2013

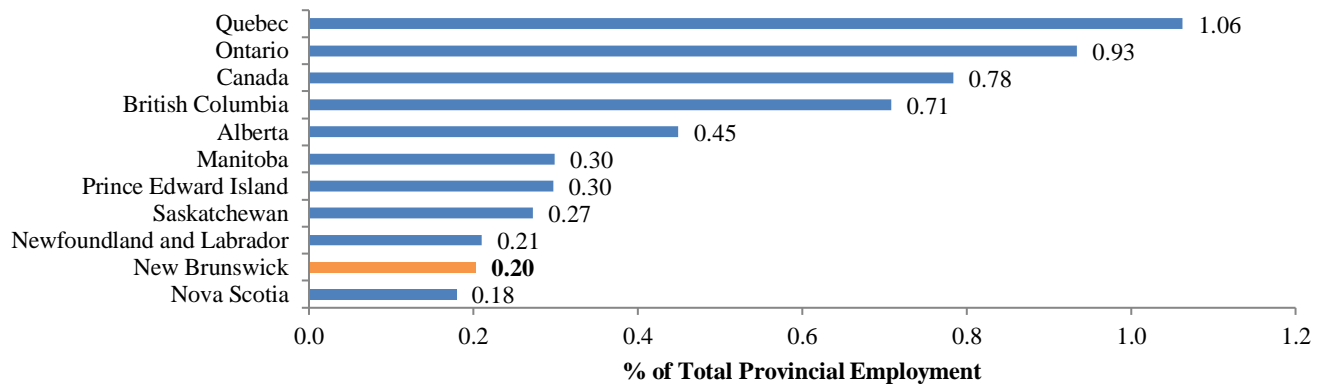
Panel A: Total R&D Personnel



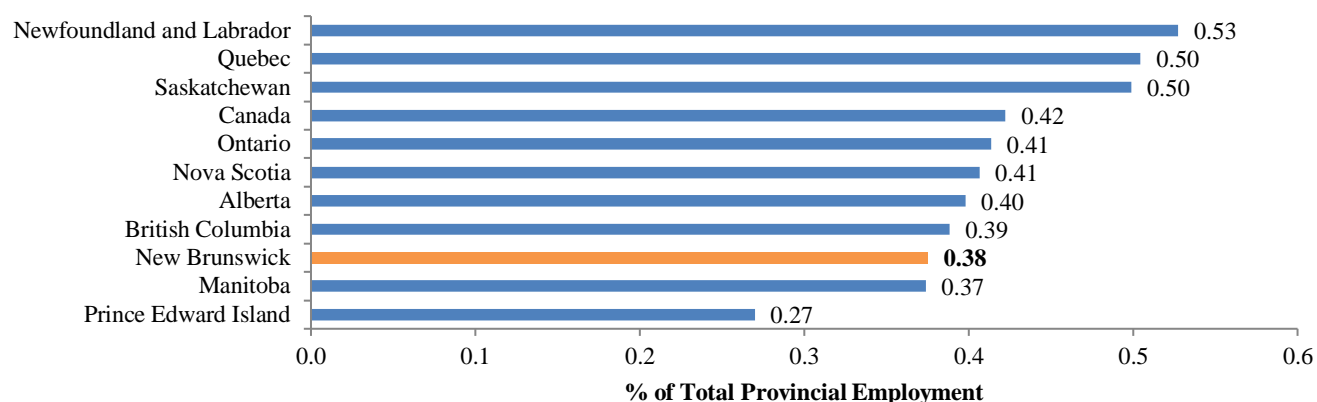
Panel B: Government



Panel C: Business



Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0023-01 & Table 14-10-0090-01

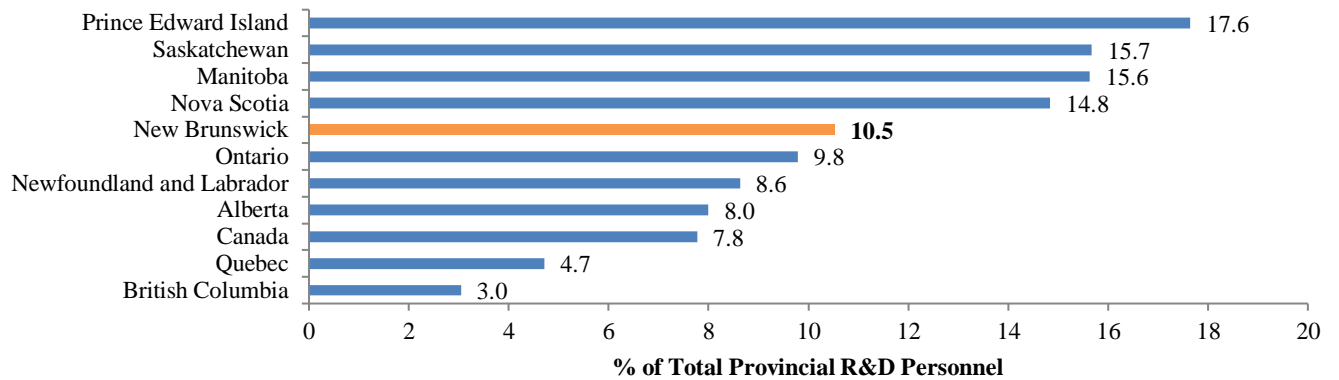
c. Relative Importance of Each Performer Sector to Total R&D Personnel

Chart 10 shows the R&D personnel by performer sector as a share of total R&D personnel for every province in 2013. New Brunswick had its highest share of R&D personnel in the higher education sector at 58.3 per cent of its total R&D personnel. The business sector followed with 31.6 per cent of its total R&D personnel, and the government sector had the lowest share of R&D personnel at 10.5 per cent.

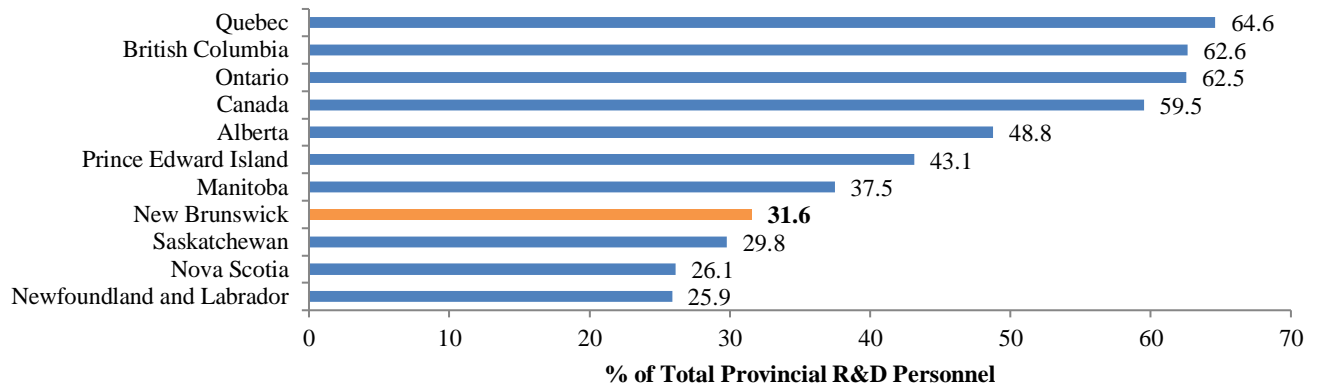
The Atlantic provinces generally had higher shares of R&D personnel in the higher education and government sectors compared to the other provinces (Chart 10). In the higher education sector, New Brunswick ranked third, following Newfoundland and Labrador at 65.0 per cent of its total R&D personnel and Nova Scotia at 59.4 per cent. Prince Edward Island was the exception, ranking seventh at 39.2 per cent of its total R&D personnel. In the government sector, New Brunswick ranked fifth, while Prince Edward Island ranked first at 17.6 per cent of its total R&D personnel and Nova Scotia ranked fourth at 14.8 per cent. The Atlantic provinces, however, had lower shares of R&D personnel in the business sector compared to the other provinces. The provinces with the highest share of R&D spending in the business sector—Quebec, British Columbia, and Ontario—had the highest shares of R&D personnel in this sector. Quebec, the highest ranked province, had 64.6 per cent of its total R&D personnel in the business sector, about twice as large as New Brunswick’s share. While the Atlantic provinces generally had higher shares of total R&D personnel in the higher education and government sectors and lower shares in the business sector, Quebec, British Columbia, and Ontario had relatively higher shares in the business sector and lower shares in the higher education and government sectors.

Chart 10: R&D Personnel by Performance Sector as a Share of Total R&D Personnel by Province, 2013

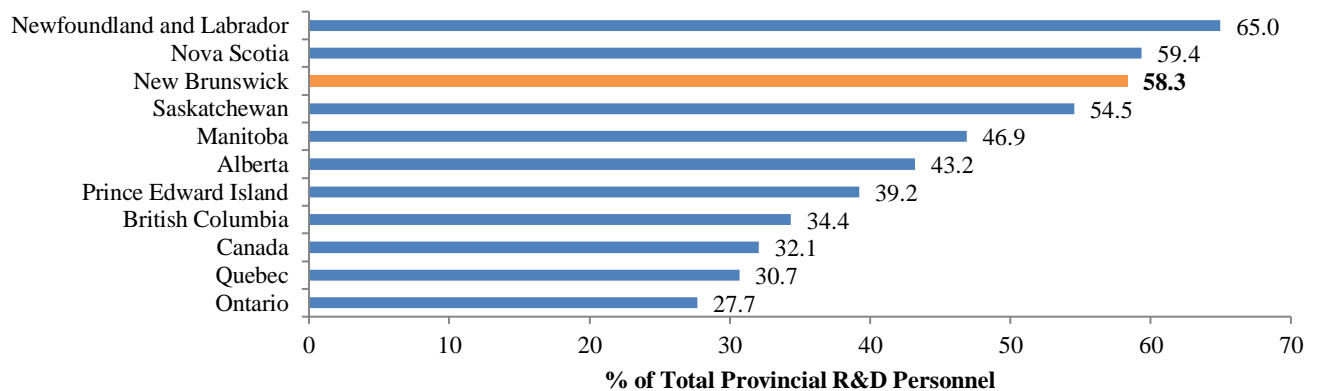
Panel A: Government



Panel B: Business



Panel C: Higher Education



Source: Statistics Canada, Table 27-10-0023-01

Consistent with the findings in Chart 10, New Brunswick had its highest share of Canada’s R&D personnel in the higher education sector at 1.78 per cent of Canada’s total.²² The government sector followed closely with 1.33 per cent of Canada’s R&D personnel in this sector. The business sector had the smallest share of the performing sectors; New Brunswick’s R&D personnel in the business sector comprised 0.52 per cent of Canada’s R&D personnel in this sector. This relatively low share in the business sector drove down New Brunswick’s total R&D personnel as a share of Canada’s. New Brunswick’s total personnel made up only 0.98 per cent of Canada’s total R&D personnel.

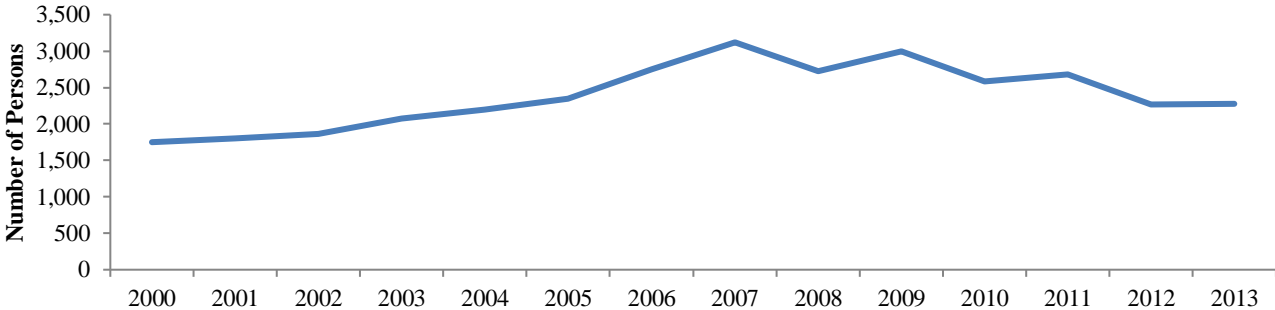
ii. Trends over Time in New Brunswick

a. R&D Personnel

R&D personnel increased in New Brunswick for all performer sectors, except the government sector, from 2000 to 2013 (Chart 11).²³ Total R&D personnel rose 30.3 per cent from 1,750 employees in 2000 to 2,280 employees in 2013. Despite this improvement, however, the province’s 2013 level was much lower than its peak 2007 level of 3,120 employees. Similarly, the business sector saw a 26.3 per cent increase from 570 employees in 2000 to 720 employees in 2013, which was lower than the peak 2007 level of 1,590 employees. The higher education sector enjoyed the greatest increase; R&D personnel increased 58.3 per cent from 840 employees in 2000 to 1,330 employees in 2013.

However, the government sector was the outlier among the performer sectors. This sector saw a significant decline in its R&D employees over the period. R&D personnel fell 27.3 per cent from 330 employees in 2000 to 240 employees in 2013.

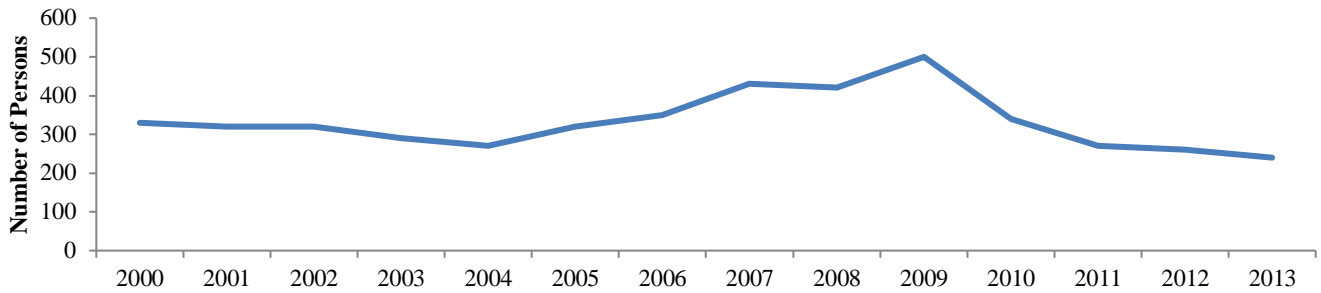
Chart 11: R&D Personnel by Performer Sector in New Brunswick, 2000-2013
Panel A: Total R&D Personnel



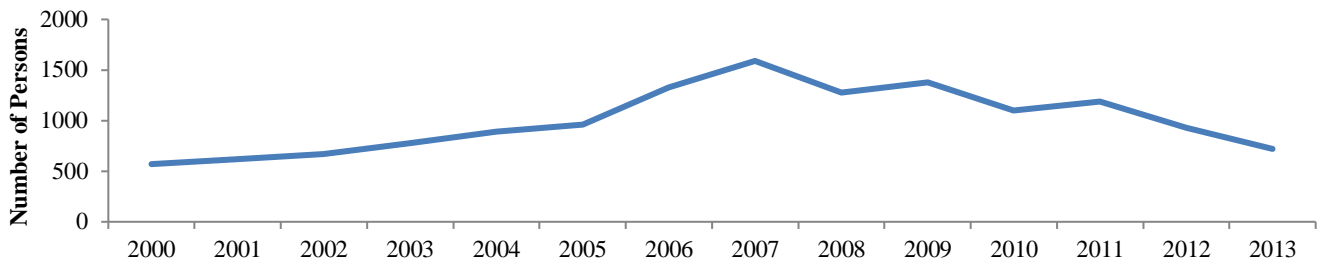
²² Refer to Appendix Chart 4 for the R&D personnel in New Brunswick as a share of Canada’s R&D personnel in 2013.

²³ Refer to database Table 4 for R&D personnel in New Brunswick from 2000 to 2013.

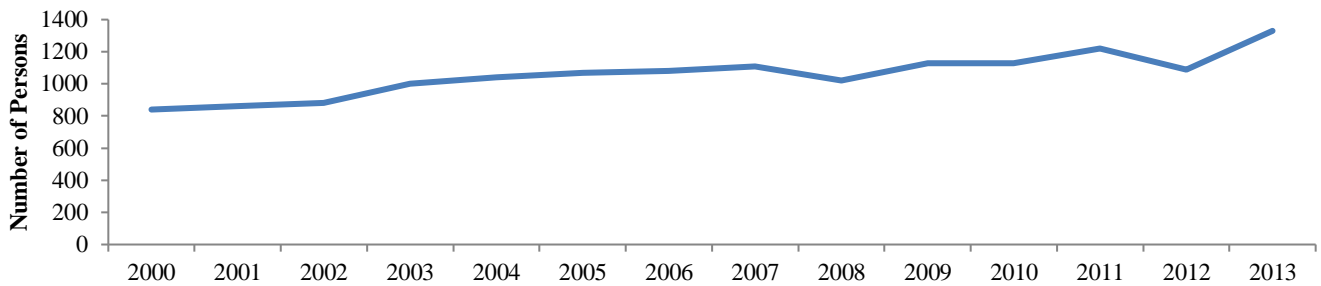
Panel B: Government



Panel C: Business



Panel D: Higher Education



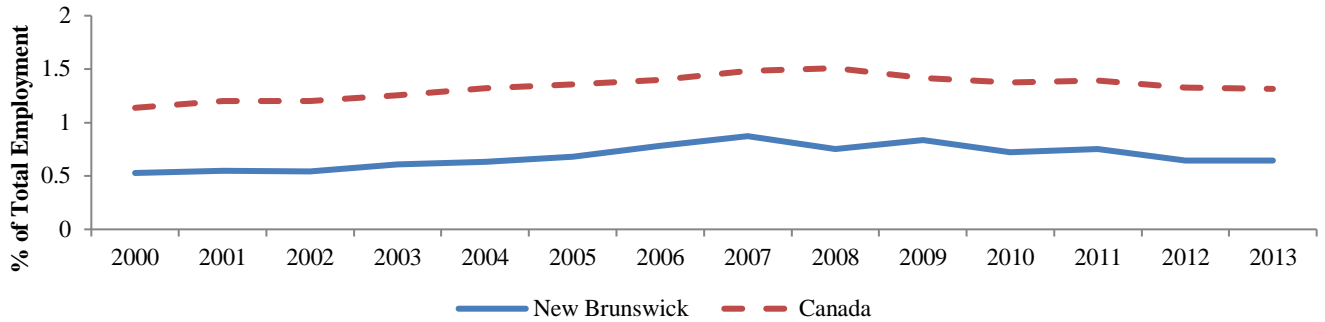
Source: Statistics Canada, Table 27-10-0023-01

b. R&D Personnel as a Share of Total Employment

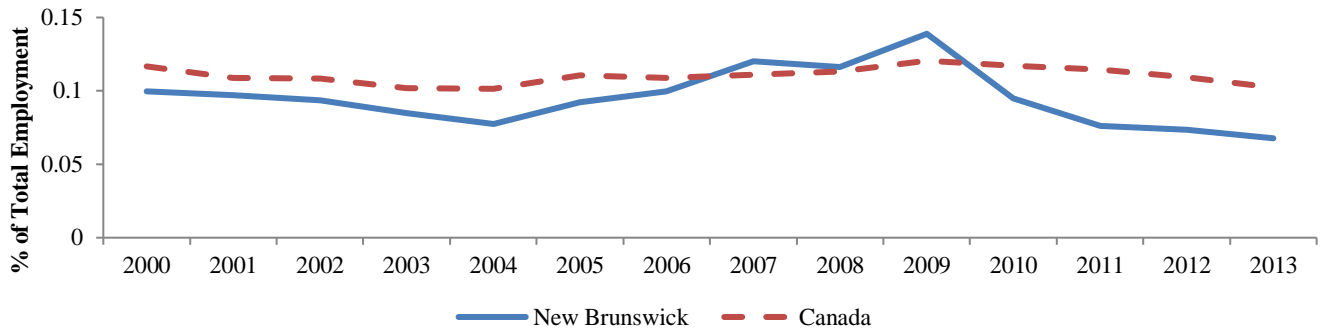
New Brunswick's R&D personnel as a share of total employment increased from 2000 to 2013 for every performer sector apart from the government sector (Chart 12). New Brunswick's R&D personnel in total and the higher education sector increased by 0.12 percentage points. The province's R&D personnel in the business sector increased slightly by 0.03 percentage points. After peaking at 0.14 per cent of total employment in 2009, R&D personnel in the government sector in New Brunswick fell to 0.07 per cent in 2013, 0.03 percentage points lower than the share in 2000.

Chart 12: R&D Personnel by Performer Sector as a Share of Total Employment in New Brunswick and Canada, 2000-2013

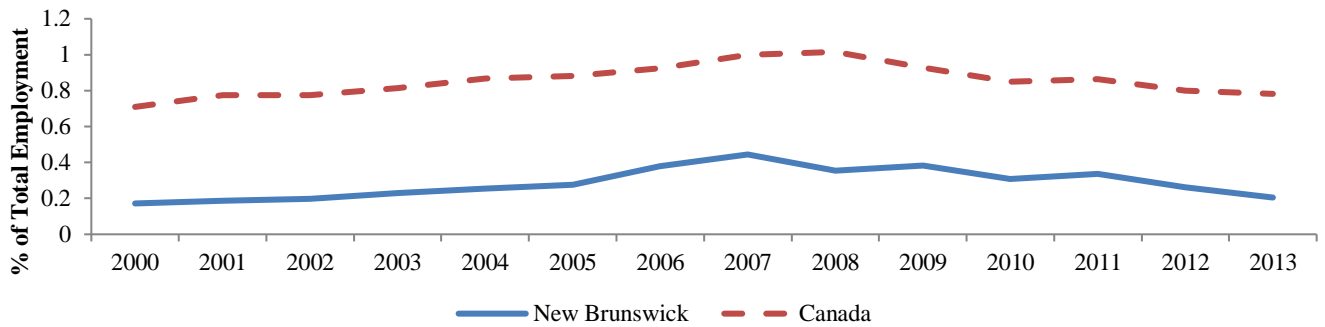
Panel A: Total R&D Personnel



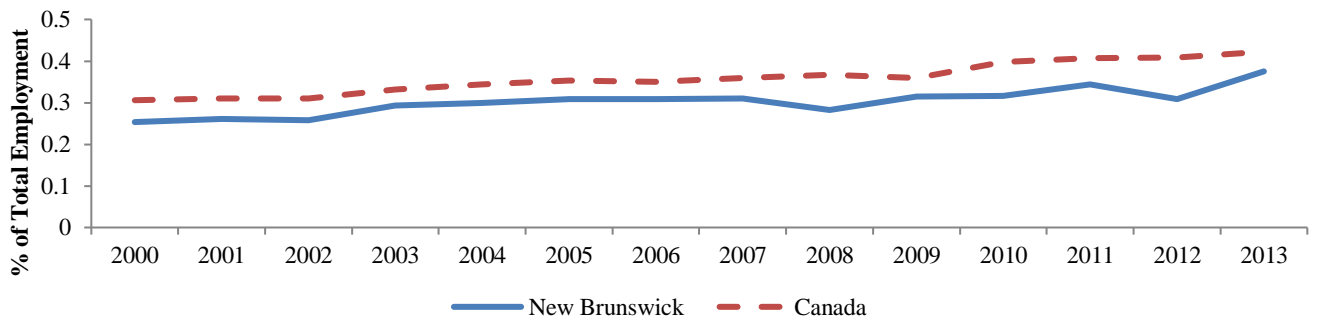
Panel B: Government



Panel C: Business



Panel D: Higher Education



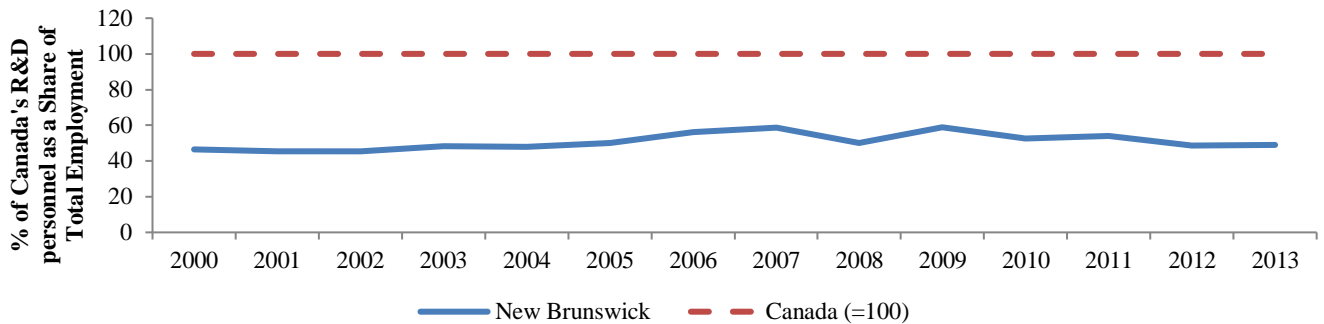
Source: Statistics Canada, Table 27-10-0023-01 & Table 14-10-0090-01

c. R&D Personnel as a Share of Total Employment Relative to Canada's

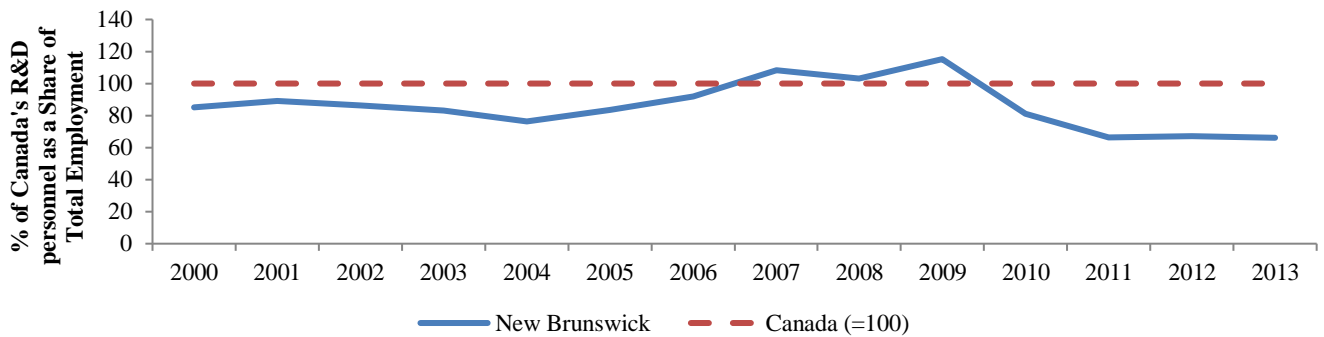
Chart 13 shows New Brunswick's relative R&D personnel as a share of total employment from 2000 to 2013. R&D personnel in New Brunswick remained lower than Canada's throughout the period for every sector apart from the government sector. Most notably, the business sector had a significantly smaller share of R&D personnel relative to Canada compared to the other sectors. On average over the period, New Brunswick's R&D personnel as a share of total employment was 32.7 per cent of Canada's in the business sector, compared to 85.8 per cent in the government sector and 84.3 per cent in the higher education sector.

