The State of Science, Technology, and Innovation in Canada 2025

Expert Panel Report

CCA | CAC

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COUNCIL OF CANADIAN ACADEMIES
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The Council of Canadian Academies (CCA) offices in Ottawa are located on the unceded traditional territory of the Anishinaabe Algonquin People, who have cared for these lands for millennia.

The CCA is committed to reconciliation and honouring Indigenous sovereignty. Through our work in providing evidence for decision-making, we recognize that a wide range of knowledges and experiences contribute to building a more equitable and just society. We encourage all who engage with our work to further learn about and acknowledge the past and present context of the land now known as Canada and of the Indigenous Nations and Peoples who steward it.

Expert Panel on the State of Science, Technology, and Innovation in Canada

Expert panel members serve as individuals and do not represent their organizations of affiliation or employment. Each panel member was selected for their expertise, experience, and demonstrated leadership in fields relevant to this project.

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Message from the Chair

This expert panel report is the latest in a series of CCA assessments commissioned by the Government of Canada to examine the nation's science, technology and innovation (STI) performance.

The last such report was published in 2018, before COVID-19 and the Russian invasion of Ukraine. Even as the current work unfolded, there were further dramatic developments in global affairs. President Donald Trump's second term has upended Canada's deeply interconnected relationship with the United States and roiled international trade. The impacts of the AI revolution are accelerating in every corner of the economy, and as air quality concerns in Canada reminded us in the summer months, the consequences of climate change are worsening.

It is too early for the impacts of all these challenges to be reflected in the current report. Nonetheless, as in prior iterations, this CCA assessment brings together the best available data from across the STI landscape. It both follows the data streams of prior reports and taps new sources in new areas. The data as always are imperfect, and gaps persist. The panel feels strongly that we need to dramatically upgrade our capacity to track and report real-time changes in our innovation economy domestically and globally to help Canadian decision-makers navigate these turbulent times.

That said, there is coherence and consistency in the picture that emerges, not least because so much of what we report confirms longstanding weaknesses in Canada's STI ecosystem. Put simply, Canada is facing a period of unprecedented challenges with a weak hand: declining productivity and erosion of our standard of living arising in large measure from the steady worsening of our innovation performance. Remedying this weakness is urgent given not only the perturbations in trade, but the clear prospect of further declines as the private and public sectors in other countries adapt faster to new realities.

We understand and explore the reality that Canada's longstanding economic dependence on our abundant natural resources will inevitably have some effect on various innovation indices. However, in the long run, Canada's greatest natural resource is its talented, well-educated, and diverse population. Our greatest weakness is an economy that consistently underuses and undervalues the capacity of Canadians to create prosperity for future generations. Remedying that weakness in the years ahead is not achievable by government policy shifts alone but must be a priority for leaders in every social and economic sector.

The report reflects the contributions of many individuals and teams who richly merit acknowledgment. Expert panel members, all volunteers, began meeting in July 2024. For more than a year, they generously shared their time, expertise and experience, and wrestled tirelessly with the inevitable ambiguities in framing the information herein. The excellent CCA team tenaciously sought and verified information at every stage of the process. The report was strengthened by peer reviews, the work of David Wolfe as peer review monitor, and many others who provided input along the way. On behalf of the CCA, I also want to thank the contributors to the compendium of commissioned papers that accompany this publication.

Last, sincere thanks are due to the sponsors who commissioned this work. While CCA panels are not asked to make specific policy recommendations, they are encouraged to weigh the implications of their findings, and this assessment, like others before it, does so. Together, these reports paint a consistent picture: notwithstanding real strengths in science broadly defined and an impressive history of technology development, Canada is an innovation laggard on multiple fronts. The priorities for action, long signalled across multiple expert reviews and CCA assessments, should by now be unmistakable. What is urgently needed is nothing less than a coordinated and wide-ranging overhaul of innovation-related policies by all of Canada's governments.

Sincerely,

Ilse Treurnicht
Chair, Expert Panel on the State of Science, Technology, and Innovation in Canada

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The CCA received a Strategic Initiatives Fund grant from the Social Sciences and Humanities Research Council (SSHRC). This funding supported the development of the following papers, available on the CCA website:

- **Kyle Briggs:** *Challenges and opportunities for Canadian deep tech commercialization*
- **François Claveau, Jérémie Dion, Francis Lareau, Éric Montpetit, Mathieu Ouimet, and Louis Renaud-Desjardins:** *Scholarly citations in Canadian policy documents*
- **Wendy Cukier:** *State of equity, diversity, and inclusion within Canada's science, technology, and innovation ecosystem*
- **Janet Halliwell:** *Academic-Facing large research infrastructures in/for Canada: Mapping the landscape and issues*
- **Dieter Kogler:** *The evolution and state of the science–technology knowledge nexus across Canadian regional innovation systems*
- **Vincent Larivière, Carolina Pradier, and Diego Kozlowski:** *Using OpenAlex to assess Canadian research outputs: An exploratory analysis*
- **Dan Munro and Creig Lamb:** *Measuring innovation in the age of intangibles*
- **Viet Vu and Graham Dobbs:** *In innovation we trust: The definitions and drivers of trust and innovation in Canada*

The SSHRC grant was also used to support a virtual event to give focus to the Indigenous dimensions of science, technology, and innovation in Canada. The following experts provided presentations:

- **Kori Czuy,** Relational Science Educator. Manager, Indigenous Science, TELUS Spark Science Centre: *Ethics, Protocols, and Relationality*
- **Tia Laroque-Graham,** Director of Innovation, pawâcikêwikamik: The Innovation Collective, Saskatchewan Indian Institute of Technologies (SIIT): *SIIT pawâcikêwikamik: The Innovation Collective*
- **Dawn Martin-Hill,** Professor Emeritus, Indigenous Studies Department, McMaster University: *Equity in Indigenous knowledge production and training*
- **Ryan St. Germaine,** Founder and CEO of Indigenous Tech Circle: *Bridging worlds: My journey in tech, identity, and building community*
- **Jeff Ward,** Founder and CEO, Animikii: *Animikii's evolution*

Peer Reviewers

This report was reviewed in draft form by reviewers selected by the CCA for their diverse perspectives and areas of expertise. Their anonymized submissions were considered in full by the expert panel. Reviewers were not asked to endorse the conclusions, nor did they see the final draft before its release. Responsibility for the final content of this report rests with the expert panel and the CCA.

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The peer review process was monitored on behalf of the CCA by **David A. Wolfe**, Professor Emeritus and Co-Director of the Innovation Policy Lab, Munk School of Global Affairs and Public Policy, University of Toronto.

Executive Summary

Canada faces an unenviable set of circumstances: a worsening productivity crisis; a shifting and potentially diminished relationship with the United States, our largest trading partner; stubbornly low private sector R&D spending; and lacklustre technology adoption across the economy. While many groups have been signalling concern about Canada's innovation performance over the course of the last two or more decades, the expert panel for this report believes the ongoing deterioration has reached a point where maintaining the nation's standard of living may be at risk. Several areas of acute concern are described below, and a summary of the panel's response to the full charge is available in Chapter 10 of the report.

The performance of Canada's business and government sectors continues to decline relative to other countries when it comes to science, technology, and innovation (STI)

Canada's R&D intensity (expenditures on R&D as a percentage of GDP) decreased between 2000 and 2023. By contrast, in most peer countries, including all other G7 countries, R&D intensity increased, as did the average R&D intensity of OECD countries. After an extended period of decline, on a per-GDP basis, government in-house R&D expenditures have been reduced by half since the beginning of the century and sat at less than half the OECD average in 2023.

Business R&D expenditures are stubbornly low and declining in several key industries. Canadian firms are slow to adopt new technologies and the rate of technology adoption is falling over time. Firms also continue to underinvest in innovation talent development. Canada's industrial structure does not fully explain these persistent trends. While small- and medium-sized enterprises (SMEs) are a large part of the Canadian economy, there is a dearth of large firms in innovative sectors. Managing intellectual property in a manner that creates long-term value for the Canadian economy is an ongoing challenge. As a result, the benefits of Canadian innovations are often realized south of the border. Additional focus on building strategic sectors from fundamental research through to firm scale-up and innovation impact may ultimately be needed to reverse the poor productivity trend.

Data show promising early signs of increased R&D activity in SMEs. The strategic funding of new and existing businesses, including innovative larger firms, is vital to maximizing their economic contribution and spillover benefits. Canadian startups and scaling firms struggle to access domestic capital and customers, and too often rely on foreign (mostly U.S.) risk capital. This phenomenon is particularly acute in capital-intensive areas such as life sciences and deep tech, where Canada has world-leading capabilities.

The performance of Canada's higher education sector is a rare bright spot, producing some of the world's top talent

Canadian post-secondary institutions produce high-quality talent, an essential component of a thriving STI ecosystem. Canada is also among the most educated nations in the world, with a high proportion of its population having completed a post-secondary degree. Despite growing competition and heavy investments from new international players, Canada's higher education sector continues to perform well. A handful of its post-secondary institutions are ranked among the best in the world. Canada also has world-class research outputs in a variety of scientific disciplines. Notably, much of this research is a product of collaborations with researchers in the United States, but also countries including China and Iran, which can be of concern in terms of research security. There is a general lack of alignment in Canada's areas of STI strength across publications, patents, and R&D expenditures. This reflects, in part, Canada's industrial structure, the diversity of its STI ecosystem, and the transitioning innovation economy, but also highlights Canada's persistent challenges in reaping the benefits of its research strengths through innovation and commercialization.

At the same time, the business model used to fund post-secondary institutions is fragile and relies heavily on student fees to support both research and operations. Current immigration restrictions are limiting the financial support provided by international students and expenditures per student are falling. Canada's vaunted high expenditures on research in post-secondary institutions can be misleading; they reflect both international variations in measurement and a disproportionate subsidy from the institutions themselves. Even as Canada has an opportunity to recruit top researchers and students from the United States, its current system of research supports does not adequately resource the careers of its promising graduates, scientists, and scholars. In short, while Canada's impressive talent base is an advantage in a fast-moving STI world, this competitive edge is at risk. Recent changes to our immigration system exacerbate this risk.

Aggressive AI adoption could transform Canada's STI ecosystem

AI is the most disruptive general-purpose technology of our time, and Canada has played a critical role in the development of the field, as evidenced by Geoffrey Hinton's recent Nobel Prize, and awards to other noteworthy scientists. AI will not only impact every sector of the economy but is already reshaping research and innovation approaches themselves. Canada can be a leader in AI adoption and improve productivity or stand on the sidelines and lose ground to competitors. Early evidence suggests that Canadian firms are not ready to seize this opportunity, that they do not see the relevance of AI to their own businesses. AI is not a one-size-fits-all tool and will require expertise to adapt and use in key industries, such as manufacturing, natural resources, and information and communications technologies (ICTs). Both supply- and demand-side policies will be required to facilitate broad adoption, as well as AI literacy, talent development, and upskilling through targeted education and training programs to strengthen Canada's workforce. Efforts to address the potential risks and disruptions associated with widespread AI deployment could focus on increasing social trust and supporting well-managed adoption.

Concentrating efforts on local and sectoral areas of strength and expertise could improve STI outcomes

By focusing on city-level data, the panel observed many pockets of strength across the country, suggesting vibrant local innovation ecosystems. However, STI policy in Canada tends to be characterized by a "peanut butter" approach that seeks to spread resources evenly across the country on the grounds of fairness, rather than strategically cultivating areas of strength and growth. Careful analysis is needed to review the full policy and program suite to determine the most impactful way to support wealth creation and broader benefits to society.

Decision-makers in Canada must navigate complex and fast-moving circumstances despite incomplete and dated frameworks and metrics for critical performance indicators

Many of the ways that STI performance is conceived of and measured reflect out-of-date frameworks that emerged in an earlier economic reality. Today, digitalization, the intangibles economy, and the dominance of services necessitate and can enable new approaches to capturing the structure and dynamics of current STI ecosystems. While the panel has endeavoured to present the best data available, many important parts of the STI ecosystem are not currently measurable. As a result, these data ultimately miss key pieces of the STI ecosystem. What is often being measured is the *research and invention* ecosystem—roughly, the creation of new knowledge or technology—rather than the *innovation* ecosystem, which involves the use and impact of relevant knowledge or technology.

Beyond the need for more and better data, measurement, and conceptual frameworks, there is a need for more capacity in real-time monitoring, assessment, and foresight activities, as well as cross-sectoral dialogues—all of which can provide more robust means of analyzing emerging technologies, industries, and trends. The STI ecosystem is dynamic and can shift rapidly, requiring more agile and ever-evolving interventions; up-to-date insights are essential to calibrate these interventions.

Closing reflections

While new metrics should be developed, the panel's findings leave no doubt about the need for action. It is clear that Canada still lacks effective approaches to support the development and commercialization—across the continuum from research to deployment—of the most promising areas that could improve national competitiveness and provide greater overall economic and societal benefits.

A high-performing STI ecosystem is essential to the well-being of all people in Canada. Without ambitious and decisive action across the ecosystem to reverse declining performance, Canada's economy will struggle to provide Canadians with a standard of living they have come to expect. Without improved governance, greater public–private collaboration, and effective execution, Canada's highly fragmented system will likely continue to underperform. The nation's ability to deliver quality public health care and education, job opportunities, and affordable housing will be jeopardized. The set of societal challenges Canada faces today surely provides the burning platform needed to drive bold changes.

Glossary

Absorptive capacity: The ability of an organization to recognize, assimilate, and functionalize new ideas, information, or technologies, or incorporate highly qualified personnel, in order to innovate or create a competitive advantage.

Business Enterprise Expenditures on R&D (BERD): The total intramural expenditures on R&D performed by businesses in a given country or economy.

Census metropolitan area (CMA): A geographical region that consists of one or more adjacent municipalities centred on a core urban area with a population of at least 100,000.

Extramural: Activities performed outside of the funding unit. For example, extramural R&D expenditures are those that are funded by one sector but performed by another, such as business funding R&D performed in the higher education sector.

Government (Intramural) Expenditures on R&D (GOVERD): The total intramural expenditures on R&D performed by government organizations.

Gross Domestic Expenditures on R&D (GERD): The total national spending on R&D, including expenditures in the business, higher education, government, and non-profit sectors.

Higher Education Expenditures on R&D (HERD): The total intramural expenditures on R&D performed by post-secondary institutions.

Industrial R&D: R&D activities and related variables undertaken by companies and industrial not-for-profit organizations. Statistics Canada uses this term for collecting and reporting R&D data from the private sector.

Innovation: A product or process that is new or significantly improved (or a combination of both), differs substantially from the unit's previous products or processes, and has been either introduced to the market (for products) or implemented within the unit (for processes) (OECD & Eurostat, 2018).

Innovation ecosystem: A dynamic, evolving, and interdependent set of actors, activities, resources, institutions, and relationships, that are important for the innovation performance of a region or country (Chatti *et al.*, 2024).

Intellectual property (IP): An intangible asset that is afforded legal protection from unauthorized use, distribution, or sale through patents, copyrights, or other forms of protection.

Intramural: Activities or expenditures performed within a funding unit, rather than being outsourced to external entities in other sectors.

Multinational enterprise (MNE): A company that is headquartered in one country with operations in other countries.

Research and development (R&D): The systematic process of investigation and experimentation aimed at discovering new knowledge and applying it to create new or improved products, services, or processes through scientific or technological advancements.

Research infrastructure: Facilities, mobile assets, resources, and services that are used by the research community and are essential to advancing research. Research infrastructure includes major scientific equipment and instruments; knowledge-based resources such as collections, archives, and scientific data; e-infrastructures such as computing, data systems, and communication networks; and the human capital and expertise required to operate and maintain the infrastructure.

Research security: Policies and measures designed to protect IP, sensitive data, and national interests in scientific research from foreign interference and espionage.

Scale-up: A company that started with at least 10 employees at the beginning of the growth period and subsequently experienced at least three consecutive years of 20% or more year-over-year growth in either employment (i.e., *employment-based scale-up)* or revenue (i.e., *revenue-based scale-up*).

Science, technology, and innovation (STI): The interconnected fields of scientific research, technological advancement, and innovation that contribute to economic growth and societal development.

Scientific Research and Experimental Development (SR&ED) tax incentive: A Canadian government tax incentive program designed to encourage businesses to invest in R&D by providing tax credits for eligible expenditures.

Small- and medium-sized enterprises (SMEs): A non-subsidiary, independent firm that employs fewer than a given number of employees depending on the country it is in. For instance, in the European Union, SMEs are typically defined as enterprises with fewer than 250 employees, while the threshold can be up to 500 employees in the United States, depending on the industry. In Canada, SMEs are most commonly defined as enterprises with fewer than 500 employees.

Technology adoption: The process by which businesses and organizations integrate and implement new technologies into their operations.

Abbreviations

BERD	business enterprise expenditures on R&D
CAGR	compound annual growth rate
CFI	Canada Foundation for Innovation
CMA	census metropolitan area
EPO	European Patent Office
GERD	gross domestic expenditures on R&D
GOVERD	government (intramural) expenditures on R&D
HASS	humanities, arts, and social sciences
HERD	higher education expenditures on R&D
HQP	highly qualified personnel
ICT	information and communication technology
IP	intellectual property
IR&D	industrial research and development
ISCED	International Standard Classification of Education
MNE	multinational enterprise
NAICS	North American Industry Classification System
PE	private equity
R&D	research and development
RSA	related scientific activities
S&T	science and technology
SMEs	small- and medium-sized enterprises
SR&ED	Scientific Research and Experimental Development (tax incentive)
STEM	science, technology, engineering, and mathematics
STI	science, technology, and innovation
USPTO	United States Patent and Trademark Office
VC	venture capital
WIPO	World Intellectual Property Organization

Contents

1

Introduction

Canada is in a productivity crisis. Its labour productivity level stands far below those of leading countries and GDP growth is below the OECD average (OECD, 2025a). In 2022, 17% of people in Canada were food insecure—up five percentage points since 2018 (StatCan, 2024a). Housing affordability has decreased sharply since the beginning of the COVID-19 pandemic (Bank of Canada, n.d.), and income inequality is at its highest point in the last 25 years (StatCan, 2024b). While quality of life indicators have improved in absolute terms, Canada's standing on the Human Development Index sat at 16th in 2023, down from 3rd in 1990 (UNDP, 2024). Rising levels of protectionism and a trade war with Canada's largest trading partner, along with China emerging as an advanced technology economy, pose further risks to Canada's technological competitiveness and social and economic well-being.

Given this context, Canada's science, technology, and innovation (STI) performance matters more than ever. Enhancing Canada's productivity relies on using new technologies to unlock new value. New scientific knowledge is required to fuel emerging industries and effectively address global grand challenges confronting society. Building domestic resilience to shifting trade patterns, and to future health and environmental threats, hinges on fostering Canadian research strengths and empowering a highly skilled scientific workforce to cultivate strategic areas of domestic STI leadership.

From the invention and commercialization of the BlackBerry to the discovery and testing of the use of lipid nanoparticles for drug delivery, Canada has a celebrated history of success in scientific breakthroughs, technological advancements, and commercial innovations. A number of Canadian post-secondary institutions are ranked among the strongest in the world, the population is highly skilled and educated, and Canada excels in information and communications technology (ICT) (OECD, 2024a; QS, 2024; Science-Metrix, 2024; StatCan, 2024c; THE, 2024). People in Canada recognize and enjoy the benefits of science, technology, and innovation in their daily lives.

Despite these strengths, Canada faces daunting challenges and declining performance. Canada's performance can only be properly understood in relation to other countries: spending on research and development (R&D) is low and losing ground relative to others. Promising homegrown startups often struggle to access capital domestically; many rely instead on foreign sources. Canada is not capitalizing on its early advantages in AI as other countries ramp up their efforts. Canadian firms are slow to adopt new technologies and adoption rates are falling over time.

1.1 The charge to the panel

Since its inception in 2005, the Council of Canadian Academies (CCA) has conducted a series of assessments dedicated to understanding Canada's STI performance. This series of reports has provided an essential touchstone for understanding performance, trends, and challenges. Governments and others have used the results of these assessments to inform national strategies, industry-focused policies and programs, and research priorities and spending (CCA, 2025a).

The most recent CCA assessment on the state of STI in Canada was published in 2018. Much has changed since then: a global pandemic, a cost-of-living crisis along with inflation, the emergence of AI as a game-changing technology, the rise of China as a technology leader, increasing protectionism, and intensifying climate change—to name just a few examples. Recognizing the need for a new examination of the state of STI in Canada, Innovation, Science and Economic Development Canada (ISED; hereafter called "the sponsor") asked the CCA to convene an expert panel to answer the following question and sub-questions:

What is the state of science, technology, and innovation in Canada, and how does Canada compare internationally?

1. What are the S&T[1] areas—i.e., scientific disciplines and technological applications—in which Canada excels, and how does Canada compare to peer countries?
    - How are these strengths distributed by region and sector across the country?
    - In which S&T areas has Canada shown the greatest improvement / decline in recent years, and why?
    - Which S&T areas have the potential to emerge as areas of prominent strength for Canada?
2. How are expenditures in different S&T activities evolving over time in Canada and in relation to peer countries?
3. How does Canada's distributed science, technology, and innovation ecosystem enable or limit success at various points on the technology development spectrum, including discovery, invention,

(continues)

1 For the purpose of this assessment, "S&T" (science and technology) includes R&D and related scientific activities (RSA).

(continued)

demonstration, commercialization, and company growth (including the pros and cons of this system)?

- What are the key barriers and knowledge gaps in translating Canadian strengths in S&T into innovation, wealth creation, and broader benefits to society?
- How can these barriers and knowledge gaps be addressed?

1.2 The panel's approach

The panel underscored that the primary motivation for assessing the performance of Canada's STI ecosystem is the benefits it creates for society. While the productivity crisis was front and centre, the panel also recognized a range of wider benefits. Improvements in the understanding of disease function, advanced materials, or quantum computing can lead to improvements in health and well-being. When policy-makers and the public and private sectors can use the latest scientific advances to enhance Canada's national defence, adapt to a changing climate, improve public health, or protect the food supply, everyone in Canada is safer for it. When firms improve construction efficiencies, housing becomes more affordable.

1.2.1 Scoping decisions

The panel relied on an expansive interpretation of *science and technology* (consistent with OECD practice), encompassing both R&D and RSA (e.g., information services, administration, and routine data collection). *Science* is interpreted in a broad sense, including all disciplines and multiple ways of knowing. This assessment considers S&T investments and capacity as well as technology adoption, and it focuses primarily on technology-based innovation while recognizing the value of, and increasing interest in, social and business process innovation. The panel considered the geographically distributed nature of Canada's STI ecosystem and the importance of differences across regions; this analysis seeks to delineate these distinctions wherever feasible. Research security and research infrastructure were assessed relatively superficially in recognition of the CCA's separate expert panel assessments examining these two topics (CCA, 2024a, 2025b). The panel did not explore educational outcomes at the kindergarten to grade 12 levels, nor did it assess science culture, including scientific literacy and engagement in Canada.

International comparisons are used to interpret Canada's performance; the panel chose to compare Canada with G7 counterparts (France, Germany, Italy, Japan, the United Kingdom, and the United States), the Nordic countries (Denmark, Finland, Norway, and Sweden), as well as Australia, China, Israel, the Netherlands, South Korea, Switzerland, and Taiwan. However, it should be noted that data are often not available for all indicators for all countries in all years.

1.2.2 The STI ecosystem

Although formal evaluation of specific policies and programs was out of scope, assessing the state of STI in Canada includes looking generally at what roles government and policy play in advancing domestic STI. Contemporary thinking conceptualizes STI as a multidimensional and evolving *ecosystem*. This is a change from the theories of the past (Box 1.1).

Box 1.1 An evolution of STI policy thinking since 1945

The prevailing wisdom about how STI interact and can best be supported by public policy has evolved over time. This evolution can be roughly divided into three main periods following World War II.

Science policy and the linear model (1945–1970): The postwar period emphasized science policy and favoured a *linear model* of innovation. The theory was that governments should fund universities to provide basic research and education to create a supply of new knowledge and talent that would then be adopted for use by industry and governments. The linear model envisions a pipeline in which funding for research at one end leads almost automatically to innovation benefits flowing out the other end, with policy interventions limited to instances of market failure (Narayanamurti & Odumosu, 2016; Shneiderman, 2016). In this simplistic conception, the greater the investment in research and education, the greater the returns for society (Doern *et al.*, 2016).