Chart 13: R&D Personnel by Performer Sector as a Share of Total Employment in New Brunswick Relative to Canada's, 2000-2013

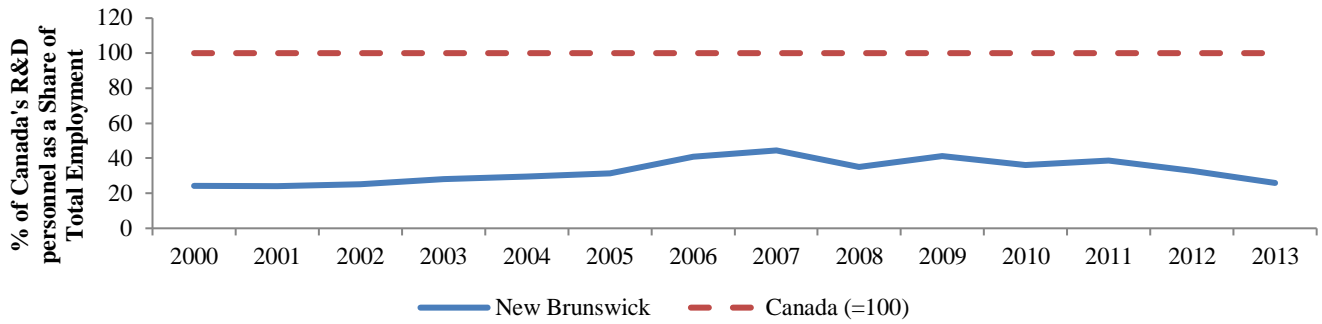
Panel A: Total R&D Personnel



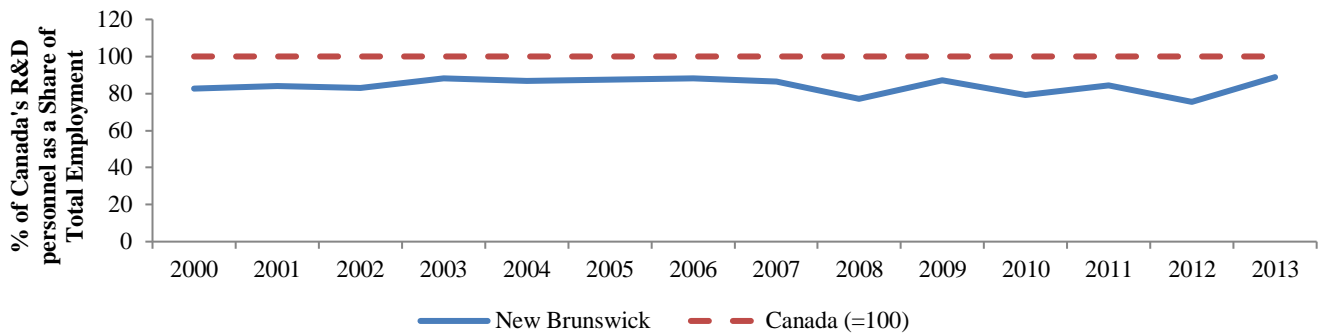
Panel B: Government



Panel C: Business



Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0023-01 & Table 14-10-0090-01

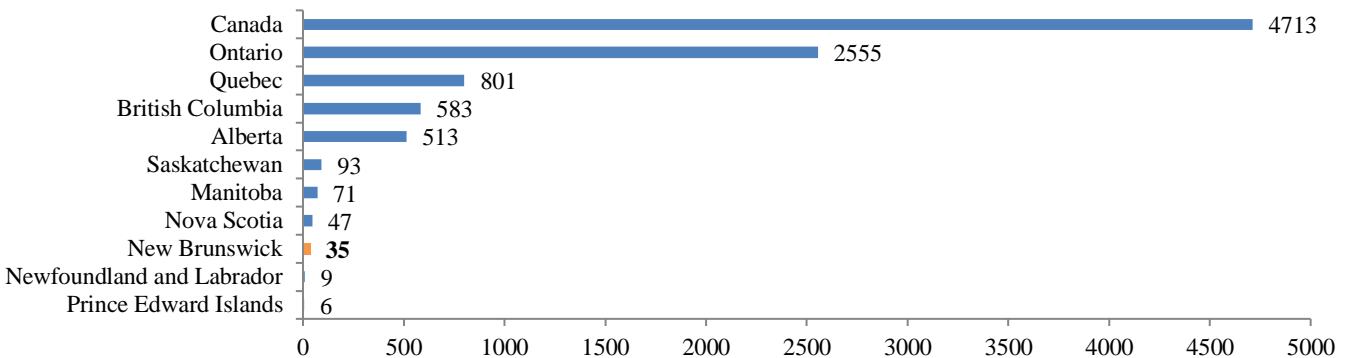
Chart 13 also shows that New Brunswick’s R&D personnel relative to Canada’s increased from 2000 to 2013 in the business and higher education sectors, which resulted in New Brunswick’s increased total R&D personnel relative to Canada’s by 2013. Total R&D personnel in New Brunswick relative to Canada’s increased by 2.5 percentage points from 46.3 per cent of Canada’s in 2000 to 48.9 per cent in 2013. The higher education sector saw an increase of 6.0 percentage-points from 82.8 per cent of Canada’s in 2000 to 88.8 per cent in 2013. New Brunswick’s relative R&D personnel increased in the business sector by 1.7 percentage points; however, by 2017, New Brunswick’s R&D personnel in the business sector was still much lower than Canada’s at 25.9 per cent. R&D personnel relative to Canada’s in the government sector declined significantly by 19.1 percentage points over the period, falling to 66.1 per cent of Canada’s in 2013.

C. Patents

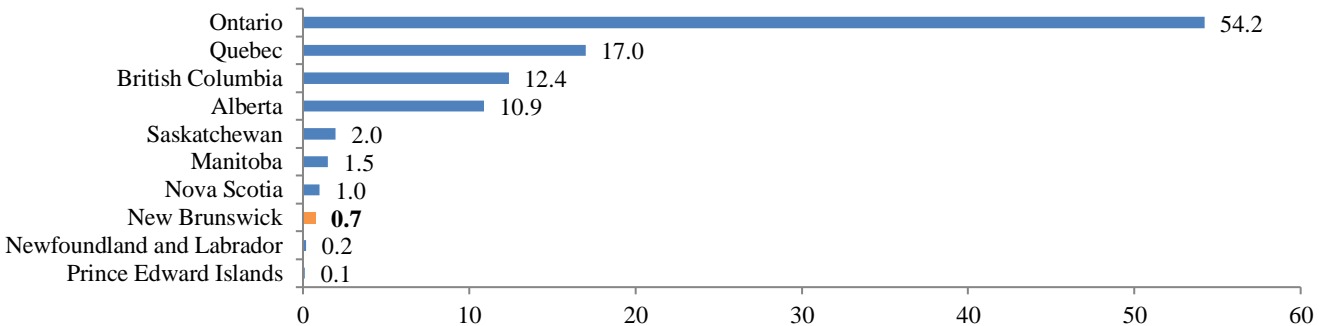
Patent statistics represent the creation of new technologies and products—the direct result of research and development. As an indicator of the creation of new knowledge, patents are a commonly used measure of innovative activity.²⁴ Chart 14 shows the number of patents granted by the United States Patent and Trademark Office by province in 2016.²⁵ New Brunswick had 35 patents granted or 0.7 per cent of total patents granted in Canada, ranking eighth of the ten provinces and second of the Atlantic region. The four Atlantic provinces had the least number of patents granted in Canada. Ontario, Quebec and British Columbia had the most patents granted in 2016, exceeding New Brunswick by a significant margin. Ontario ranked first with 2,555 patents granted, 73 times more than New Brunswick’s total patents.

Chart 14: Number of Patents Granted by USPTO in Canada by Province, 2016

Panel A: Absolute



Panel B: Share of Total Patents Granted in Canada



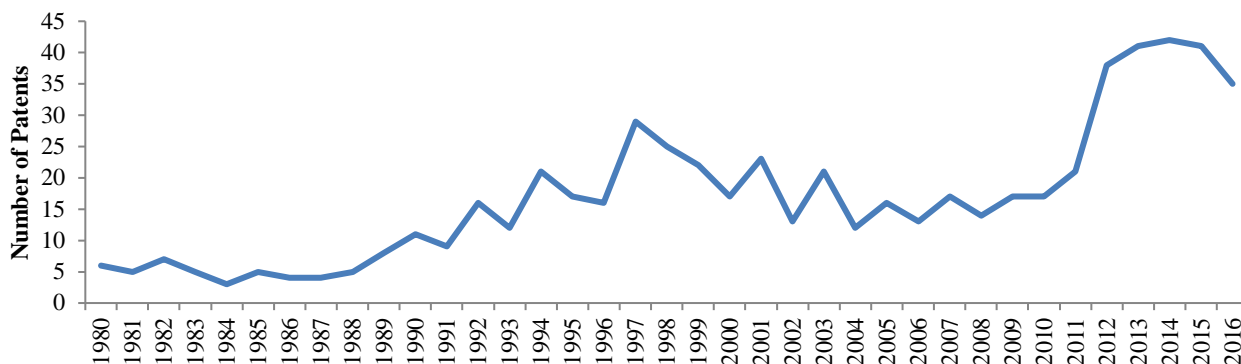
Source: Institut de la statistique du Québec

²⁴ See Greenspon and Rodrigues’s (2017) study on patenting trends in Canada and their implications for Canadian innovative activity.

²⁵ This report uses patents granted the United States Patent and Trademark Office rather than the Canadian Intellectual Property Office. Canadians apply for more USPO patents than CIPO patents (Greenspon and Rodrigues, 2017). Furthermore, USPTO data by province from 1980 to 2016 is easily accessible from the Institut de la statistique du Québec, whereas CIPO data by province is not available before 2012.

Chart 15 shows the number of patents granted by the United States Patent and Trademark Office in New Brunswick from 1980 to 2016. The number of patents grew over the period from only 5 patents in 1980 to 35 patents in 2016. In particular, the post-2010 period saw a significant rise in the number of patents granted in New Brunswick. For example, the number of patents granted peaked in 2014 at 42 patents. As patents are a key indicator of innovation, the significant increase in patents over the period is encouraging for New Brunswick.

Chart 15: Number of Patents Granted by USPTO in New Brunswick, 1980-2016



Source: Institut de la statistique du Québec

D. Firm-Based Innovation Statistics

This subsection examines several firm-based innovation statistics from the Survey of Innovation and Business Strategy (SIBS).²⁶ We analyze the following measures of firm-based innovation: the share of innovative firms, types of innovation implemented, and types of advanced and emerging technologies adopted. Unfortunately, SIBS only provides regional level data, rather than provincial.²⁷ Consequently, firm-based data for New Brunswick is not available. This subsection, thus, compares the following four regions used by SIBS: Atlantic, Quebec, Ontario, and the West.²⁸ Although not a perfect proxy, we use the data for the Atlantic region as a general indicator of firm-based innovation in New Brunswick.

Chart 16 shows the share of innovative firms in Canada by region for the 2015-2017 period. Innovative firms are defined as enterprises that have introduced a new or significantly improved product, process, marketing method, or organizational method (Statistics Canada, 2018).²⁹ During this period, the Atlantic region had the smallest share of innovative firms at 69.1

²⁶ Since 2009, the Survey of Innovation and Business Strategy by Statistics Canada has measured firm-based innovation statistics in the Canadian business sector. Key topics include the prevalence of innovation among firms, types of innovations implemented, barriers to innovation, and firms' connections to global markets (Statistics Canada, 2019).

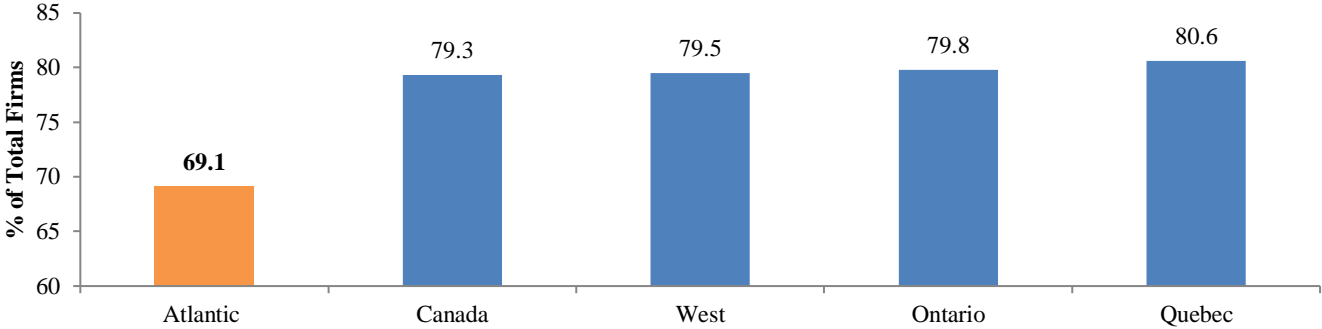
²⁷ SIBS only releases estimates at the regional level, due to sample size issues for small provinces.

²⁸ This report uses the term "the West", whereas Statistics Canada uses "Rest of Canada". "The West" is defined as Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories and Nunavut.

²⁹ This report uses the types of innovations as defined by Statistics Canada, rather than the 2018 Oslo Manual.

per cent of its total firms, 10.2 percentage points below the Canadian average. The three other regions had similar shares, which were slightly above the Canadian average and significantly higher than the Atlantic region’s share. Quebec ranked first with 80.6 per cent of its total firms that were innovative, exceeding the Atlantic region by 11.5 percentage points. Ontario and the rest of Canada followed closely at 79.8 per cent and 79.5 per cent, respectively.

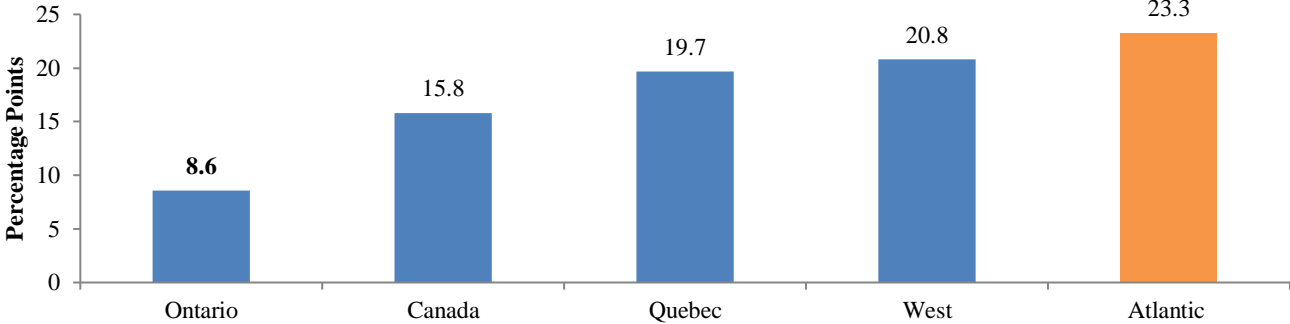
Chart 16: Share of Firms that Are Innovative in Canada by Region, 2015-2017



Source: Statistics Canada, Survey of Innovation and Business Strategy, Table 27-10-0155-01

Although firms in the Atlantic provinces were less likely to be innovative during the 2015-2017 period compared to firms in other regions, Atlantic Canada experienced the greatest improvement in the share of innovative firms from the 2010-2012 period to the 2015 to 2017 period (Chart 17). The share of innovative firms increased by 23.3 percentage points, from 45.8 per cent of total firms in 2010-2012 to 69.1 per cent in 2015-2017. The other regions also saw growth in their shares of innovative firms, but these changes were less substantial than the improvements observed in the Atlantic region. In Ontario, for example, the share of innovative firms grew by 8.6 percentage points from 71.2 per cent in 2010-2012 to 79.8 per cent in 2015-2017.

Chart 17: Change in Share of Firms that Are Innovative in Canada by Region from 2010-2012 to 2015-2017



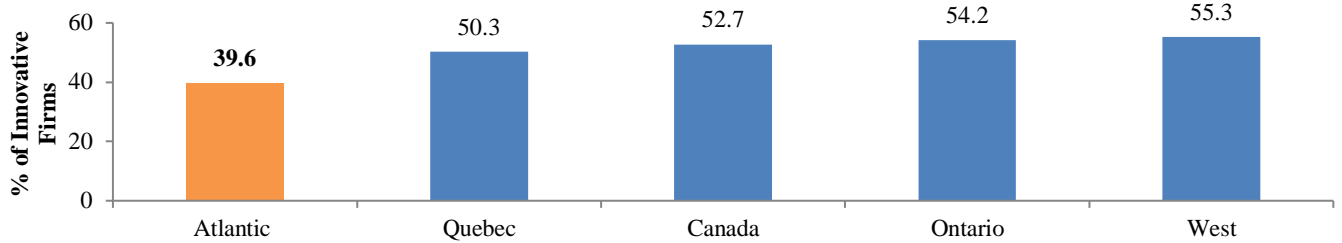
Source: Statistics Canada, Survey of Innovation and Business Strategy, Table 27-10-0120-01 & Table 27-10-0155-01

Chart 18 shows the type of innovation introduced by firms in Canada by region in the 2015-2017 period. Statistics Canada categorizes innovation into four types: product innovation, involving the introduction of a new or improved good or service; process innovation, involving the implementation of a new or improved process in the production or distribution of goods or services; marketing innovation, involving the implementation of a new marketing strategy; and organization innovation, involving the implementation of a new methods related to business practices or workplace organization (Statistics Canada, 2018). Compared to the other regions, firms in Atlantic Canada were least likely to implement any type of innovation. The following are key findings from Chart 18:

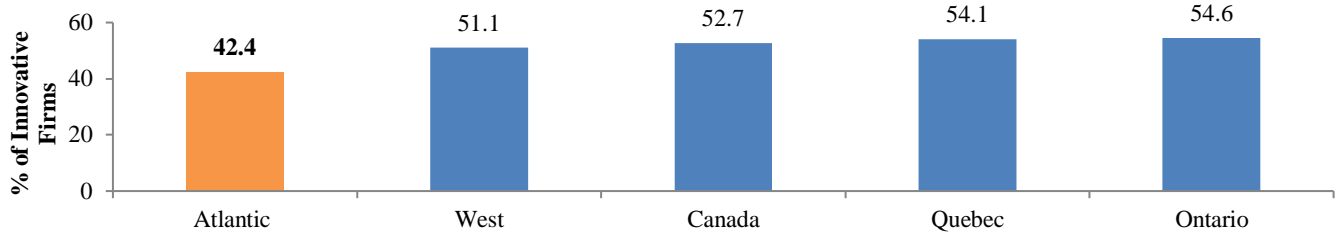
- Of the four types of innovation, innovative firms in Atlantic Canada were most likely to adopt organizational innovation.
 - 50.5 per cent of innovative firms in Atlantic Canada implemented an organizational innovation
 - This share was 9.0 percentage points below the Canadian average. Atlantic Canada had its best performance relative to the Canadian average in organizational innovation.
- Marketing was the second most common type of innovation in Atlantic Canada.
 - 45.3 per cent of innovative firms in Atlantic Canada implemented a marketing innovation.
 - This share was 9.1 percentage points below the Canadian average.
- Process innovation was the third most common types of innovation in Atlantic Canada.
 - 42.4 per cent of innovative firms in Atlantic Canada implemented a process innovation.
 - This share was 10.5 percentage points below the Canadian average.
- The least common type of innovation in the Atlantic region was product innovation.
 - 39.6 per cent of innovative firms in Atlantic Canada implemented a product innovation.
 - This share was 13.1 percentage points below the Canadian average. Atlantic Canada had its worst relative performance in product innovation.

Chart 18: Types of Innovation Implemented by Firms in Canada by Region, 2015-2017

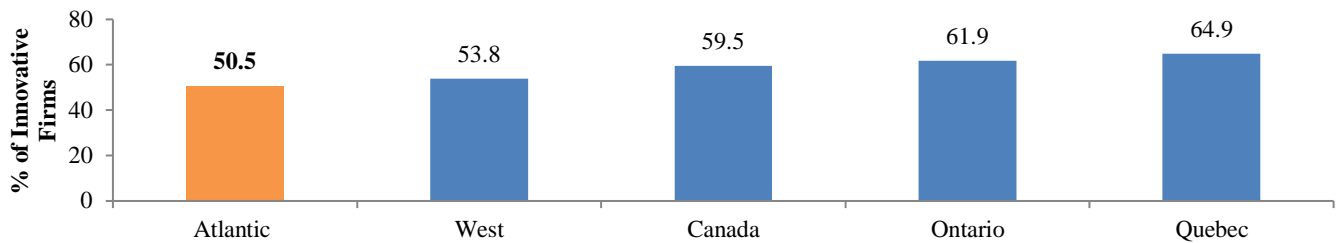
Panel A: Product



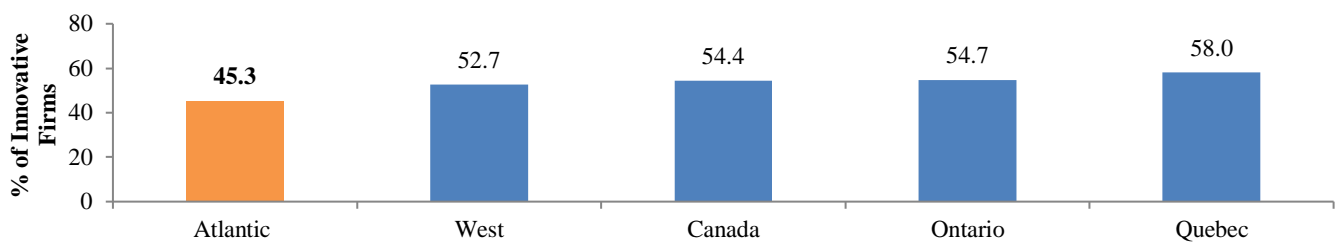
Panel B: Process



Panel C: Organizational



Panel D: Marketing

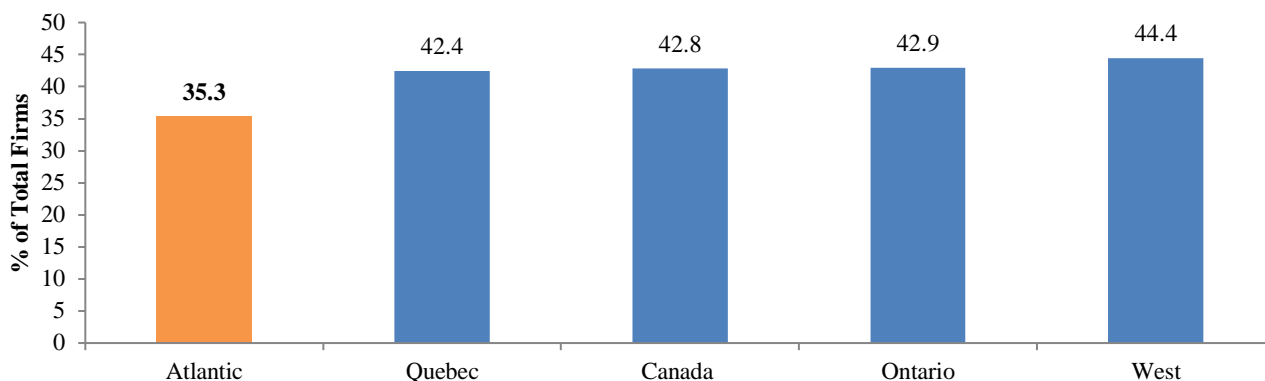


Source: Statistics Canada, Survey of Innovation and Business Strategy, Table 27-10-0155-01

Chart 19 shows the share of firms that used advanced technologies by region in 2017. Advanced technologies consist of any equipment or software that carries out new or improved processes (Statistics Canada, 2018). Among the regions, Atlantic Canada had the smallest share of firms using advanced technologies at 35.3 per cent of its total firms. In comparison, the other regions had shares greater than 42.0 per cent. Western Canada ranked first with 44.4 per cent of total firms that used advanced technologies, exceeding the Atlantic region by 9.1 percentage points. Of all the types of advanced technologies, business intelligence technologies—those used for data analysis—were the most commonly used in the Atlantic region, with 19.2 per cent of firms adopting them (Table 6). In comparison, only 7.2 per cent of firms in the Atlantic region

adopted clean technologies (those that reduce environmental impact), which were the least used advanced technology.

Chart 19: Share of Firms that Use Advanced Technologies in Canada by Region, 2017



Source: Statistics Canada, Survey of Innovation and Business Strategy, Table 27-10-0367-01

Table 6: Types of Advanced Technology Used by Firms in Canada by Region, 2017

| Type of Advanced Technology | Atlantic | Quebec | Ontario | West | Canada |
|---|------------|--------|---------|------|--------|
| | % of Firms | | | | |
| Clean technologies | 7.1 | 9.0 | 10.2 | 10.9 | 10.0 |
| Security or advanced authentication systems | 7.9 | 14.4 | 13.8 | 13.3 | 13.5 |
| Processing or fabrication technologies | 9.3 | 13.0 | 11.9 | 12.3 | 12.2 |
| Material handling, supply chain or logistics technologies | 9.8 | 12.5 | 12.0 | 14.4 | 12.7 |
| Design or information control technologies | 14.2 | 18.7 | 17.6 | 17.5 | 17.7 |
| Business intelligence technologies | 19.6 | 17.9 | 25.1 | 23.7 | 22.5 |

Source: Statistics Canada, Survey of Innovations and Business Strategy, Table 27-10-0367-01

The Survey of Innovation and Business Strategy also provides the reasons firms did not adopt or use advanced technologies (Table 7). In the Atlantic region, 42.3 per cent of firms reported that using advanced technologies was not applicable to their business operations, 4.9 percentage points above the Canadian average. In addition, 38.3 per cent of firms reported not using advanced technologies because the investment was not necessary to continue their operations. Following these top reasons, 18.6 per cent of firms were not convinced of the economic benefit of these advanced technologies, while 15.2 per cent of firms cited the high cost of implementing them. The share of firms that reported the top three reasons in Atlantic Canada exceeded their respective Canadian averages. This suggests that, compared to firms in the rest of Canada, firms in Atlantic Canada are more likely to find innovative activities unnecessary or irrelevant. In other words, the business strategies of firms in the Atlantic provinces are less likely to involve innovation.

Table 7: Reasons Firms Did Not Adopt or Use Advanced Technologies in Canada by Region, 2017

| Reason | Atlantic | Quebec | Ontario | West | Canada | Canada–Atlantic |
|--|------------|--------|---------|------|--------|-------------------|
| | % of Firms | | | | | Percentage Points |
| Organizational culture too inflexible | 2.7 | 2.6 | 2.1 | 5.1 | 3.2 | 0.5 |
| Lack of technical support or services (from consultants or vendors) | 3.4 | 1.5 | 2.0 | 5.5 | 3.1 | -0.3 |
| Difficulty in obtaining financing | 4.0 | 5.1 | 7.3 | 5.0 | 5.8 | 1.8 |
| Decisions made by parent, affiliates or subsidiary businesses | 6.6 | 6.2 | 9.2 | 5.2 | 7.0 | 0.4 |
| Lack of information regarding advanced technology | 7.8 | 7.0 | 8.7 | 10.6 | 8.8 | 1.0 |
| Difficulty in integrating new advanced technologies with existing systems, standards and processes | 10.3 | 9.9 | 10.1 | 11.6 | 10.5 | 0.2 |
| Lack of technical skills required to support this type of investment | 10.8 | 8.1 | 10.9 | 10.5 | 10.1 | -0.7 |
| High cost of advanced technologies | 15.2 | 16.3 | 19.0 | 19.4 | 18.2 | 3.0 |
| Not convinced of economic benefit | 18.6 | 12.4 | 16.1 | 25.3 | 18.2 | -0.4 |
| Investment not necessary for continuing operations | 38.3 | 38.1 | 34.3 | 39.0 | 37.0 | -1.3 |
| Adoption or use of advanced technologies not applicable to the business's activities | 42.3 | 36.8 | 40.6 | 32.9 | 37.4 | -4.9 |

Source: Statistics Canada, Survey of Innovations and Business Strategy, Table 27-10-0368-01

E. Business Investment

As most technological advances are embodied in capital equipment, the rate of business investment is closely related to the rate of technological advancement. This sub-section examines fixed non-residential capital investment levels and trends for New Brunswick, the provinces, and Canada in the business sector. We also analyze the four types of non-residential investment, namely non-residential buildings, engineering construction, machinery and equipment, and intellectual property products. Finally, this section examines investment in intellectual property products more closely by analyzing its three types: mineral exploration and evaluation, research and development, and software.

i. Cross-Sectional Analysis of Non-Residential Investment by Province

a. Non-Residential Investment as a Share of Nominal GDP

Chart 20 compares types of provincial non-residential investment in the business sector as a share of nominal GDP in 2018.³⁰ New Brunswick spent \$5.12 billion or 13.8 per cent of its nominal GDP on non-residential investment. For New Brunswick, machinery and equipment ranked the highest among the four types of non-residential investment at \$1.86 billion or 5.0 per cent of the province's nominal GDP. Following machinery and equipment, New Brunswick invested \$1.44 billion or 3.9 per cent of its nominal GDP on engineering construction and \$1.06

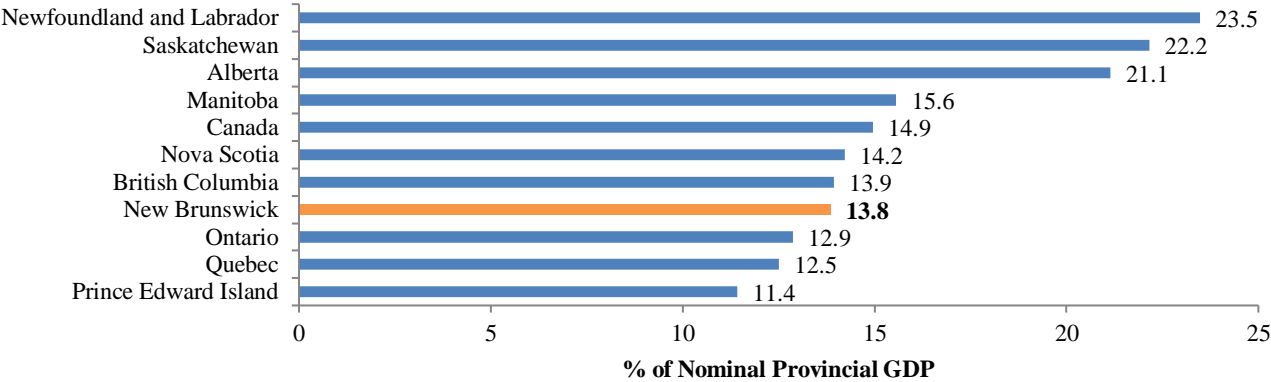
³⁰ Refer to database Table 9 for estimates on non-residential fixed capital investment by province.

billion or 2.9 per cent on non-residential buildings. Finally, the province spent the least in investment in intellectual property products at \$750 million or 2.0 per cent of its nominal GDP.

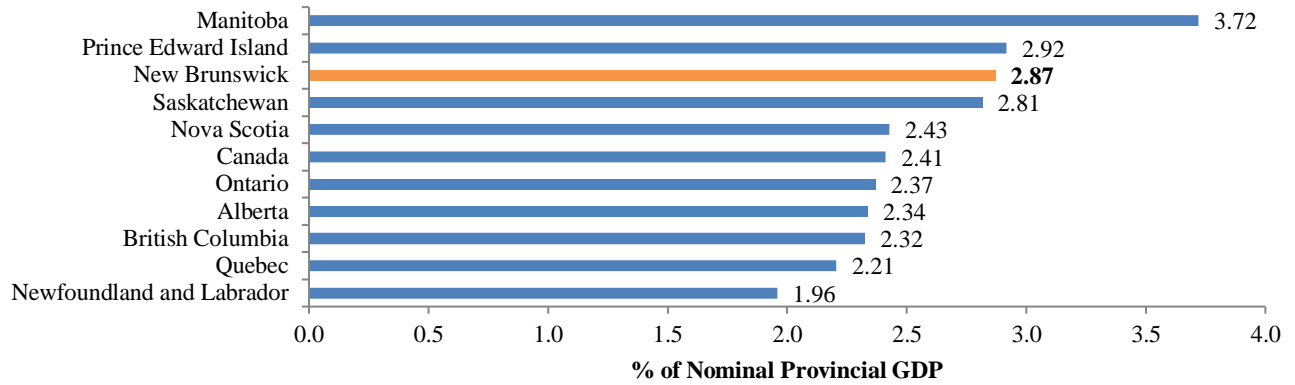
New Brunswick ranked seventh of the ten provinces and third of the Atlantic provinces for total non-residential investment (Chart 20). Newfoundland had the highest total investment at 23.5 per cent of its nominal GDP, exceeding New Brunswick by 9.7 percentage points. However, New Brunswick ranked higher than Quebec and Ontario, the two most innovative provinces according to previously discussed indicators of innovation. New Brunswick’s total non-residential investment as a share of nominal GDP slightly exceeded Quebec’s and Ontario’s by 1.3 and 0.9 percentage points, respectively.

Among the provinces, New Brunswick ranked high in non-residential buildings and machinery and equipment, but low in engineering and construction and intellectual property products (Chart 20). For investment in both non-residential buildings and machinery and equipment, New Brunswick had the third highest share of nominal GDP among the ten provinces and second highest among the Atlantic provinces. In contrast, for engineering and construction, New Brunswick ranked sixth at 3.91 per cent. Newfoundland, the highest ranked province, spent 14.2 per cent of its nominal GDP on investment in engineering and construction, exceeding New Brunswick’s by 10.3 percentage points. Most significantly, of all the types of investment, New Brunswick had its lowest rank in intellectual property products, the type of investment most related to innovation and R&D. The poor results in intellectual property products are consistent with New Brunswick’s weak R&D performance. Among the provinces, New Brunswick ranked seventh in intellectual property products at 2.03 per cent. Ontario and Quebec had the highest investment as a share of nominal GDP in intellectual property products, exceeding New Brunswick by 1.02 and 1.00 percentage points, respectively.

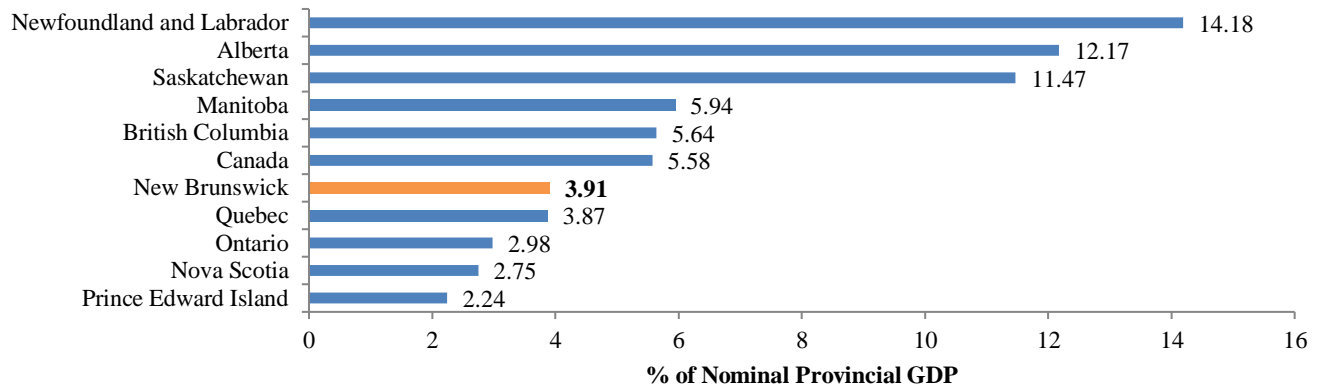
Chart 20: Type of Non-Residential Investment as a Share of Nominal GDP by Province, 2018
Panel A: Total Non-Residential Investment



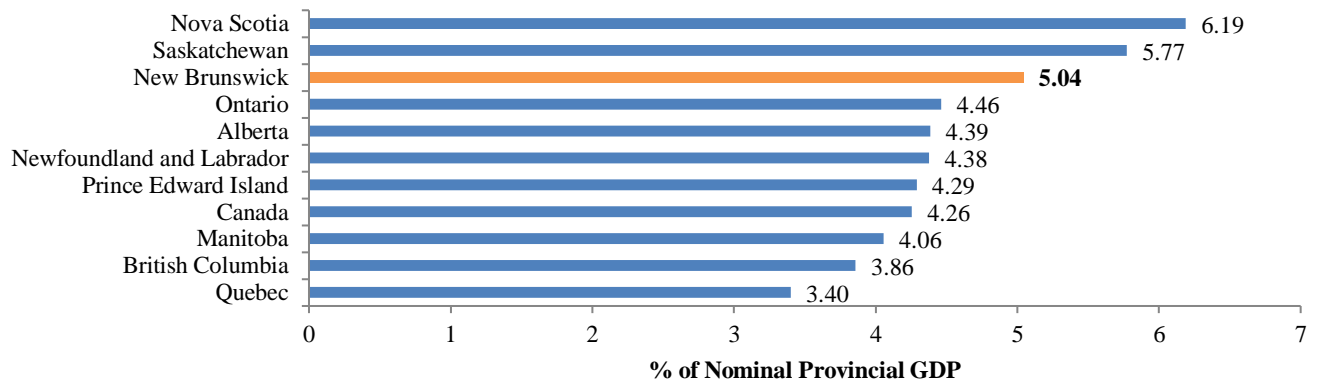
Panel B: Non-Residential Buildings



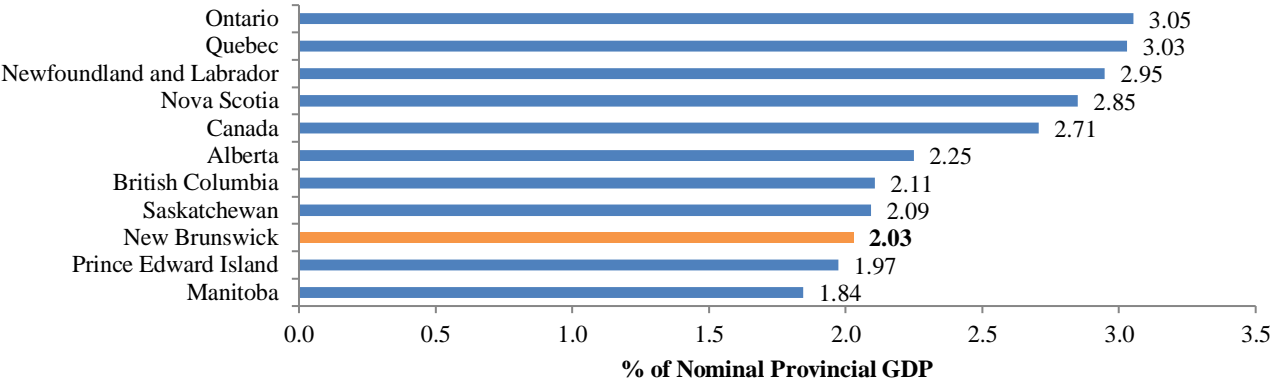
Panel C: Engineering Construction



Panel D: Machinery and Equipment



Panel E: Intellectual Property Products



Source: Statistics Canada, Table 36-10-0098-01 & Table 36-10-0222-01

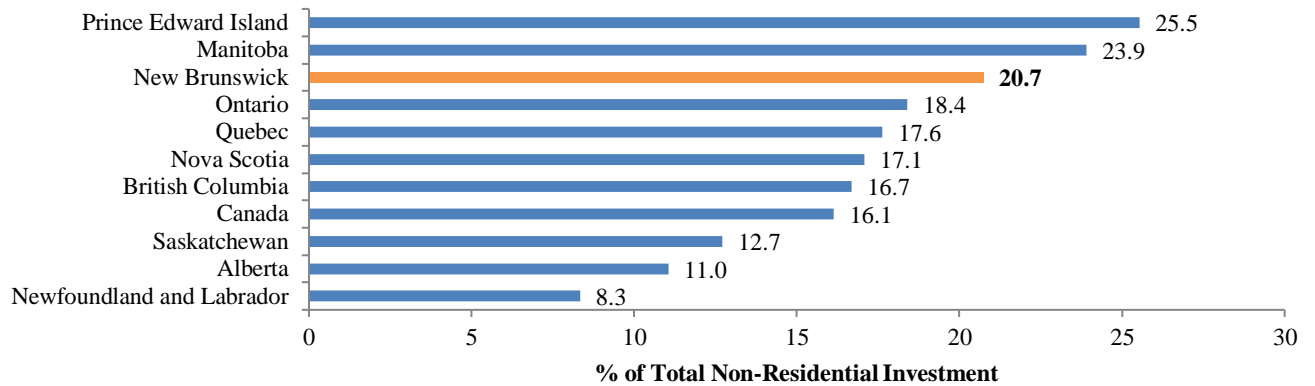
b. Relative Importance of Each Type of Investment to Total Non-Residential Investment

Chart 21 compares the types of non-residential investment as a share of total provincial non-residential investment in 2018. New Brunswick had its largest share of non-residential investment in machinery and equipment, spending 36.4 per cent. Engineering construction and non-residential buildings followed with 28.2 per cent and 20.7 per cent of total non-residential investment, respectively. Intellectual property products made up the smallest share of total non-residential investment. New Brunswick allocated 14.7 per cent of its non-residential investment in intellectual property products, significantly smaller than the shares for the other types of investment.

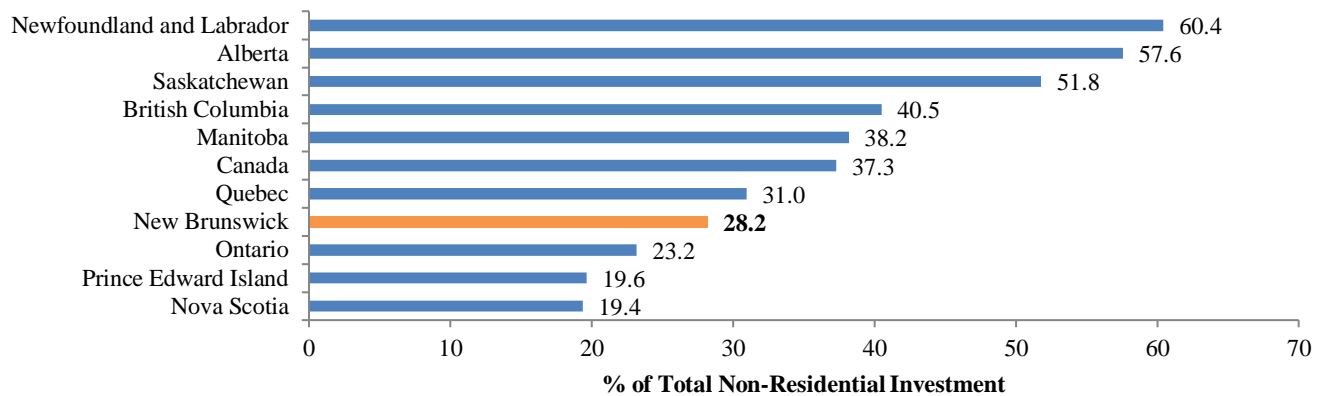
Compared across provinces, New Brunswick had relatively high shares of total non-residential investment in non-residential buildings and machinery and equipment, which is consistent with the findings for non-residential investment as a share of nominal GDP (Chart 21). New Brunswick ranked third for both types of investments. The province ranked much lower for engineering and construction and intellectual property products. For engineering and construction, New Brunswick ranked seventh of the ten provinces and second of the Atlantic provinces. Most interestingly, New Brunswick ranked slightly higher in intellectual property products, exceeding the shares of four provinces. However, Quebec and Ontario, the provinces with the largest shares of total non-residential investment in intellectual property products, exceeded New Brunswick significantly by 9.5 and 9.0 percentage points, respectively.

Chart 21: Type of Investment as a Share of Total Non-Residential Investment by Province, 2018

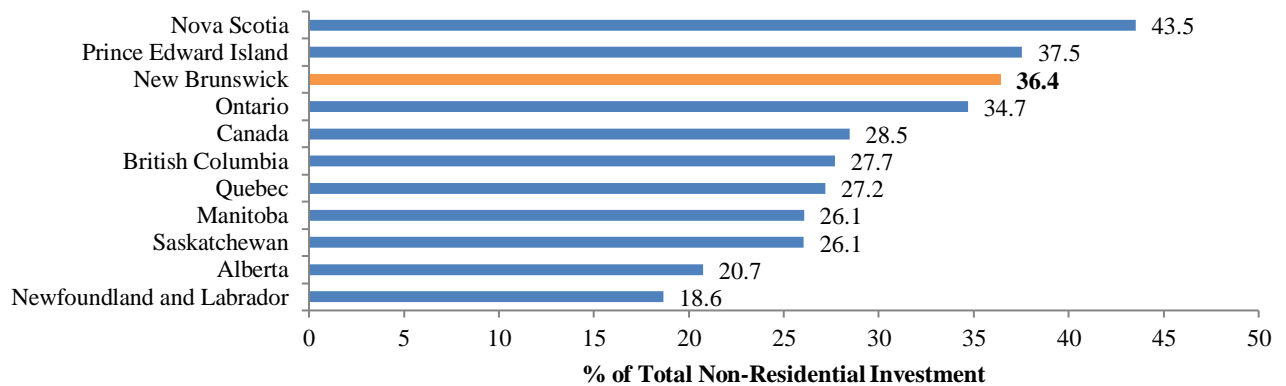
Panel A: Non-Residential Buildings



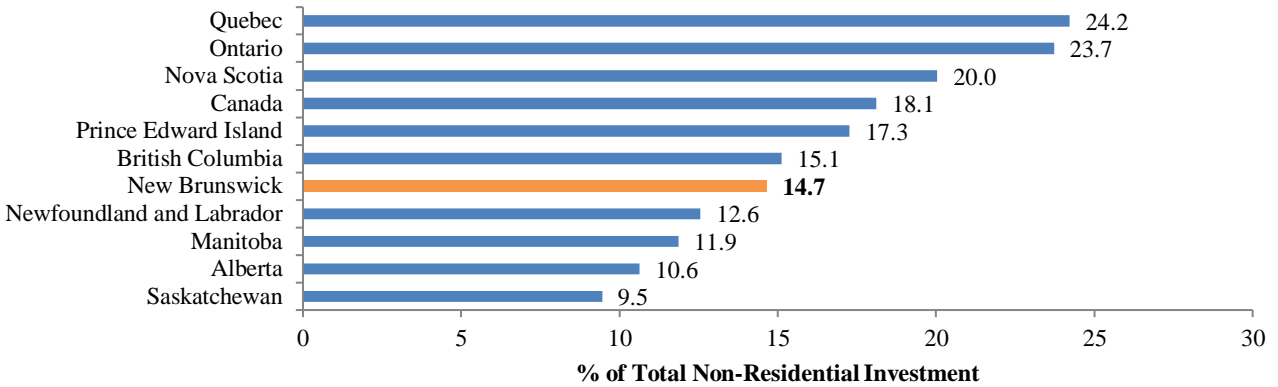
Panel B: Engineering Construction



Panel C: Machinery and Equipment



Panel D: Intellectual Property Products



Source: Statistics Canada, Table 36-10-0098-01

ii. Trends over Time in Non-Residential Investment in New Brunswick

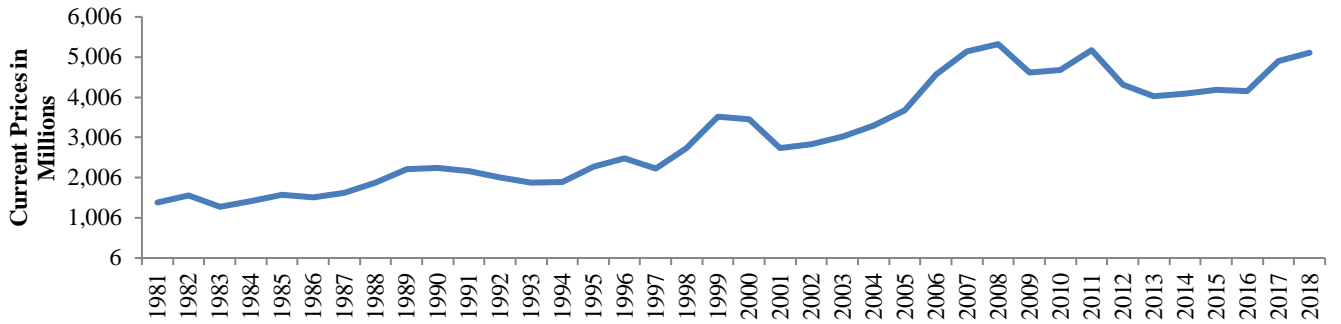
a. Non-Residential Investment

Non-Residential investment in current and constant 2012 dollars in New Brunswick increased from 1981 to 2018 (Chart 22 and 23).³¹ Total non-residential investment rose from \$1.38 billion in 1981 to \$5.12 billion in 2018; in constant 2012 dollars, non-residential investment increased 62.6 per cent from \$2.76 billion in 1981 to \$4.48 billion in 2018, though, by the end of the period, it remained below its peak level of \$5.64 billion in 2006. All other performer sectors increased in nominal terms. Investment in non-residential buildings increased from \$311 million in 1981 to \$1.06 billion in 2018; engineering construction from \$350 million in 1981 to 1.44 billion in 2018; machinery and equipment from \$645 million in 1981 to \$1.86 billion in 2018; and intellectual property products from \$74 million in 1981 to \$750 million in 2018.