Technology policy and critical technologies (1970–1995): By the 1970s, the limits of the linear model of innovation were becoming apparent. Despite relatively high upstream investments in basic research, economic competitiveness was under pressure in the West. In contrast, Japan and other emerging markets showed strong competitiveness despite relatively low levels of basic scientific research (Fransman, 1997;

(continues)

(continued)

Freeman, 1997). A new focus on technology and its diffusion and adoption by firms began to take hold (Science Council, 1979; GC, 1983). *Technology policy* emphasized new support for the development of specific "critical technologies" that were deemed important to ensuring national security and industrial competitiveness, such as microelectronics, ICTs, advanced materials, biotechnology, and energy.

Innovation policy and systems of innovation (1995–present): By the end of the 20th century, scholarship had shifted to a more holistic understanding of the drivers of innovation, based on the recognition of national—and, later, regional and local—systems of innovation (Niosi, 2000; Holbrook & Wolfe, 2002). Policy attention focused not only on market failures but also on system failures, as well as on the interactions and flows of knowledge, talent, and resources among a "triple helix" of key sectors—government, industry, and academia (Freeman, 1997; Etzkowitz & Leydesdorff, 2000; Haddad *et al.*, 2022). Carayannis *et al.* (2012) extended this to a quintuple helix model with the inclusion of civil society and the natural environment as key elements. Although providing a richer perspective than previous ways of thinking about STI, the innovation system concept risked eliciting a mechanical and static view of the required policy interventions (Beaudry *et al.*, 2021).

From innovation systems to innovation ecosystems

In recent years, theory has broadened the conceptualization of STI to an ecosystem approach that recognizes even more complexity. Innovation ecosystems are nonlinear, dynamic and relational; interventions require tailoring and adjustment over time (Bassis & Armellini, 2018; Beaudry *et al.*, 2021). Innovation ecosystems operate at multiple scales (e.g., national, regional, local). Given this complexity, broad framework policies are necessary but insufficient. Since solutions to emerging issues will vary by industry and technology, some interventions will need to be narrowly focused. The emphasis of innovation policy has shifted from purely supply-side interventions to a balanced approach that includes demand-side interventions through procurement, regulation, and the promotion of societal adoption of new innovations. The STI ecosystem approach also gives more attention to the role of society (Zheng & Cai, 2022). The panel's analysis of Canada's STI ecosystem recognizes the importance of the interactions across actors at the regional, national, and global scale for understanding performance, opportunities, and challenges (Figure 1.1). Unfortunately, many of the available metrics and data reflect earlier eras of STI policy thinking, a barrier that is revisited in Chapter 9.

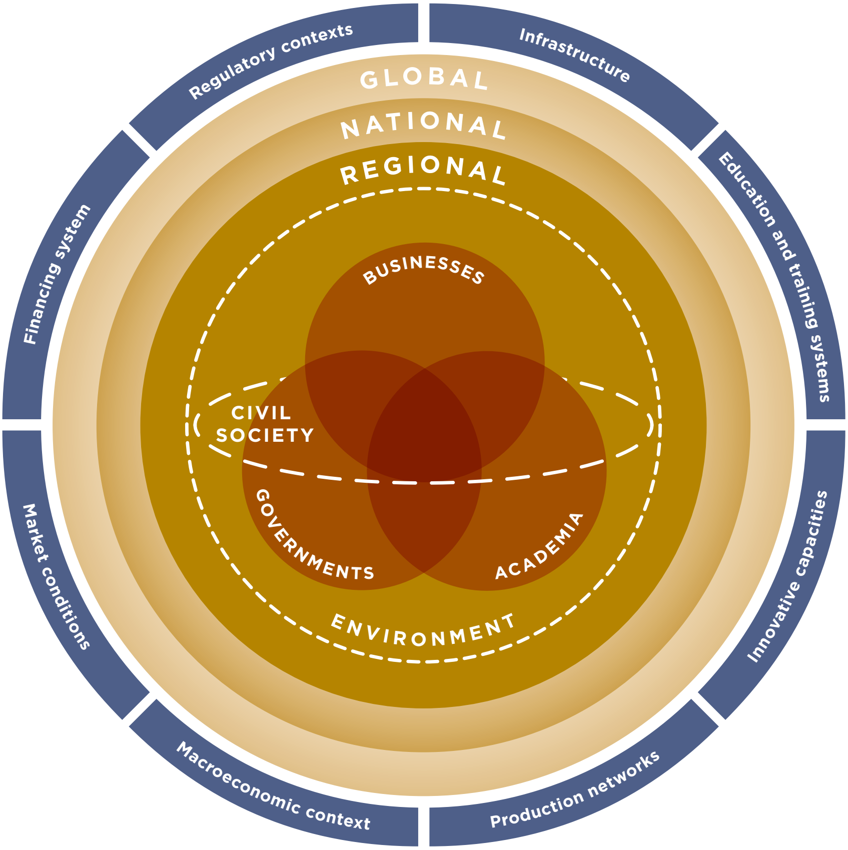


Figure 1.1 The STI ecosystem

Businesses, post-secondary institutions, governments, and civil society organizations all interact with one another in the STI ecosystem, since scientific and technological breakthroughs may originate and be refined in any of these. Businesses play a central role in meeting market demands through commercializing scientific and technological breakthroughs and adopting new technologies. The connections among these actors are multifaceted and exist at regional, national, and global scales. The nature and strength of a nation's STI ecosystem are products of the financing system, infrastructure, market conditions, increasingly complex production networks, regulatory contexts, education and training systems, the macroeconomic context, and its innovative capacities, including entrepreneurial and absorptive capacities. Innovation is embedded within and interacts with society at large and the natural environment.

The need for purposeful interactions throughout the ecosystem has implications for governance, funding, performance, and success metrics (Etzkowitz, 2003; OECD, 2022; Chatti *et al.*, 2024). Most Canadian and U.S. post-secondary institutions and funding agencies, however, reward researchers based on traditional metrics of publications, citations, and, more recently, patents, and give less recognition to the non-research missions of the institution (Carter *et al.*, 2021; Park *et al.*, 2024b). Inclusive innovation has also gained traction globally as an important concept, further broadening the framing of the innovation ecosystem by asking "where innovation occurs, why it occurs, who is involved in the innovation process, what are the outcomes, and who are the beneficiaries" (Earl *et al.*, 2023). Recognizing this context, the OECD has adopted an inclusive growth program that emphasizes indicators of overall social well-being when choosing policies, and more broadly has adopted a transformative STI framework which is viewed as necessary to harness STI to address the challenges of the day (Boarini *et al.*, 2015; Mahon, 2019; OECD, 2024b). This could signal the emergence of a new conceptual framework for understanding STI and its relationship with society (Section 9.6).

1.2.3 Methodology and sources of evidence

Several priorities guided the panel's research and analysis. The panel was asked by the sponsor to report on what has changed since the most recent analysis in 2018 in terms of both the broader context and Canadian performance. To achieve this, the panel relied on many of the same data sources as those considered in the 2018 report. The panel also analyzed data and commissioned research to understand what global and domestic trends are influencing Canadian STI performance.

The panel relied on many sources of evidence to inform its deliberations. Peer-reviewed literature and policy writing in the grey literature provided the foundational evidence. This was supplemented by considerable data from Statistics Canada, the OECD, and elsewhere. The panel also commissioned Elsevier's Science-Metrix to conduct extensive bibliometric analysis using the Scopus database to measure Canada's research performance, as well as technometric analysis based on patent data as an indicator of Canada's performance in transforming ideas into inventions (Science-Metrix, 2024; available on the CCA website). These core approaches were complemented by commissioned studies that offer analyses of research strengths using other databases and lenses (e.g., Claveau *et al.*, 2025; Kogler, 2025; Larivière *et al.*, 2025).

The report includes detailed tables and figures that provide readers with an extensive data set; this allows for more granular analysis of various fields and activities. This additional data can benefit a wide range of decision contexts, such as informing research funding priorities, identifying strengths and weaknesses in STI ecosystem supports, and revealing resource gaps.

Limits to quantitative analysis in the age of intangibles

The panel recognizes that the available data informing this assessment tell only part of the story of Canada's STI ecosystem—there is no single or composite measure that can fully capture the state of, or strength of, STI in Canada. As recognized in previous assessments, measures such as bibliometrics and patent counts provide only a partial description of research and technological performance (CCA, 2018a). Lags in data availability, as well as challenges in comparing STI among countries, further exacerbate this.

The changing structure of the Canadian economy also complicates efforts to measure performance over time. Traditional measures of R&D performance are largely based on the assumption of a *tangibles* economy grounded in industrial innovation and the export of goods in well-defined sectors (Creutzberg & Kinder, 2023). However, such measures may not adequately account for cross-border digital flows in, for example, service industries, cloud platforms, and highly dispersed research teams, nor for emerging sectors (e.g., agritech, fintech, Software-as-Service or SaaS) that may not easily fit into existing industry classifications (Creutzberg & Kinder, 2023). Understanding how to best capitalize on such intangible assets will be important for enhancing economic well-being in Canada (Park *et al.*, 2024b). Munro and Lamb (2025) argue that a multipronged approach is the most effective way to understand innovation performance in the age of intangibles. This includes reporting on input, output, and outcome measures; measuring technology adoption and use; and capturing intangible investments (Munro & Lamb, 2025). Moreover, these standard measures emerged from earlier policy frameworks, and do not provide sufficient insights into the relationships among actors in the STI ecosystem. Recognizing the risk of valuing what is measured rather than what is meaningful (Ridgway, 1956), the panel complemented quantitative analysis with qualitative analysis in order to tell a more complete story. The panel also noted areas where additional data-gathering and analysis is needed going forward to provide a more complete view of the STI ecosystem (throughout and Section 9.7).

Traditional STI measurement approaches are rooted in colonial frameworks that prioritize economic growth while excluding Indigenous values and worldviews. Evaluation methods often exclude Indigenous voices and relational approaches to knowledge, using language and structures that reflect colonial systems (Williams *et al.*, 2020; CCA, 2023). These systems can marginalize Indigenous values relating to success, such as reciprocity, relationality, and community well-being (CCA, 2023). A shift toward principles-based rather than box-checking approaches can reshape systems to allow Indigenous perspectives to become more than auxiliary to Western perspectives (CCA, 2023).

New sources of evidence and insights

The panel's analysis builds on the approach of previous assessments in this series but adds important new features:

- Past technometric analyses relied on the United States Patent and Trademark Office (USPTO); this report also includes European Patent Office (EPO) data.
- In response to an analysis by the CCA Scientific Advisory Committee, this assessment commissioned papers exploring new ways to measure research outputs in the humanities, arts, and social sciences disciplines through the Overton and OpenAlex databases (CCA SAC Subcommittee, 2021).
- To a greater extent than in past reports in this series, this report considers risk-based funding such as angel, venture capital (VC), and private equity (PE) investment.

The panel also assessed regional performance at the census metropolitan area (CMA) level rather than focusing solely on national and provincial/territorial performance. This regional analysis was informed by the Web of Science database, complementing the bibliometric analysis conducted using Scopus. Informed by an analysis by the CCA's Scientific Advisory Committee, the panel decided not to pursue an opinion survey and instead relied on the findings of well-established surveys to provide insights about institutional strengths (CCA SAC Subcommittee, 2021).

Commissioned evidence syntheses

The CCA received a Strategic Initiatives Fund grant from the Social Sciences and Humanities Research Council (SSHRC). Using this funding, it engaged external experts to synthesize evidence in order to provide new insights into various aspects of the charge; the evidence was considered by the panel and allowed for a deeper analysis of key issues. Paper topics and author names are available in this report's frontmatter, and the publications can be read in full online here.

Historically, this series of CCA reports on Canada's STI ecosystem has focused on quantitative indicators of performance, including citation counts, patent counts, and R&D expenditures. However, these approaches are not well-suited to identifying and understanding the contributions of Indigenous knowledges and STI in Canada; to characterizing strengths in Indigenous knowledges and scholarship in Canada; or to describing strategies for supporting STI in ways that are respectful to and inclusive of the priorities and expertise of Indigenous communities. Recognizing that the panel was not equipped to assess these elements, the SSHRC grant was also used to give focus to the Indigenous dimensions of STI in Canada (Section 9.1). This was explored via a virtual event, which represented a first step in recognizing Indigenous leadership and examined ideas and insights on a variety of topics. The experts who spoke at this virtual event are listed in the report's frontmatter.

1.3 Report structure

Chapter 2 sets out the essential context for understanding STI performance in Canada, including the key drivers shaping Canada's STI ecosystem. **Chapter 3** assesses the resources being directed toward the system in terms of expenditures, education, personnel, and infrastructure, and **Chapter 4** provides a more detailed discussion of industrial R&D expenditures. **Chapter 5** presents data on financing and startups. **Chapter 6** assesses performance based on research publications, while **Chapter 7** does so using patent data. Innovation performance is then assessed in **Chapter 8**. Building on this picture of the state of STI in Canada, in **Chapter 9** the panel identifies barriers and knowledge gaps for improving STI outcomes in Canada. **Chapter 10** concludes the report by directly answering the charge.

2

Key Drivers Shaping STI in Canada

Chapter findings

- Canada's longstanding poor productivity performance has reached crisis levels, compromising the standard of living for people in Canada.
- Rising U.S. protectionism threatens Canada's economy. This necessitates a move toward a more diversified and resilient economic structure.
- AI offers widespread, game-changing applications across the STI ecosystem and the economy. Despite being an early leader in the development of this field, Canada is losing ground when it comes to adoption.
- Other drivers shaping STI include a changing economic structure, the effects of the pandemic, the politicization of science, and STI system challenges.

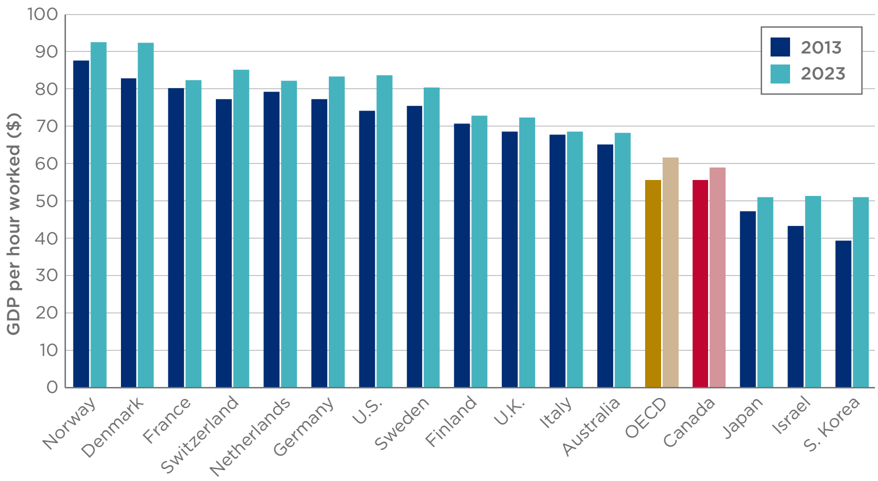
The panel identified three considerations that it saw as key to interpreting the charge: Canada's productivity crisis, Canada–U.S. relations, and the opportunities of AI adoption. These themes are recurring throughout the report, informing the panel's research and analysis. Beyond these three themes, much has changed since the CCA last published a report on the state of STI in 2018. A global pandemic exposed the fragility of supply chains, underscored the importance of domestic production capacity, and revealed how quickly scientific innovation can happen when it is directed and adequately supported. The STI system itself is facing new financial pressures, working to become more open while simultaneously enhancing research security, and operating in a context where science is increasingly politicized. Anchoring the panel's assessment in these key contextual factors is essential for understanding where Canada stands today.

2.1 Canada's productivity crisis

Productivity is at the core of a country's economic performance (Atkinson & Zhang, 2024), and innovation is considered the main driver of productivity growth (Dieppe, 2021).

Canada faces a worsening productivity crisis

On a variety of measures, Canada is losing ground in productivity. Canada had the second-lowest labour productivity among G7 countries in 2023 (OECD, 2025a) (Figure 2.1), though productivity varies across sectors. Government productivity lags the national average while levels in the energy sector far exceed all others (StatCan, 2025a). Industrial production and ICT are also among the sectors that lead in productivity (StatCan, 2025a). Grappling with low productivity is not a new issue for Canada, but as underlying economic factors evolve, there is increasing concern (Rogers, 2024). Canada's productivity performance matters for all people in Canada. Low productivity is putting the standard of living at risk, driving down real wages, and compromising the ability of governments to maintain public services such as education and health care (Caranci & Marple, 2024).



Data source: OECD (2025a)

Figure 2.1 Labour productivity expressed by GDP per hour worked, 2013 and 2023

Canada's labour productivity sits far below that of many comparator countries, notably that of the United States and the Nordic countries.

Low productivity growth is contributing to low GDP growth

Canada's GDP grew by 20% (adjusted for inflation) between 2013 and 2023, the second-highest in the G7 (after the United States at 27%), but below the OECD average over this period (22%) (OECD, 2025a). However, the growth of Canada's *per capita* GDP over this period (5.1%) is the lowest in the G7 and far below the performance of many peer countries; in the United States GDP per capita increased by nearly 20% over this period (OECD, 2025a). GDP per capita rose in the final quarter of 2024 and the first quarter of 2025 following six quarters of decline (StatCan, 2024d, 2025b,c). Population levels are a complicating factor, both in terms of overall population growth compared to peer countries, and relating to large influxes of international students and temporary foreign workers. These phenomena have contributed to the reduced growth of Canada's per capita GDP in recent years (Petit, 2025) (Section 9.1). In absolute terms, per capita GDP in the United States in 2023 was nearly 50% higher than in Canada (Tombe, 2024a). Longer-term prospects for GDP growth in Canada remain bleak; a recent OECD analysis of economic and fiscal scenarios anticipates that Canada's per capita GDP growth will be the lowest among 47 countries assessed in the coming decades (Guillemette & Turner, 2021).

This assessment examines the question of productivity indirectly through a focus on innovation. While solutions to the productivity crisis will need to be multifaceted, the STI ecosystem has a substantial role to play. Earlier CCA analysis has pointed to weak business spending on R&D as a primary factor for poor productivity growth (CCA, 2013b); Canadian businesses invest less in productive capital than their U.S. peers (Zhang & Ostertag, 2025). Increased adoption of new technologies has been identified as one of several key strategies for reversing declining productivity in Canada (Caranci & Marple, 2024). Canada's productivity crisis is partly a reflection of weak productivity performance in information and cultural industries,[2] as well as professional, scientific, and technical services[3] relative to that of the United States (Caranci & Marple, 2024). In that respect, unpacking Canada's STI performance can highlight areas of strength to build on and weaknesses to confront to improve productivity in high-tech industries. Loss of high-quality workers and innovative new firms could also contribute to the productivity crisis (Alexopoulos *et al.*, 2025). While some of these issues may appear abstract or confined to the purview of government policy-makers or innovative firms, faltering productivity and the potential contributions of STI to improved performance are in fact critical to the welfare of all people in Canada.

2.2 Canada–U.S. relations

STI activities in Canada are conducted in a complex ecosystem that is heavily integrated within a broader North American landscape. Canada's close economic and social connections to the United States have profoundly shaped its domestic STI activity and performance. There are high levels of migration among STI professionals, as well as much research collaboration between the two countries

2 This encompasses ICT services (e.g., telecommunications, web hosting and infrastructure, computing infrastructure), and publishing and broadcasting (StatCan, 2022b).

3 This encompasses activities heavily reliant on human capital, such as applied research and experimental development, and legal and managerial services (StatCan, 2024e).

(Gaida *et al.*, 2023; Science-Metrix, 2024). Governed by the Canada–United States–Mexico Agreement (CUSMA), Canada–U.S. trade represents roughly two-thirds of Canada's overall trade, while almost half of direct investment in Canada comes from the United States (StatCan, 2023a, 2025d). Canada is also the largest export market for the United States (Ercolao & Foran, 2025). The automotive sector is particularly tightly integrated (Tombe, 2024b). Much of what the United States imports from Canada is used as input for production (Stanford, 2025).

A shifting economic relationship with the United States contributes to uncertainty in the STI system

Tariff uncertainty has compromised the Canada–U.S. trade relationship, causing economic hardship and necessitating a rethinking of Canada's economic strategy vis-à-vis the United States (Macklem, 2025a). Uncertainty associated with trade policy is itself causing harm, particularly to the resource and auto sectors (Macklem, 2025a). This longstanding trade relationship has benefited both countries, and one recent economic model suggests that a move toward protectionism—assuming 25% tariffs on non-energy goods exports and 10% on energy exports in the case of this modelling exercise—would reduce Canadian exports, consumption, and GDP, putting Canada on a permanently lower growth path (down 2.5%) (Macklem, 2025b). Cutbacks to U.S. science funding are also having an impact in Canada. With 36% of Canadian research publications being co-authored with U.S. collaborators (Section 6.5), such shifts in research funding will inevitably compromise a large proportion of Canadian research in the post-secondary sector, government, and industry. Analysis of the impact of these changes on Canadian research is ongoing (e.g., E4D (2025)).

2.3 Artificial intelligence

Technological change unfolds in fits and starts. It is characterized by what seem like extended periods of incremental development and is punctuated by bursts of rapid innovation and transformative breakthroughs. General-purpose technologies such as the steam engine, electricity, ICTs, and now AI tend to dramatically transform the economy and society. These technologies are "characterized by the potential for pervasive use in a wide range of sectors and by their technological dynamism" (Bresnahan & Trajtenberg, 1995). They bring about great upheaval and therefore opportunities for those who seize them, and threats to those who do not.

AI is a game-changer that will have a wide influence across the STI landscape

As a general-purpose technology, AI has complex and multidimensional implications; in many cases, these will be hard to anticipate. AI adoption has implications for employment, productivity, competitiveness, and privacy (Billy-Ochieng *et al.*, 2024). Specific to the STI enterprise, AI is already accelerating scientific innovation itself (CCA, 2022; Nicholson, 2024). AlphaFold is an example—this AI tool predicts the structure of proteins and has widespread applications across health and bioscience research, potentially hastening drug discovery, substantially reducing the cost of R&D, and enabling new advances in structural biology (Varadi & Velankar, 2023; Callaway, 2024; Kovalevskiy *et al.*, 2024).

Given the extent to which AI may bring about economic and social change globally, the panel emphasizes that Canada cannot afford to observe this shift from the sidelines. AI is a fast-moving field, and Canada must keep pace. Despite its leading role in developing the technology, a strong AI ecosystem, and relatively high venture capital investments in this space, Canada's leadership is far from assured due to inadequate computing infrastructure, an evolving regulatory framework, and lagging AI adoption (Billy-Ochieng *et al.*, 2024) (Sections 8.2, 9.5). Among the 50 largest AI startups globally, two were based in Canada as of 2024 (Cai, 2024). While still positive, AI talent migration rates are declining in Canada (Gil & Perrault, 2025).

Levels of social trust in AI in Canada sit almost 20 percentage points below the global average (Edelman Trust Institute, 2024). While 65% of people in Canada report being trusting of technology overall, only 31% of people feel that way about AI (Edelman Trust Institute, 2024). Relatedly, the majority of people in Canada report that they are resistant to or hesitant about this technology, though optimism about the benefits of AI is increasing with time (Edelman Trust Institute, 2024; Gil & Perrault, 2025). Concerns about job loss, uncompensated use of copyrighted material to train AI, environmental damage, and biased and unreliable AI outputs are among the chief concerns (Rogers, 2025).

2.4 Other drivers for this assessment

Much has changed in Canada and around the world since the publication of the last report in this series. New skills are being prioritized in the swiftly evolving domestic and global economies; the effects of the pandemic are still reverberating; and new funding challenges have emerged. None of these factors can be left out of a consideration of the state of STI in Canada.

2.4.1 Changing economic structure

As the economy changes, so do the skills needed to power it

The rapid development of new technologies is changing the nature of work, the skills required of the Canadian workforce, and the stability of employment. Increased automation could displace nearly half of all work activities, with routine work being the most susceptible to displacement (Lamb & Lo, 2017). The COVID-19 pandemic accelerated a shift toward jobs in managerial, professional, and technical occupations, with corresponding declines in production, operation, and service jobs (Frenette, 2023). Prospective employers are increasingly emphasizing the importance of technical skills (BHER, 2022). A lack of technical skills is contributing to current skill shortages across multiple industries, hampering productivity in turn (CBoC, 2024). Computer science, data science, and IT skills are also in high demand across many industries, as are skills in the natural sciences. Additionally, management skills are highly sought after (StatCan, 2024f). Post-secondary institutions are being called upon to evolve in order to build the skills needed for a modern workforce, including innovation management skills (CCA, 2018b; Khan & Casello, 2023; Park *et al.*, 2024b). There is also recognition of the need for work-integrated learning to cultivate the technical skills employers are looking for (Walker, 2019).