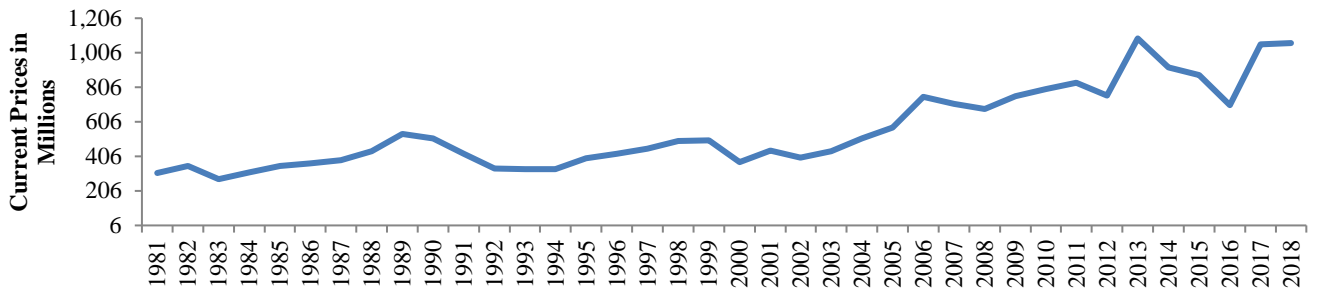
³¹ Refer to database Table 10 for non-residential fixed investment in current and constant 2012 prices from 1981 to 2018.

Chart 22: Type of Non-Residential Investment in New Brunswick, Current Dollars, 1981-2018

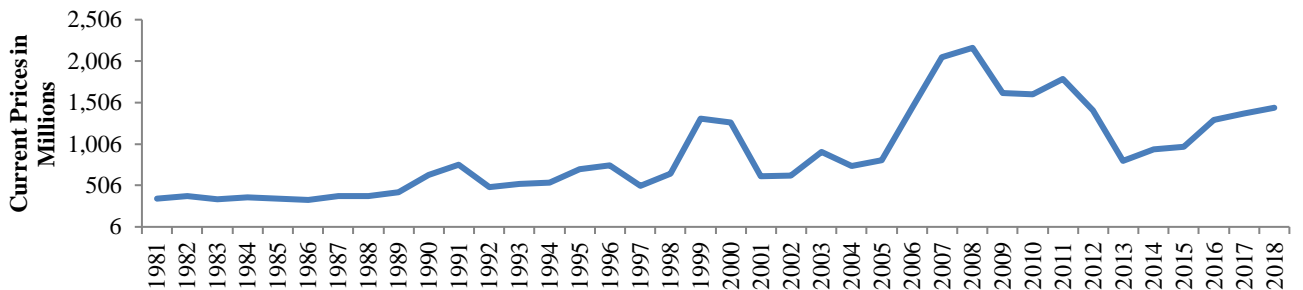
Panel A: Total Non-Residential Investment



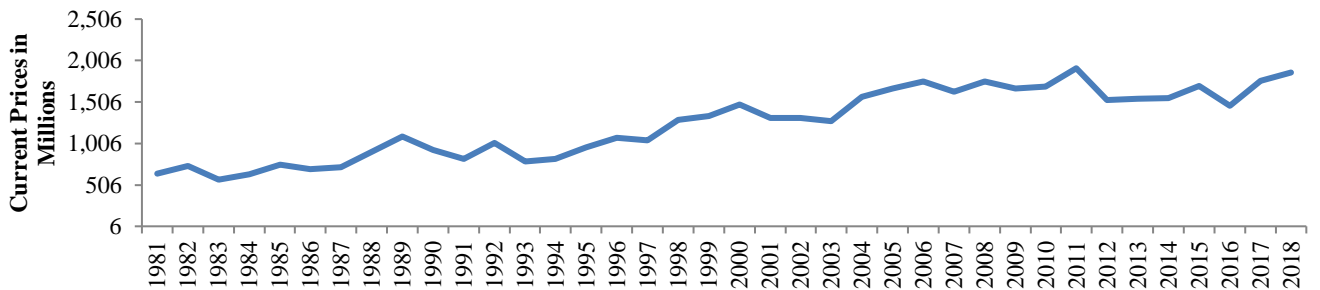
Panel B: Non-Residential Buildings



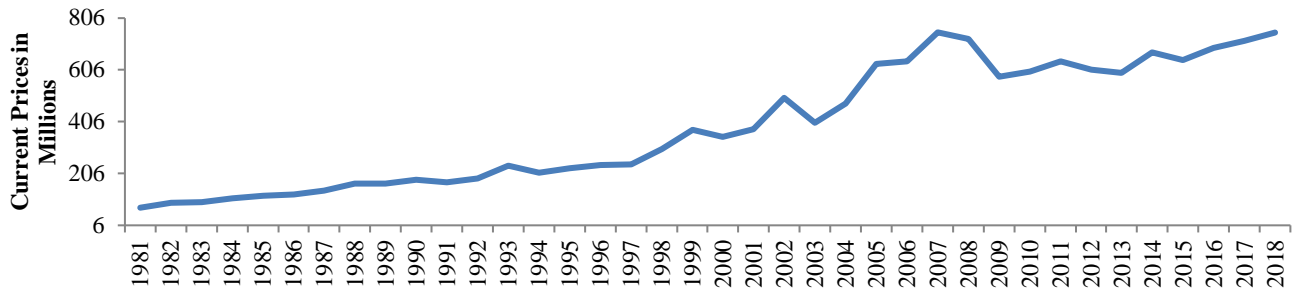
Panel C: Engineering Construction



Panel D: Machinery and Equipment

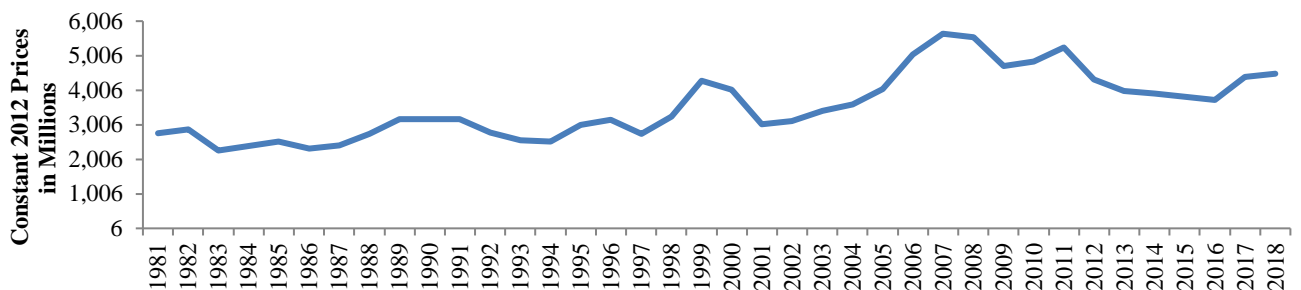


Panel E: Intellectual Property Products



Source: Statistics Canada, Table 36-10-0098-01

Chart 23: Total Non-Residential Investment in New Brunswick, Constant 2012 Dollars, 1981-2018



Source: Statistics Canada, Table 36-10-0098-01

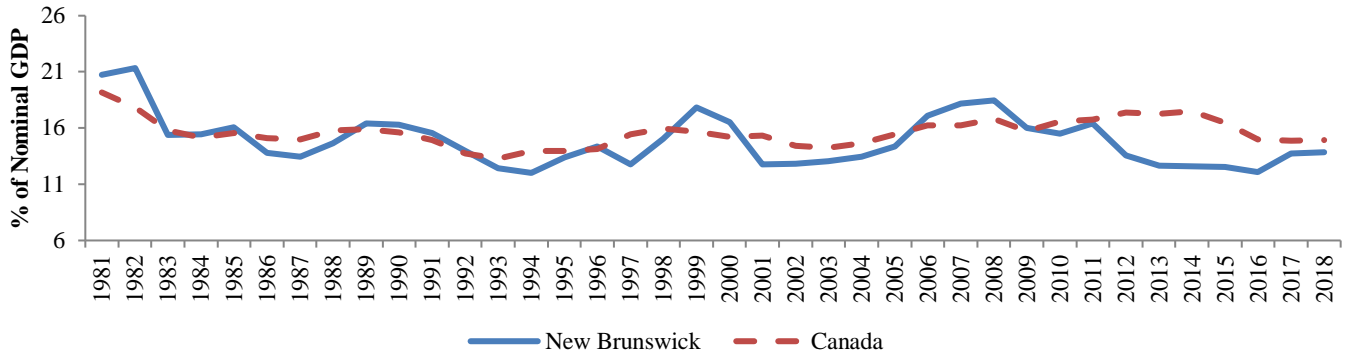
b. Non-Residential Investment as a Share of Nominal GDP

Between 1981 and 2018, New Brunswick’s non-residential investment as a share of nominal GDP declined for most types of investment (Chart 24). Total non-residential investment in New Brunswick decreased by 6.9 percentage points from 20.7 per cent of nominal GDP in 1981 to 13.8 per cent in 2018, while the Canadian average decreased by only 4.2 percentage points. This decline was largely driven by decreasing investment in non-residential buildings, engineering construction, and machinery and equipment.

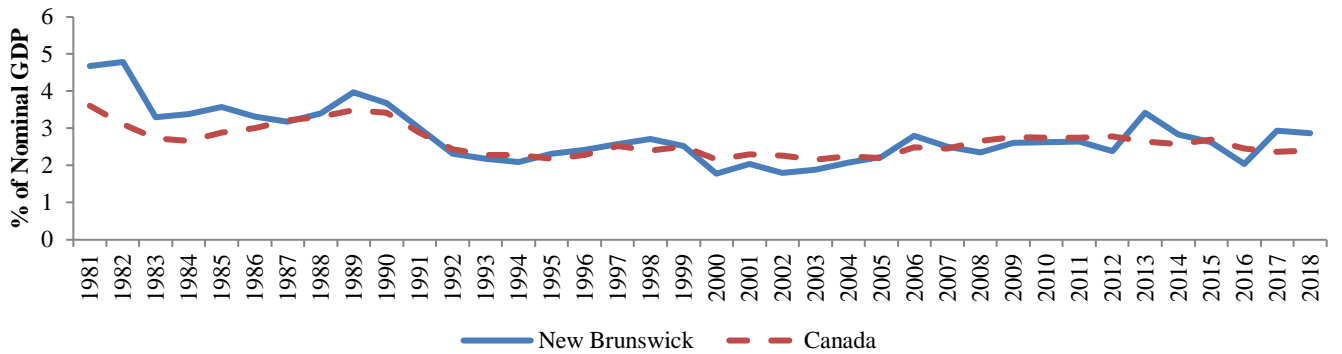
Investment in machinery and equipment declined the most among the types of investment over the period, falling by 4.7 percentage points from 9.7 per cent of nominal GDP in 1981 to 5.0 per cent in 2018 (Chart 24). This decrease exceeded that of the national average at 3.7 percentage points. Non-residential buildings and engineering construction declined by 1.8 and 1.4 percentage points, respectively, both exceeding declines in the Canadian average. Investment in intellectual property products was the exception. New Brunswick’s investment in intellectual property products increased modestly by 0.92 percentage point from 1.1 per cent of nominal GDP in 1981 to 2.0 per cent in 2018; in comparison, intellectual property products in Canada increased by 0.96 percentage points. For all types of investment, Canada experienced greater improvement than New Brunswick from 1981 to 2018.

Chart 24: Type of Non-Residential Investment as a Share of Nominal GDP in New Brunswick and Canada, 1981-2018

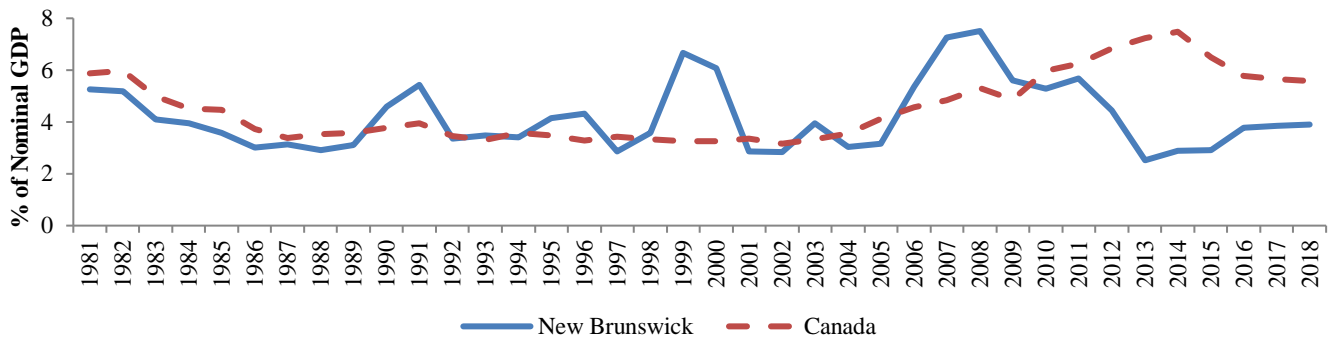
Panel A: Total Non-Residential Investment



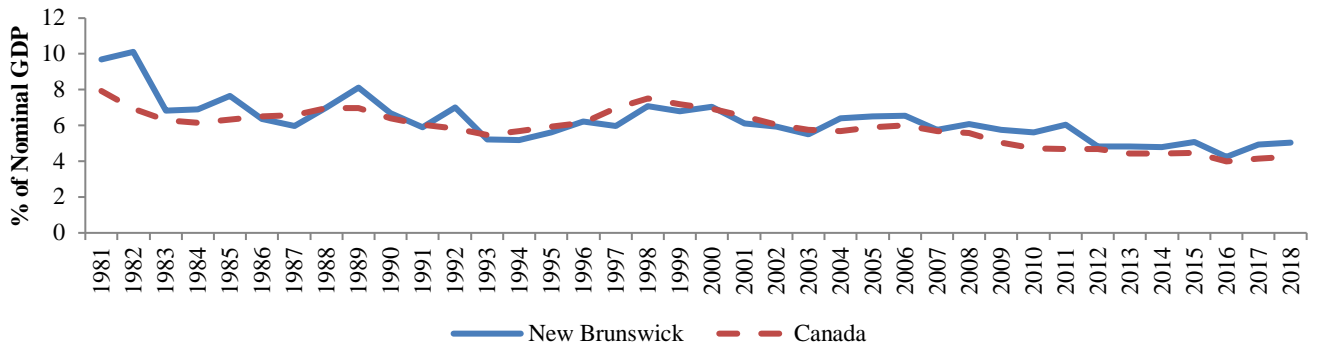
Panel B: Non-Residential Buildings



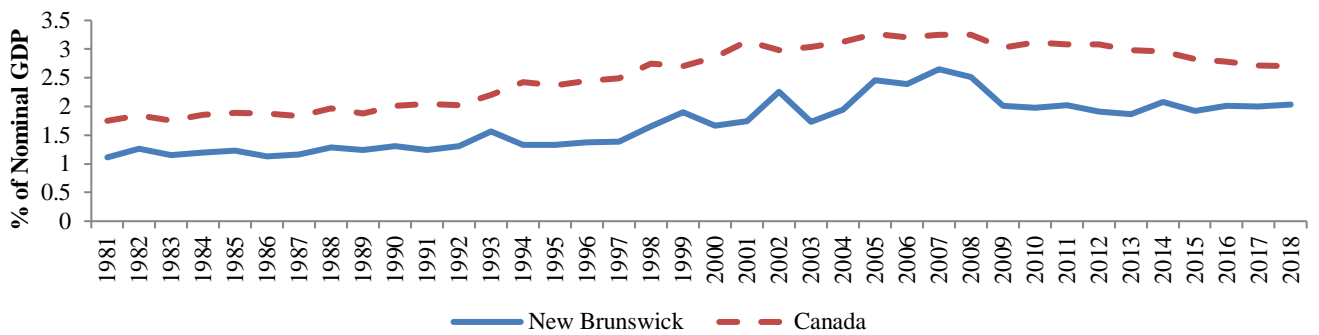
Panel C: Engineering Construction



Panel D: Machinery and Equipment



Panel E: Intellectual Property Products



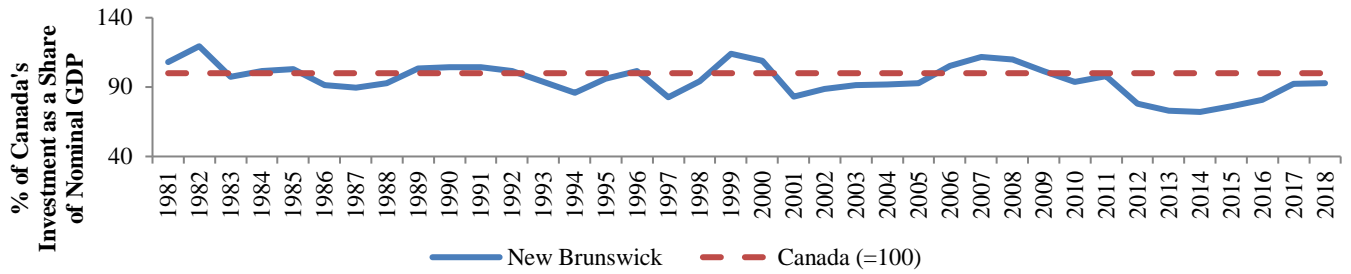
Source: Statistics Canada, Table 36-10-0098-01 & Table 36-10-0222-01

c. Non-Residential Investment as a Share of Nominal GDP Relative to Canada's

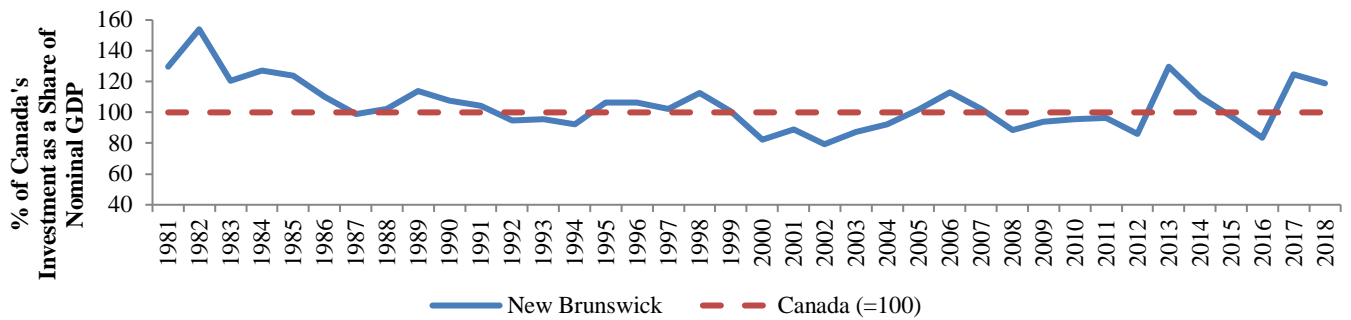
Chart 25 shows the non-residential investment in New Brunswick relative to Canada's from 1981 to 2017. Although New Brunswick's investment in intellectual property products increased, it remained well below Canada's for the entire period. Apart from intellectual property products, the other types of investment in New Brunswick fluctuated below and above Canada's throughout the period. In contrast, New Brunswick's investment in intellectual property products never reached Canada's, averaging 65.7 per cent of Canada's over the period.

Chart 25: Type of Non-Residential Investment as a Share of Nominal GDP in New Brunswick Relative to Canada's, 1981-2018

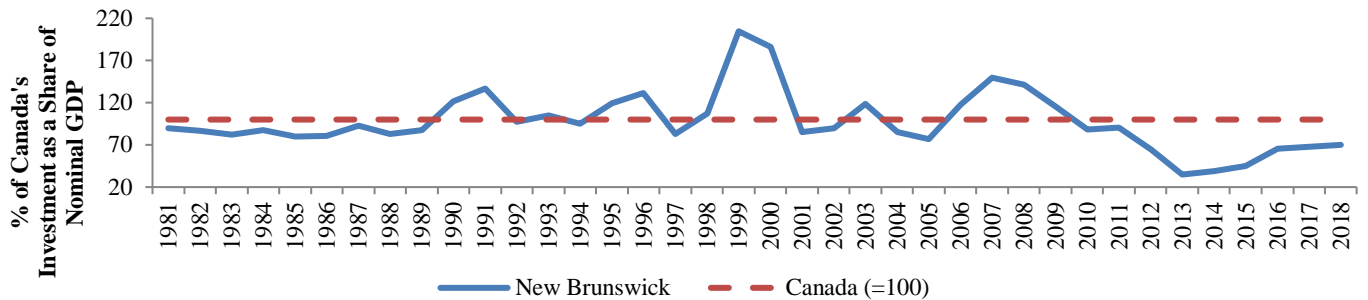
Panel A: Total Non-Residential Investment



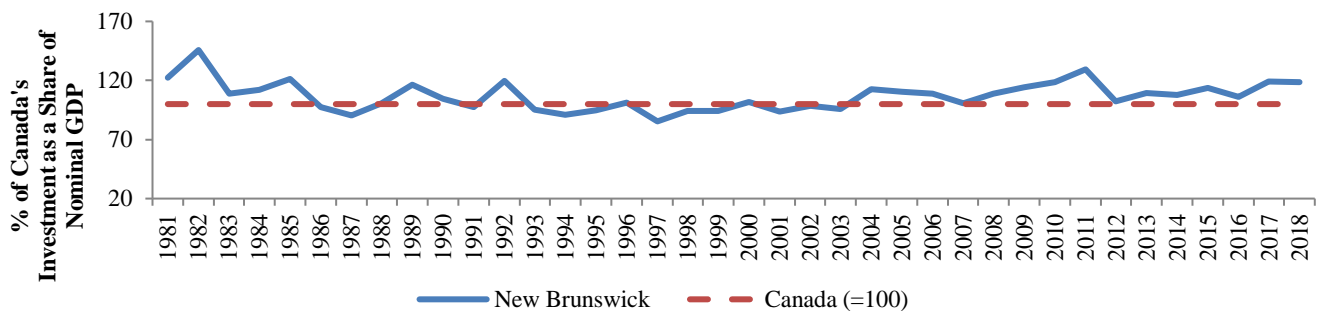
Panel B: Non-Residential Buildings



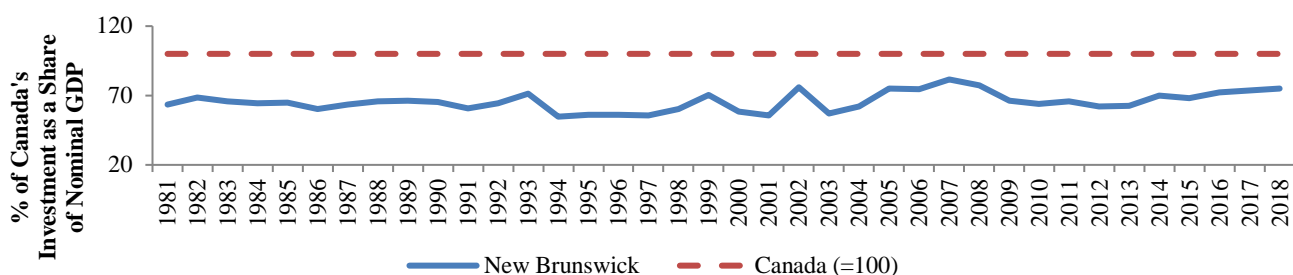
Panel C: Engineering Construction



Panel D: Machinery and Equipment



Panel E: Intellectual Property Products



Source: Statistics Canada, Table 36-10-0098-01 & Table 36-10-0222-01

However, New Brunswick’s relative investment in intellectual property products improved over the period, while the other types of investment declined relative to Canada’s (Chart 25). Relative investment in intellectual property products increased by 11.4 percentage points from 63.6 per cent of Canada’s to 75.0 per cent. In comparison, relative investment in engineering construction decreased by 19.4 percentage points from 89.5 per cent of Canada’s in 1981 to 70.1 per cent in 2018. This decrease in engineering construction reflects a lack of natural resource-based development in New Brunswick. Non-residential buildings declined by 10.5 percentage points from 129.5 per cent of Canada’s in 1981 to 119.0 per cent in 2018. Machinery and equipment declined less substantially by 3.8 percentage points from 122.3 per cent of Canada’s in 1981 to 118.5 per cent in 2018. Due to these declines, total non-residential investment decreased by 15.6 percentage points from 108.2 of Canada’s in 1981 to 92.6 per cent in 2018.

Similarly, apart from intellectual property products, every type of non-residential investment in New Brunswick as a share of Canada’s total non-residential fixed investment declined from 1981 to 2018.³² New Brunswick’s investment in engineering construction decreased the most significantly, declining by 0.45 percentage points from 1.61 per cent of Canada’s in 1981 to 1.16 per cent in 2018. Investment in non-residential buildings and machinery and equipment as shares of Canada’s decreased by 0.36 and 0.24 percentage points, respectively. Consequently, total non-residential investment as a share of Canada’s decreased by 0.41 percentage points from 1.95 per cent of Canada’s in 1981 to 1.54 per cent in 2018. In contrast, New Brunswick’s investment in intellectual property products increased by 0.10 percentage points from 1.15 per cent of Canada’s in 1981 to 1.25 per cent in 2018.

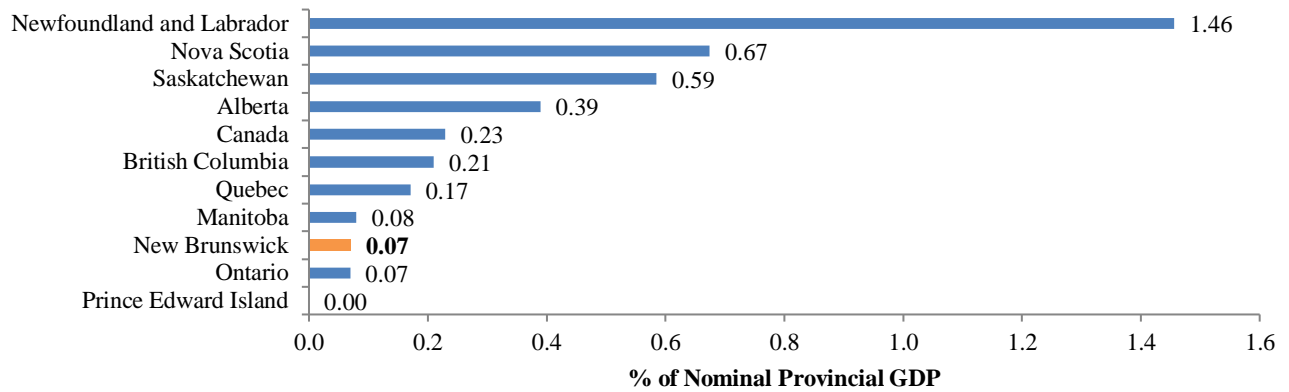
³² Refer to Appendix Chart 5 for non-residential investment in New Brunswick as a share of Canada’s by type of investment from 1981 to 2018.

iii. Cross-Sectional Analysis of Investment in Intellectual Property Products by Province

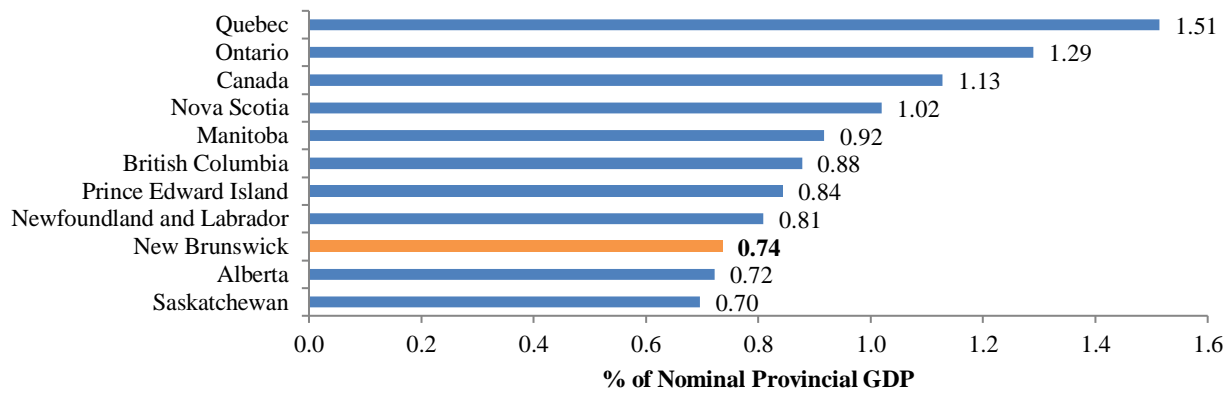
Chart 26 compares investment in three types of intellectual property products as a share of nominal GDP by province in 2018. Of the three types, New Brunswick invested the most in software at \$452 million or 1.22 per cent of its nominal GDP. Research and development followed at \$272 million or 0.74 per cent of nominal GDP, while mineral and exploration had the lowest spending at \$26 million or 0.07 per cent of nominal GDP.³³

Chart 26: Type of Investment in Intellectual Property Products as a Share of Nominal GDP by Province, 2018

Panel A: Mineral Exploration and Evaluation

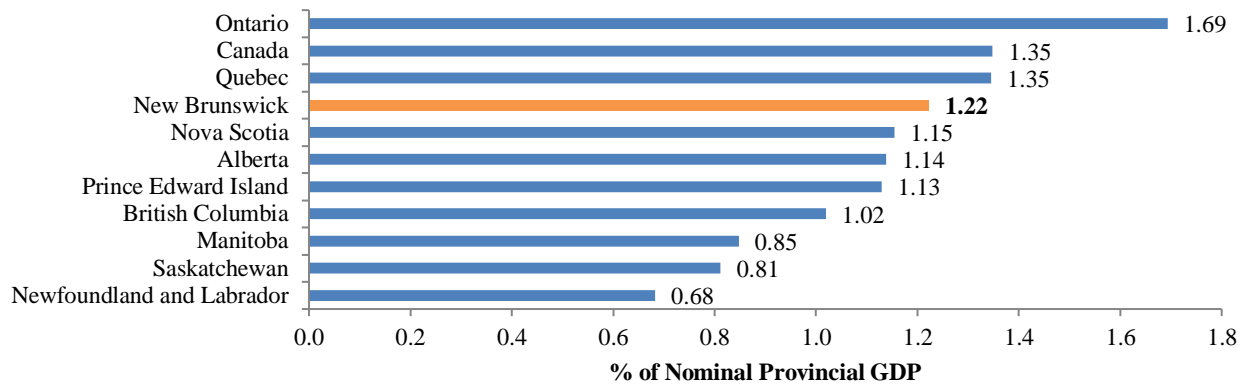


Panel B: Research and Development



³³ New Brunswick’s R&D investment (0.74 per cent of nominal GDP) is lower than its R&D spending (0.95 per cent of nominal GDP), which this report discussed earlier. Three reasons could explain this discrepancy. First, methodology differences could account for this discrepancy, as R&D investment and R&D expenditures are from different surveys. Second, R&D investment only includes spending in fixed non-residential capital, while R&D spending is comprehensive (i.e. includes all expenditures). Lastly, the findings for R&D investment and R&D spending are from different reference years (investment in 2018 vs. spending in 2017).

Panel C: Software



Source: Statistics Canada, Table 36-10-0098-01 & Table 36-10-0222-01

Among the provinces, New Brunswick ranked low in mineral exploration and evaluation and research and development, but high in software (Chart 26). For mineral exploration and evaluation, New Brunswick had the second lowest investment, significantly below the investments of top-ranking Nova Scotia and Newfoundland and Labrador. More significantly, New Brunswick ranked eighth in R&D investment. The most innovative provinces, Quebec and Ontario, had the largest shares, exceeding New Brunswick by 0.77 and 0.55 percentage points, respectively. New Brunswick's investment in software, however, ranked higher than most provinces. New Brunswick had the third highest share of the ten provinces and highest share of the Atlantic provinces.

Software comprised the majority of New Brunswick's total investment in intellectual property products.³⁴ New Brunswick invested 60.3 per cent of its total investment in intellectual property products in software, compared to 36.3 per cent for R&D and 3.5 per cent for mineral exploration and evaluation. Compared to the other provinces, New Brunswick ranked eighth in mineral exploration and evaluation, and sixth in R&D. Most notably, New Brunswick had the largest share in software among the provinces. For comparison, Quebec and Ontario had 44.4 per cent and 55.5 per cent of total investment in intellectual property products as software, respectively.

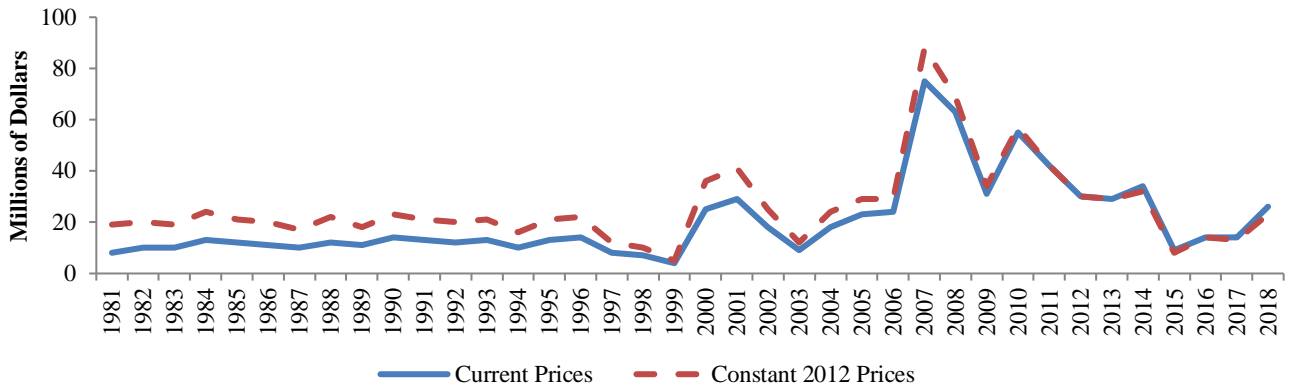
³⁴ Refer to Appendix Chart 6 for types of investment in intellectual property products as a share of total investment in intellectual property products by province in 2018.

iv. Trends over Time in Types of Investment in Intellectual Property Products in New Brunswick

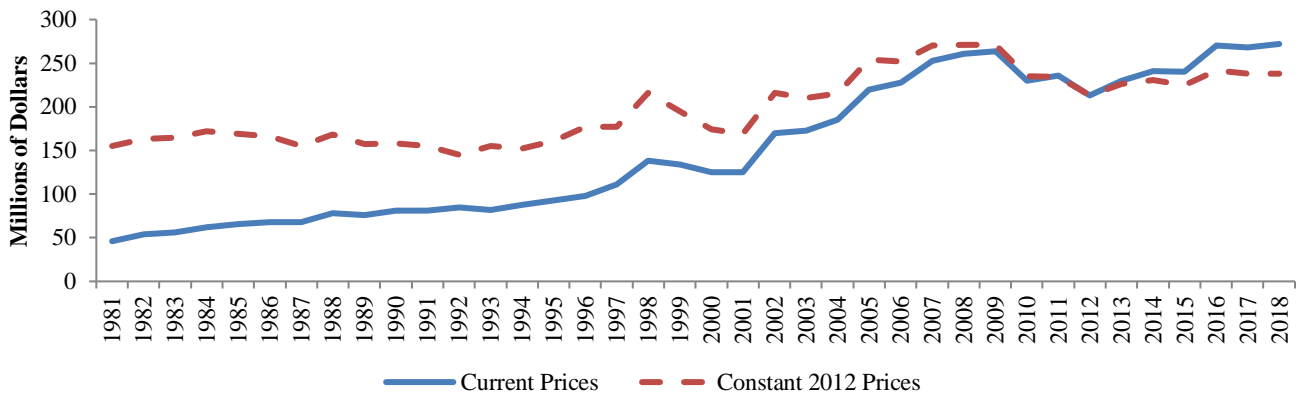
a. Investment in Intellectual Property Products

All three types of investment in intellectual property products experienced growth from 1981 to 2018 (Chart 27).³⁵ In real terms, investment in mineral exploration increased 21.1 per cent from \$19 million in 1981 to \$23 million in 2018, and research and development rose 53.5 per cent from \$155 million in 1981 to \$238 million in 2018. Software experienced the most substantial growth, increasing from eleven times its 1981 value of \$35 million to \$403 million in 2018.

Chart 27: Type of Investment in Intellectual Property Products in New Brunswick, 1981-2018
Panel A: Mineral Exploration and Evaluation

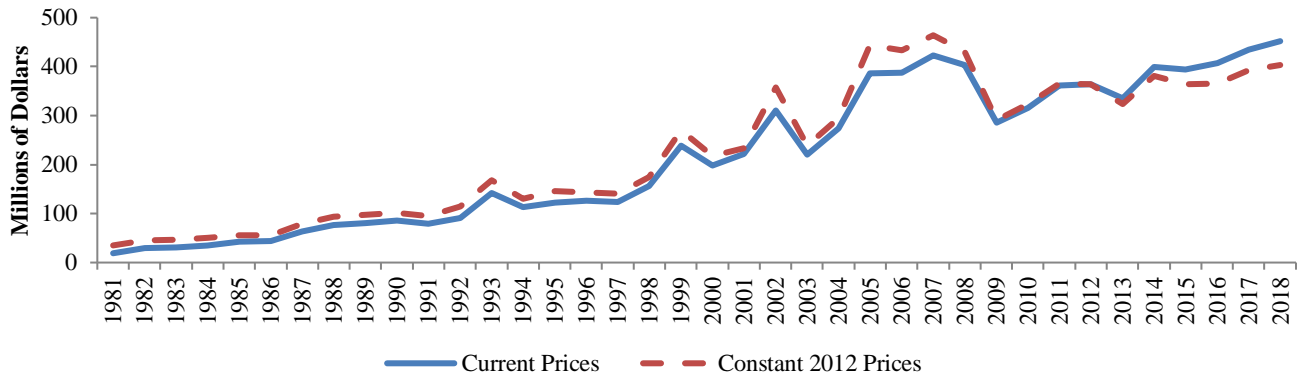


Panel B: Research and Development



³⁵ Refer to database Table 12 for investment in intellectual property products in current and constant 2012 prices from 1981 to 2018.

Panel C: Software



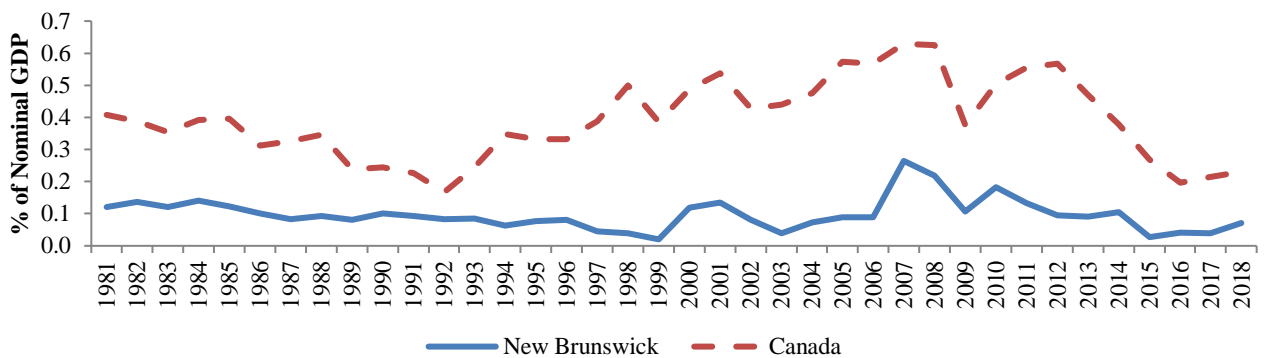
Source: Statistics Canada, Table 36-10-0098-01

b. Investment in Intellectual Property Products as a Share of Nominal GDP

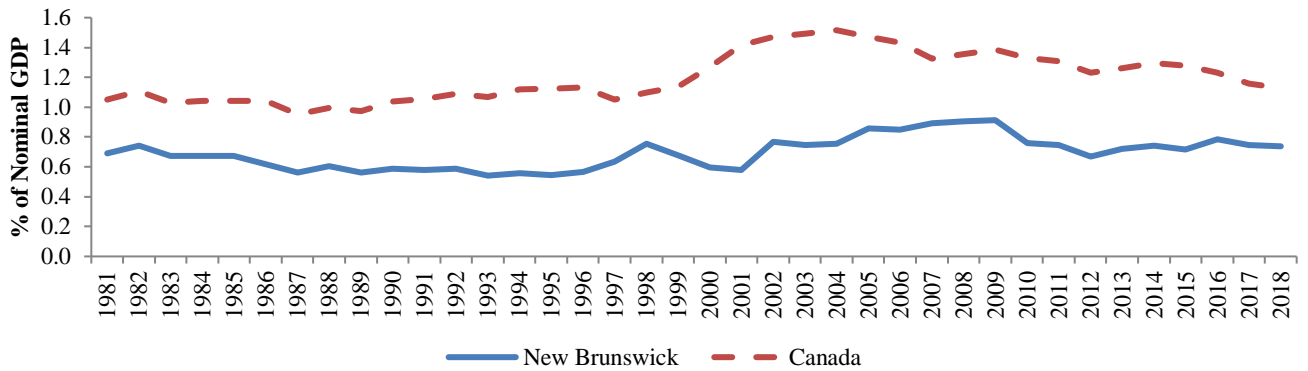
From 1981 to 2018, New Brunswick’s investment in intellectual property products as a share of nominal GDP increased for R&D and software, but declined for mineral exploration and evaluation (Chart 28). New Brunswick’s investment in R&D as a share of nominal GDP increased by 0.05 percentage points from 0.69 per cent of nominal GDP in 1981 to 0.74 per cent in 2018, while investment in software grew by 0.93 percentage points from 0.29 per cent in 1981 to 1.22 per cent in 2018. Investment in mineral exploration and evaluation, however, decreased by 0.05 percentage points from 0.12 per cent of nominal GDP in 1981 to 0.07 per cent in 2018.

Chart 28: Type of Investment in Intellectual Property Products as a Share of Nominal GDP in New Brunswick and Canada, 1981-2018

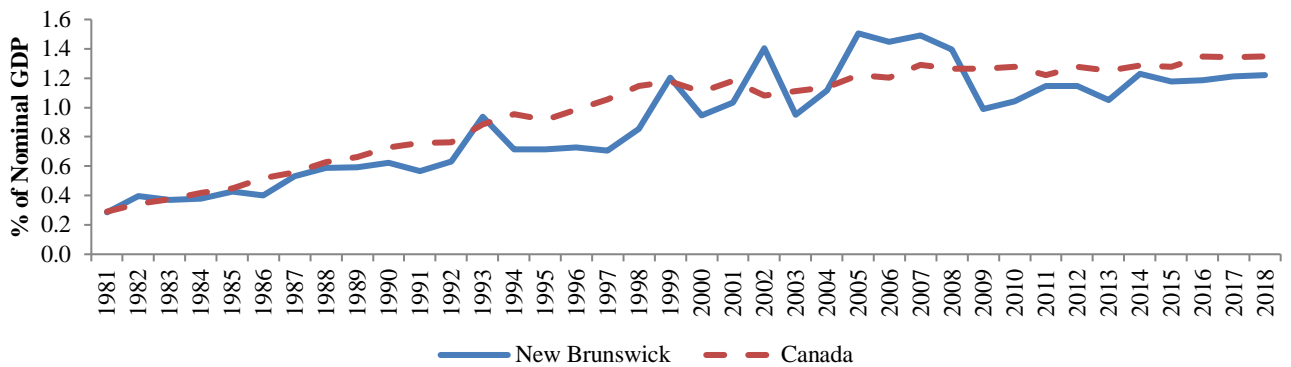
Panel A: Mineral Exploration and Evaluation



Panel B: Research and Development



Panel C: Software



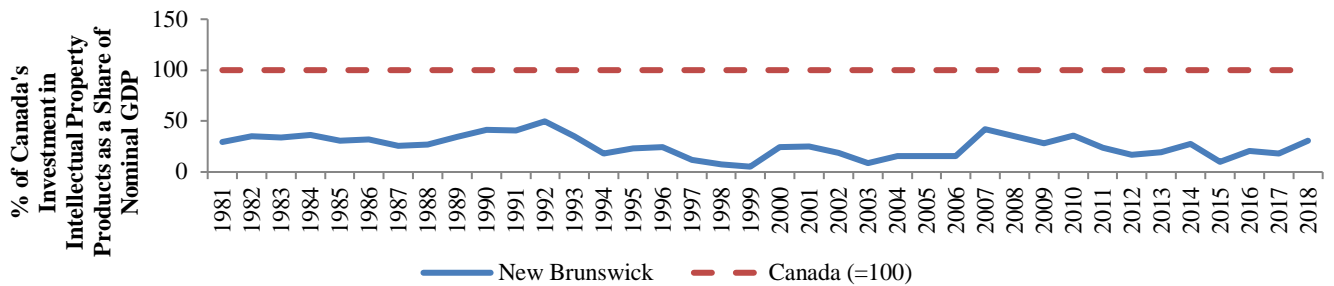
Source: Statistics Canada, Table 36-10-0098-01 & Table 36-10-0222-01

a. Investment in Intellectual Property Products as a Share of Nominal GDP Relative to Canada's

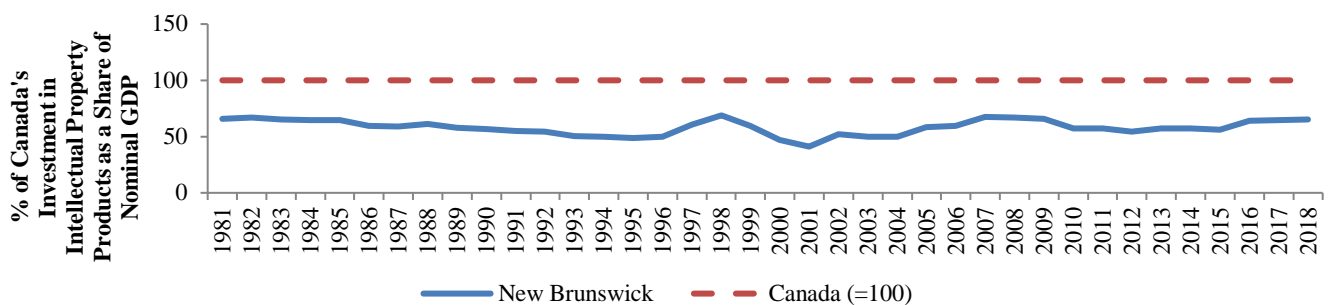
The trends in relative investment in intellectual property products for New Brunswick contrast those of the absolute. New Brunswick's relative investment in intellectual property products increased for mineral exploration and evaluation, but declined for R&D and software (Chart 29). Between 1981 and 2018, New Brunswick's investment in mineral exploration and evaluation relative to Canada's increased by 1.19 percentage points; however, by 2018, the province's investment remained well below the national average at 30.6 per cent of Canada's. For R&D, New Brunswick's relative investment decreased by 0.6 percentage points from 65.8 per cent of Canada's in 1981 to 65.2 per cent in 2018. Similar to mineral exploration and evaluation, New Brunswick's investment in R&D was consistently below Canada's over the period. Relative investment in software experienced the most significant decline between 1981 and 2018, falling 7.56 percentage points. After peaking at 130.0 per cent of Canada's in 2002, New Brunswick's relative investment in software decreased to 90.7 per cent in 2018.

Chart 29: Type of Investment in Intellectual Property Products as a Share of Nominal GDP in New Brunswick Relative to Canada's, 1981-2018

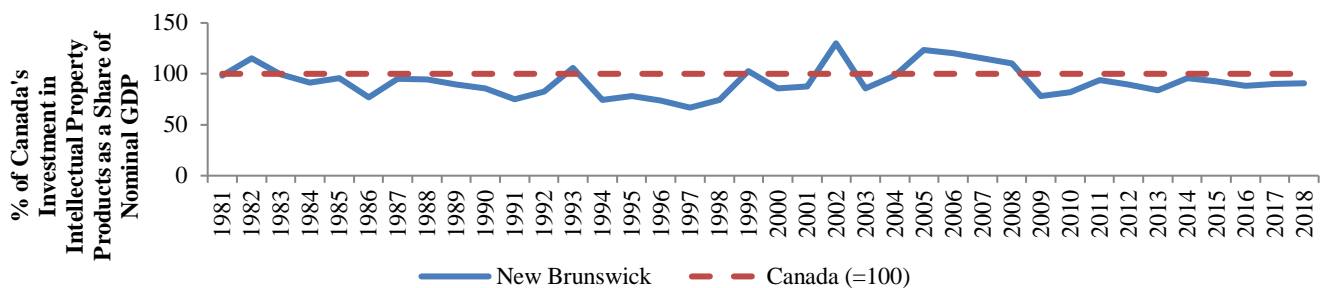
Panel A: Mineral Exploration and Evaluation



Panel B: Research and Development



Panel C: Software



Source: Statistics Canada, Table 36-10-0098-01 & Table 36-10-0222-01

For every type of intellectual property product, investment in New Brunswick as a share of Canada's declined from 1981 to 2018.³⁶ New Brunswick's investment in software as a share of Canada's fell the most significantly over the period. Investment in software decreased by 0.27 percentage points from 1.77 per cent of Canada's in 1981 to 1.51 per cent in 2018. In comparison, investment in R&D as a share of Canada's fell by 0.10 percentage points, and investment in mineral exploration and evaluation decreased by 0.02 percentage points from 1981 to 2018.