Energy demands in Canada are evolving in response to population growth, the push toward electrification, and the increased demand for electricity to power AI (NRCan, 2024). Climate change is a related pressure; it shapes the policy framework for energy generation, transmission, and use, while also jeopardizing the reliability of energy supplies and infrastructure through extreme weather events. Demand for Canada's natural resources—energy, critical minerals, and others—is growing both domestically and internationally (NRCan, 2025). STI talent is key to enabling Canada to navigate these changing pressures and demands.

2.4.2 Ripples from the pandemic

Fast, united progress on critical issues is possible with societal and political will

Global vaccine development efforts highlighted the importance of international STI cooperation during the COVID-19 pandemic (OECD, 2021a). Despite supply chain and manufacturing challenges, Canada performed well in the rapid and widespread deployment of vaccines, demonstrating what is possible with sufficient effort and resources (OAG, 2022). This showcases the ability of a range of actors to organize resources around mission-driven endeavours, and to pursue—and succeed in—moonshot efforts through collaboration.

Other experiences during the COVID-19 pandemic taught Canadian policy-makers valuable lessons. Supply problems early in the pandemic drew attention to the fragility of supply chains; the importance of local suppliers, redundancies, automation, reduced complexity, and circular supply chains is now widely acknowledged (McKinnon *et al.*, 2021). Weaknesses in domestic capacity were exposed, and the federal government made significant investments in a Canadian strategy to revive domestic biomanufacturing capacity (Breznitz, 2020; ISED, 2021).

2.4.3 Politicization of science

The politicization of science threatens democracy and social cohesion

Trust in science has been a barometer for how willingly the public supports science and for the degree of acceptable oversight. Public opinion surveys tend to show that scientists score high on societal trust in Canada, especially when compared with other professionals such as politicians and business leaders (Environics, 2023). However, almost 60% of people in Canada agree that science has become politicized in this country (Edelman Trust Institute, 2024). There may be a growing science–society disconnect; despite high levels of trust in scientists, low levels of trust in government leaders are eroding the public's confidence in the deployment of scientific innovations (Edelman Trust Institute, 2024; Vu and Dobbs, 2025). When science becomes politicized, it becomes less useful for decision-making, and in turn, the value placed on science may fall (Druckman, 2022).

2.4.4 STI ecosystem challenges

Canada's STI ecosystem is grappling with many challenges, including some that are common globally and others that are more specific to Canada.

Canada's post-secondary institutions face a funding crisis

Many institutions find their financing situation to be unsustainable and are running considerable deficits (Friesen, 2024). Colleges are facing particularly challenging circumstances due to their greater reliance on students and government for revenues compared with universities that receive a greater share of revenue from self-generated income (e.g., endowments) (Usher & Balfour, 2024). The costs continue to increase, while access to income brought in by higher tuition fees for international students—which universities and colleges have become more reliant on—is increasingly restrained (Usher & Balfour, 2024). Since 2024, international student visas have been curtailed in response to concerns about housing shortages and large increases in international student enrolment, particularly at colleges based in Ontario (IRCC 2024; Ouellet &

Crawley, 2024) (Section 3.2.2). These funding challenges may negatively impact scientific excellence and undermine development of new models of innovation.

Canada's national research infrastructure is under-resourced and lacks coordination

Without a long-term strategy and an integrated approach to selecting and maintaining national research infrastructure, it is difficult to assess the state and performance of current assets (CSPC, 2024). In research commissioned to inform this assessment, Halliwell (2025) concludes that "the Canadian landscape of [national research infrastructure] is messy, uncoordinated, generally poorly resourced and lacking in an overarching strategic vision/perspective." The CCA is currently undertaking an assessment on enhancing national-scale research infrastructure in Canada (CCA, 2024a).

A confluence of factors offers an opportunity to broaden and reinvigorate Canada's talent base

Historically, Canada has struggled to retain top talent in its STI ecosystem. Early-career researchers may leave for better salaries, opportunities, or infrastructure abroad (Bouchard *et al.*, 2023) (Section 3.2). That said, recent political changes and reduced funding for science in the United States may create opportunities to attract and retain top talent in Canada (Bergeron *et al.*, 2025).

Cukier (2025) notes the need to enhance opportunities for equity-deserving groups in order to address looming labour shortages in Canada's S&T sector, where over 320,000 workers are expected to retire in the next decade (IRCC, 2022). While racialized individuals and immigrants have high levels of representation in the technology sector, women and Indigenous people have low levels of representation (TAP, 2024). This exclusion can diminish the performance of the ecosystem (Hofstra *et al.*, 2020).

A global move toward open science is colliding with new geopolitical realities

Research institutions are operating in a global context and are subject to, and participating in, changing social and cultural norms. These include growing recognition of the value of multi-, inter-, and trans-disciplinary approaches to research (Bouchard *et al.*, 2023). There is also growing value placed on making science open to ensure research reproducibility and safeguard research integrity (Dai *et al.*, 2018; CSA, 2022). Momentum is building to adjust the incentive system surrounding academic research to better value research quality and impact, including the extent to which the research has broader benefits to society (Wilsdon, 2015; Carter *et al.*, 2021).

International partnerships and collaborations are widely recognized for advancing scientific discovery (CCA, 2024b). Canada has long been an active international collaborator in science, and the majority of Canadian research publications feature international collaborators (Science-Metrix, 2024). As a relatively small country, Canada has much to gain from international collaborations (CCA, 2024b). With finite resources, however, there is a need to be strategic in determining "which partnership opportunities to support, while also recognizing the evolving geopolitical, economic, and security realities facing Canada" (CCA, 2024b).

With a goal of protecting sensitive Canadian research from risks that could compromise the country's economic and strategic interests and national security, the federal government has taken several steps to regulate research activities (SIGRE, 2022; ISED, 2023a). These include prohibiting recipients of federal research funds from collaborating with specific foreign research organizations based in China, Iran, and Russia; this is noteworthy, as China and Iran are both top research-collaborating countries with Canada (ISED, 2023a,b) (Section 6.5). A range of strategies can be deployed to advance international collaborative research while safeguarding research security (CCA, 2025b). Maintaining adequate cybersecurity in the face of mounting threats is a related pressure (WEF, 2024).

3

Expenditures, Education, Personnel, and Infrastructure

Chapter findings

- Canada continues to fall behind many peer countries in R&D spending, particularly in the business and government sectors.
- Federal government support for business R&D is primarily delivered through tax incentives, although direct support has increased in recent years.
- Canada has one of the most highly educated populations in the world, along with above-average performance in STEM fields, but it falls slightly behind many peer countries in educational attainment at the highest (post-graduate) levels.
- Although post-graduate training in Canada appears to attract and retain some of the most highly cited researchers in key technology fields, many ultimately leave Canada for employment opportunities in other countries.
- Canada has extensive research infrastructure, but complex and overlapping governance and funding systems and the lack of a strategic portfolio approach can limit the productivity and innovation of Canadian researchers.

Canada's national STI performance depends on the resources and supports that act as inputs to the ecosystem. This performance can be measured by four types of inputs: (i) expenditures on R&D, (ii) education, (iii) R&D personnel, and (iv) research infrastructure. While these inputs are typically necessary, they are not sufficient. A robust STI ecosystem also needs the *ideas* that are explored by R&D, conducted by the relevant talent using the required infrastructure. However, because ideas are hard to measure, focusing on the four inputs mentioned above provides quantifiable indicators of the STI ecosystem as a whole.

3.1 Expenditures on R&D

Expenditures on R&D can be understood in terms of two questions: (i) who *performs* the R&D, and (ii) who *funds* the R&D. There are three main sectors that perform R&D in Canada: the business sector, the higher education sector, and the government sector. R&D expenditures in these sectors are labelled BERD, HERD, and GOVERD, respectively. These indicators measure R&D performed within a given sector regardless of which sector funded it—known as *intramural*

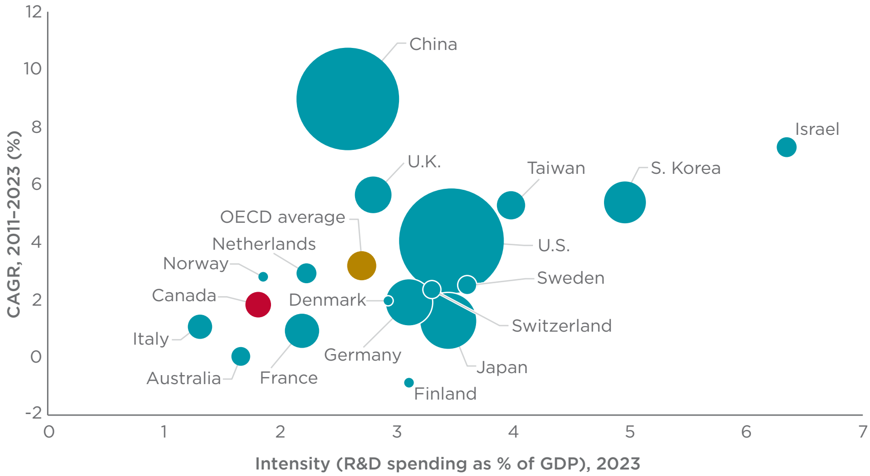
R&D. However, these sectors also sometimes fund R&D performed by a different sector, such as when a business funds R&D performed in a post-secondary institution. This cross-sectoral funding is known as *extramural* R&D.[4] There are three primary types of indicators for R&D expenditures: magnitude (total amount of spending), intensity (spending as a percentage of GDP or revenues), and growth rate (typically compound annual growth rate, or CAGR).

3.1.1 National R&D expenditures

Canada continues to fall further and further behind many peer countries in R&D spending

Gross domestic expenditures on R&D (GERD) measure a country's total investment in R&D. Canada's GERD was nearly $55 billion in 2024 (in current dollars) (StatCan, 2024g). Adjusted for inflation, it increased by slightly over 26% between 2011 and 2023, with a CAGR of 1.8%, compared to an OECD average CAGR of 3.2% (OECD, 2025b) (Figure 3.1).

4 *Extramural R&D* is defined here as R&D outside of a specific sector. For example, a business funding R&D performed by a different business would be considered intramural R&D, whereas a business funding a university would be considered extramural R&D.



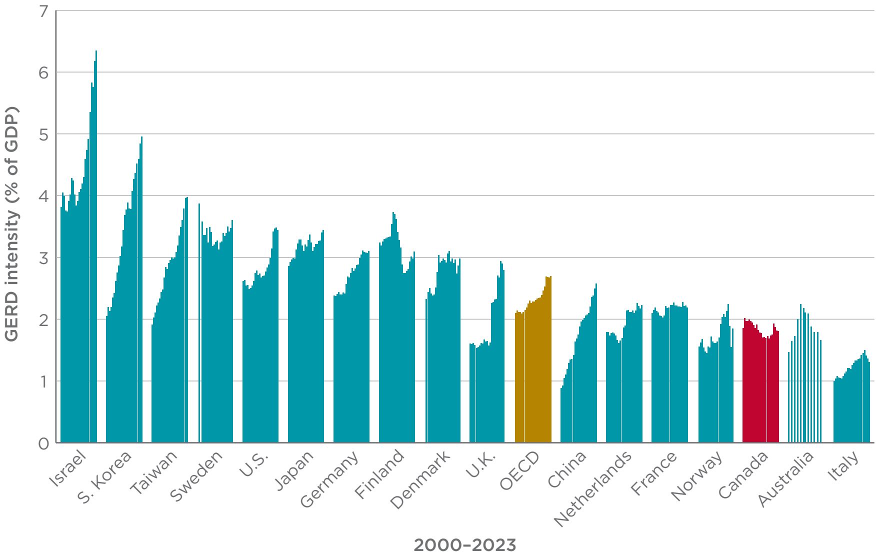
Data source: OECD (2025b)

Figure 3.1 GERD magnitude, intensity, and growth rate among select countries, 2011–2023

The intensity (x-axis), compound annual growth rate (y-axis), and magnitude (bubble size) of R&D expenditures in select countries.

Date ranges vary for some countries due to data availability: magnitude and intensity data for Australia and Switzerland are from 2021, while the CAGR is from 2009 to 2021; similarly, magnitude and intensity data for the U.K. are from 2022, while the CAGR is from 2010 to 2022. Spending amounts are in 2020 constant U.S. dollars (millions), converted to purchasing power parity.

R&D intensity indicates the degree to which national resources are invested in R&D and allows for comparisons among countries with different economies. Canada's R&D intensity decreased from 1.9% of GDP in 2000 to 1.8% in 2023, while it increased in all other G7 countries. In 2023, Canada's R&D intensity was the second-lowest in the G7 (ahead of Italy) and approximately two-thirds of the OECD average (2.7%). Indeed, among the comparator countries, Canada is one of only three countries (with Finland and Sweden) in which R&D intensity was lower in 2023 than in 2000 (Figure 3.2).



Data source: OECD (2025b)

Figure 3.2 GERD intensity among select countries, 2000–2023

Canada's GERD intensity is quite low relative to comparator countries.

Data for Australia are only available up to 2021 and the U.K. only up to 2022, and data for Australia and Sweden are missing for some years. Additionally, the U.K. changed its methodology for measuring and reporting R&D expenditures, which was retroactively applied to 2014, explaining the sudden jump in the figure in that year. For details, see the metadata of the OECD MSTI database (OECD, 2025b).

Canada's lacklustre GERD intensity trend is due in large part to a period of stagnant GERD growth between roughly 2007 and 2015, during which GDP continued to grow. However, GERD subsequently began to grow faster than GDP between 2016 and 2022, due primarily to increases in BERD (Section 3.1.2).

Importantly, while higher levels of R&D spending are not guaranteed to produce better STI outcomes, in the view of the panel, Canada's relatively low R&D expenditures and intensity are an impediment to the effectiveness and efficiency of its domestic STI ecosystem.

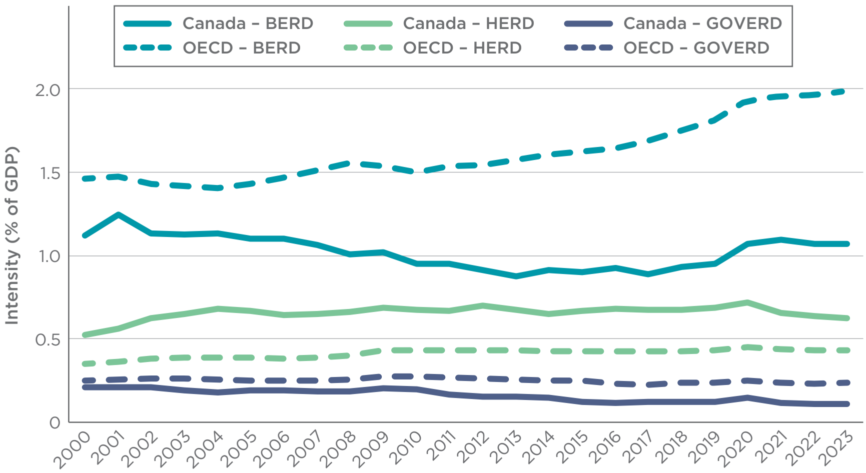
3.1.2 R&D expenditures by performing sector

Compared with most peer countries, Canada has higher expenditures on R&D performed in the higher education sector, and lower expenditures on R&D performed in the business and government sectors. In Canada, BERD accounted for about 59% of GERD in 2023, with HERD accounting for 35% and GOVERD for

6%. By contrast, BERD averaged about 75% of GERD among OECD countries in 2023, while HERD accounted for 16% and GOVERD for 9% (OECD, 2025b).

Canada is falling further and further behind other OECD countries in business and government R&D intensity

Canada's BERD intensity fell from about 77% of the OECD average in 2000 to 57% in 2023. At the same time, GOVERD intensity fell from about 85% to 47% of the OECD average. As a result, Canada's GOVERD intensity was about half as large in 2023 (0.1%) as it was in 2000 (0.2%).[5] During this time, HERD remained relatively consistent, accounting for between 0.5% and 0.7% of GDP—about 1.5 times the OECD average over that period (Figure 3.3).



Data source: OECD (2025b)

Figure 3.3 BERD, HERD, and GOVERD intensity, 2000–2023

National expenditures on business, higher education, and government R&D as a percentage of GDP in Canada and among OECD countries (average), from 2000 to 2023.

5 Some of the decline in GOVERD in Canada can be attributed to the transfer of Atomic Energy of Canada Limited's intramural R&D activities to the Canadian Nuclear Laboratories in 2015–2016, which is counted as an extramural R&D performer. However, this only accounts for a small part (<10%) of overall GOVERD.

Canada's industrial structure contributes to, but does not fully explain, its relatively low BERD intensity

Canada's economy is concentrated in somewhat less R&D-intensive industries relative to some comparator countries. When adjusted for industrial structure,[6] Canada's 2019 BERD intensity increases from 1.4% to 2.1% of GDP, moving from below the OECD average (1.8%) to above it (OECD, 2021b).[7] However, differences in industrial structure do not entirely explain Canada's relatively low level of BERD intensity, nor the trend of flat BERD intensity between 2010 and 2019. Similarly, industrial structure has been found to play only a minor role in Canada's low productivity growth (OECD, 2025c). Instead, factors such as a lack of large firms (Section 4.2.1) may be more significant.

This difference between adjusted and unadjusted BERD intensity can provide a rough measure of how much a given country specializes in R&D-intensive industries (OECD, 2021b). For example, countries with R&D-intensive economies such as Israel, South Korea, Japan, and Germany have a significantly lower BERD intensity when adjusted for industrial structure, while countries with less R&D-intensive (and more resource-intensive) economies such as Norway, Aotearoa New Zealand, Iceland, and Canada have a higher adjusted BERD intensity.

3.1.3 R&D expenditures by funding sector

As noted above, BERD, HERD, and GOVERD are indicators that measure R&D expenditures *performed by* (respectively) the business, higher education, and government sectors. However, these sectors also fund the R&D activities performed by other sectors (i.e., extramural R&D expenditures).

The federal government was the largest source of extramural R&D funding in Canada in 2023, followed by foreign sources (Table 3.1). By contrast, the business sector provided the lowest share of extramural funding, while the higher education sector did not fund any R&D performed in other sectors. The biggest percentage increases in extramural R&D funding between 2018 and 2023 came from the foreign sector (25%), while business extramural R&D funding decreased by nearly 10%. Funding for R&D performed by businesses increased from both federal (46%) and provincial/territorial (5%) governments, as well as from foreign sources (26%). Private non-profits fund more R&D in the higher education sector than do businesses or provincial/territorial governments, and they are the only source of extramural higher education R&D funding that increased between 2018 and 2023 (15%).

6 Adjusting BERD intensity for industrial structure means looking at what a country's BERD intensity would be if it had the same mix of industries as the average OECD country, rather than its actual mix of industries. This can allow for more meaningful comparisons across countries.

7 Note that the estimate of 1.4% BERD intensity differs from the estimate presented in Figure 3.3, in which Canada's 2019 BERD intensity was 0.95%. This is due to differences in the calculation methodology and data sources that were drawn upon. For details see OECD (2021b).

Table 3.1 Major flows of R&D funding in Canada, 2018 and 2023

		Funding sector (millions $) 2023 (2018)							
		Business enterprise	**Federal government**	**Foreign**	**Higher education**	**Private non-profit**	**Provincial governments**	**Provincial research orgs**	**Total**
Performing sector (millions $)	Business enterprise	*19,462 (15,709)*	1,379 (947)	4,193 (3,320)		243 (248)	296 (283)		25,572 (20,508)
	Federal government	49 (11)	*2,095 (2,278)*				1 (1)		2,144 (2,290)
	Higher education	1,020 (1,170)	3,505 (3,527)	128 (135)	*7,347 (7,328)*	1,713 (1,491)	1,163 (1,202)		14,876 (14,852)
	Private non-profit	7 (7)	51 (39)	10 (10)		*58 (54)*	68 (58)		195 (168)
	Provincial governments						*392 (333)*		392 (333)
	Provincial research orgs	14 (15)	1 (1)	1 (1)			17 (15)	*7 (6)*	39 (37)
	Total	**20,551 (16,913)**	**7,030 (6,793)**	**4,332 (3,466)**	**7,347 (7,328)**	**2,015 (1,891)**	**1,938 (1,891)**	**7 (6)**	**43,219 (38,189)**

Data source: StatCan (2024g)

In each cell, amounts on top are 2023 spending, amounts below in parentheses are 2018 spending. Green cells indicate an increase between 2018 and 2023 whereas red cells indicate a decrease over that period. Amounts in *italics* indicate intramural funding (e.g., business sector funding R&D performed by the business sector). Amounts are in 2017 constant market prices. Dark grey cells = data were not available.

Canada has a relatively higher proportion of GERD funded by foreign sources compared to other countries; across the OECD, an average of 7% of GERD was funded by foreign sources in 2022, versus 10% in Canada (OECD, 2025b). Additionally, the share of higher education R&D that is self-funded in Canada is much higher compared with that of many other countries. This is partly due to differences in how funding for higher education R&D is calculated in Canada versus the OECD; in Canada, public general university funds from governments are counted within the higher education funding sector. By contrast, in the OECD, general university funds are typically counted within the government funding of higher education, which can result in discrepancies when comparing Canadian and OECD data on sources of funding for HERD (StatCan, 2009) (Box 3.1).

Box 3.1 How HERD is calculated

HERD is a measure of expenditures on R&D performed by institutions of higher education. It is composed of two types of expenditures: (i) sponsored research, paid for from funds received from organizations outside the institution (such as governments, businesses, and others, as depicted in Table 3.1), and (ii) non-sponsored research, paid for from the institution's own funds. These two components are further subdivided into direct and indirect costs. Direct costs are those that can be attributed to a specific project or individual, such as researcher salaries. By contrast, indirect costs include costs shared across multiple projects, activities, or researchers, such as utility bills for buildings (StatCan, 2020a).

There are unique methodological challenges associated with estimating each of these four types of expenditures (sponsored/direct, sponsored/indirect, non-sponsored/direct, and non-sponsored/indirect). For example, non-sponsored direct costs include faculty time spent on research, which requires estimating the proportion of faculty time spent on research as well as researcher salaries. Current estimates by Statistics Canada are based on a faculty time-use survey from 2014–2015, from which faculty research time coefficients were derived based on S&T field (as per the OECD's Frascati Manual) and institution size (StatCan, 2020a). There are also additional challenges when determining such estimates for colleges, and the tracking of such data is highly inconsistent across provinces/territories and even among neighbouring institutions.

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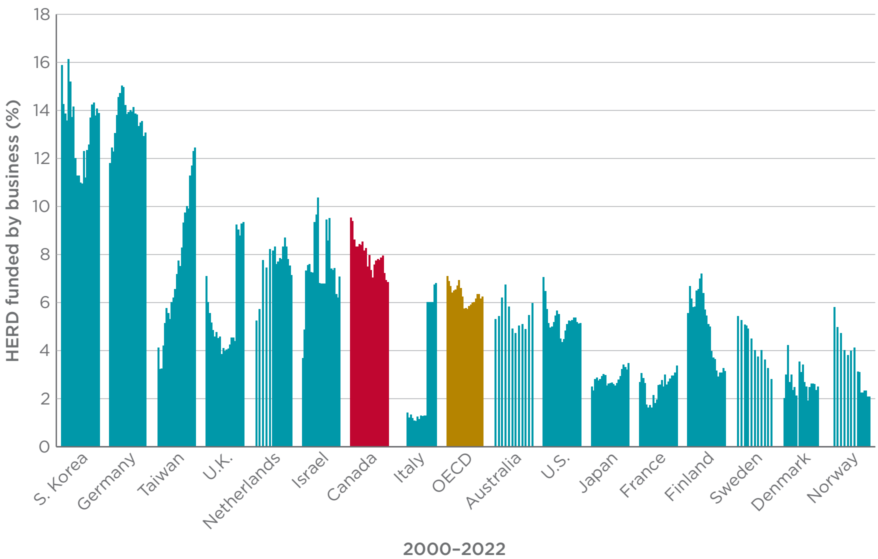
However, as noted in Canada's Fundamental Science Review (2017), the model by which Canada funds HERD—with relatively low levels of government funding of both direct and indirect costs leading to an overreliance on increased tuition fees to make up the difference—may result in challenges for the higher education sector and hinder research performance.

For a detailed breakdown of the methodology for calculating HERD, see StatCan (2020a). For a critical analysis of how Canada's HERD funding model impacts post-secondary finances and research performance, see Advisory Panel (2017).

Canada has a greater proportion of HERD funded by the business sector than many comparator countries

Canada's business investment in HERD is among the highest in the OECD, but has decreased over the past two decades. Nearly 10% of HERD was funded by the business sector in 2000, dropping to 7% by 2023 (OECD, 2025b). Over this time, business funding of HERD increased in some countries, particularly Taiwan (Figure 3.4).