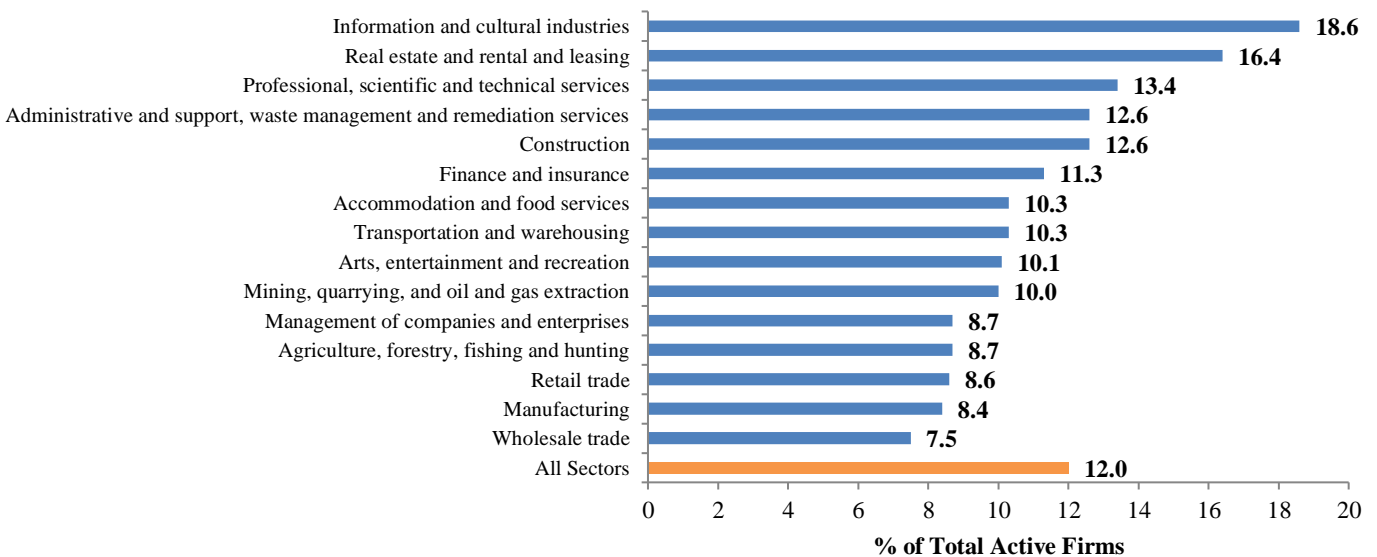
³⁶ Refer to Appendix Chart 7 for investment in intellectual property products in New Brunswick as a share of Canada's by type of intellectual property product from 1981 to 2018.

F. Business Entry

New businesses bring new innovations and technological advances when entering the market. As a result, business creation helps fuel innovative activity, while barriers to business entry may inhibit it. Business entry rates, thus, provide insight into a province’s propensity for innovation.

Chart 30 shows the gross and net business entry rate in New Brunswick across 15 industries in 2017.³⁷ The business entry rate for total sectors was 12.0 per cent. Information and cultural industries had the highest entry rate at 18.6 per cent, while wholesale trade had the lowest at 7.5 per cent. For total sectors, the net business entry rate in New Brunswick was 0.2 per cent; this rate indicates a slow rate of net business creation in the province. Three industries—information and cultural industries, real estate and rental and leasing, and construction—had positive net entry rates, which likely drove the positive net entry rate for all sectors. Five industries had a net entry rate of zero. Seven of fifteen industries had negative net entry rates. Most notably, three industries with a negative net entry rate—manufacturing; professional, scientific, and technical services; and wholesale trade—were part of the Information and Communication Technology sector, which is known to be highly innovative.³⁸

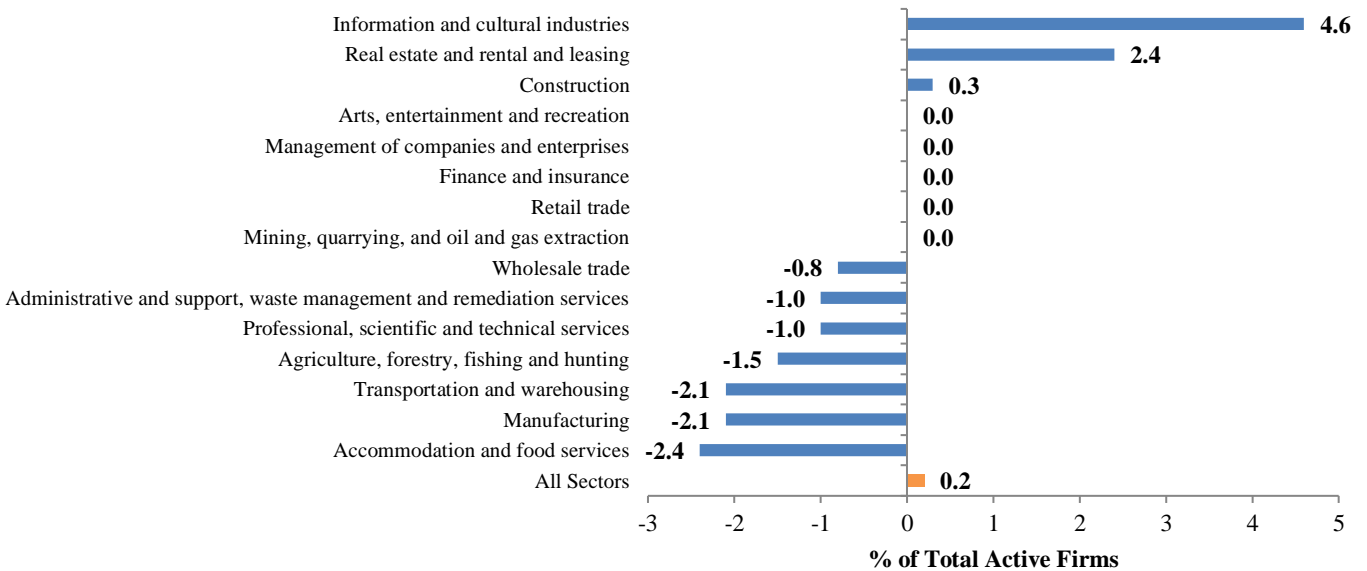
Chart 30: Business Entry Rates in New Brunswick by Industry, 2017
Panel A: Gross Entry Rate



³⁷ The exit rate is the difference between the gross and net business entry rate. Refer to database Table T13 for estimates on business entry and exit rates in 2017.

³⁸ Statistics Canada (2015) defines the ICT sector as comprising the following industries: manufacturing; wholesale trade; information and cultural industries; professional, scientific, and technical services; and other services (except Public Administration).

Panel B: Net Entry Rate

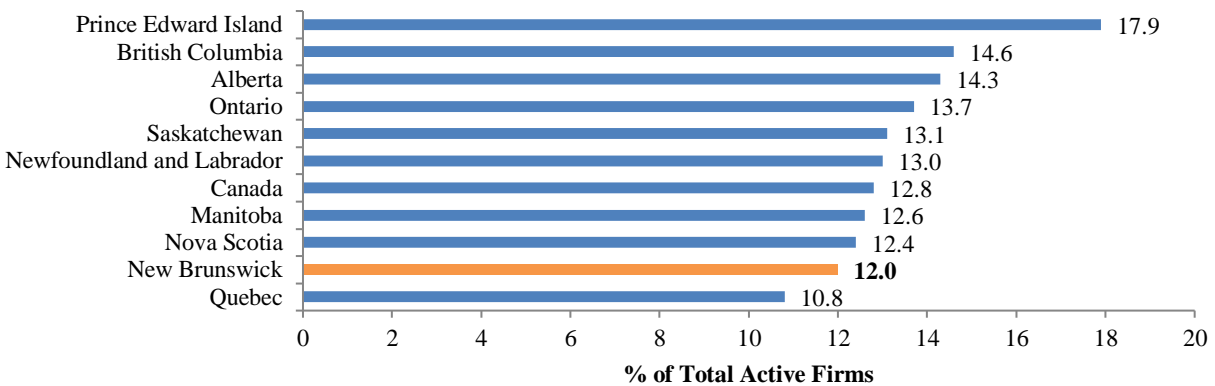


Source: Statistics Canada, Table 33-10-0087-01

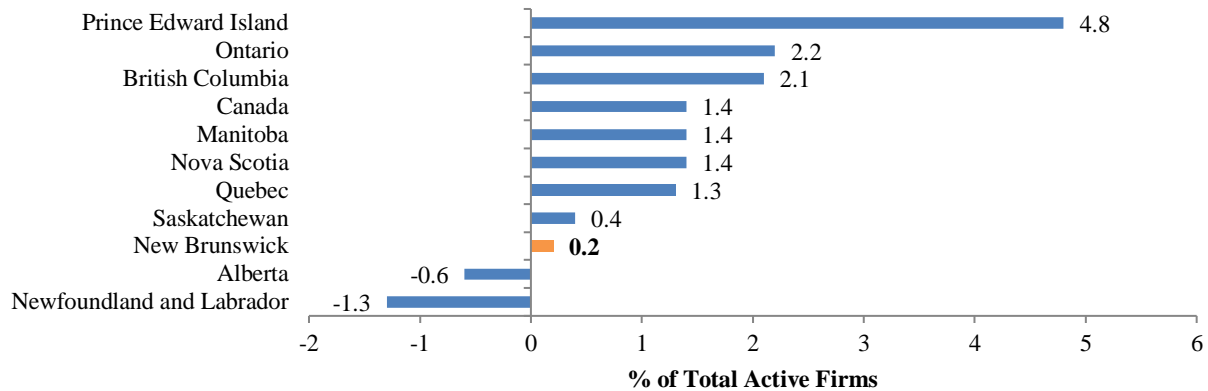
Relative to the other provinces, New Brunswick’s gross and net entry rates were low (Chart 31). For the gross entry rate, the province ranked ninth of ten provinces and last of the Atlantic provinces. For net entry rate, the province ranked eighth of the ten provinces and third of the Atlantic provinces. Top-ranking Prince Edward Island exceeded New Brunswick by 4.6 percentage points for net entry rate. Other high-ranking provinces also had net entry rates that exceeded New Brunswick’s by a wide margin. Ontario’s net entry rate, for example, exceeded New Brunswick’s by 2.0 percentage points.

Chart 31: Business Entry Rates by Province, 2017

Panel A: Gross Entry Rate



Panel B: Net Entry Rate

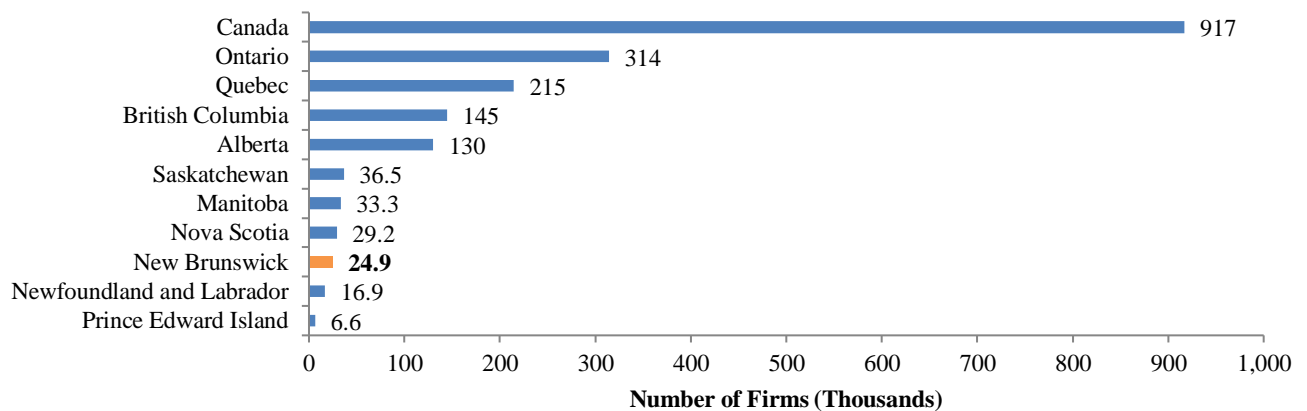


Source: Statistics Canada, Table 33-10-0087-01

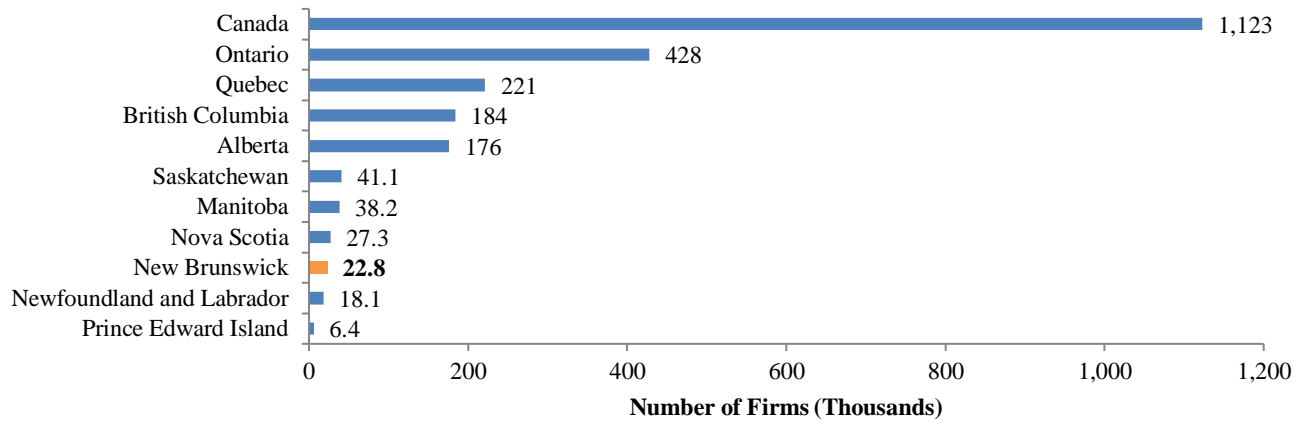
New Brunswick had 24,920 active businesses in 2002 and 22,790 in 2017 (Chart 32). New Brunswick ranked eighth in the number of active businesses in both 2002 and 2007, which is consistent with its rank among the provinces in population. The Atlantic provinces had the fewest number of active businesses in Canada. New Brunswick ranked the lowest among the provinces in terms of compound annual growth in the number of active businesses between 2002 and 2017. In New Brunswick, the number of active businesses declined at a rate of 0.59 per cent per year over the 15-year period. Atlantic Canada had relatively weaker growth compared to the other Canadian regions. New Brunswick, Nova Scotia, and Prince Edward Island experienced negative growth, while Newfoundland and Labrador had positive but relatively low growth. In contrast, the number of active businesses in Ontario grew by 2.08 per cent per year between 2002 and 2017, exceeding New Brunswick's growth rate by 2.67 percentage points.

Chart 32: Number of Active Businesses by Province, 2002-2017

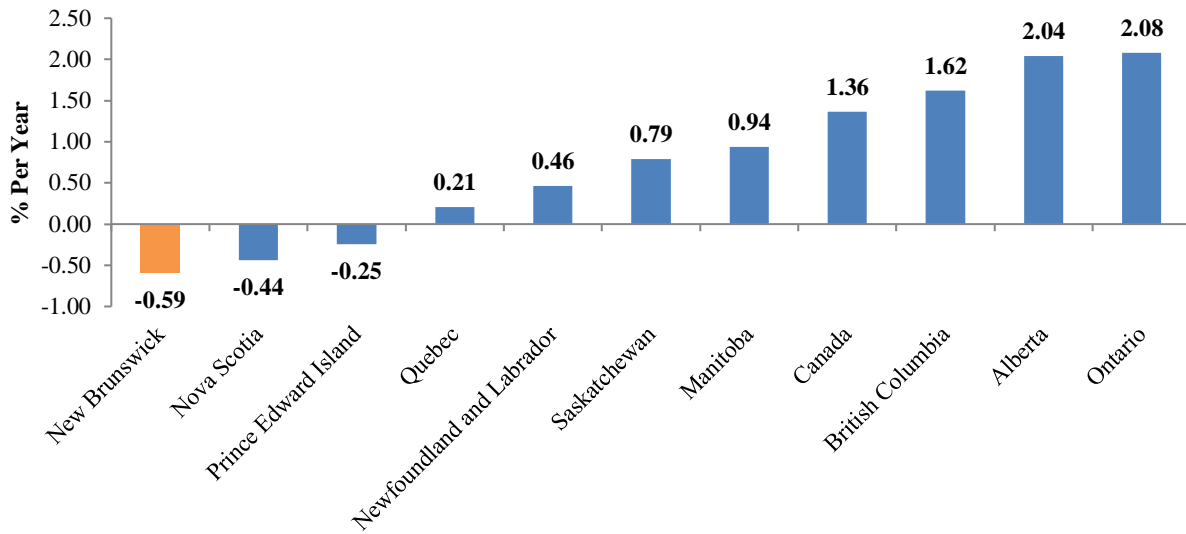
Panel A: 2002



Panel B: 2017



Panel C: Compound Annual Growth, 2002-2017



Source: Statistics Canada, Table 33-10-0087-01

II. Literature Review

A. Innovation Situation in Atlantic Canada and New Brunswick

Most of the literature on innovation in Canada has documented New Brunswick’s and, more generally, Atlantic Canada’s weak innovation performance. Compared to the other provinces and regions, New Brunswick and Atlantic Canada have consistently ranked low in terms of innovation between the early 2000s and 2010s. The Conference Board of Canada (2018) assessed the state of innovation in Canada from 2013 to 2015 and scored each province by letter grade for every indicator. They examined numerous indicators of innovative activity, such as public and business R&D spending, the number of researchers and scientific articles, ICT investment, business entry rate, and patents. The authors concluded that the Atlantic provinces had the weakest innovation performances, while Ontario and Quebec had the strongest. In particular, New Brunswick ranked last, due to especially low scores in the number of researchers engaged in R&D, business R&D spending, and patents. New Brunswick was the only province unable to receive a score higher than “C” for any indicator.

| REPORT CARD | | | | | | | | | | | |
|--------------------------|--------|------|--------|------|------|------|------|------|-------|-------|------|
| Innovation Indicators | | | | | | | | | | | |
| | Canada | N.L. | P.E.I. | N.S. | N.B. | Que. | Ont. | Man. | Sask. | Alta. | B.C. |
| Public R&D | B | B | B | A+ | C | A | A | B | D | D | C |
| Researchers | D | D- | D- | D- | D- | C | C | D- | D- | D- | D- |
| Scientific articles | C | C | D | B | D | C | B | C | C | C | C |
| Entrepreneurial ambition | A | B | n.a. | C | n.a. | A | A+ | A | A | A+ | A+ |
| Venture capital | C | D | D | C | D | B | C | D | D | D | B |
| Business R&D | D | D- | D- | D- | D- | C | D | D- | D- | D- | D- |
| ICT investment | C | D | D | D | C | D | C | D | D- | C | D |
| Patents | D | D- | D | D- | D- | D | D | D- | D- | D | D |
| Enterprise entry | n.a. | A | A | C | C | D | B | B | B | A | A |
| Labour productivity | D | C | D- | D- | D | D | D | D | C | B | D |

Image Source: The Conference Board of Canada, 2018

Other studies have also found poor results in several innovation indicators for Atlantic Canada and New Brunswick. These results are consistent with this report’s findings:

- Global Advantage Consulting Group (2019) conducted a comprehensive study of New Brunswick’s innovation ecosystem for the University of New Brunswick. They concluded that in 2016 New Brunswick had the weakest R&D performance of the

provinces. The authors found that the provincial government was not adequately supporting innovation and research, compared to the other sectors; the provincial government, for example, funded \$11 million in 2016, significantly lower than the \$131 million funded by the higher education sector. Moreover, unlike most provinces, New Brunswick's business sector was not a significant performer of R&D; instead, the province relied on the higher education sector.³⁹

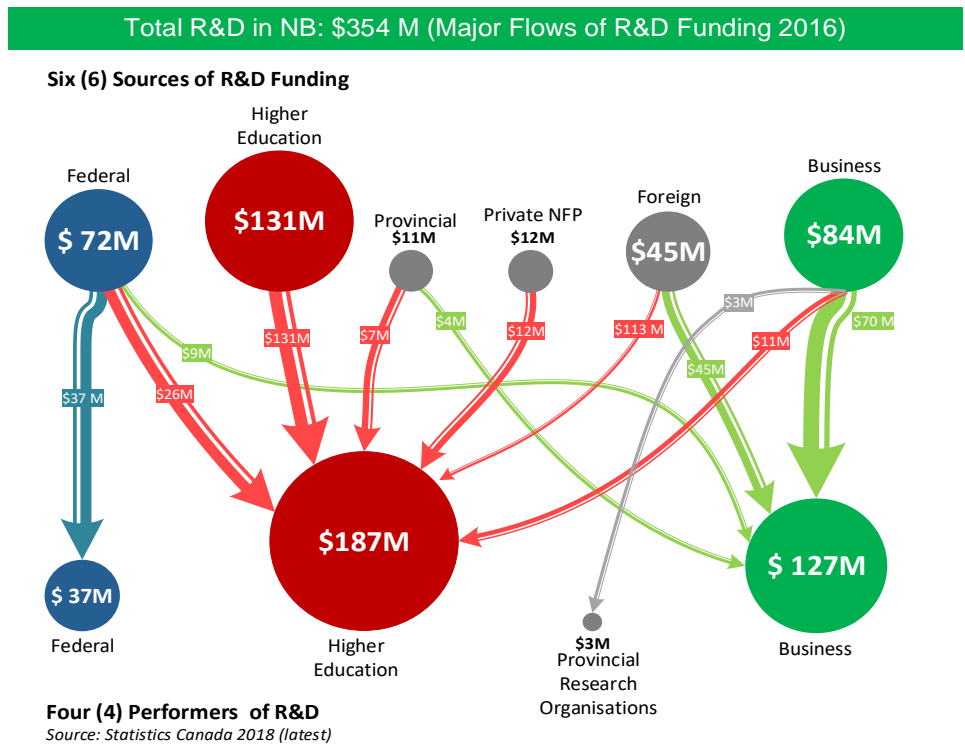


Image Source: Global Advantage Consulting Group, 2018

- The Expert Panel on the State of Science and Technology and Industrial Research and Development in Canada (2018) compared R&D spending among the provinces between 2011 and 2015. New Brunswick ranked ninth of the ten provinces. While the highest ranked provinces relied on the business sector as their main source of R&D investment, the higher education sector was the largest source of funding in Atlantic Canada.
- Locke, Davis, Freedman, Godin, and Holbrook (2004) found that Atlantic Canada and New Brunswick relied on the higher education sector to perform R&D. In comparison, Atlantic Canada's and New Brunswick's shares of business R&D were much lower than the Canadian average. The study identified the same structural features of innovation in New Brunswick as documented in this report.

³⁹ See also the Council of Canadian Academies (2018), Innovation Working Group (2012), and Maritime Provinces Higher Education Commission (2005) for more analysis on R&D expenditures in Atlantic Canada.

- The Atlantic Provinces Economic Council (2002) used the 1998/1999 Workplace Employee Survey to examine innovation in Atlantic Canada at the firm level. They found that the share of large innovative firms in the Atlantic region was lower than the Canadian average, but the share of small innovative firms exceeded the national rate. The share of firms that adopted new technology was also lower than the national average. These results are consistent with this report's current findings from the Survey of Innovation and Business Strategy.

B. Explaining the Weak State of Innovation in Atlantic Canada and New Brunswick

Much of the literature has examined the reasons for the innovation gap in Atlantic Canada and New Brunswick relative to the national average and other Canadian regions. Bourgeois and LeBlanc (2002) studied the link between innovative activity and economic development in Atlantic Canada, using the 1999 Survey of Innovation and the 1999 Workplace and Employee Survey. They listed two major barriers to innovation in Atlantic Canada: financial and labour issues. First, financial barriers concern the high costs of investing in innovation and the difficulty in receiving R&D funding. They found that 63 per cent of manufacturing firms in the Atlantic provinces cited high costs of purchasing new technology and investing in R&D as the primary barrier to conducting innovative activity, while 33 per cent reported financing issues, such as not meeting the requirements to receive government R&D funding. Lastly, Bourgeois and LeBlanc cited labour and knowledge related issues, such as labour shortages. According to the 1999 Survey of Innovation, 38 per cent of firms in the Atlantic region reported a shortage of skilled labour.

Recent studies have posited similar barriers to innovation and point to a lack of innovative culture in New Brunswick. Decourcey, Casey, Fillmore, and Whalen (2017) found that, compared to other regions in Canada, the Atlantic provinces received less R&D funding, had less access to capital to fund new business projects and innovations, and had less access to skilled labour. They also focused on the relatively weak business environment in Atlantic Canada, attributing difficulty in entering large markets and introducing new products in smaller local markets in the region.

Similarly, Holden (2018) studied the reasons for Atlantic Canada's weak innovation in the manufacturing sector, using the 2018 Management Issues Survey by Canadian Manufacturers and Exporters:

- Atlantic Canada faced persistent labour shortages, particularly among highly skilled workers. According to the 2018 Management Issues Survey, these shortages were the

largest barrier to innovation. In Atlantic Canada, the out-migration of young people with post-secondary education has long been one of the major factors behind the region's labour and skills shortages.⁴⁰

- The study found a “technology information gap” among the Atlantic provinces. In other words, manufacturing firms in Atlantic Canada were unaware of new available technologies and their benefits, resulting in under-investment.
- Atlantic Canada suffered from an uncompetitive business environment, due to high corporate taxes in the region and the rising cost of business operations. Moreover, 32 per cent of respondents believed that the federal and provincial governments were not adequately supporting the growth of their firms and that their support had been declining over time.
- The high cost of purchasing new technologies dissuaded firms from investing in innovation. Along with the high cost, firms were uncertain of the economic return of new technologies and, thus, unwilling to adopt them.

A study by Mordue and Karmally (2020) also provides insight into a potential barrier to R&D in manufacturing. The authors examine the relationship between the state of R&D in the auto industry in Canadian locations and these locations' proximity to automakers' headquarters. Canada is not considered a core nation in the automotive industry, and does not host any automaker's corporate headquarters. The authors conclude that automakers tend to conduct R&D in core automotive nations, nearby their global headquarters. More generally, this study may suggest the importance of a region's core versus periphery status in their propensity for R&D. New Brunswick's reliance on branch plants rather than large corporations has likely contributed to its low business R&D.

Other studies have focused on Atlantic Canada's dependence on the higher education sector for R&D. Garlick, Davies, Polese, and Kitagawa (2006) assessed the role of higher education institutions in Atlantic Canada's level of innovation and economic development. As discussed previously, the higher education sector accounts for the largest share of R&D in Atlantic Canada and New Brunswick, while the business sector is the main performer in highly innovative provinces, such as Ontario and Quebec. The authors noted that the primary industries in Atlantic Canada—resource sectors, such as forestry, fishing, and mining—were not “major consumers of university-based research,” the main performer of R&D performed in the region. Consequently, Atlantic Canada had difficulty establishing relationships between the university sector and industry, especially with respect to collaborations in R&D ventures. Similarly, the Maritime Provinces Higher Education Commission (2005) determined that the lack of research linkages between the business and university sectors in Atlantic Canada contributed to the region's weaker innovation environment. The authors concluded, “Without adequate business

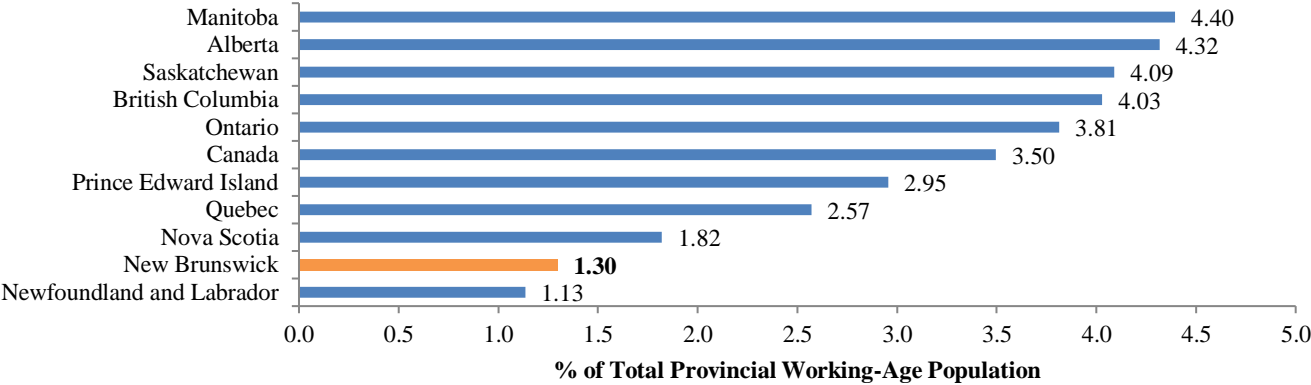
⁴⁰ See also Emery's op-ed “Does an aging population prevent entrepreneurship?” (2020b), which links New Brunswick's aging population and outmigration of young people with the province's stagnant state of innovation.

sector involvement, the Atlantic region cannot hope to participate in national innovation in the same way as other regions.”

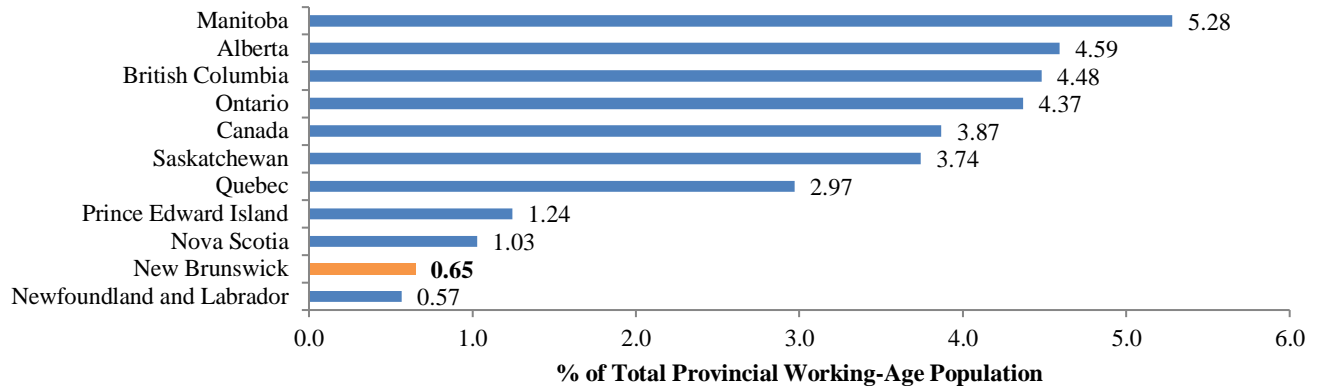
Lastly, New Brunswick’s small immigrant population may have also contributed to the province’s poor innovation performance. In a study for Statistics Canada, Ostrovsky and Picot (2020) analyzed the relationship between immigrant status and innovation incidence in Canadian firms. Using the Survey on Financing and Growth of Small and Medium Enterprises in 2011, 2014, and 2017, the authors found that immigrant-owned firms were more likely than those owned by the Canadian-born to implement a product or process innovation. More specifically, immigrants were 8.6 per cent more likely to implement a product innovation, and 20.1 per cent more likely to implement a process innovation. The authors attributed these results to the high educational attainment of immigrants. New immigrants are more likely to be university-educated than the Canadian-born, and university-educated immigrants are more likely to have studied a STEM field. Firm owners with a STEM background are more likely to adopt new technologies, particularly product or process innovations.

Chart 33 shows that New Brunswick ranked ninth in the share of very recent immigrants and recent immigrants in the provincial population in 2019. Chart 34 shows that the province ranked eighth in the share of immigrants in the provincial population who immigrated from 2018 to 2019. Thus, with a relatively smaller immigrant population and lower rate of immigration into the province, New Brunswick would be unable to fully enjoy the strong innovation performance fostered by immigrant-owned firms.

Chart 33: Immigrant Population in Canada by Province, 2019
Panel A: Very Recent Immigrants



Panel B: Recent Immigrants

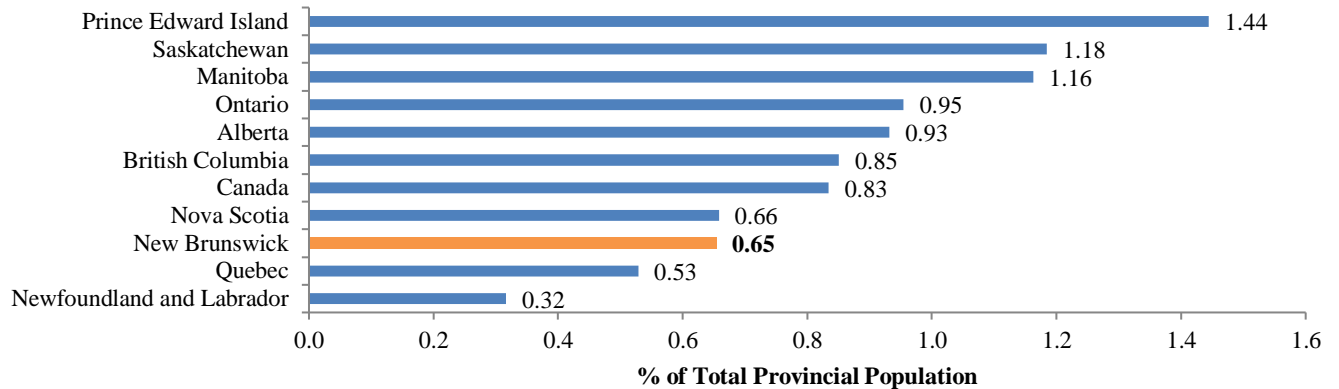


Source: Statistics Canada, Labour Force Survey, Table 14-10-0083-01

Note: “Very recent immigrants” refers to working-age immigrants who have settled in Canada for less than 5 years.

“Recent immigrants” refers to working-age immigrants who have settled in Canada between 5 and 10 years.

Chart 34: International Immigration in Canada by Province, 2018-2019



Source: Statistics Canada, Table 17-10-0014-01 & Table 17-10-0005-01

C. Recommendations to Enhance Innovation in Atlantic Canada and New Brunswick

One of the most prevalent recommendations in the literature is increasing R&D collaboration among the government, business, and higher education sectors in Atlantic Canada. The Maritime Provinces Higher Education Commission (2005) advocated close interactions and research partnerships among the sectors to overcome the challenges of conducting R&D, such as high costs, and to share the benefits of new innovations. A study by Saunders (2015) similarly proposed enhanced collaborations between the business sector and academia in the Atlantic provinces to stimulate innovation in firms. While the business sector could provide funding, higher education institutions could perform R&D and help firms apply the research to their business operations. Garlick, Davies, Polese, and Kitagawa (2006) also proposed a collaborative

approach between sectors and regions to create a culture of innovation in Atlantic Canada. More specifically, they advocated creating a federal or provincial agency to help facilitate interactions between research universities and industries.

Many studies proposed objectives to foster innovation in Atlantic Canada and New Brunswick. For example, Decourcey, Casey, Fillmore, and Whalen (2017) recommended numerous goals to enhance the innovation environment in Atlantic Canada. Recommendations included improving access to capital through investment, increasing research collaborations between the public and private sectors, expanding or improving existing government supports for innovative businesses, and supporting research clusters. More specific to New Brunswick, the Innovation Working Group (2012) outlined five objectives to improve innovation in the province:

- Increase the provincial government's role in stimulating innovation in New Brunswick
- Improve New Brunswick's business conditions to increase competitiveness and to attract investment
- Encourage innovative thinkers in the province by supporting entrepreneurship and strengthening the relationship between the business and university sectors
- Strengthen the province's access to capital, skilled workers, and ideas
- Improve collaboration among the business, higher education, and government sectors

III. Summary and Conclusion

This section presents a summary and conclusion of this report. In particular, it provides an overall assessment of the innovation situation in New Brunswick by summarizing the key indicators discussed. We first assess the level of innovation in New Brunswick, then the trends in innovation. Lastly, this section summarizes the barriers to innovation in the province and offers concluding remarks.

A. Levels of Innovation

This report finds that New Brunswick’s innovation situation was weak. Overall, New Brunswick ranked low among the provinces and below the national average for all indicators. New Brunswick had particularly poor results for R&D spending and personnel in the business sector, patents, and firm-based innovation statistics. However, there were exceptions in certain sectors and types of investment. Most notably, New Brunswick ranked high among the provinces in the share of total R&D spending and share of total R&D personnel in the government and higher education sectors. These results indicate a reliance on the public sector over the private sector for R&D. Table 8 summarizes the key results for each indicator.

Table 8: Summary of the Level of Innovation in New Brunswick by Indicator

| Indicator | Findings |
|----------------------------------|---|
| R&D Spending | <ul style="list-style-type: none"> • R&D spending per capita: Ranked low among provinces and below national average for total spending and for all performer sectors • % of GDP: Ranked low among provinces and below national average for total spending and for all performer sectors • % of total R&D spending: Ranked high in the higher education and government sectors; ranked low in business sector |
| R&D Personnel | <ul style="list-style-type: none"> • % of total employment: Ranked low among provinces and below national average for total R&D personnel and for all performer sectors • % of total R&D personnel: Ranked high in the higher education and government sectors; ranked low in business sector |
| Patents | <ul style="list-style-type: none"> • Number of patents: Ranked low among provinces |
| Firm-Based Innovation Statistics | <ul style="list-style-type: none"> • % of innovative firms: Ranked last among regions • % of firms that use advanced technologies: Ranked last among regions • Least likely to have firms implement any type of innovation |

| | |
|--|--|
| Non-Residential Fixed Capital Investment | <ul style="list-style-type: none"> • % of GDP: Ranked low among provinces and below national average for total investment and 2 of 4 investment types (engineering construction, and intellectual property products) • % of total investment: Ranked low among provinces for 2 of 4 investment types (engineering construction and intellectual property products) |
| Investment in Intellectual Property Products | <ul style="list-style-type: none"> • % of GDP: Ranked low among provinces and below national average in 2 of 3 types of IPP (mineral exploration and evaluation, and R&D) • % of total IPP investment: Ranked low among provinces and below national average in 2 of 3 types of IPP (mineral exploration and evaluation, and R&D) |
| Business Entry | <ul style="list-style-type: none"> • Gross and net entry rates: Ranked low among the provinces and below the national average |

B. Trends in Innovation

This report finds that New Brunswick’s innovation situation has generally improved over time in absolute terms and relative to the Canadian average. In particular, the province improved in five of seven indicators: R&D spending, R&D personnel, patents, firm-based innovation statistics, and investment in intellectual property products. However, results for two indicators—non-residential fixed capital investment and number of active businesses—deteriorated. Table 9 summarizes the key trends for each indicator.

Table 9: Summary of the Trends in Innovation in New Brunswick by Indicator

| Indicator | Findings |
|------------------|--|
| R&D Spending | <ul style="list-style-type: none"> • Absolute change: Improved from 1981 to 2017 for total spending and all performer sectors, except the government sector • Relative change: Improved from 1981 to 2017 for total spending and all performer sectors, except the government sector |
| R&D Personnel | <ul style="list-style-type: none"> • Absolute change: Improved from 2000 to 2013 for total personnel and all performer sectors, except the government sector • Relative change: Improved from 2000 to 2013 for total personnel and all performer sectors, except the government sector |
| Patents | <ul style="list-style-type: none"> • Absolute change: Improved from 1980 to 2016 |

| | |
|--|--|
| Firm-Based Innovation Statistics | <ul style="list-style-type: none"> • Absolute change: Improved from period 2010-2012 to 2015-2017 |
| Non-Residential Fixed Capital Investment | <ul style="list-style-type: none"> • Absolute change: Deteriorated from 1981 to 2018 for total investment and all performer sectors, except intellectual property products • Relative change: Deteriorated from 1981 to 2018 for total investment and all performer sectors, except intellectual property products |
| Investment in Intellectual Property Products | <ul style="list-style-type: none"> • Absolute change: Improved from 1981 to 2018 for all types of IPP, except mineral exploration and evaluation • Relative change: Deteriorated from 1981 to 2018 for all types of IPP, except total IPP and mineral exploration and evaluation |
| Business Entry | <ul style="list-style-type: none"> • Absolute change: Number of active businesses deteriorated from 2002 to 2017 |

C. Barriers to Innovation

Despite improving in recent years, New Brunswick’s state of innovation remains among the weakest in Canada. Several barriers have dampened New Brunswick’s ability to develop a culture of innovation, as noted in the literature. Most barriers centre on financial issues, labour shortage issues, and a lack of motivation among firms to innovate.

The following are eight key barriers to innovation in New Brunswick, as highlighted in this report. First, New Brunswick has less R&D funding and access to capital compared to other provinces. Collaboration on R&D ventures among performer sectors is also lacking, particularly between the higher education and business sectors. Industries in the province have relatively low R&D intensity, and New Brunswick’s industrial structure is not conducive to R&D. At the firm-level, businesses in New Brunswick are less interested in adopting new technologies, and many cite the high costs of purchasing and implementing new technologies as a major barrier to innovating. Moreover, New Brunswick suffers from an uncompetitive business environment, due to high corporate taxes and rising business costs, which deters innovation. Lastly, population issues, including the out-migration of young educated people and low immigration flows, have contributed to the lack of innovation in the province.

Due to these issues, New Brunswick’s innovation performance was poor relative to the other provinces. New Brunswick had especially low rankings in business R&D, patents, and firm-level innovation—all of which are directly linked to the province’s barriers to innovation. However, New Brunswick has shown great improvement in most innovation indicators. To

continue this upward-trend, researchers and policymakers must prioritize finding solutions to the barriers to innovation in New Brunswick.

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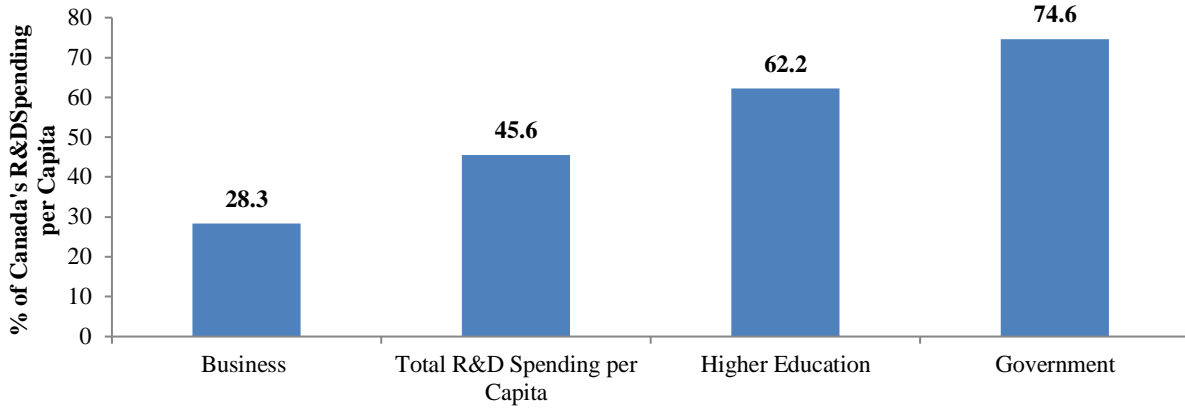
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Appendix

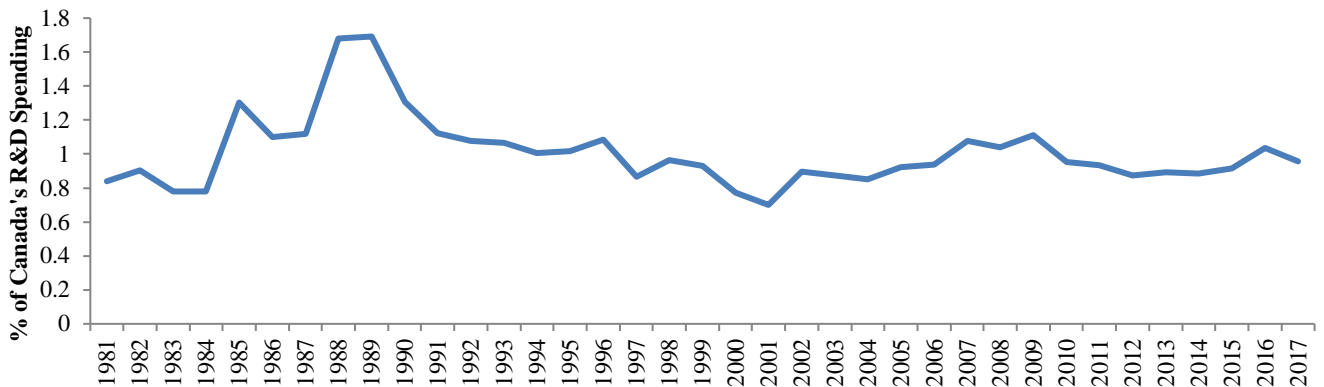
Appendix Chart 1: R&D Spending per Capita by Performer Sector in New Brunswick as a Share of Canada's, 2017



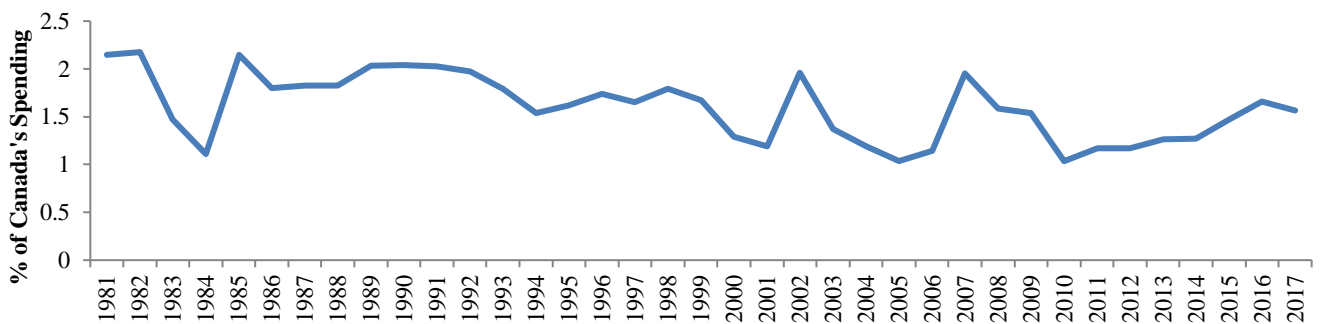
Source: Statistics Canada, Table 27-10-0273-01 & Table 17-10-0005-01

Appendix Chart 2: R&D Spending by Performer Sector in New Brunswick as a Share of Canada's, 1981-2017

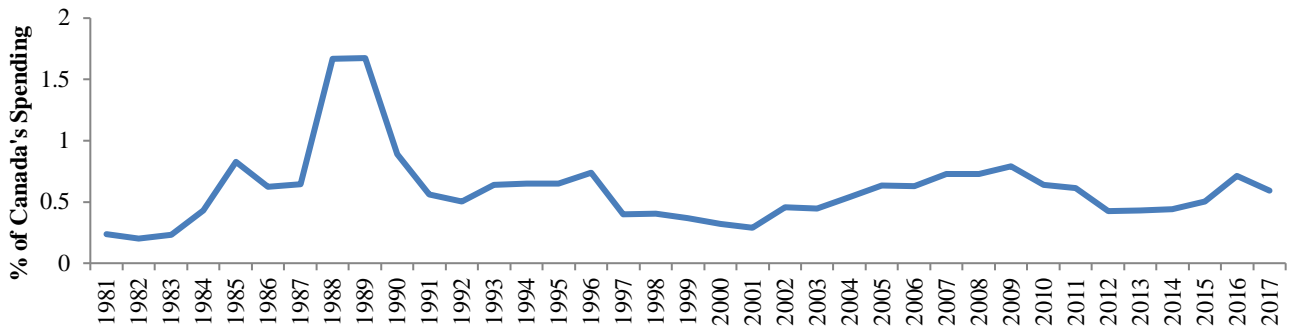
Panel A: Total R&D Spending



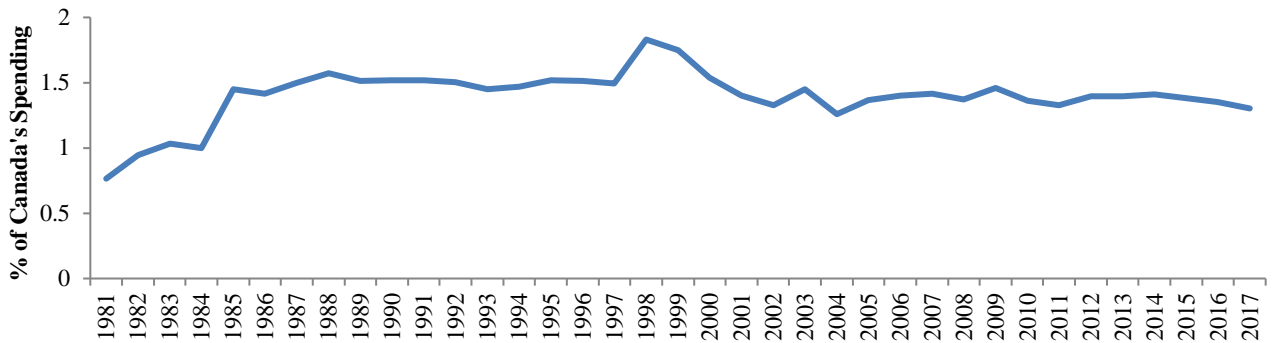
Panel B: Government



Panel C: Business



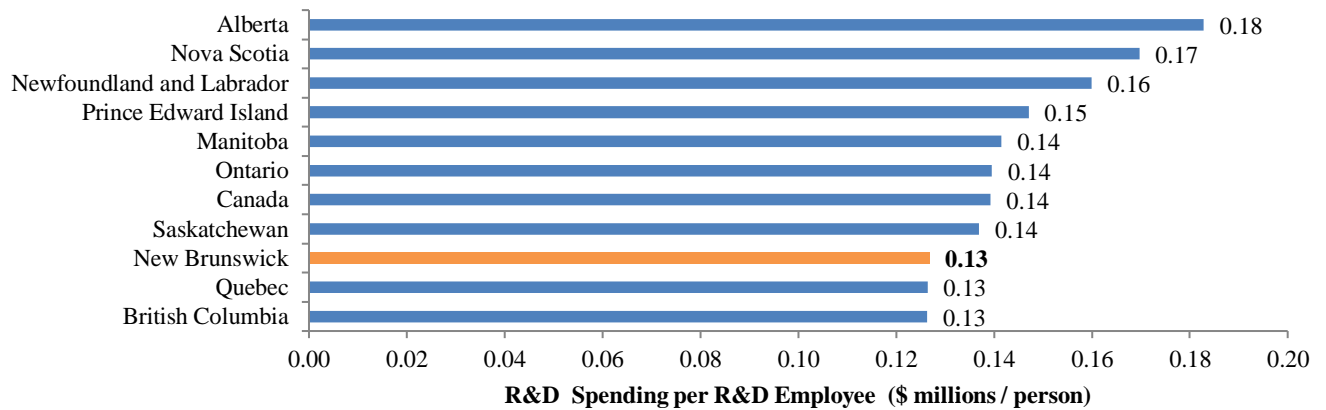
Panel D: Higher Education



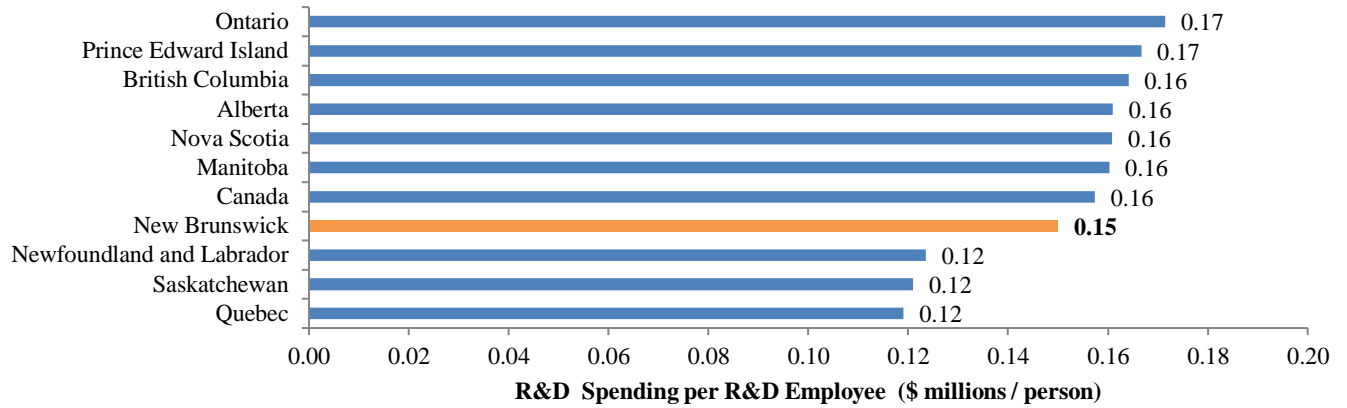
Source: Statistics Canada, Table 27-10-0273-01