Data source: OECD (2025b)

Figure 3.4 Percentage of HERD funded by business, 2000–2022

The percentage of business funding is relatively high in Canada but declining over time.

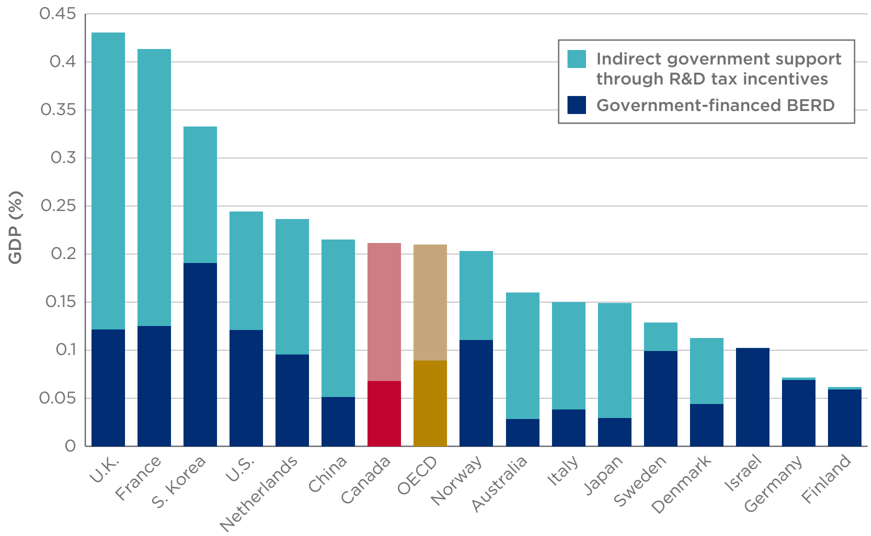
Data are not available for all countries for all years. Additionally, the U.K. changed its methodology for measuring and reporting R&D expenditures, which was retroactively applied for this indicator from reference year 2018, explaining the sudden jump in the figure in that year. Similarly, Italy changed its methodology for surveying higher education institutions in 2016, which likely explains its similar jump in 2017. For details, see the metadata of the OECD MSTI database (OECD, 2025b).

In 2022–2023, almost all (98%) business-funded HERD in Canada was performed in universities, with U15 universities[8] accounting for the vast majority (76%). Moreover, business-funded research at U15 universities increased by 44% between 2010 and 2023 (U15 Canada, 2025). However, colleges, institutes, and polytechnics also provide an important resource for businesses to outsource applied R&D work, particularly for small- and medium-sized enterprises (SMEs). In 2021–2022, 62% (5,427) of applied R&D partnerships at colleges, institutes, and polytechnics were with SMEs, while about 13% (1,160) were with large enterprises (the remaining 25% of partnerships were with government, non-profits, and international partners) (CICan, 2023).

8 The U15 is an association representing 15 leading research universities in Canada: University of Alberta, University of British Columbia, University of Calgary, Dalhousie University, Université Laval, University of Manitoba, McGill University, McMaster University, Université de Montréal, University of Ottawa, Queen's University, University of Saskatchewan, University of Toronto, University of Waterloo, and Western University.

Federal government support for business R&D is primarily through tax incentives

The proportion of BERD in Canada funded by the federal government has increased relative to the OECD. About 6.5% of all BERD was funded by the federal government in 2022, compared to an OECD average of 4.8%. By contrast, in 2010, only about 3.7% of BERD in Canada was funded by the federal government, compared to an OECD average of nearly 8% (OECD, 2025b). On average, federal government support for business R&D in Canada accounted for about 0.21% of national GDP between 2018 and 2023, which is roughly the same as the OECD average (Figure 3.5). Additionally, provincial/territorial government support for business R&D accounted for about 0.05% of GDP. Over this period, about 68% of federal government support for business R&D in Canada came from tax incentives; the OECD average was about 57%.

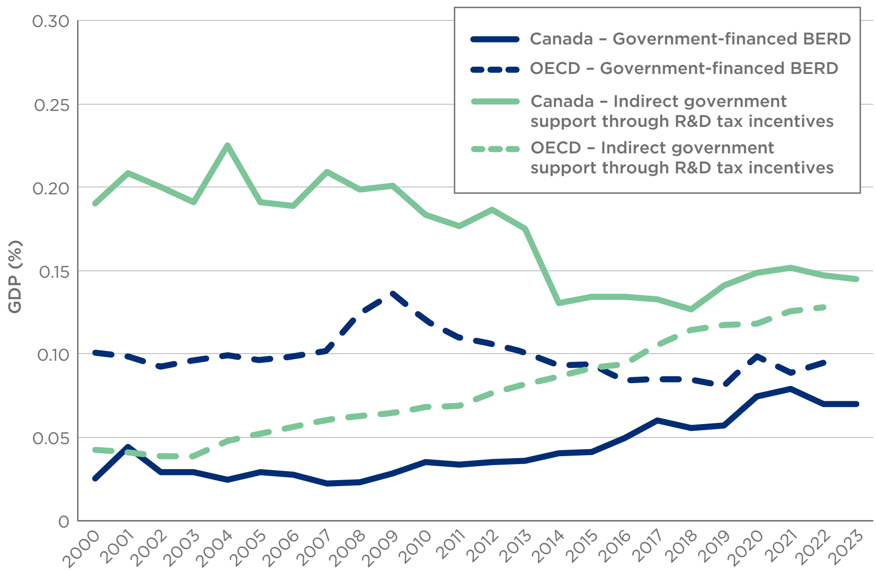


Data source: OECD (2025d)

Figure 3.5 Government support for business R&D, average 2018–2023

The mix of federal government support (direct vs. indirect) for business R&D as % of GDP. Data is averaged from 2018 to 2023.

Historically, Canada's federal support for business R&D has rested on high levels of indirect support (e.g., tax incentives) and relatively low levels of direct support compared with other countries. However, indirect government support for business R&D through tax incentives decreased in Canada (as a percentage of GDP) between 2000 and 2021, while direct support increased. In the broader OECD context, that trend was reversed, with the overall result of bringing Canada much closer to the OECD average (Figure 3.6). However, this decline in R&D support through tax incentives may also reflect the overall decline in business R&D in Canada, as the less business spends on R&D, the less will be refunded through tax incentives. Furthermore, the large, abrupt decrease in indirect support for R&D in Canada that occurred in 2014 is due in large part to changes to the scientific research and experimental development (SR&ED) tax incentive program that came into force in that year.[9]



Data source: OECD (2025d)

Figure 3.6 Direct and indirect support for BERD as % of GDP, 2000–2023

Government-funded BERD is low but climbing relative to the OECD average. The trends are reversed for indirect government support.

SR&ED is counted as part of indirect government support. Data for the OECD was only available up to 2022.

9 The changes to SR&ED were as follows: "The base of eligible expenditures is narrowed by removing capital expenditures starting in 2014. The 'prescribed proxy amount' that is used to compute overhead expenditures is reduced from 65% of direct labour costs in 2012, to 60% in 2013, and to 55% effective January 1, 2014. Only 80% of contract payments can be used for the purposes of calculating SR&ED investment tax credits effective January 1, 2013. The general SR&ED investment tax credit is reduced from 20% to 15% effective January 1, 2014, and lease costs can no longer be claimed for SR&ED purposes" (CRA, 2015).

In 2023, direct federal government funding for business R&D was just under $1.4 billion (inflation-adjusted 2017 constant market prices) (StatCan, 2024g). In 2022–2023, over 56% of federal direct support came from two sources: the National Research Council of Canada (NRC) (32%) and ISED (24%) (Table 3.2). The overwhelming majority of the funding from NRC was through its Industrial Research Assistance Program, which distributed over $489 million in grants and contributions in that period (NRC, 2023). The federal government also provides direct funding for business R&D outside of departments and agencies through specialized programs, such as the Climate Action and Awareness Fund, Sustainable Development Technology Canada (pre-2024), and the Canada Growth Fund.

Table 3.2 Major federal department and agency funding of BERD, 2022–2023

Department / Agency	Funding of business R&D (millions $)	Share of total federal funding of business R&D (%)
National Research Council Canada	505	32.3
Innovation, Science and Economic Development Canada	374	23.9
Canadian Space Agency	207	13.2
National Defence	104	6.7
Natural Resources Canada	53	3.4
Agriculture and Agri-Food Canada	9	0.6
Environment and Climate Change Canada	7	0.4
Public Health Agency of Canada	5	0.3
Natural Sciences and Engineering Research Council of Canada	2	0.1
Health Canada	2	0.1
Other departments and agencies	295	18.9

Data source: StatCan (2025e)

Amounts are in 2022–23 current dollars. Total federal funding of BERD differs slightly between Table 3.1 ($1.4 billion) and Table 3.2 ($1.6 billion). In part, this is because they use different currency conversions (2017 constant market prices vs 2022–23 current dollars); additionally, the department/agency table displays intentions and estimates, whereas the performer table displays expenditures. In the category of "Other departments and agencies" some of these departments and agencies may provide more than $2 million (the lowest amount listed in the table) in BERD funding but are not included in the table because their total S&T expenditures are less than 2% of all federal S&T expenditures.

Federal contributions to colleges and institutes for applied research with industry are, arguably, also a form of business R&D investment (although they are not captured in federal funding of BERD). Moreover, for every dollar of public funding for applied R&D these institutions are able to leverage a nearly equal investment from the private sector (Amyot, 2022; CICan, 2023). In 2021–22, the federal government funded $151 million in applied R&D at colleges and institutes (primarily through tri-agency[10] funding), while the private sector contributed $137 million.

The largest and most significant federal tax program supporting business R&D is the SR&ED tax incentive

In the 2023–24 fiscal year, 21,537 claims for Canada's SR&ED tax credit were processed, with a total value of about $4.2 billion (CRA, 2025). The majority of SR&ED funding goes to SMEs. Small firms (<$10 million in taxable capital) are eligible for a fully refundable tax credit of 35% on the first $3 million of SR&ED, while larger firms (>$50 million in taxable capital) are only eligible for the non-refundable tax credit of 15% (CRA, 2022). As a result, while firms with revenues under $5 million are responsible for about 16% of all BERD, firms with revenues under $4 million receive nearly one-third of all SR&ED funding. Similarly, firms with over $250 million in revenues receive only one-quarter of all SR&ED tax credits, yet those with over $500 million in revenues account for over 37% of all business R&D (Table 3.3).

Table 3.3 Share of SR&ED and BERD by firm size, 2022

	SR&ED		BERD	
Firm size	Gross income (millions $)	Share of SR&ED (%)	Total revenues (millions $)	Share of BERD (%)
Small	<4	32	<5	16
Small-medium	4 to 20	23	5 to 50	23
Medium	20 to 250	20	50 to 500	24
Large	>250	25	>500	37

Data sources: StatCan (2024h); CRA (2025)

Firm size by revenue group is categorized differently by the Canada Revenue Agency SR&ED data and Statistics Canada's Annual Survey of Research and Development in Canadian Industry.

10 The Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC), and SSHRC.

Firms focused on software development received the greatest allocation of SR&ED tax credits between 2021–22 and 2023–24 (37%), followed by electrical (18%) and mechanical (14%) engineering (Table 3.4). This reflects some areas of Canada's business R&D strengths, such as software publication, ICT manufacturing and design, and other fields of manufacturing (Section 4.2).

Table 3.4 Average share of SR&ED tax credits by field of science, 2021–22 to 2023–24

Field of science	% of total SR&ED tax credits
Software development	36.6
Electrical engineering	18.2
Mechanical engineering	13.5
Medical sciences and engineering	11.6
Chemistry or chemical engineering	7.2
Materials engineering	4.9
Earth sciences - environmental	3.7
Agricultural sciences	1.9
Food processing	1.5
Civil engineering	0.8

Data source: CRA (2025)

Foreign-controlled firms can access the SR&ED tax credit as long as the firm performing the work is a resident of Canada; however, they are only eligible for the basic investment tax credit rate of 15%, rather than the "enhanced" rate of 35% (CRA, 2022). Data about the amount or share of SR&ED that goes to foreign-controlled firms in Canada is not publicly available.

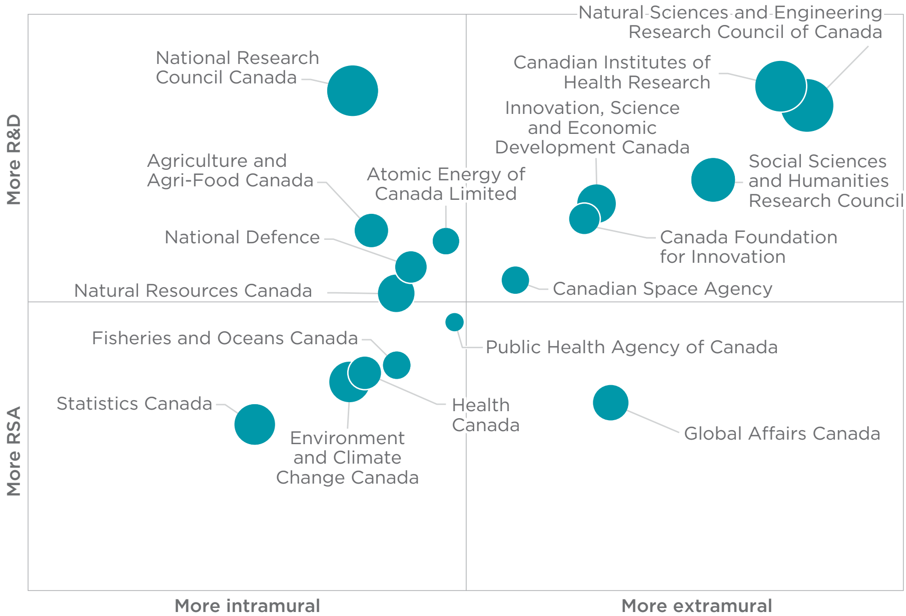
The SR&ED tax incentive program has both supporters and detractors. Some favour SR&ED's neutrality and have called for enhancing this feature by offering consistent tax credits across firm sizes and types (Lester, 2022; CCIC, 2024). Others have critiqued SR&ED as burdensome, inefficient, difficult to administer, and also limited in applicability as it excludes public companies (McIntyre, 2024). However, solutions to these challenges are also complex, as appropriate reporting and oversight are required to protect public funds (Lester, 2022).

3.1.4 Federal S&T expenditures

Federal S&T expenditures increased over 40% between 2010–2011 ($11.6 billion) and 2023–2024 ($16.3 billion), with extramural expenditures growing more (54%) than intramural ones (26%) (StatCan, 2025f). Federally-performed (intramural) S&T, often referred to as "government science," is the S&T conducted by government researchers in federal research establishments. It is an often overlooked but vital component of Canada's STI ecosystem, essential for supporting the provision of public goods unlikely to be provided effectively by other actors (Doern & Kinder, 2007). In terms of scientific publications, government researchers are important contributors in key areas of public stewardship such as public health, agriculture and food science, and Earth and environmental sciences (Science-Metrix, 2024).

Federal S&T includes two categories of activities: R&D and RSA. *R&D* is defined as "creative and systematic work undertaken in order to increase the stock of knowledge … and to devise new applications of existing knowledge" (OECD, 2015a) and is generally directed toward improving processes and products. *RSA* is defined as "all systematic activities which are closely concerned with the generation, advancement, dissemination and application of scientific and technological knowledge" (StatCan, 2024i), such as routine data collection, information services, and administration (StatCan, 2015). However, this definition may diminish the significance of RSA. Indeed, many of the important public good services and risk management functions associated with government—from weather forecasting to science-based regulation of public health, food safety, and environmental protection—are supported by RSA (GC, 2007). For example, RSA includes regulatory science that supports pre-market approval and post-market monitoring of new drugs and medical devices. RSA constitutes the majority of federal intramural S&T (62% of intramural S&T spending in 2022-23, up from 49% in 2010-11), and federal expenditures on RSA have grown faster than expenditures on R&D between 2010-11 and 2022-23 (StatCan, 2024j). As noted in Section 3.1.2, Government intramural R&D (GOVERD) is lower than comparator countries and is continuing to decline.

Funding for higher education R&D accounted for 27% of all federal S&T expenditures between 2010–2011 and 2023–2024, almost entirely through tri-agency funding (Figure 3.7). Other federal S&T expenditures included federal RSA (26% of all expenditures), federal R&D (20%), and funding for business R&D (9%) (StatCan, 2025e,f).



Data source: StatCan (2025f)

Figure 3.7 Intramural and extramural R&D and RSA by select federal departments and agencies, total 2010–11 to 2023–24

The relative distribution of extramural and intramural R&D and RSA expenditures across federal departments and agencies. Distance from the centre represents how specialized a particular department or agency is in each of the four types of activities (intramural, extramural, RSA, R&D) by showing how much more they spend on that activity compared with the other three types. The x-axis subtracts each department's intramural S&T expenditures from its extramural S&T expenditures; similarly, the y-axis subtracts total RSA spending from total R&D spending. Bubble size represents total S&T expenditures from 2010-11 to 2023-24.

Atomic Energy of Canada Limited's federal intramural R&D activities were transferred to the Canadian Nuclear Laboratories in 2015-16, which is counted as a government-owned, contractor-operated extramural R&D performer. The former Canadian International Development Agency was merged with what is now Global Affairs Canada in 2013 and is represented here as part of that department.

3.1.5 Provincial/territorial R&D expenditures

Ontario accounted for over 45% of Canada's total R&D expenditures between 2010 and 2022, while Quebec accounted for over 25%. British Columbia and Alberta accounted for 11% and 10% respectively, while the Atlantic provinces collectively accounted for about 4%. Saskatchewan and Manitoba each accounted for about 2%. Over this period, R&D expenditures grew much more quickly in the Territories and British Columbia compared with the other provinces (StatCan, 2024g). Only Quebec and Ontario have a GERD intensity higher than the national average (StatCan, 2023b, 2024g).

Both intramural and extramural R&D expenditures in Ontario, Quebec, British Columbia, and Alberta are concentrated mainly in the business sector; these provinces also have the highest level of foreign-funded R&D. In the Atlantic and Prairie provinces, R&D expenditures are concentrated more in the higher education sector, with lower levels of business sector R&D. Alberta is the only province where the provincial government spends a substantial amount (4%) on performing R&D (StatCan, 2024g).

3.2 Education

Canada has a consistent set of internationally recognized universities ranking in the top 200 globally, according to both the Times Higher Education World University Rankings and the QS World University Rankings. Since 2011, University of Toronto, University of British Columbia, and McGill University have ranked within the top 50 universities globally, according to these surveys. Additionally, McMaster University, Université de Montréal, and University of Alberta are frequently ranked within the top 100 to 150 universities in the world (QS, 2024; THE, 2024).

On average, Canada had the sixth-highest level of annual expenditures per post-secondary student in the OECD between 2016 and 2021 (averaging roughly $22,000 per student); however, expenditures per student decreased by 15% over this period, with Canada's rank dropping from 5th in 2016 to 8th in 2021 (OECD, 2025e).

Despite its highly ranked universities, high levels of per-student funding, and reported high HERD, Canada faces significant financial challenges in its higher education sector (Section 2.4.4). Furthermore, much of the data presented in this section are current only up to 2021 or 2022 and therefore do not reflect substantial changes in Canada's higher education system that have occurred since then.

3.2.1 Educational attainment

Since 1994, Canada has led the world in educational attainment. In 2022, over 63% of 25-to-64-year-olds in Canada had completed a post-secondary degree, compared with an OECD average of about 41%.

However, these data can be misleading, and result in inflated estimates of Canada's performance when compared with other countries. Specifically, the cited data refer to the percentage of the population that has attained a tertiary degree, defined by the International Standard Classification of Education (ISCED) as levels 5, 6, 7, and 8 (UNESCO & UIS, 2011). However, the data for Canada also include ISCED level 4 educational attainment (post-secondary, non-tertiary education), which includes, among other credentials, degrees granted by Quebec's collèges d'enseignement général et professionnel (CÉGEP) (StatCan, 2021a; OECD, 2024c). This results in an inflated estimate of educational attainment in Canada compared with other countries, which only include ISCED levels 5–8.[11]

While Canada leads the world in overall post-secondary educational attainment, it falls behind many peer countries in educational attainment at the highest levels. In 2023, 12% of 25-to-64-year-olds in Canada had completed a Master's or Doctoral degree, compared with an OECD average of 15% (OECD, 2023a). Approximately 51% of Doctoral degrees awarded in Canada in 2022 were in STEM fields, compared with the OECD average of 43%. At the Bachelor's (or equivalent) level, the proportion of STEM degrees is 26%, which is slightly higher than the OECD average of 23% (OECD, 2024d). However, the fact that Canada produces a high proportion of STEM graduates does not mean that they are in fields that align with industry needs (Section 3.2.3) or that these graduates stay in Canada (Section 3.2.4).

Canada lags many peer countries in technical and vocational education and training (TVET), falling below the OECD average for TVET graduates in 2022. This is due in part to the fact that Canada is somewhat of an outlier among comparator countries in not offering TVET as a separate program at the upper secondary level (outside of Quebec), with vocational training instead being integrated into other programs or offered as standalone courses (OECD, 2023b). As such, comparisons with other countries may be somewhat misleading. Nevertheless, Canada's lack of dedicated TVET programs may create challenges insofar as TVET can play an important role in enhancing regional and national innovation ecosystems through applied research and technology diffusion (de Otero, 2019).

11 While other countries also have methodological challenges related to determining levels of educational attainment among their populations, Canada is the only OECD country that experiences this particular challenge, and the only one for which the OECD explicitly notes that estimates of the proportion of the population with a tertiary education are inflated: "The Canadian Labour Force Survey does not allow for a clear delineation of attainment at ISCED 4 and at ISCED 5; as a result, some credentials that should be classified as ISCED 4 cannot be identified and are therefore included in ISCED 5. Thus, the proportion of the population with tertiary education ISCED level 5 is inflated" (OECD, 2024c).

3.2.2 Number of post-secondary graduates

Canada produced more than 500,000 post-secondary graduates in 2022, up from approximately 275,000 in 2000. Not all degree programs grew at the same rate over this time: career, technical or professional training programs and Bachelor's (or equivalent) programs had the lowest growth in number of annual graduates between 2000 and 2022, while graduate programs (Master's and Doctoral degrees or equivalents) had the highest growth. The growth rate of post-secondary graduates slowed significantly between 2000–2011 and 2011–2022 for all degree program types, suggesting a potential slowdown in the growth of post-secondary attainment in Canada (Table 3.5).

Table 3.5 Number of graduates and growth rate of degree programs by type, 2001–2021

	2000	2011	2022	Change, 2000–2022 (%)	Change, 2000–2011 (%)	Change, 2011–2022 (%)
Career, technical or professional training program	113,706	161,274	198,114	74.2	41.8	22.8
Bachelor's or equivalent	128,865	183,633	226,182	75.5	42.5	23.2
Master's or equivalent	29,106	49,941	72,471	149.0	71.6	45.1
Doctoral or equivalent	3,861	6,258	8,037	108.2	62.1	28.4
Total	**275,538**	**401,106**	**504,804**	**83.2**	**45.6**	**25.9**

Data source: StatCan (2024k)

The number of post-secondary graduates in Canada who have successfully completed their degree. Program types are based on the ISCED, except for *career, technical or professional training programs*, which combines ISCED program types for post-secondary non-tertiary education and short-cycle tertiary education. These programs are offered primarily, though not exclusively, by colleges in Canada. Similarly, Bachelor's degrees or their equivalent are granted primarily by universities in Canada, though colleges grant a small portion as well (CCA, 2018a).

Notably, Canada produces more women post-secondary graduates than men, at every level except Doctoral programs. In 2022, women accounted for 56% of graduates in career, technical or professional training programs, 59% of undergraduates, 60% of Master's graduates, and 49% of Doctoral graduates (StatCan, 2024l).

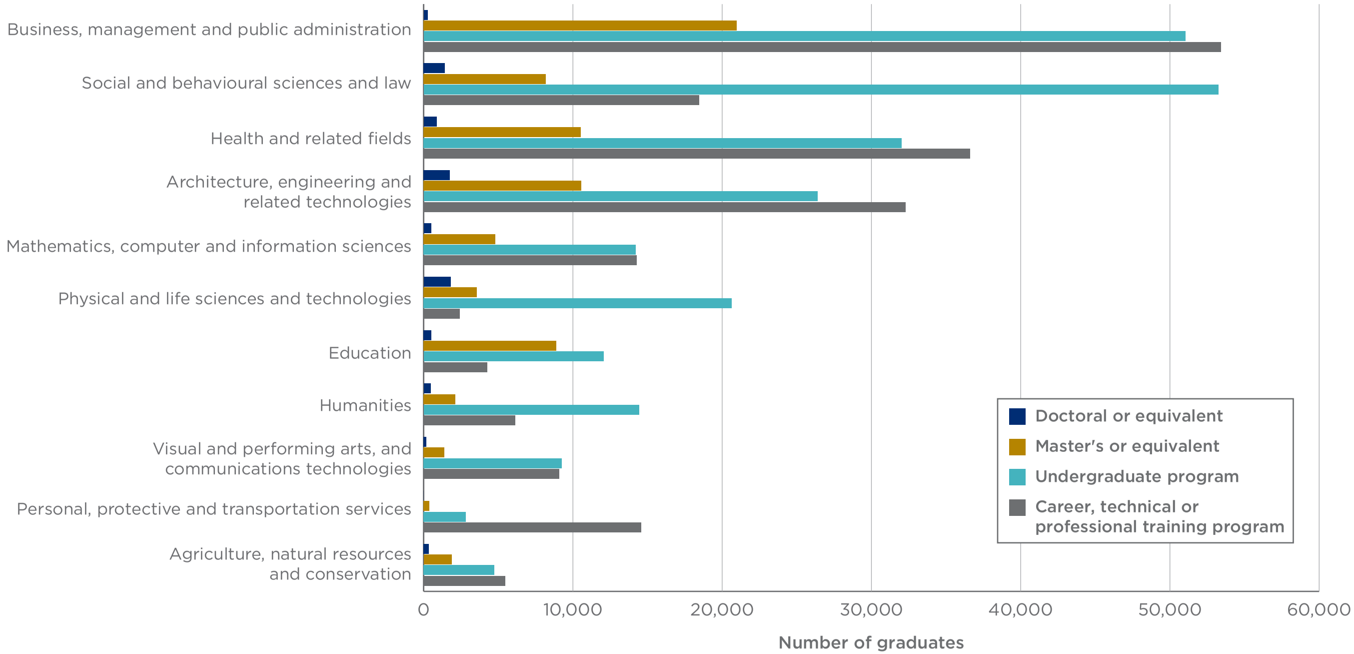
Growth in the number of students graduating from Canadian post-secondary institutions in recent years has been largely driven by international students

Approximately 74% of the total growth in the number of graduates at Canadian colleges and universities between 2010 and 2022 was due to international students. The number of international students graduating from Canadian colleges and universities increased by 403% between 2010 and 2022. International students comprised over 25% of all college and university graduates in Canada in 2022, compared with 7% in 2010. By contrast, the number of Canadian graduates grew by approximately 10% during that time and accounted for 74% of all graduates in 2022. The increase in international student graduates is mainly concentrated in colleges (814% increase between 2010 and 2022), and mainly in Ontario, which graduated nearly 100,000 international students between 2010 and 2022—more than 2.7 times the number of international students in all the rest of the provinces and territories *combined* (about 34,000) (StatCan, 2024m). This increase in Ontario colleges was due in part to exploitative recruitment tactics practised by some institutions (Hui, 2023). At the Master's and Doctoral levels, about 57% of the growth in graduates between 2010 and 2022 was driven by international students. In 2022, international students accounted for about 28% of all Master's and Doctoral students, an increase from 13% in 2010 (StatCan, 2024n).

The main factor driving the rise in international student enrolment is likely financial, since "international students pay much higher tuition fees than domestic students and are thus seen as a way to offset stagnant government funding" (Usher & Balfour, 2024). International students accounted for an estimated $5.1 billion in tuition fees in the 2020–2021 academic year, representing 12.2% of university revenues (Matias *et al.*, 2021). The cap on international students announced by the federal government in 2024 will likely have significant financial implications for Canada's post-secondary institutions, as well as for its future workforce and R&D performed in institutions of higher education (as student fees contribute significantly to research budgets). These impacts are still unfolding; while they are an important subject for future research, they are beyond the scope of this assessment.

3.2.3 Top fields of study

Canada has a large number of graduates in business and administration at the college, undergraduate, and Master's levels. Additionally, Canada has a high number of graduates in social sciences, health, and other STEM fields across all levels (Figure 3.8).



Data source: StatCan (2024l)

Figure 3.8 Top fields of study in Canadian post-secondary institutions (graduates), 2022

The business, management and public administration field had the largest number of graduates from career, technical or professional training programs (53,400), undergraduate programs (51,000), and Master's (21,000) levels in 2022. By contrast, the greatest number of Doctoral graduates were in physical and life sciences and technologies (1,800), architecture, engineering and related technologies (1,700), and social and behavioural sciences and law (1,400).

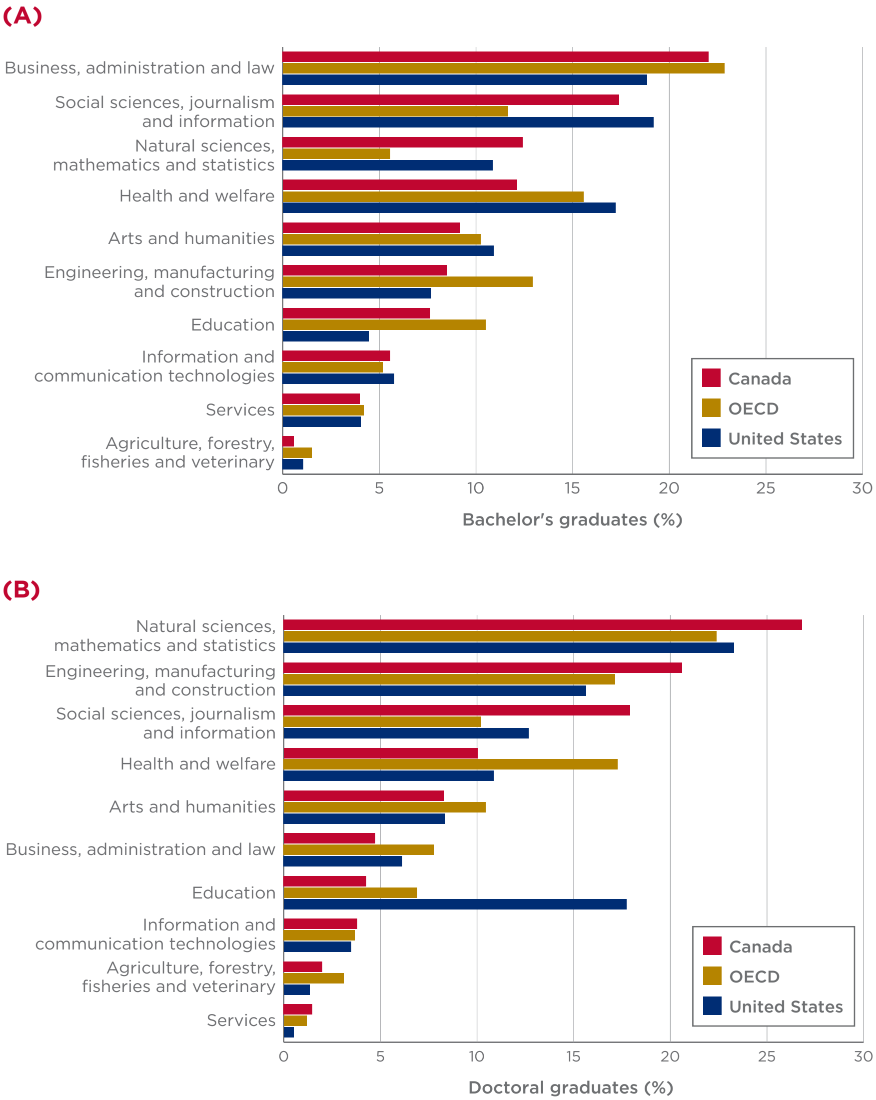
Compared with the 2022 OECD average, Canada had a higher proportion of both Bachelor's and Doctoral graduates in the fields of social sciences, journalism and information; natural sciences, mathematics and statistics; and information and communication technologies. Additionally, Canada had a higher proportion of Doctoral graduates in the fields of engineering, manufacturing and construction; and services. Canada fell below the OECD average in all other fields (Figure 3.9).

Canada's high number and proportion of graduates in the social sciences, particularly at the Doctoral level, is reflected in Canada's high bibliometric performance in this field (Section 6.3.1). However, Canada's high bibliometric performance in health-related fields is not reflected in its below average number and proportion of graduates in this area compared to other countries.

An important research area is the degree of alignment between fields in which Canada produces research graduates and the needs of industry. Indeed, lack of skills is the second-most cited obstacle to innovation, according to a survey of Canadian firms (Section 8.3). Across all industries, the biggest shortage—often by a wide margin—is in the skilled trades, but innovation management is also often identified as a challenge (Sections 2.4.1 and 9.1).

3.2.4 Post-graduate mobility and retention

Canada produces many highly educated post-secondary graduates, many of whom continue to post-graduate training and eventually become employed as part of the S&T workforce, either in Canada or elsewhere. Additionally, Canada attracts many foreigners for post-graduate training, as well as foreign graduate degree-holders for its domestic workforce. For most fields there is a net increase of highly qualified personnel (HQP) between "undergraduate" and "employed in Canada;" that is, more HQP end up employed in Canada than started at the undergraduate level (Gaida *et al.*, 2023). However, while post-graduate training in Canada appears to attract some of the most highly cited researchers in key fields, many leave for employment opportunities in other countries, leading to a net decrease in HQP between post-graduate training and employment in Canada (with the exception of biotechnology, gene technologies, and vaccines). It should be noted, however, that mobility patterns among these top researchers are not necessarily representative of the broader HQP population.



Data source: OECD (2024d)

Figure 3.9 Percentage of Bachelor's and Doctoral graduates in Canada by field of study, 2022

Percentage of graduates by field compared among Canada, the OECD, and the United States for 2022 at the Bachelor's (panel A) and Doctoral level (panel B).

Classification of fields of study is based on the ISCED (UNESCO & UIS, 2011).

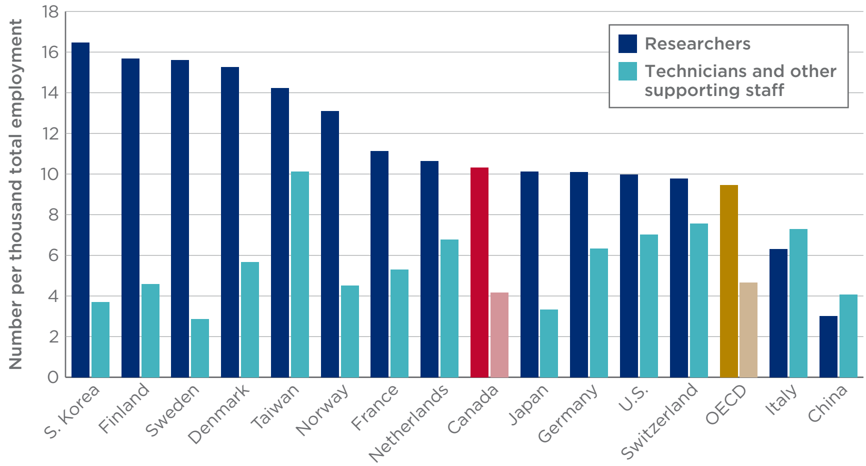
Part of the reason Canada loses HQP to other countries—particularly the United States—is likely due to differences in wages. For example, full-time, full-year tech workers in the United States make, on average, about 37% more than equivalent tech workers in Canada ($129,700[12] versus $94,800). Similarly, a tech worker with a PhD makes about 52% more in the United States than in Canada ($160,776 versus $106,026), while a non-tech worker with a PhD makes about 32% more ($124,796 versus $94,600) (Li & Ari, 2023). While an R&D workforce includes more than just tech workers and Doctoral graduates, these data provide an insight into the Canada–United States wage disparity in STEM fields. Likewise, the cost of living in Canada's innovation hubs may be a deterrent to retaining HQP (Hauen, 2024; Lowey, 2024b). On the other hand, 2025 funding cuts to research in the United States have the potential to make Canada a relatively more appealing location to live and work, possibly reversing the "brain drain" effect (Stevis-Gridneff, 2025). However, an influx of HQP could potentially put stress on the STI ecosystem without the proper increase in support and services for research (Zandstra, 2025).

Absorptive capacity—including positions available for HQP—may also be lacking in Canada. In a 2024 study of 411 students enrolled in a graduate program at a Canadian university and 171 respondents who completed a graduate program at a Canadian university within the last 10 years, more than half expressed their intention to leave or had already left Canada post-degree (Bailey *et al.*, 2024). Of those who left or plan to leave, "finances/salary" and "available opportunities" were cited as the most important factors affecting their decision.

3.3 R&D personnel

On average, Canada had approximately 10.9 researchers per thousand employed people between 2018 and 2022 (compared to 7.2 in 2000), which is higher than both the United States (10.0) and the OECD (9.5) average. However, Canada had fewer R&D technicians and support staff (4.2) employed people compared with peer countries—the second-lowest in the G7 (excluding the United Kingdom, for which data is not available), and lower than the OECD average (4.7) (Figure 3.10). In the view of the panel, Canada's relatively low level of R&D technicians and support staff is a serious impediment to improving Canadian research and innovation, as it means that researchers may be spending more time and resources on administrative and technical tasks instead of research.

12 All values are presented in Canadian dollars.



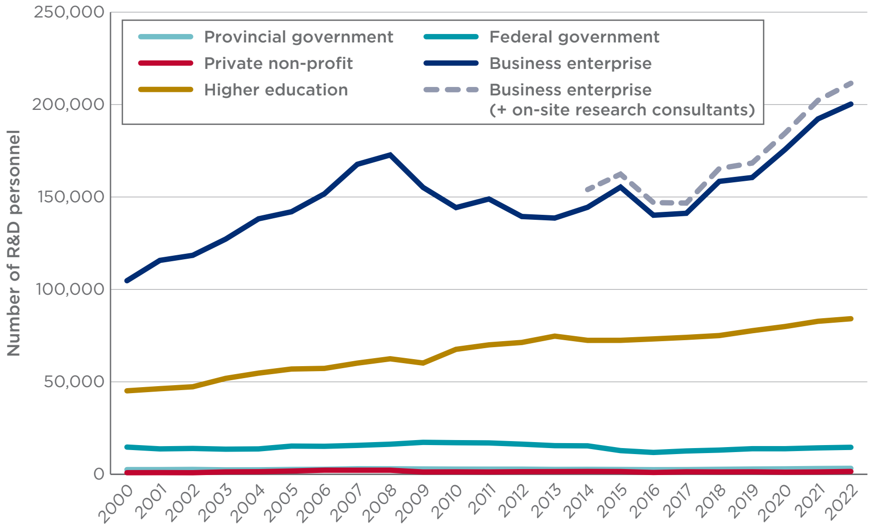
Data source: OECD (2025b,f)

Figure 3.10 R&D personnel per thousand total employment, average 2018–2022

R&D personnel includes the occupational subcategories of researchers, technicians, and support staff (OECD, 2015a). The figure uses the averages (2018–2022) due to data gaps for some countries for some years.

Most R&D personnel in Canada are employed in the business sector, while their numbers in the federal government are declining

Over two-thirds (67%) of Canada's R&D personnel were employed in the business sector in 2022, compared with 27% in the higher education sector. The federal government accounts for about 5% of R&D personnel in Canada, while provincial/territorial governments account for about 1%. Between 2000 and 2022, the total number of R&D personnel in Canada increased by nearly 88%, with the biggest increases in the business (102%) and higher education (86%) sectors. By contrast, the number of R&D personnel in the federal government decreased by 1% (Figure 3.11). In the view of the panel, however, the number of R&D personnel in the business sector may be influenced by classification in the SR&ED program, given the dissonance with other data.



Data source: StatCan (2025g)

Figure 3.11 R&D personnel in Canada by performing sector, 2000–2022

The vast majority of Canada's R&D personnel are employed in business enterprises and higher education.

In 2014, Statistics Canada added the occupational category of *on-site research consultants,* to the existing R&D personnel occupational categories of *researchers, technicians*, and *support staff*. Those data are only available for the business enterprise and private non-profit sectors. The change in categories is indicated with a dashed line for the business enterprise sector to allow for more accurate representation of long-term trends; data have not been included for the private non-profit sector due to the low number of such personnel in this sector.

A downturn in R&D personnel in the business sector can be observed following the 2008 financial crisis—this reduced level of R&D personnel persisted until about 2017. No such downturn is yet evident following the COVID-19 pandemic. Notably, the increase in business sector R&D personnel that began around 2017 coincides with the increase in BERD intensity observed at the same time (Figure 3.3).

A handful of industries employ most business sector R&D personnel in Canada

The largest employer of R&D personnel is the professional, scientific, and technical services industry, which accounted for over 42% of all business sector R&D personnel in Canada in 2022, increasing by 72% between 2014 and 2022.

The manufacturing industry was the second-largest employer of business sector R&D personnel in 2022 (a share of 24%); however, the total number of R&D personnel employed in that industry declined by about 2% over the same period (StatCan, 2024o). The ICT industry—a customized industry group which includes some sub-industries of both the professional, scientific, and technical services industry and the manufacturing industry—accounts for about 47% of all business sector R&D personnel. This industry increased the number of R&D personnel that it employs by 82% between 2014 and 2022.

3.4 Research infrastructure[13]

R&D can be an expensive and resource-intensive process, necessitating the creation and sharing of infrastructure. Research infrastructure includes fixed-site facilities such as laboratories, particle accelerators, museums and their collections, mobile assets such as Arctic research icebreakers, and distributed and digital research infrastructure such as computing and communication networks. The management of research infrastructure in Canada is complicated and features an often-overlapping network of owners, funders, and users (Halliwell, 2025). A review by Canada's Chief Science Advisor revealed "considerable complexity and heterogeneity in the government's approach" to the support of national research infrastructure, with no formal coordination among the multiple organizations that fund and operate the facilities (GC, 2020). This complexity is challenging to manage strategically, which can limit the productivity and innovation of Canadian researchers and complicates attempts to assess the existing ecosystem.

There is no national strategy for research infrastructure in Canada, nor any systematic process across the entire ecosystem for its planning, development, and support. Research infrastructure investments in Canada have typically been planned and developed as largely independent, time-limited projects, rather than through a comprehensive portfolio or lifecycle approach. Nor has there been an explicit commitment from the federal government to invest in a broader strategic approach for managing a national research infrastructure portfolio, although the current effort to develop a Major Research Facility (MRF) Framework is a move in that direction.

While this section focuses primarily on physical research infrastructure funded by the Canada Foundation for Innovation (CFI), significant investment has been made in soft infrastructure, which includes digital research infrastructure, and the data and systems required to make broad access available. Additionally,

13 A separate CCA expert panel is conducting an assessment on the state of Canada's national research infrastructure (CCA, 2024a).

international scorecards like the *Global Innovation Index* published by the World Intellectual Property Organization (WIPO) identify other types of infrastructure related to innovation capacity, such as ICT use and access (e.g., percentage of population covered by mobile networks, households with internet access, broadband internet traffic) (WIPO, 2024).

In Canada, CANARIE's Research Software Program, launched in 2007, and a related research data management program initiated in 2018 together fund research software tools that streamline access to digital infrastructure and allow researchers to focus on their work rather than on the underlying technology (RS Working Group, 2023). Likewise, the Digital Research Alliance of Canada serves researchers in Canada "by integrating and funding the infrastructure and activities required for advanced research computing, research data management, and research software" (The Alliance, n.d.). More than 20 federal departments and agencies house research facilities or sites (including, for example, experimental farms) that support the delivery of government priorities and departmental mandates (Halliwell, 2025). The NRC in particular has responsibility for much research infrastructure, including the management of astronomical observatories established by the federal government. NRC assets range from large to small scale, are sited across Canada, and include both digital and physical infrastructure. These infrastructures facilitate extensive partnerships with academic, private sector, and Indigenous partners. Canada also participates in several large-scale international research infrastructure projects through joint ownership, funding, or governance arrangements, such as the Square Kilometre Array, the Canada-France-Hawaii Telescope, and the James Webb Space Telescope. More details on Canada's research infrastructure ecosystem—including digital research infrastructure, as well as challenges and approaches for mitigating challenges—are presented in a commissioned research paper (Halliwell, 2025).

3.4.1 CFI-funded infrastructure

CFI is the primary funding agency that invests in academic research infrastructure in Canada. Since 1998, it has funded over 13,000 projects valued at over $9 billion. CFI-eligible institutions include post-secondary institutions, research hospitals, and non-profit organizations. The CFI funding model relies on third-party contribution agreements and typically provides 40% of a project's funding; the remaining 60% of the cost is covered by partners, in particular by provincial/territorial governments, but also post-secondary institutions, businesses, and charities (CCA, 2018a). CFI also offers an Infrastructure Operating Fund to support the operation and staffing of research infrastructure (CFI, n.d.). Natural sciences, engineering, and technology, together with medical, health, and life sciences, account for the greatest number of CFI awards each year, with natural sciences receiving far more awards than the rest. By location, roughly half of all CFI-funded research facilities are in Ontario (51%), followed by Quebec (19%) and British Columbia (13%). The Prairie provinces account for approximately 10% of all CFI-funded facilities, and the Atlantic provinces account for about 7% (CFI, 2024).

Among the most prominent CFI-funded research infrastructures are its 19 Major Scientific Initiatives (MSIs), which are intended to be "research facilities of national importance" (CFI, 2023). In 2024, six of CFI's MSIs were selected to be designated as MRFs to better address the unique challenges and funding needs of national-scale facilities. While the MRF Framework is not publicly available, it has been described as a more strategic, portfolio-based approach that takes into account Canada's scientific priorities and strategies, as well as providing funding across the full lifecycle of the infrastructure.

In a survey of users of CFI infrastructure, a high proportion (88%) of highly specialized research equipment was considered by respondents to be state-of-the-art, with an anticipated average lifespan of 8.3 years before needing renewal (Figure 3.12). Computing hardware and software were determined to have the shortest remaining lifespan of 4.8 years, but were considered either "state-of-the-art" or "useful" at the time of the survey. Buildings comprise the largest proportion of infrastructure that is characterized as "obsolete" (7%), according to survey respondents.

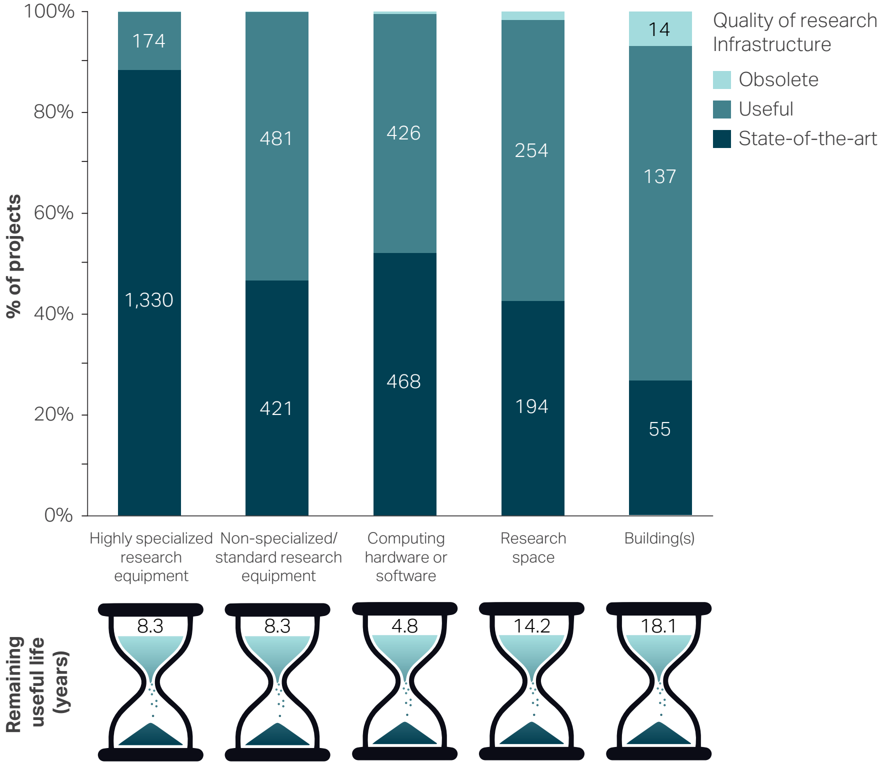


Figure 3.12 The state of CFI-funded infrastructure

Survey results from researchers leading CFI-funded projects on the quality and expected lifespan of equipment, software, space, and buildings associated with research infrastructure.