Appendix Chart 3: R&D Spending per R&D Employee by Performer Sector and Province, 2013

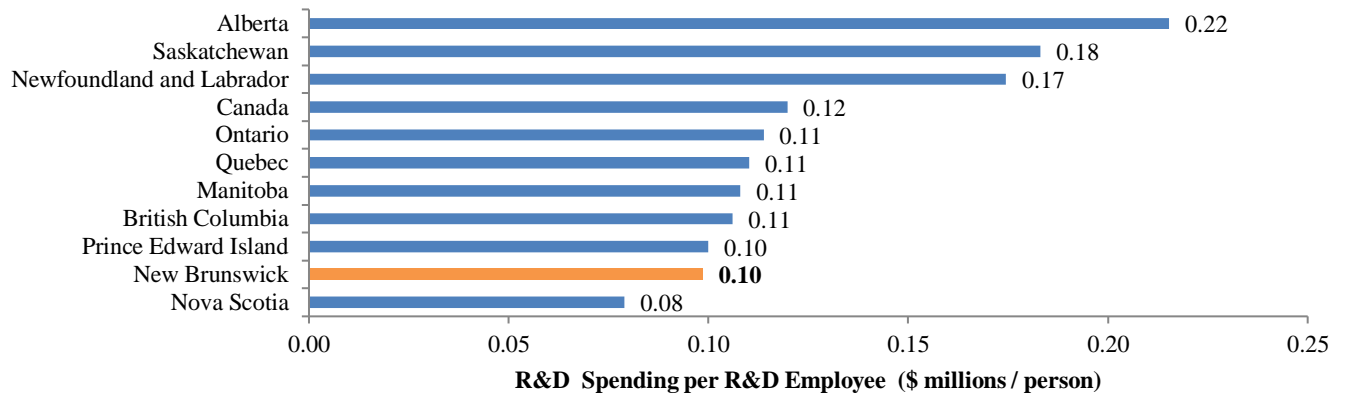
Panel A: Total R&D Spending per R&D Employee



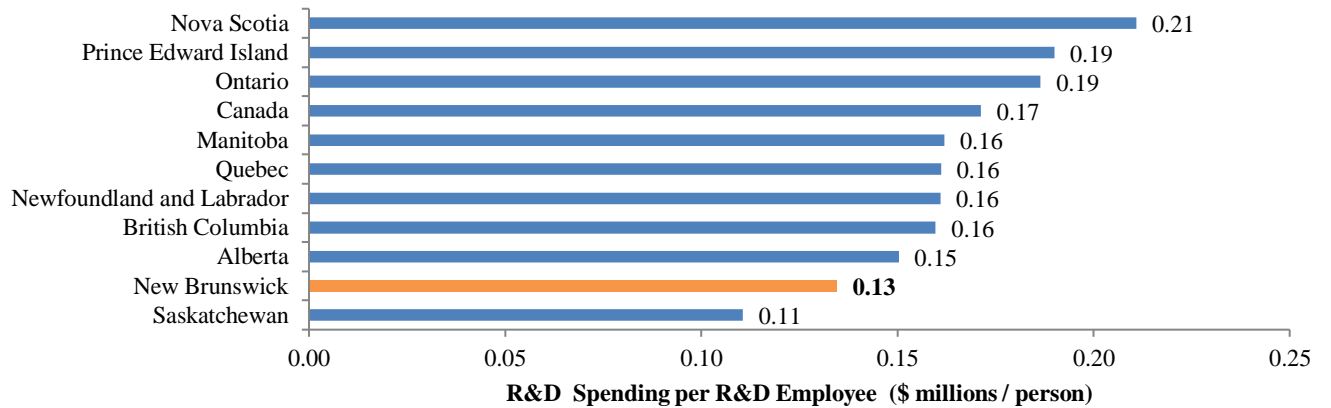
Panel B: Government



Panel C: Business

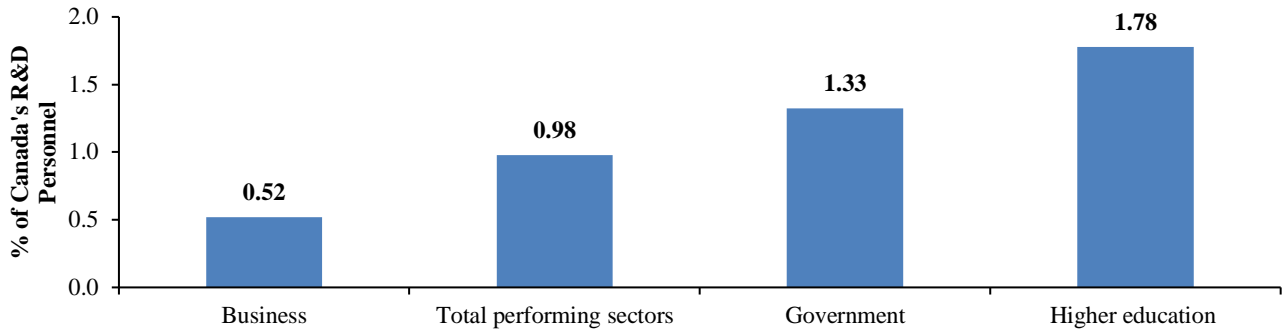


Panel D: Higher Education



Source: Statistics Canada, Table 27-10-0273-01 & Table 27-10-0023-01

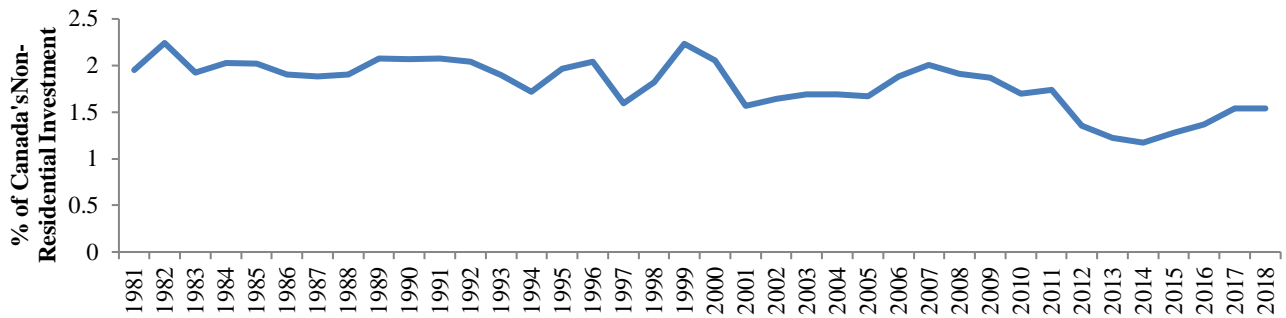
Appendix Chart 4: R&D Personnel by Performer Sector in New Brunswick as a Share of Canada's, 2013



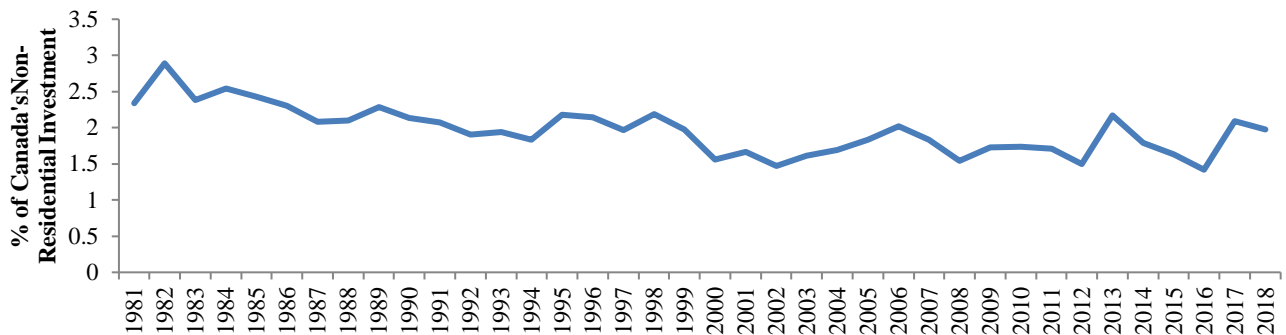
Source: Statistics Canada, Table 27-10-0023-01

Appendix Chart 5: Type of Non-Residential Investment in New Brunswick as a Share of Canada's, 1981-2018

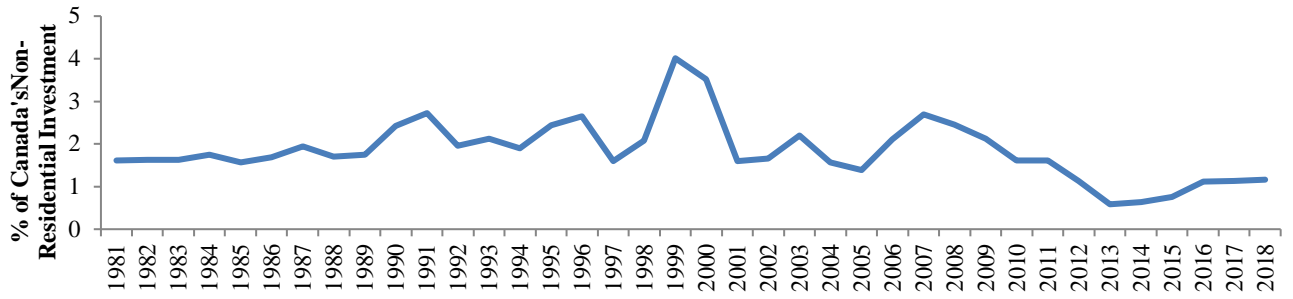
Panel A: Total Non-Residential Investment



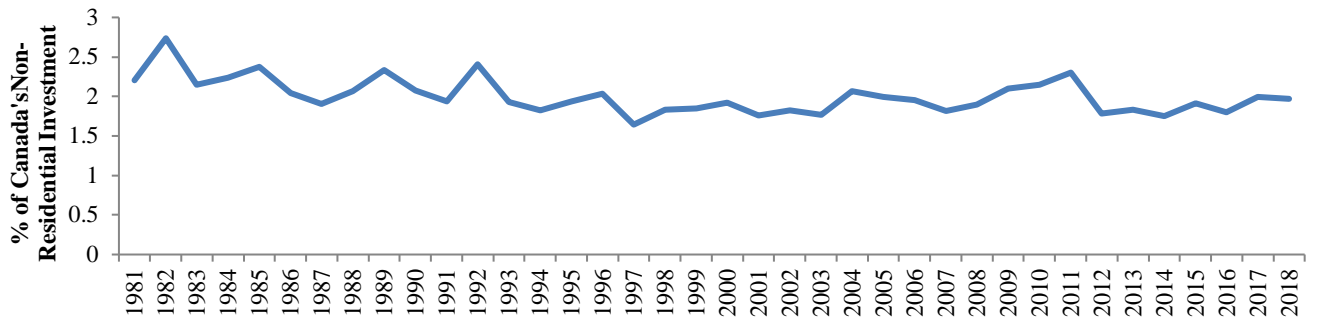
Panel B: Non-Residential Buildings



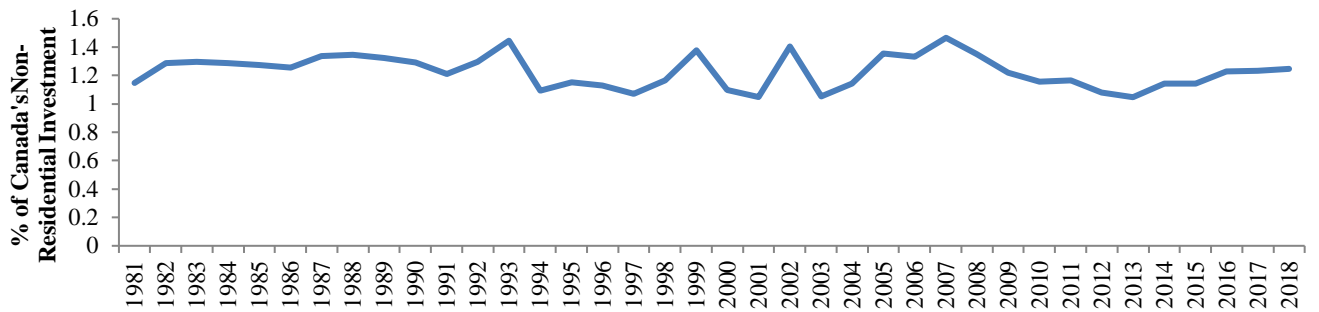
Panel C: Engineering Construction



Panel D: Machinery and Equipment



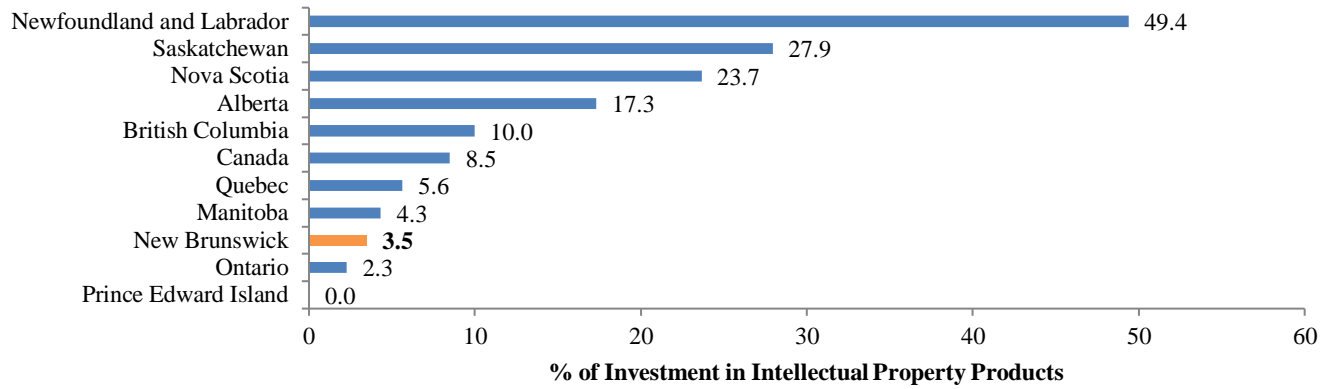
Panel E: Intellectual Property Products



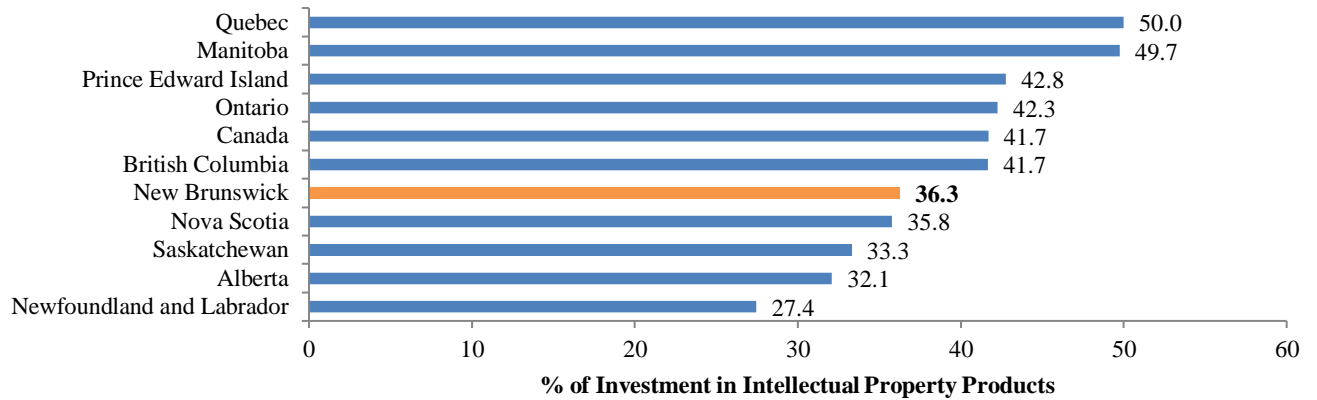
Source: Statistics Canada, Table 36-10-0098-01

Appendix Chart 6: Type of Investment as a Share of Total Investment in Intellectual Property Products by Province, 2018

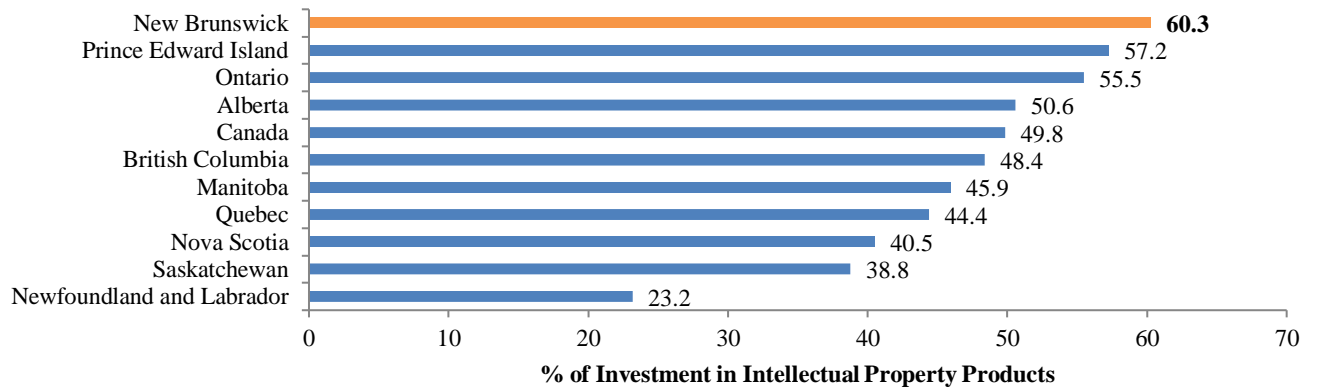
Panel A: Mineral Exploration and Evaluation



Panel B: Research and Development



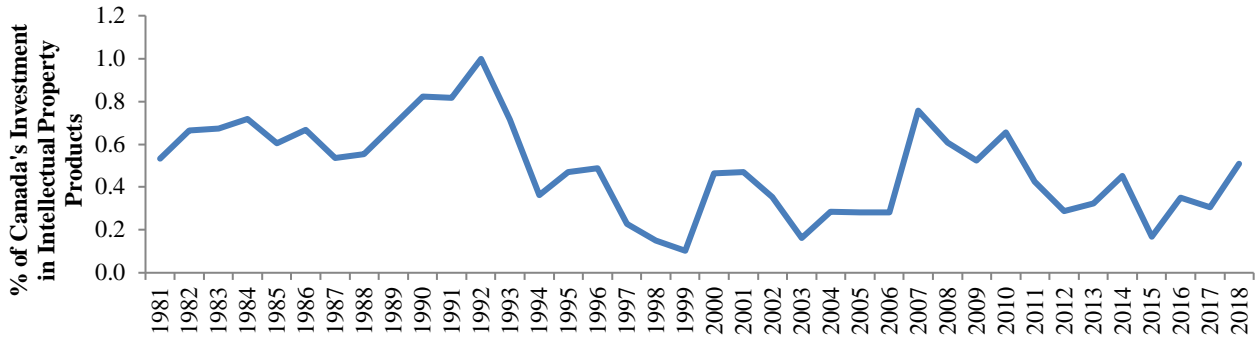
Panel C: Software



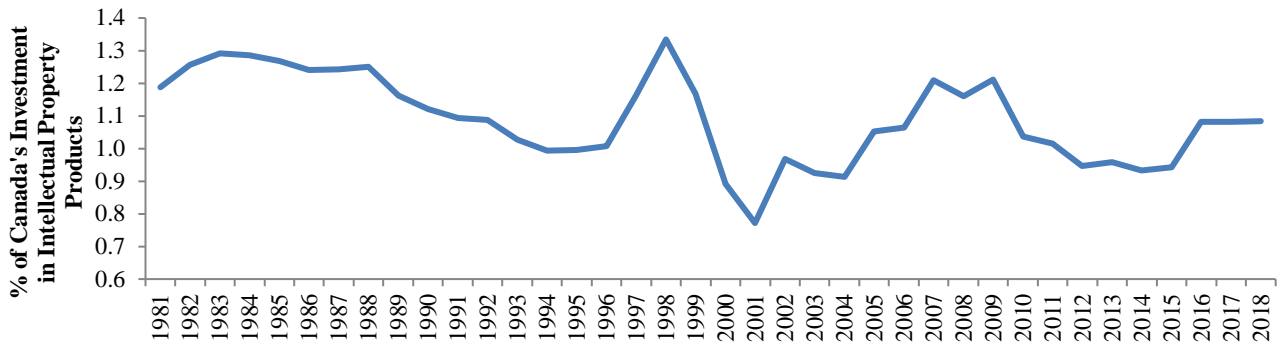
Source: Statistics Canada, Table 36-10-0098-01

Appendix Chart 7: Type of Investment in Intellectual Property Products in New Brunswick as a Share of Canada's, 1981-2018

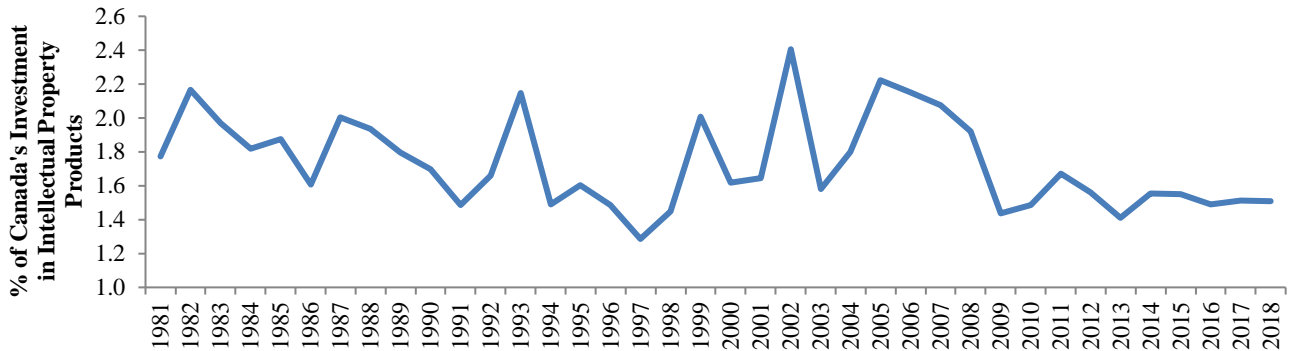
Panel A: Mineral Exploration and Evaluation



Panel B: Research and Development



Panel C: Software



Source: Statistics Canada, Table 36-10-0098-01