3.4.2 Technology access centres

Technology access centres (TACs) and Collegiate Centres for Technology Transfer[14] (CCTTs) are applied research, training, and innovation centres affiliated with Canadian colleges, institutes, or CÉGEPs. Funded primarily by NSERC, with additional support from CFI and provincial/territorial governments, TACs provide specialized infrastructure to support business innovation,

14 CCTTs are applied research centres based in Quebec's CÉGEPs and operate within the Réseau Trans-tech network through Synchronex (CÉPRCQ, n.d.). In contrast, TACs are specialized applied R&D centres located in colleges and CÉGEPs across Canada, supported through the national Technology Access Centre grant program.

particularly for SMEs, with the industry partner retaining IP developed through this partnership. They aim to integrate research infrastructure, industry needs, and student training.

There are 67 TACs across Canada, equipped in total with $477 million in specialized facilities (Tech-Access Canada, 2022). In 2022, they collaborated with over 5,000 clients and partners—81% of which were SMEs (Méthot *et al.*, 2022). TACs employ more than 2,000 innovation specialists and offer paid work placements to more than 2,300 post-secondary students, primarily from colleges. Likewise, TACs generated $58 million in applied research revenue, with more than half coming from private sector contributions. This funding represents a fourfold return on the $14 million in base funding from NSERC.

4

Industrial R&D

Chapter findings

- Canada's industrial R&D strengths, both domestically and relative to other countries, are in industries such as science and engineering research, ICT services and telecommunications, and publishing and broadcasting. Compared with other countries, Canadian businesses have lower R&D expenditures in several manufacturing industries that are domestic strengths.
- Canada has a much smaller share of R&D performed in large enterprises and a much larger share performed in SMEs compared with other countries. R&D expenditures in Canadian SMEs have noticeably increased in recent years relative to larger firms.
- Foreign multinational firms account for 35–44% of Canada's BERD and are increasing their R&D expenditures in Canada at a faster rate than domestic firms.

Industrial R&D is key to driving innovation (Pegkas *et al.*, 2019). Expenditures on industrial R&D are positively correlated with increased productivity (OECD/APO, 2022), although both innovation and productivity can be increased without R&D (e.g., through technology adoption and use). As noted in Chapter 3, Canada has a relatively low BERD intensity compared to the OECD average. This not only reduces Canada's economic competitiveness, but moreover, there is evidence that the impact of public R&D expenditures on productivity is greater when industrial R&D intensity is higher (OECD/APO, 2022). Thus, Canada's low BERD may limit the impact of its above-average HERD (and its below-average GOVERD).

The relative magnitude, intensity, and growth of BERD in different industries can be studied to identify strengths and weaknesses in Canada's industrial R&D ecosystem, and to identify the characteristics of firms that perform R&D in Canada. Of course, expenditures are only a proxy indicator for areas of R&D strength, since differences in R&D expenditures across industries are determined by a variety of factors, including differences in the cost of R&D; for example, it is much less expensive to develop a new software app than a new high-precision medical device.

4.1 Industrial R&D trends

Over the past two decades, Canada's R&D focus has shifted away from manufacturing and toward services

Historically, Canada's industrial R&D was concentrated in the manufacturing sector, which accounted for nearly 70% of all BERD in Canada in 2000. However, by 2024, it accounted for less than 24%. By contrast, service-producing industries (i.e., companies that primarily earn revenue by providing intangible products and services) accounted for approximately 28% of all BERD in Canada in 2000 but grew to account for nearly 70% by 2024.[15] Adjusted for inflation, expenditures on R&D in the manufacturing industry declined by 46% between 2000 and 2024, while R&D expenditures in the services industry increased by 291% (StatCan, 2017a, 2024p). Services-producing industries also accounted for the largest number and share of R&D-performing firms in Canada in 2022, along with the largest number and share of R&D personnel (Table 4.1).

As in many other countries, the decline in manufacturing and increase in services reflect the ongoing deindustrialization of Canada over the past several decades (RBC, 2024), as well as the decline of several notable R&D-intensive Canadian manufacturing companies such as Nortel, RIM/BlackBerry, and Bombardier (Section 4.2.5). Although the shift from manufacturing to services is also apparent in the United States, the magnitude is much smaller. In 2011, manufacturing accounted for nearly 70% of all U.S. BERD (the highest share since 2000), dropping to 54% in 2021. Over the same period, services increased from 29% to 44% of U.S. BERD (OECD, 2025b). In the panel's view, the steep decline in Canadian manufacturing may point to a growing weakness in Canada's industrial R&D ecosystem due to a lack of investment in high-technology manufacturing and a lack of large firms characteristic of a modern manufacturing sector. Nevertheless, there are potential opportunities for Canada to strengthen its manufacturing sector, which warrants further research.

15 Due to changes in how Statistics Canada has measured BERD since 2014 (StatCan, 2020b), results from before and after 2014 are not directly comparable. However, these methodological changes do not undermine the general trend of Canada's BERD significantly decreasing in manufacturing while also increasing in services.

The ICT sector—represented here by a customized grouping of ICT industries from the manufacturing and services sectors[16]—accounted for a very high share (45%) of all industrial R&D expenditures in Canada in 2024. It also has a very high R&D intensity (8%) and accounts for nearly 30% of all R&D-performing firms (Table 4.1). This sector is reflective of a more general shift from manufacturing to services: in 2001, manufacturing accounted for about 70% of R&D expenditures in the ICT sector, while services accounted for 30%; however, by 2024, manufacturing accounted for only 6% and services 94% (StatCan, 2017a, 2024p).

16 Specifically, this grouping includes the following NAICS industries: Computer and peripheral equipment manufacturing [3341], Communications equipment manufacturing [3342], Audio and video equipment manufacturing [3343], Semiconductor and other electronic component manufacturing [3344], Manufacturing and reproducing magnetic and optical media [3346], Computer and communications equipment and supplies merchant wholesalers [4173], Software publishers [5132], Telecommunications [517], Computing infrastructure providers, data processing, web hosting, and related services [518], Web search portals and all other information services [51929], Computer systems design and related services [5415], and Electronic and precision equipment repair and maintenance [8112].

Table 4.1 Business R&D expenditures, firms, and personnel by industry, 2014 and 2022

	R&D expenditures			R&D-performing firms		R&D personnel		
	Magnitude (millions $, adjusted for inflation)	Share of total R&D spending (%)	Intensity of industry revenues (%)	Number	Share (%)	Number	Share (%)	Share of GDP (%)
Services-producing industries	19,573 (11,228)	68.3 (55.4)	3.0 (2.6)	11,098 (10,942)	63.2 (57.8)	153,294 (95,447)	72.5 (62.0)	73.6 (71.5)
Manufacturing	7,024 (6,786)	24.5 (33.5)	1.4 (1.7)	4,856 (6,713)	27.7 (35.4)	50,120 (51,092)	23.7 (33.2)	9.8 (10.7)
Mining, quarrying, and oil and gas extraction	1,242 (1,613)	4.3 (8.0)	0.7 (1.3)	115 (206)	0.7 (1.1)	2,581 (2,671)	1.2 (1.7)	5.0 (5.2)
Utilities	488 (442)	1.7 (2.2)	0.7 (0.8)	47 (37)	0.3 (0.2)	2,334 (1,777)	1.1 (1.2)	2.1 (2.2)
Construction	174 (100)	0.6 (0.5)	0.9 (0.7)	364 (522)	2.1 (2.8)	1,612 (1,594)	0.8 (1.0)	7.6 (8.3)
Agriculture, forestry, fishing and hunting	165 (92)	0.6 (0.5)	2.6 (1.3)	353 (521)	2.0 (2.8)	1,598 (1,427)	0.8 (0.9)	2.0 (1.9)
Total, all industries	**28,667 (20,263)**	**100**	**2.1 (2.0)**	**17,550 (18,941)**	**100**	**211,549 (154,019)**	**100**	**100**
Information and communication technology (ICT)	*12,468 (6,199)*	*43.5 (30.6)*	*7.5 (7.1)*	*5,219 (4,303)*	*29.7 (22.7)*	*98,975 (54,488)*	*46.8 (35.4)*	*5.7 (4.2)*

Data source: StatCan (2024o,p,q,r, 2025h)

In each cell, amounts on top are 2022 spending, amounts below in parentheses are 2014 spending. Green cells indicate an increase between 2014 and 2022, whereas red cells indicate a decrease during the period. Magnitude values are in constant 2020 dollars. The table uses the 2014–2022 period because data for certain categories are not available for either the pre-2014 or post-2022 time periods. The ICT sector is presented in italics and positioned below the total for all industries so as to avoid double-counting, as it is a customized grouping of ICT industries from the manufacturing and services sectors, whose R&D spending is already accounted for in the total for those sectors.

The high-level industry categories in Table 4.1 can obscure more granular trends. For example, the table shows a notable decline in R&D spending and intensity in the mining, quarrying, and oil and gas extraction industries. However, this decline is not evenly distributed across the two industries: R&D expenditures in the mining and quarrying sector increased by 217% between 2014 and 2022 (adjusted for inflation), while decreasing by 41% in the oil and gas sector. Additionally, while R&D intensity in the mining and quarrying sector increased by 0.2%, it decreased by 1% in the oil and gas sector. Similarly, changing R&D expenditures in the manufacturing sector between 2014 and 2022 were driven in part by a substantial decrease in the manufacture of transportation equipment, as well as increases in the manufacture of machinery, computers, electronics, and electrical equipment, while increases in R&D expenditures in the services sector were overwhelmingly driven by the ICT sector (StatCan, 2024p,r).

It is instructive to compare industries' share of R&D spending to their share of Canada's GDP. For instance, in 2022, the manufacturing sector accounted for less than 10% of GDP, but nearly 25% of R&D spending. Similarly, the ICT sector accounted for less than 6% of GDP, but nearly 44% of R&D spending. On the other hand, the construction sector accounted for nearly 8% of GDP, but only 0.6% of R&D spending. These data suggest that Canada's economy is concentrated in less R&D-intensive industries (Section 3.1.2). Furthermore, many of Canada's high-output sectors (e.g., natural resources, construction) are profitable despite their low R&D intensity, which may reduce incentives to invest. These factors contribute to Canada's low BERD intensity relative to other countries.

4.2 Industrial R&D strengths

Canada's current industrial R&D strengths—as determined by the magnitude, intensity, and growth of R&D expenditures—are primarily concentrated in several types of industries:

- Scientific research and development services;
- ICT services and manufacturing;
- Machinery manufacturing and wholesale;
- Pharmaceutical manufacturing and wholesale; and
- Various other manufacturing industries, including aerospace, precision instruments, and motor vehicles.

How these R&D strengths are distributed across specific sub-industries is explored in greater detail below. However, it is important to recognize that there are challenges regarding the interpretation of various established industry classification systems, such as NAICS and the International Standard Industrial

Classification (ISIC), and the assignment of R&D activities to particular industries. In particular, the scientific research and development services and wholesale trade NAICS industries accounted for over 21% of all business R&D in Canada in 2022 (StatCan, 2024p), yet it can be somewhat unclear exactly what type of R&D is being performed by them (Box 4.1). For instance, R&D expenditures in the pharmaceutical sector are divided not only between the manufacturing and wholesale trade industries but also the scientific research and development services industry. This is not a new challenge; it was noted in this series of assessments in both 2013 and 2018 (CCA, 2013a, 2018a).

Box 4.1 Scientific research and development services and wholesale trade

Scientific research and development services [NAICS 5417]: Firms in this industry conduct basic and applied research and experimental development across a wide variety of diverse fields in the natural and social sciences, for the purpose of both creating new knowledge and applying knowledge for innovation (StatCan, 2022c). This industry group likely includes startups and other early-stage, pre-commercial firms that are not distributing any products or services but are engaged in scientifically intense R&D for the purpose of future commercialization (Lonmo, 2007). As such, "the strength of this industry may signal promise in Canada's startups, and its R&D talent and infrastructure more generally" (CCA, 2018a). In 2022, R&D in scientific research and development services was concentrated in the fields of medical biotechnology (23%), electrical, electronic, and communications technology engineering (16%), basic medicine (12%), software engineering and technology (8%), and health sciences (6%) (StatCan, 2024s).

Wholesale trade [NAICS 41]: High R&D expenditures in the wholesale trade sector are likely the result of foreign multinational firms with domestic satellites in Canada that only perform marketing and R&D operations. In cases where manufacturing is performed outside Canada, spending may be assigned to the wholesale trade industry rather than the relevant manufacturing industry (CCA, 2013a). Such entities are known to exist in the wholesale trade industry and are sometimes referred to as "factory-less goods producers" (Fort & Klimek, 2018). In 2022, R&D in wholesale trade was concentrated in the fields of electrical, electronic, and communications technology engineering (35%), software engineering and technology (21%), clinical medicine (11%), and information technology and bioinformatics (10%) (StatCan, 2024s).

In the view of the panel, the relative strength of the scientific R&D services industry in Canada, both domestically and relative to other countries, should be interpreted with caution. This may partly reflect the relative weakness of R&D in more traditional industrial sectors, as well as the lack of large firms in Canada's STI ecosystem.

Canada's industrial R&D spending is concentrated in engineering, ICT, and medicine

R&D expenditures in engineering accounted for over 77% of Canada's BERD in 2022, with nearly 40% accounted for by the field of software engineering and technology (Table 4.2). R&D in medical and health sciences collectively accounted for about 11% of Canada's BERD, while natural sciences, computer sciences, information technology and bioinformatics accounted for 10%, and agricultural sciences 2%.

Table 4.2 Top sub-fields of industrial R&D in Canada, 2022

Field of R&D	Magnitude (millions $)	Share of BERD (%)
Software engineering and technology	11,882	39.1
Electrical engineering, electronic engineering and communications technology	4,847	15.9
Mechanical engineering	3,293	10.8
Medical biotechnology	1,242	4.1
Chemical engineering	1,136	3.7
Materials engineering	898	3.0
Computer sciences	841	2.8
Clinical medicine	807	2.7
Information technology and bioinformatics	708	2.3
Basic medicine	674	2.2
Earth and related environmental sciences	524	1.7
Health sciences	497	1.6
Other engineering and technologies	475	1.6
Environmental engineering	433	1.4
Chemical sciences	365	1.2

Data source: StatCan (2024s)

These 15 fields of R&D collectively account for 94% of Canada's BERD, and no other field accounted for more than 1%. Amounts are in 2022 dollars.

R&D expenditures in software engineering and technology increased by 124% between 2016 and 2022, by 175% in medical biotechnology, and by 201% in Earth and environmental sciences. R&D expenditures in medical and health sciences also increased substantially across all its sub-fields. Data on R&D expenditures in all fields of social sciences and humanities are too variable to draw any conclusions about trends, and collectively accounted for 0.7% of Canada's total BERD in 2022 (StatCan, 2024s).

4.2.1 R&D expenditures by industry

There are 10 industries in Canada with an R&D intensity, magnitude, and CAGR at or above the respective medians for all industries. Four of those ten industries also have an R&D intensity, magnitude, and CAGR above the average for all industries (Table 4.3 and Figure 4.1). Collectively, these 10 industries represent about 54% of Canada's industrial R&D expenditures. Notably, many of these industries are dominated by small firms (fewer than 100 employees) with a high proportion of micro-firms (fewer than 5 employees).

These leading industries include firms specializing in science and engineering research as well as other professional and technical services; various industries in the ICT sector, including software and computer design; industries in the publishing, media, broadcasting, and internet sector; precision instrument manufacturing; wholesalers (pharmaceuticals, machinery, and equipment); and administrative and support, waste management and remediation services.

Table 4.3 Industries with intensity, magnitude, and CAGR above the average and/or median of all industries (2018–2022), and share of small firms (2023)

	R&D expenditures			Firm size	
Industry [NAICS]	**Intensity (%)**	**Magnitude (millions $)**	**CAGR (%)**	**Firms with <100 employees (%)**	**Firms with <5 employees (%)**
Research and development in the physical, engineering and life sciences [54171]	27.0	2,537	9.8	93.9	40.4
Software publishers [5132]	11.8	1,771	8.5	n/a	n/a
Computer systems design and related services [5415]	11.3	4,688	9.7	98.6	79.9
All other information and cultural industries [512, 5131, 516, 519]	8.0	543	15.2	n/a	n/a
Average, all industries	**3.9**	**432**	**6.1**	**98.1***	**59.2***

(continues)

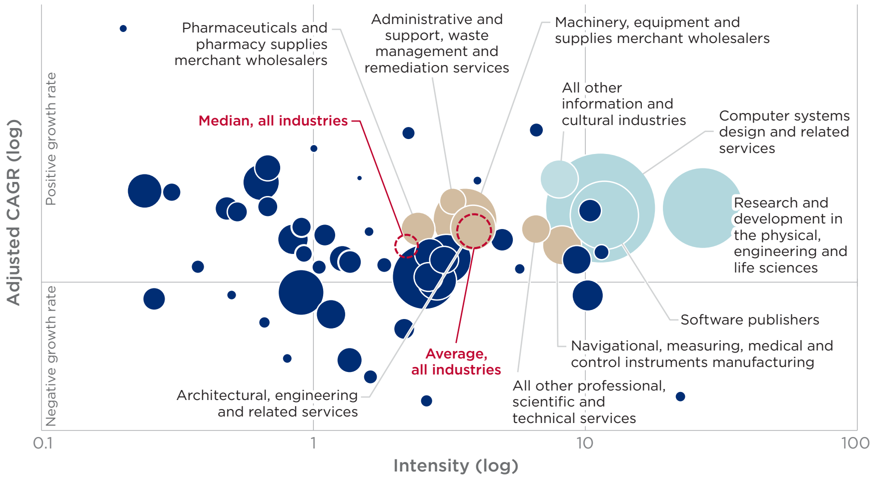
(continued)

Industry [NAICS]	R&D expenditures			Firm size	
	Intensity (%)	Magnitude (millions $)	CAGR (%)	Firms with <100 employees (%)	Firms with <5 employees (%)
Navigational, measuring, medical and control instruments manufacturing [3345]	8.2	545	4.2	90.9	27.0
All other professional, scientific and technical services [5411, 5412, 5414, 5418, 5419]	6.6	300	6.4	99.2	68.7
Architectural, engineering and related services [5413]	3.9	758	6.6	97.8	61.6
Machinery, equipment and supplies merchant wholesalers [417]	3.6	1,560	7.7	97.7	38.1
Administrative and support, waste management and remediation services [56]	3.3	249	10.8	96.8	52.3
Pharmaceuticals and pharmacy supplies merchant wholesalers [41451]	2.4	425	6.4	84.9	28.5
Median, all industries	**2.2**	**193**	**4.2**	**98.1***	**59.2***

Data sources: ISED (2024a); StatCan (2024p,r)

This table lists all industries with an R&D intensity, magnitude, and CAGR at or above the median and/or average values for all industries. Light blue cells correspond to industries whose R&D intensity, magnitude, and CAGR are above both the average *and* median for all industries, whereas beige-coloured cells correspond to industries whose R&D intensity, magnitude, and CAGR are above only the median for all industries (but not the average). Industry names and numeric codes are those used by NAICS. The table uses the most granular NAICS data available, which may vary by industry (e.g., data for some industries are only available in groups of three-digit NAICS codes, while data for other industries are available at a higher level of granularity, such as five-digit NAICS codes). Expenditures are adjusted for inflation using 2020 constant dollars. Data about firm size were not available for any publishing industries [NAICS 513].

*Data about average and median firm size are the total proportion of firms of that size in Canada.



Data source: StatCan (2024p,r)

Figure 4.1 Canada's industrial R&D strengths

This figure identifies fields of industrial R&D strength based on magnitude (bubble size), intensity (x-axis), and CAGR (y-axis). The analysis is based on data from 2018 to 2022. The colouring corresponds to Table 4.3. Light blue bubbles correspond to industries whose R&D intensity, magnitude, and CAGR are above both the average and median for all industries, whereas beige bubbles correspond to industries whose R&D intensity, magnitude, and CAGR are above only the median for all industries, but not the average. The remaining industries are identified in navy for the purpose of comparison. One industry—aerospace product and parts manufacturing [NAICS 3364]—has been excluded from the figure due to its extremely low CAGR (-14.1%), which makes it difficult to visually represent in the plot area.

Expenditures are adjusted for inflation using 2020 constant dollars. CAGR values in this figure are increased by 14.2 percentage points so they can be displayed on a log scale; however, the CAGR numbers are correct in the corresponding Table 4.3. The horizontal line in the figure corresponds to where a CAGR of zero would sit, thereby demarcating industries with positive and negative growth rates.

Beyond these 10 leading industries, there is a wide range of other sectors among the leaders in magnitude, intensity, or growth rate of R&D expenditures (Table 4.4). For instance, the social sciences and humanities is the second-most R&D-intensive industry in Canada, though it has a relatively small magnitude of spending and a negative growth rate. As noted, many of the industries in Canada that lead in the size and intensity of their R&D expenditures are involved in various parts of the ICT sector, including manufacturing, services, and infrastructure.

Despite the decline in manufacturing R&D described above, many manufacturing industries are also among Canada's R&D strengths, including machinery, aerospace, and motor vehicles manufacturing. The pharmaceutical industry is also an R&D strength in both the wholesale trade and manufacturing sectors. Natural resource–based industries are among Canada's leaders in R&D expenditures, albeit in different ways. The oil and gas extraction services industry has a very high level of spending but a very low intensity and negative growth rate. By contrast, R&D expenditures in the forestry industry are relatively low in magnitude and intensity but among the fastest-growing across all industries, as with the mining industry and the fishing, hunting, and trapping industry. The finance industry also exhibits some of the fastest-growing R&D expenditures and a relatively high magnitude of spending, albeit with a very low intensity (Table 4.4).

Table 4.4 Top 10 industries with the highest R&D magnitude, intensity, and CAGR (average 2018–2022)

	R&D expenditures (2022)			Firm size (2023)	
Industry [NAICS] – Highest magnitude	**Magnitude (millions $)**	**Intensity (%)**	**CAGR (%)**	**Firms with <100 employees (%)**	**Firms with <5 employees (%)**
Computer systems design and related services [5415]	**4,688**	**11.3**	9.7	98.6	79.9
Research and development in the physical, engineering and life sciences [54171]	**2,537**	**27.0**	9.8	93.9	40.4
Software publishers [5132]	**1,771**	**11.8**	8.5	n/a	n/a
Telecommunications, computing infrastructure providers, data processing, web hosting and related services [517, 518]	**1,611**	2.6	0.6	95.2	43.5
Machinery, equipment and supplies merchant wholesalers [417]	**1,560**	3.6	7.7	97.7	38.1
Machinery manufacturing [333]	**935**	3.1	2.5	91.9	31.3
Oil and gas extraction, contract drilling and related services [211, 213111, 213118]	**790**	0.9	-1.0	94.4	62.2
Aerospace product and parts manufacturing [3364]	**762**	3.4	-14.1	71.1	23.6
Architectural, engineering and related services [5413]	**758**	3.9	6.6	97.8	61.6
Pharmaceutical and medicine manufacturing [3254]	**573**	2.8	0.2	82.7	31.5
Industry [NAICS] – Highest intensity	**Magnitude**	**Intensity**	**CAGR**	**<100**	**<5**
Research and development in the physical, engineering and life sciences [54171]	**2,537**	**27.0**	9.8	93.9	40.4
Research and development in the social sciences and humanities [54172]	30	**22.3**	-7.8	97.9	45.3
Software publishers [5132]	**1,771**	**11.8**	8.5	n/a	n/a
Computer and peripheral equipment manufacturing [3341]	75	**11.4**	3.3	95.3	46.6
Computer systems design and related services [5415]	**4,688**	**11.3**	9.7	98.6	79.9
Health care and social assistance [62]	191	**10.4**	9.3	97.3	56.4
Communications equipment manufacturing [3342]	353	**10.2**	-1.3	90.5	38.9
Semiconductor and other electronic component manufacturing [3344]	299	**9.3**	2.4	85.6	23.5
Navigational, measuring, medical and control instruments manufacturing [3345]	545	**8.2**	4.2	90.9	27.0
All other information and cultural industries [512, 5131, 516, 519]	543	**8.0**	**15.2**	n/a	n/a

(continues)

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Industry [NAICS] – Highest CAGR	Magnitude	Intensity	CAGR	<100	<5
Natural gas distribution and water, sewage and other systems [2212, 2213]	31	0.2	**70.2**	94.9	37.2
Educational services [61]	61	6.6	**27.2**	92.8	41.8
Management of companies and enterprises [55]	57	2.2	**26.4**	85	35.9
Beverage and tobacco product manufacturing [312]	23	1.0	**22.1**	95.5	25.4
Mining and quarrying, contract drilling and related support activities [212, 213117, 213119]	262	0.7	**17.5**	93.1	44.1
Forestry, logging and support activities for forestry [113, 1153]	8	1.5	**15.3**	98.6	60.8
All other information and cultural industries [512, 5131, 516, 519]	543	**8.0**	**15.2**	n/a	n/a
Fishing, hunting and trapping and aquaculture [114, 1125]	21	4.0	**14.8**	98.2	67.2
Motor vehicle, motor vehicle body and trailer and motor vehicle parts manufacturing [3361-3363]	512	0.6	**14.5**	78.9	30.8
Finance and insurance [52]	446	0.2	**12.8**	97.7	51.6

Data sources: ISED (2024a); StatCan (2024p,r)

This table ranks industries by average magnitude, intensity, and CAGR of R&D expenditures between 2018 and 2022. Values in teal cells indicate top 10 industries in R&D magnitude, intensity, or CAGR. The firm size for industries composed of multiple NAICS codes are the average of those sub-industries. Data about firm size were not available for any publishing industries [NAICS 513].

4.2.2 International comparisons

Canada compares favourably in several industries relative to other G7 countries, as measured by the difference in average intensity and growth of R&D expenditures between 2017 and 2021.[17] Many of these align with Canada's domestic R&D strengths identified above, including scientific R&D, ICT industries (software publishing, ICT services, and telecommunications), and publishing. By contrast, Canada underperforms relative to G7 countries in several manufacturing industries that are among its greatest domestic R&D strengths, including motor vehicles, pharmaceuticals, computers, precision instruments, and machinery (Tables 4.5 and 4.6). This may point to R&D weaknesses in Canada's manufacturing sector.

In natural resource-based industries, Canada's R&D expenditures in mining and quarrying (which includes oil and gas extraction) are growing much faster than the G7 average (1.4% versus -8% CAGR), although its intensity is slightly lower (0.8% versus 1%) (OECD, 2024e, 2025g). By contrast, Canada's agriculture, forestry, and fishing industry is growing much more slowly than the G7 average, while its intensity is roughly comparable (Tables 4.5 and 4.6).

17 Section 5.1.1 uses NAICS to classify industries, whereas the international comparisons in this section are based on the ISIC categorization system.

Table 4.5 Canada's most R&D-intensive industries compared with the G7 average (2017–2021)

Industry	Intensity (%)		CAGR (%)	
	Canada	G7	Canada	G7
Scientific research and development	32.2	10.3	4.1	2.2
Publishing of books, periodicals and other publishing activities	11.9	0.3	22.0	5.4
Software publishing	16.1	8.3	9.7	4.0
Computer programming, consultancy and related activities	10.6	4.4	9.0	3.8
Information service activities	8.5	4.3	13.5	8.5
Manufacture of food products and beverages	1.9	0.8	4.8	1.1
Manufacture of paper and paper products	2.0	1.3	7.2	-0.1
Telecommunications	2.3	2.1	9.8	-5.7
Manufacture of basic metals	2.1	2.2	7.5	-1.4
Manufacture of fabricated metal products, except machinery and equipment	1.7	1.9	-0.7	3.6
Manufacture of electrical equipment	7.3	8.8	6.0	1.3
Manufacture of machinery and equipment n.e.c.	5.0	7.6	-1.1	0.4
Manufacture of rubber and plastics products	2.0	5.2	1.9	-4.1
Manufacture of medical and dental instruments and supplies	5.3	10.2	25.6	3.4
Manufacture of other transport equipment	9.6	15.2	-12.0	-2.0
Manufacture of textiles	2.3	8.2	0.9	-3.4
Manufacture of chemicals and chemical products	2.0	8.1	-6.8	0.6
Manufacture of computer, electronic and optical products	17.5	25.6	2.1	0.7
Manufacture of basic pharmaceutical products and pharmaceutical preparations	9.7	24.0	2.4	2.6
Manufacture of motor vehicles, trailers and semi-trailers	2.5	21.1	17.7	2.2

Data source: OECD (2024e, 2025g)

This table lists the 20 industries in Canada that had the highest average R&D intensity between 2017 and 2021, ranked by the difference between Canada and the G7 average. It also displays the CAGR for those industries. Numbers in green are above the G7 average, and numbers in red are below it. Not all countries have data for all industries over this time period; as a result, the G7 average is skewed.

Industries *not elsewhere classified* are labelled "n.e.c," which refers to manufacturing activities related to machinery and equipment that do not fit into any of the more specific machinery manufacturing categories elsewhere in the ISIC classification.

Table 4.6 Canada's top and bottom industries by difference in CAGR, compared with the G7 average (2017–2021)

	Industry	CAGR (%) Canada	CAGR (%) G7	Intensity (%) Canada	Intensity (%) G7
Top 10 industries	Manufacture of wearing apparel	20.3	-6.0	0.6	1.8
	Manufacture of medical and dental instruments and supplies	25.6	3.4	5.3	10.2
	Accommodation and food service activities	8.8	-9.9	0.02	0.01
	Residential care activities and social work activities without accommodation	2.1	-14.8	0.01	0.03
	Publishing of books, periodicals and other publishing activities	22.0	5.4	11.9	0.3
	Manufacture of motor vehicles, trailers and semi-trailers	17.7	2.2	2.5	21.1
	Telecommunications	9.8	-5.7	2.3	2.1
	Administrative and support service activities	7.3	-6.7	0.2	0.1
	Real estate activities	20.7	8.2	0.01	0.02
	Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities	10.7	-1.6	0.8	0.6
Bottom 10 industries	Manufacture of machinery and equipment n.e.c.	-1.1	0.4	5.0	7.6
	Financial and insurance activities	8.0	9.6	0.3	0.4
	Wholesale and retail trade; repair of motor vehicles and motorcycles	7.0	10.1	1.0	0.4
	Manufacture of leather and related products	-1.8	2.5	0.0	1.8
	Manufacture of fabricated metal products, except machinery and equipment	-0.7	3.7	1.7	1.9
	Manufacture of chemicals and chemical products	-6.8	0.6	2.0	8.1
	Manufacture of other transport equipment	-12.0	-2.0	9.6	15.2
	Agriculture, forestry and fishing	2.0	12.3	0.4	0.3
	Transportation and storage	-6.0	4.7	0.1	0.3
	Manufacture of other non-metallic mineral products	-11.7	0.3	0.5	2.8

Data source: OECD (2024e, 2025g)

Unlike Table 4.5, this table lists the 10 industries where Canada has the biggest lead in CAGR over the G7 average, and the 10 industries in which Canada has the biggest deficit in CAGR compared to the G7 average. The table is ordered by the difference between Canada and the G7 average. It also displays the intensity for those industries. Numbers in green are above the G7 average, while numbers in red are below it.

Industries *not elsewhere classified* are labelled "n.e.c," which refers to manufacturing activities related to machinery and equipment that do not fit into any of the more specific machinery manufacturing categories elsewhere in the ISIC classification.

Canada underperforms in strategically important advanced industries compared with other countries

According to the EU Industrial R&D Investment Scoreboard, among the top 2,500 large or mid-sized R&D-spending firms globally, Canada had an R&D intensity in nine strategically important, advanced, traded industrial sectors that was much lower than the global average and compared with the United States in 2021 (Table 4.7). Moreover, the United States accounted for over 47% of the global share of R&D spending in these nine industrial sectors, while Canada accounted for only 0.5% (Long & Atkinson, 2023). In other words, despite having a population roughly 10 times as large as Canada's, the United States has a share of global R&D in these sectors that is 100 times as large.

Table 4.7 R&D intensity in strategically important advanced sectors, as a multiple of the global average, 2021

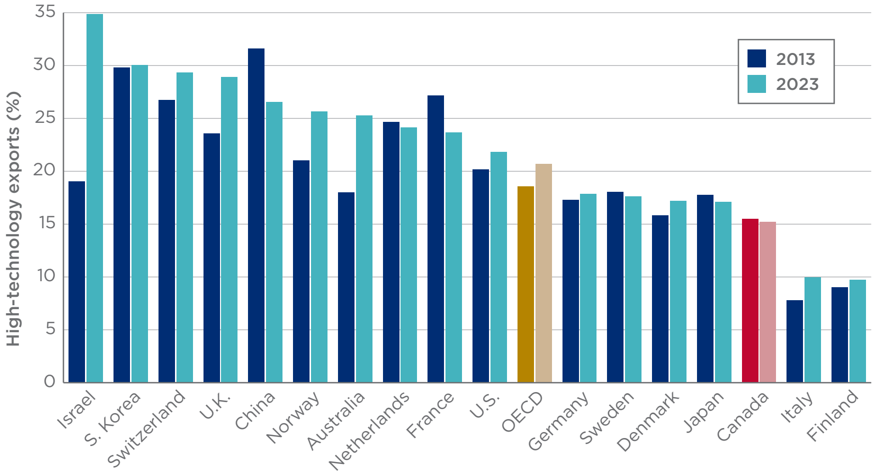
Sector	Australia	Canada	China	Denmark	Finland	France	Germany	Israel	Italy	Japan	Netherlands	Taiwan	U.K.	U.S.
Aerospace & defence		0.45	0.18			4.43	0.17	5.83	1.51		16.04		2.33	1.79
Software & computer services	0.04	0.41	0.73	0.09	0.18	0.35	0.55	1.12		0.31	0.33	0.65	0.36	3.14
Automobiles & parts		0.27	0.57			1.39	7.45	0.32	0.10	4.50	5.19	0.12	0.30	0.67
Pharmaceuticals & biotechnology	0.30	0.18	0.32	4.82	0.17	1.17	1.49	0.79	0.15	1.27	0.68		2.04	2.18
Technology hardware & equipment	0.22	0.09	1.07	0.31	8.18	0.02	0.25	0.93		0.80	3.35	10.82	0.02	2.20
Industrial engineering		0.09	1.59	2.50	6.54	0.55	1.60		0.32	2.38	2.93		0.43	0.84
Electronic & electrical equipment		0.06	1.29	0.24		0.83	1.88	0.34	0.07	3.38	0.44	11.68	0.26	0.50
General industrials			1.07			0.34	1.54	0.71	0.30	4.62	7.35	0.33	0.29	1.13
Alternative energy			0.34	43.70		1.43	13.61							0.47
All advanced sectors	**0.12**	**0.22**	**0.75**	**1.45**	**1.82**	**0.77**	**1.97**	**0.85**	**0.11**	**1.71**	**2.27**	**3.22**	**0.71**	**1.96**

Data sources: EC (2021); Long & Atkinson (2023)

This table shows R&D intensity in nine industrial sectors and for all sectors, as multiples of the global average (e.g., an R&D intensity of more than twice the global average would result in a score of 2.0, while an R&D intensity of half the global average would result in a score of 0.5). See Long & Atkinson (2023) for details of the calculation methodology, and the EU Industrial R&D Investment Scoreboard (2021) for the raw data. Grey cells indicate that no firms from that country and sector were among the top 2,500 global R&D spenders.

4.2.3 Export market share in R&D-intensive industries

Compared with other countries, high-technology exports of manufactured goods comprised a relatively small share (15%) of Canada's total exports in 2023. By contrast, the OECD average was 21% (Figure 4.2).



Data source: WB (2025a)

Figure 4.2 High-technology exports as a percentage of total manufactured exports, 2013 and 2023

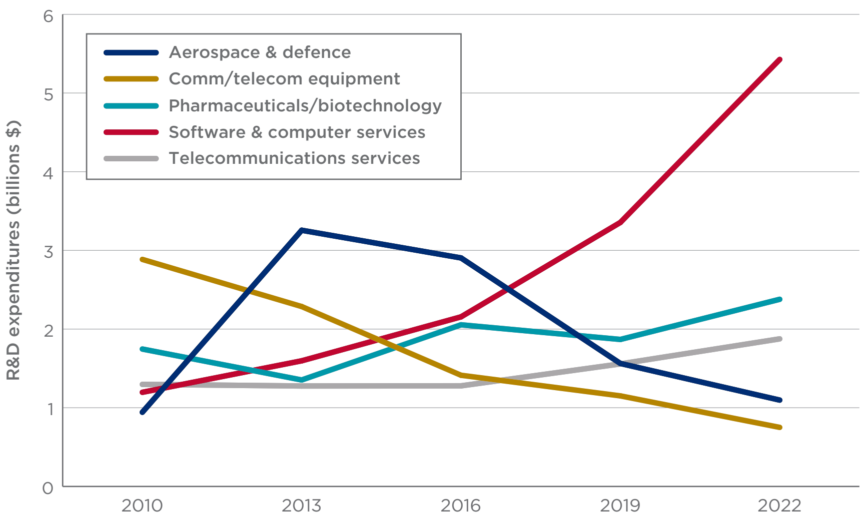
For methodology and definition of high-technology exports, see WB (2025b).

Canada's global export market share in R&D-intensive industries has declined or stagnated

According to OECD metrics, Canada's share of the global export market for aerospace declined from 5.6% in 2000 to 4.0% in 2020; likewise, its share in the global computer, electronic, and optical export market declined from 2.0% in 2000 to 0.4% in 2020. These declines are due in part to the decline of large Canadian firms such as Bombardier, Nortel, and RIM/BlackBerry. In the pharmaceutical industry, Canada's share remained relatively constant, at 1.2% in both 2000 and 2020.

4.2.4 Firm-level analysis

Shifting to a firm-level analysis of R&D expenditures reveals many of the same domestic R&D strengths that were identified earlier in this chapter, including ICT services and manufacturing, pharmaceuticals, and aerospace. Software and computer services became the dominant industry among the top 100 R&D-spending firms in Canada between 2010 and 2022. This was largely due to two companies: Shopify and Constellation Software Inc. There has also been growth in the pharmaceutical and biotechnology industry—due mainly to Bausch Health Companies (formerly Valeant Pharmaceuticals) and Zymeworks—and the telecommunications services industry, which is dominated by the "Big 3:" Telus, Bell, and Rogers. By contrast, R&D expenditures in the aerospace and the communication equipment industries largely decreased due almost entirely to the substantial declines of Bombardier and RIM/BlackBerry, respectively (Figure 4.3 and Table 4.8).



Data source: RE$EARCH Infosource Inc. (2011, 2014, 2017, 2020, 2023)

Figure 4.3 Trends in R&D expenditures among top spending firms in key sectors, 2010–2022

This figure highlights the five sectors that consistently represented the largest share of R&D investment among Canada's top 100 business R&D spenders between 2010 and 2022. For each year, values reflect the total R&D expenditures by firms in the given sector that ranked among the top 100 R&D spenders in Canada in that year. The number of firms contributing to each sector total varies by both sector and year. Amounts are adjusted for inflation (2020 constant dollars).

Although the software and computer services industry accounts for the largest share of R&D spending among the top 100 firms, the pharmaceutical and biotechnology industry consistently had the largest number of firms among the top 100 R&D spenders between 2010 and 2022, which grew considerably over that period. Furthermore, pharmaceutical and biotechnology firms in the top 100 have an average R&D intensity higher than most other industries, which increased substantially between 2010 and 2022.

Table 4.8 identifies the top 20 R&D-spending firms in Canada in 2022, as well as their rank in previous years. It is based on data from RE$EARCH Infosource Inc. (2022), which compiles this list from several sources but, occasionally, eligible companies may be missed. In the panel's view, some large U.S. technology companies that undertake R&D in Canada may be missing from this list. Between 2000 and 2008, Nortel was the top R&D spending firm in Canada, accounting for nearly half (48%) of Canada's total BERD at its peak in 2000 (MacKinnon *et al.*, 2015; StatCan, 2017a). By 2010, it ranked 20th.

Table 4.8 Top 20 R&D-spending firms, 2010–2022

Company	R&D spending, 2022 (millions $)	Rank				
		2022	2019	2016	2013	2010
Shopify Inc.	1,956	1	11	28		
Constellation Software Inc.	1,314	2	3	9	16	25
Magna International Inc.	845	3	1	2	3	5
TELUS Corporation	819	4	8	20	21	16
AMD Canada (fs)	699	5	13	16	14	8
Bausch Health Companies Inc.*	688	6	5	3	20	33
BCE Inc.	644	7	7	5	4	2
Pratt & Whitney Canada Corp. (fs)	641	8	4	6	5	6
Canadian Natural Resources Limited	587	9	10	4	8	
Open Text Corporation	573	10	14	15	19	14
Rogers Communications Inc.	497	11	12	7	7	16
IBM Canada Ltd. (fs)	461	12	9	8	6	3
Ericsson Canada Inc. (fs)	446	13	15	11	10	7
BRP Inc.	368	14	19	19	22	
CGI Group Inc.	322	15	17	13	11	29
Zymeworks Inc.	271	16	23	53		

(continues)

(continued)

Company	R&D spending, 2022 (millions $)	Rank 2022	Rank 2019	Rank 2016	Rank 2013	Rank 2010
BlackBerry Limited**	269	17	16	10	2	1
CAE Inc.	218	18	20	21	23	19
Cisco Canada (fs)	198	19	22	22	29	
Sanofi Canada (fs)	166	20	26	23	24	12
Below is a list of firms that were not among the top 20 R&D spenders of 2022, but were among the top 20 R&D spenders of 2019, 2016, 2013, or 2010, along with their ranking in those years and R&D spending in 2022 (if applicable)						
Bombardier Inc.	135	27	6	1	1	10
GlaxoSmithKline Inc. (fs)	113	30	40	44	25	18
Imperial Oil Limited	74	41	21	18	15	21
Syncrude Canada Ltd.	46	51	32	45	17	30
Suncor Energy Inc.	n/a		2	17		32
Huawei Canada (fs)	n/a		18	25	51	
Pfizer Canada Inc. (fs)	n/a		28	30	33	13
Ontario Power Generation Inc.	n/a		46	34	26	15
Cenovus Energy Inc.	n/a		75	39	13	
Apotex Inc.	n/a			12	12	11
General Motors of Canada Limited (fs)	n/a			14	18	
Atomic Energy of Canada Limited	n/a			40	9	4
Alcatel-Lucent (fs)	n/a					9
Nortel Networks Corporation	n/a					20

Data source: RE$EARCH Infosource Inc. (2011, 2014, 2017, 2020, 2023)

R&D spending amounts are in 2022 dollars. Grey cells indicate that the firm did not appear on the top 100 list in that year.

*Bausch Health Companies Inc. was called Valeant Pharmaceuticals International until 2018.
**BlackBerry Limited was called Research in Motion Limited until 2013.
(fs) = foreign subsidiary (includes R&D spending for Canadian operations only).

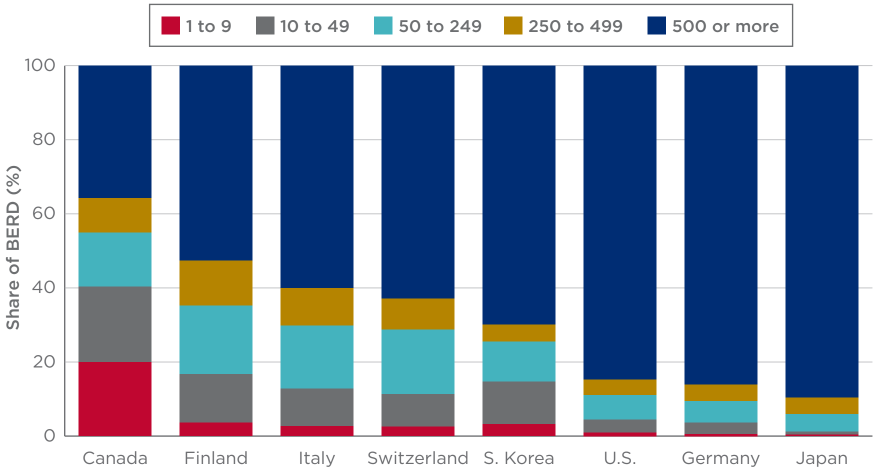
4.3 Industrial R&D expenditures by firm characteristics

While the previous section focused on identifying industries whose R&D expenditures make them potential areas of strength for Canada, this section examines some of the characteristic features of R&D-performing firms in

Canada, such as their size (number of employees), country of control (Canada or foreign), and tendency to outsource R&D to other firms.

4.3.1 Firm size

In Canada, firms with fewer than 250 employees accounted for about 55% of all BERD in 2021; in the United States, these firms accounted for about 11%. By contrast, large enterprises (i.e., greater than 500 employees) accounted for about 36% of BERD in Canada compared with 85% in the United States (Figure 4.4). Yet both countries had roughly the same proportion of large enterprises in 2022 (about 0.3% of all firms), while the United States had a somewhat larger proportion of total employment in large firms (54%, versus 46% in Canada) (ISED, 2024b; StatCan, 2025i; U.S. Census Bureau, 2025).



Data source: OECD (2025h)

Figure 4.4 Share of BERD by firm size (number of employees), 2021

Smaller firms account for a greater share of BERD in Canada than in other countries.

Canada's concentration of R&D in smaller firms, along with its relatively small proportion of R&D spending among larger firms, may have negative impacts on Canada's STI outcomes. Large firms tend to perform more R&D than smaller firms, and a lack of large firms likely contributes to Canada's relatively low BERD intensity (Section 3.1.2). Canada's lack of large firms partially explains its low labour productivity compared with that of the United States (Leung *et al.*, 2008; RBC, 2024). Additionally, larger firms tend to pay employees more and tend to create more jobs compared with smaller firms[18] (Atkinson & Zhang, 2024), have higher rates of innovation and technology adoption (Chapter 8), and create more knowledge spillover benefits from their R&D (Kim & Lester, 2019). Of course, not all industries benefit from firm consolidation or larger firm size. For instance, in some parts of the STI ecosystem, such as the knowledge-intensive services economy, smaller and mid-sized firms play a key role in experimentation and niche innovation (Audretsch *et al.*, 2018; Galli-Debicella, 2021). Thus, Canada's lack of large firms may be more problematic in some industries than others.

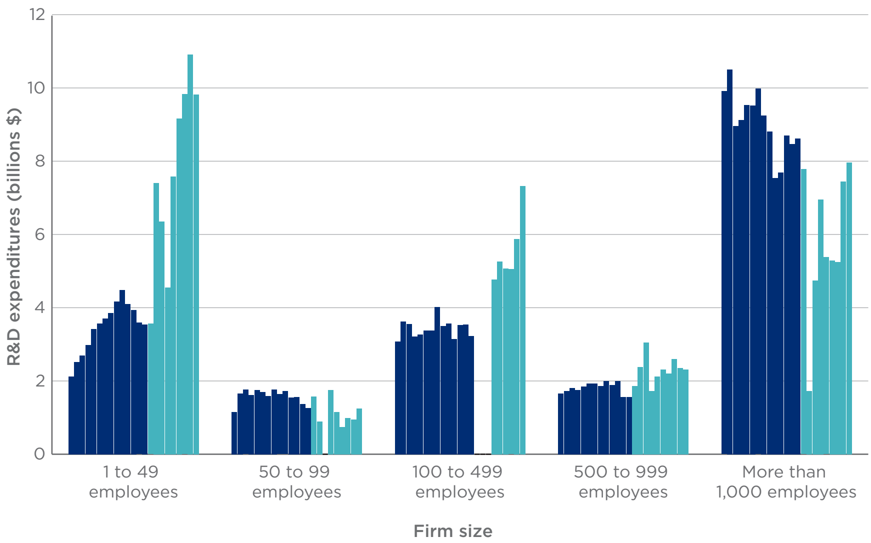
Part of the reason for Canada's relative lack of R&D-heavy large firms may be due to its challenges in scaling up small firms, the loss of promising, scalable firms to foreign competitors, the lack of large, highly productive firms, and challenges in retaining anchor companies (adMare Institute, 2023) (Section 9.3).

R&D expenditures among smaller firms in Canada are increasing

Between 2000 and 2022, R&D expenditures by SMEs increased significantly while decreasing slightly among the largest firms (Figure 4.5). However, these data should be interpreted with caution when comparing the pre-2014 and post-2014 time periods. The post-2014 jump in BERD among small firms and the apparent corresponding drop among large firms—as well as the large year-to-year variations in the post-2014 period—are mainly due to a change in the methodology of Statistics Canada's Annual Survey of Research and Development in Canadian Industry (RDCI) in 2014 (StatCan, 2020b).[19] Nevertheless, the trend of increasing R&D expenditures in small enterprises relative to larger ones is roughly preserved in both periods (2000–2013 and 2014–2022). In the 2014–2022 period, the increase in R&D expenditures among small firms was driven in large part by enterprises with five to nine employees (StatCan, 2024t). There is an additional complicating factor, as the change in methodology in 2014 also happens to coincide with changes to the SR&ED tax incentive program the same year (Section 3.1.3). It is therefore difficult to assess the impact of these changes.

18 Between 2003 and 2023, large firms (>500 employees) were responsible for 52% of all employment growth in Canada, whereas smaller firms (<100 employees) were responsible for 32% (StatCan, 2025i). However, there is also a wealth of evidence that high-growth firms account for a massively disproportionate share of job creation; by some estimates, such firms account for only 4% of all firms but 40% of net new jobs. These firms are more likely to be smaller (Rivard, 2020).

19 Furthermore, BERD among firms with 1 to 49 employees is undercounted for the years 2014, 2015, and 2016, as well as undercounted among firms with over 1,000 employees in 2015. This is because data for certain firm sizes for those years are suppressed by Statistics Canada to meet the confidentiality requirements of the *Statistics Act*.



Data source: StatCan (2017b, 2024t)

Figure 4.5 R&D expenditures by firm size, 2000–2022

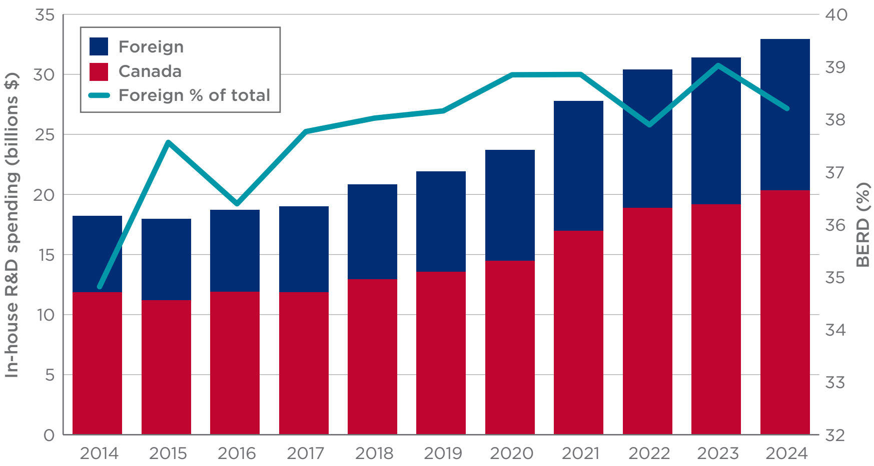
Each column in the figure represents a year from 2000 to 2022, repeated for each firm size. The colouring changes from dark to light blue beginning in the year 2014, which is the first reference year for Statistics Canada's new RDCI survey methodology. Data gaps exist for some firm sizes in some years; these data are not released due to confidentiality requirements.

The factors driving this increase in R&D spending among small firms (defined here as 1 to 49 employees) between 2014 and 2022 are unclear; it is unlikely this is solely due to an overall increase in the *number* of firms of this size, which have increased more slowly than BERD among these firms during this period (StatCan, 2017c, 2023c). Data about R&D expenditures by firm size are not available by industry, so it is not possible to determine which industries may be driving this apparent increase in R&D. The industrial composition of Canada's small firms shifted somewhat between 2014 and 2022; however, it is unclear whether this can explain the increase in R&D expenditures among these firms. It may also be the case that a greater share of small firms were performing R&D in 2022 than in past years, or that average R&D expenditures in existing small firms have simply increased over this time. In the panel's view, another possible explanation for the increase in R&D among small firms is that larger firms in Canada are launching or spinning out smaller startups to which they transfer their R&D activities. Similarly, Vu & Dobbs (2024) attribute the increase to companies outsourcing R&D to smaller firms instead of performing it in-house, as well as changes to the SR&ED tax incentive program in 2014. The panel notes that this is an important area for future research.

By contrast, the factors driving the decrease in R&D expenditures among larger firms are better understood. In particular, the decline of notable Canadian companies such as Nortel, RIM/BlackBerry, and Bombardier have contributed to this decline (Section 4.2.5).

4.3.2 Foreign-controlled and multinational enterprises

The share of BERD that comes from foreign-controlled firms has increased in Canada in recent years, rising from 30% in 2000 to 35% in 2014 to 38% in 2024 (Figure 4.6).



Data source: StatCan (2024p)

Figure 4.6 In-house R&D spending by companies in Canada, 2014–2024

While domestic companies account for the majority of in-house R&D spending, the share of expenditures from foreign-controlled firms is increasing over time.

The proportion of R&D performed by foreign-controlled firms in Canada varies widely by industry and is led (by a wide margin) by the wholesale trade industry, in which nearly 80% of R&D expenditures were by foreign-controlled firms between 2014 and 2024, compared with 42% in the manufacturing industry, which has the second-highest proportion of R&D performed by foreign-controlled firms (StatCan, 2024p). This likely reflects the unique nature of wholesale trade noted in Box 4.1, in which foreign multinational firms outsource R&D and marketing activities (but not manufacturing) to their domestic satellites in Canada.

Multinational enterprises (MNEs) were responsible for the vast majority (76%) of BERD in Canada in 2022, with foreign MNEs accounting for the largest share (44%), followed by Canadian MNEs (32%) and non-multinationals (24%) (StatCan, 2024u).[20] Similarly, about 66% of R&D personnel in Canada worked for an MNE in 2022, with foreign MNEs employing about 38% and Canadian MNEs 28%. Foreign MNEs also significantly outpaced Canadian MNEs and non-MNEs in the growth of R&D expenditures and personnel between 2014 and 2022, overtaking non-MNEs as the largest employer of R&D personnel. In 2022, R&D expenditures by foreign MNEs were concentrated in the professional, scientific, and technical services industry (45%), followed by manufacturing (26%), wholesale trade (19%), information and cultural industries (5%), and mining, quarrying, and oil and gas extraction (2%) (StatCan, 2024u). Box 4.2 further explores the role of foreign MNEs in the Canadian economy.

Box 4.2 Foreign MNEs are a critical part of Canada's innovation landscape

Many MNEs have significant operations in Canada, including in technology and pharmaceuticals. While this creates some risk of IP outflow and potentially fewer economic rewards for innovation, these firms are simultaneously cultivating Canadian talent and providing high-skill employment opportunities. Blit (2018) finds that MNE satellites pull knowledge from foreign headquarters to host countries; intuitively, these effects are particularly pronounced when local satellites employ staff with strong local networks. Studies have also found that domestic firms are more likely to enter and survive in an industry if it includes both foreign MNEs and domestic firms (Landman *et al.*, 2023). MNEs may create new market and export opportunities for domestic firms through market access spillover effects (Crescenzi *et al.*, 2015; Landman *et al.*, 2023).

Foreign MNEs are an important part of domestic STI ecosystems in countries across the world and are often welcomed by host countries. Foreign MNEs can also benefit the STI ecosystem of host countries by

(continues)

20 There is a discrepancy between this data and the data for Figure 4.6 above. According to StatCan Table 36-10-0604-01 (StatCan, 2024u), foreign multinational enterprises accounted for just over $13.3 billion in BERD in 2022. However, according to StatCan Table 27-10-0334-01 (StatCan, 2024p), foreign-controlled enterprises accounted for just under $11.5 billion in BERD in 2022.

(continued)

providing financial benefits (in the form of direct investments, buying from domestic suppliers, employment, and tax revenues), technology transfer, workforce development, and linkages to value chains (Landman *et al.*, 2023; Lenihan *et al.*, 2024). Foreign-controlled firms outsourced over $700 million in R&D spending to Canadian firms in 2022, and over $180 million in R&D to Canadian institutions of higher education (StatCan, 2024v). Furthermore, the presence of MNEs in an industry sector can improve the innovation performance of domestic firms in that sector through infrastructure and knowledge diffusion (Crescenzi *et al.*, 2015). Foreign MNEs may also help develop technology entrepreneurship in Canada (Zhang, 2025) and have been found to outperform domestic firms in terms of good management practices (Bloom *et al.*, 2012).

Foreign MNEs can also have negative impacts on R&D in domestic firms, particularly for SMEs that face challenges related to economies of scale and low market power due to crowding-out effects on market share and availability of HQP, investments, and other resources (Nguyen *et al.*, 2024). SMEs with a low absorptive capacity may face challenges utilizing knowledge and technology spillover from foreign MNEs. However, research suggests that these challenges can be mitigated by contextual features such as high R&D investment, a highly qualified domestic workforce, and exporting activity (Nguyen *et al.*, 2024).

It is unclear how much of the benefit from public funding of R&D performed by foreign-controlled firms in Canada remains within the country, versus being realized elsewhere. Foreign-controlled firms in Canada can access the SR&ED tax credit, although the amount going to such firms is not publicly available (Section 3.1.3). As in other countries, foreign-controlled firms can also participate in publicly co-funded R&D partnerships with Canadian post-secondary institutions, which could result in commercialization and manufacturing occurring outside of Canada. Current geopolitical tensions (Section 2.2) could bring about changes by discouraging foreign investments in Canada and incentivizing relocation to the United States (Shecter, 2025; Walker, 2025). As such, the role of public funding of R&D by foreign-controlled firms in Canada is an important area for future research.

4.3.3 Outsourced business R&D

In addition to performing in-house R&D, businesses also outsource R&D work by hiring organizations to carry out these activities on their behalf. Businesses may outsource R&D to other firms, as well as to institutions of higher education and (less often) government entities. These outsourced R&D performers may be located in Canada or abroad.

Most outsourced business R&D stays in Canada

Business expenditures on outsourced R&D amounted to $5.8 billion in 2022 (StatCan, 2024v), or slightly less than one-fifth as much as expenditures on in-house R&D ($30.4 billion) (StatCan, 2024p). Most of this was Canadian-controlled firms outsourcing R&D to other businesses in Canada, which accounted for about 44% of all outsourced business R&D (approximately $2.6 billion). About 32% of all outsourced BERD went to recipients outside Canada in 2022, with a value of over $1.8 billion. This is down from a high of 41% in 2018. About 8% of outsourced business R&D went to higher education institutions (down from 10% in 2000; Section 3.1.3), 4% went to other organizations and individuals, and 1% went to federal and provincial/territorial governments (StatCan, 2024v).

Many of the same industries that lead in in-house R&D expenditures are also the largest outsourcers of R&D. The ICT sector accounted for 26% of all outsourced business R&D in 2024, while scientific research and development services accounted for 24%, the manufacturing industry accounted for 21%, and wholesale trade 13% (StatCan, 2024v). Between 2014 and 2024, expenditures on both outsourced and in-house R&D increased by about 40%, with wide variations across industries (StatCan, 2024p) (Table 4.9).

Table 4.9 Changes in in-house versus outsourced R&D in select industries, 2014–2024

Industry	Change in outsourced R&D (%)	Change in in-house R&D (%)
Health care and social assistance	366.6	92.9
Finance, insurance and real estate and rental and leasing	229.0	66.1
Utilities	-74.9	27.3
Scientific research and development services	108.8	28.8
Agriculture, forestry, fishing and hunting	133.3	56.5
Mining, quarrying, and oil and gas extraction	15.8	-23.7
Construction	46.9	59.8
Information and communication technology (ICT) sector	103.1	108.8
Manufacturing	-6.0	-0.9
Wholesale trade	58.9	62.3
Total all industries	**39.9**	**40.6**

Data source: StatCan (2024p,v)

This table involves some double-counting of R&D expenditures, insofar as the same expenditures may be counted as both outsourced R&D from the firm outsourcing the work, and in-house R&D from the firm who performs the outsourced work.

5

Financing and Startups/Scale-ups

Chapter findings

- Canada has a strong base of startup companies but struggles to scale them.
- Canada has active startup ecosystems based around larger CMAs like Toronto, Vancouver, and Montréal; however, there are low amounts of financing available to early-stage startups and those looking to scale rapidly, resulting in firms seeking out foreign investors (mainly from the United States).
- Financing has predominantly gone to ICT-based startups, perhaps reflecting a lack of large, stable VC for more capital-intensive industries, resulting in unique pressures for emerging companies.
- Rates of PE exits in Canada increased between 2022 and 2024, though initial public offerings declined with only one recorded during that period.

Startups, scale-ups, and financing are essential components of a healthy and dynamic STI ecosystem. Startups serve as engines of experimentation and disruptive innovation, often commercializing novel research and testing new technologies or business models that larger firms may avoid. As they grow into scale-ups, these companies become key drivers of job creation, productivity gains, and economic growth, while also attracting global investment and talent. Financing, through mechanisms such as VC, angel investment, PE, as well as accelerators and incubators, supports these firms during high-risk early stages, helping them scale and bring their innovations to market. A well-functioning financing system not only provides capital but also validates and signals the potential of emerging ventures, helping them attract partners, customers, and skilled workers. Because of their importance to Canada's STI ecosystem, this iteration of the report provides a high-level analysis of startups, scale-ups, and financing.

5.1 Startups and scale-ups

Canada is generally considered to have a strong base of startups, but has trouble scaling them into large, impactful companies that maintain Canadian ownership and export globally (StartupBlink, 2024), despite its business accelerators and incubators (Box 5.1). In 2022, there were over 1.2 million active enterprises in Canada, two-thirds of which had four employees or fewer; 85,020 enterprises folded in 2021, and nearly 107,000 enterprises were created in 2022 (StatCan, 2024w).

Box 5.1 Business accelerators and incubators

Firms supported by business accelerators and incubators (BAI) are more likely to be younger, located in innovation-focused regions, and concentrated in high-value sectors like professional services and manufacturing (Joshi & Tu, 2024). These firms are twice as likely to engage in R&D and are far more likely to be classified as high-growth businesses. They also offer higher salaries and show steady revenue growth, unlike other firms, which can stagnate. Overall, BAIs target young, R&D-intensive firms that align with national innovation priorities, a critical group of innovation companies.

One example is the Creative Destruction Lab (CDL), which refers to the Schumpeterian concept of new technologies and innovations replacing the old. The CDL is a not-for-profit BAI that has provided mentorship to thousands of startups globally. It was founded in 2012 at the University of Toronto's Rotman School of Management and focuses on supporting early-stage S&T-based companies (personal communication, The CDL, 2025).

There are a variety of reasons why a company might apply to a business incubator or startup program like the CDL. Among the 1,770 Canadian applicants the CDL has had since 2022, nearly three-quarters cite the need to raise money as one of the main reasons to apply, along with sales and marketing help and the development of technology roadmaps. To this end, the CDL has identified the need for funding at specific stages: "Canadian S&T investment has grown, particularly in applied research and commercialization. However, the country still lags behind international peers in late-stage funding and scaling high-tech companies. CDL ventures rely heavily on external funding sources, with many seeking international capital to scale" (personal communication, The CDL, 2025).

The CDL has also identified barriers beyond capital, including challenges bridging science with business for scaling and growth, as well as regional fragmentation. Its proposed solutions include enhanced mentorship, increased mid- to late-stage funding, policy support, ecosystem coordination, and fostering collaboration between startups and industry for commercialization (personal communication, The CDL, 2025).

5.1.1 Employment and revenue scale-ups

While startups can be successful without exhibiting rapid growth, scale-ups tend to spend more on R&D and export more than startups. According to Denney *et al.* (2021), the OECD defines *scale-ups* differently depending on whether one focuses on employment growth or revenue growth. In both cases, companies must have at least 10 employees at the beginning of the growth period (four years prior to measurement). For a company to qualify as an *employment-based scale-up*, it must experience three or more consecutive years of at least 20% year-over-year growth in employment. *Revenue-based scale-ups* must experience three or more consecutive years of at least 20% year-over-year growth in revenue. Companies may fall into one or both OECD scale-up categories, but the way those in either category evolve can be fundamentally different. Additionally, by requiring companies to start with at least 10 employees, these definitions tend to select for firms that have demonstrated a workable business model, excluding very young or unproven startups (Denney *et al.*, 2021).

Employment scale-ups were consistently more common in Canada between 2009 and 2014 while showing similar growth trends as revenue scale-ups. For example, both types of scale-ups experienced declines during the 2008 financial crisis, recovering fully by 2012. However, revenue-based scale-ups tend to show high productivity, which leads to increased revenue; employment-based scale-ups do not necessarily need high productivity to contribute to job growth and may exhibit low or negative productivity (Denney *et al.*, 2021).

5.1.2 Regional and sectoral trends

Scale-ups are not uniformly distributed across the country. In 2016 (growth period occurring between 2013 and 2015), for example, provinces and territories variously measured between 4% and 10%[21] of enterprises achieving OECD employment scale-up status (Denney *et al.*, 2021). This was led by the Prairie provinces up until 2015, when they were surpassed by British Columbia and Ontario. Likewise, there are sector-based differences among employment scale-ups in Canada. Technology, administrative support, and construction were noted as sectoral leaders in terms of the number of companies. These trends share some similarities in startup financing and the priorities of startup incubators, such as the emphasis on ICTs. However, they also differ in that Ontario generally ranks higher in financing and patent-related metrics associated with innovation yet has been surpassed by British Columbia in

21 Percentages refer to the share of enterprises that achieved scale-up status out of enterprises that meet the qualification criteria. For OECD employment scale-ups, this means enterprises with at least 10 employees in the year leading to measurement.

terms of scale-ups. This provides only a partial picture of a critical part of the landscape and represents an area for further investigation.

5.1.3 Unicorn companies

Unicorns are private companies exceeding $1 billion in valuation. These companies are rare and prominent success stories, which makes them of interest when trying to understand a region's STI ecosystem. A quarter of Canada's unicorns work with AI and machine learning, while nearly another quarter are associated with cryptocurrency. Fintech is the third-most-represented field in Table 5.1.

Table 5.1 Canada's unicorns, 2025

Company	Field	VC raised to date (millions $)	Most recent valuation (billions $)
StackAdapt (ON)	AdTech, Marketing Tech, SaaS	39.3	2.5
Hopper (QC)	AI & Machine Learning, Big Data, Mobile	694.6	5.0
Cohere (ON)	AI & Machine Learning, Big Data, SaaS	940.0	5.5
Xanadu (ON)	AI & Machine Learning, CloudTech & DevOps	241.2	1.0
Visier (BC)	AI & Machine Learning, HR Tech, SaaS	219.5	1.0
Ada (ON)	AI & Machine Learning, SaaS	190.2	1.2
Nexii (BC)	CleanTech, Climate Tech, Industrials	102.4	1.6
Axelar (ON)	CloudTech & DevOps, Cryptocurrency/Blockchain	63.8	1.0
Figment (ON)	Cryptocurrency/Blockchain, FinTech	165.0	1.4
Blockstream (QC)	Cryptocurrency/Blockchain, FinTech, Mobile, TMT	600.4	2.5
Dapper Labs (BC)	Cryptocurrency/Blockchain, Gaming	643.4	7.6
LayerZero (BC)	Cryptocurrency/Blockchain, SaaS	263.3	3.0
1Password (ON)	Cybersecurity, SaaS	950.1	6.8
SSENSE (QC)	E-Commerce	0.3	4.1
ApplyBoard (ON)	EdTech	439.7	3.2
Paper (QC)	EdTech, SaaS	390.1	1.8
Wealthsimple (ON)	FinTech	875.6	4.0
Clearco (ON)	FinTech, SaaS	995.0	2.0
FreshBooks (ON)	FinTech, SaaS	213.8	1.0

(continues)

(continued)

Company	Field	VC raised to date (millions $)	Most recent valuation (billions $)
Clio (BC)	Legal Tech, SaaS	1,300.0	3.0
Tailscale (ON)	SaaS	117.3	1.0
Assent Compliance (ON)	SaaS, Supply Chain Tech	569.8	1.0
Trulioo (BC)	SaaS, TMT	490.9	1.8

Data source: Rubio (2025)

Canadian unicorns are largely made up of ICT-related companies, many of which focus on AI, fintech, and cryptocurrency. These private companies differ from the largely MNE-dominant list of top R&D spenders in Table 4.8. “TMT” refers to technology, media, and telecommunications.

5.2 Financing

Angel investment, VC, and PE are three classes of investment that can provide risk capital to innovative companies at various stages of their development (Vipond, n.d.). Typically, angel investors (including family and friends) provide the initial capital when companies launch or while they are still pre-revenue. At the same time, VC investors will support different stages of growth—from seed-stage rounds through Series A, B, C and beyond—often investing with or following on from angels. PE tends to fund mid- or late-stage companies that are already established in the market and revenue-generating. Angel investments and early-stage VC investments are smaller and higher risk. PE investments can vary widely but are typically much larger and can result in changes in ownership. Since the companies are more established, risk/return expectations are generally lower. Although only a small number of young companies meet the growth criteria of VC funding, such funding tends to be concentrated in the high-technology and emerging sectors, fuelling new economic growth. Angel investors and PE firms support both high-growth technology firms and more traditional businesses. While only a limited number of companies attract these types of investments, examining them can indicate areas of innovation and market interest.

5.2.1 Angel investing

Angel investing showed consistent growth in the number of investments between 2015 and 2018. The number of investments declined dramatically in 2019, though the dollar amount remained relatively constant aside from a slight decrease in 2020. Thus, the average size of investments increased. After

2019, the number of investments grew rapidly, returning to a record high in 2021 and falling to 2018 levels in 2022. According to self-reported data, leading investment fields varied considerably by year, with ICTs consistently ranking highest by number of investments from 2017 to 2023 (ranging from 31–48%), and by amount invested in 2018 (26%) and from 2020 to 2023 (39–41%) (Mason, 2023, 2024). Other active areas of investment included services and life sciences.

Angel investing has continued to mature in communities across the country. The number of financing deals that occur in a region can help identify innovation hubs (Table 5.2). In 2022, British Columbia surpassed Quebec with the second-most funds invested after Ontario (northern and southern combined). Northern Ontario also experienced dramatic growth in 2020 that it maintained through 2022.

Table 5.2 Amount of angel investment by region (millions $), 2019–2022

Region	2019	2020	2021	2022
British Columbia	2.1	19.7	37.1	26.0
Prairies	6.4	1.6	6.0	4.3
Southern Ontario	56.6	35.3	77.7	79.5
Northern Ontario	11.8	23.0	26.6	25.5
Quebec	59.4	22.3	85.3	24.9
Atlantic	0.6	1.1	29.4	6.1
Territories			0	
Total	**136.9**	**102.9**	**262.1**	**166.2**

Data source: Mason (2023, 2024)

In general, angel investing saw a large increase in 2021 across Canada, then fell again in most regions in 2022 according to National Angel Capital Organization (NACO) membership surveys. Grey squares indicate data were not collected.

5.2.2 Venture capital

VC is a critical component of the financing and mentorship strategies of many S&T-based startups and emerging companies. Historically, VC has played a major role in financing the development of repeated waves of global innovation: semiconductors in the 1960s, personal computing and biotechnology in the 1980s, internet-based e-commerce in the 1990s, and—after a significant decline in the 2000s—smart mobile communication technologies and cloud computing-enabled businesses in recent years (Lerner & Nanda, 2020). Howell *et al.* (2020) show that, between 1976 and 2017, VC-backed firms were two to four times more likely to file high-impact patents compared to firms that were not VC-backed. Since 2010, the share of VC-backed companies among the top 10 U.S. companies by market cap has increased from two to seven (Strebulaev, 2025). It was not until the 1980s that pension funds and other large asset holders in the United States began deploying their capital in the VC asset class (typically by investing in VC funds) (Lerner & Nanda, 2020). Arguably, this large influx of capital into high-potential, more speculative startups helped accelerate the development and eventual adoption of some of the most influential technologies of the late 20th century.

Successive governments have invested in Canada's VC industry to support high-potential innovative firms (GC, 2013; ISED, 2025a). Canadian VCs invest about half as much as VCs in the United States after adjusting for population, which partly explains why Canadian startups choose to turn to other markets for funding (NVCA, 2024; CVCA, 2025a). Slightly less than half of recent VC investment in Canadian firms is from foreign investors (CVCA, 2025a). On a per-GDP basis, the United States ranks 5th in value of VC investment while Canada ranks 10th (WIPO, 2024). In the panel's view, investment in VC assets (and innovation more broadly) by pension funds may be a critical missing ingredient in Canada's startup and scale-up ecosystem (Section 9.3).

Canada's VC ecosystem has grown considerably over the past 15 years, strongly supported by a series of targeted federal government programs, such as the Venture Capital Catalyst Initiative (Silcoff & Bradshaw, 2024) and the Venture Capital Action Plan (VCAP) (ISED, 2025b). Provincial/territorial initiatives complement these programs, as does active participation by several Crown corporations, such as Export Development Canada (EDC) and Farm Credit Canada (Hannay, 2024). As of 2023, VCAP—a program first announced in 2013—and its successors have invested $390 million in various VC funds and fund-of-funds across Canada, stimulating additional VC spending. In particular, four VCAP fund-of-funds helped engage a variety of investors, including pension funds, wealthy individuals, businesses, banks, and the governments of Ontario and Quebec (ISED, 2025b). Including the initial VCAP investment, the four fund-of-funds raised $1.4 billion, $900 million of which came from private sector investors (ISED, 2023c). Canadian-based sources accounted for 95% of the capital, while 5% was from U.S. and European investors.

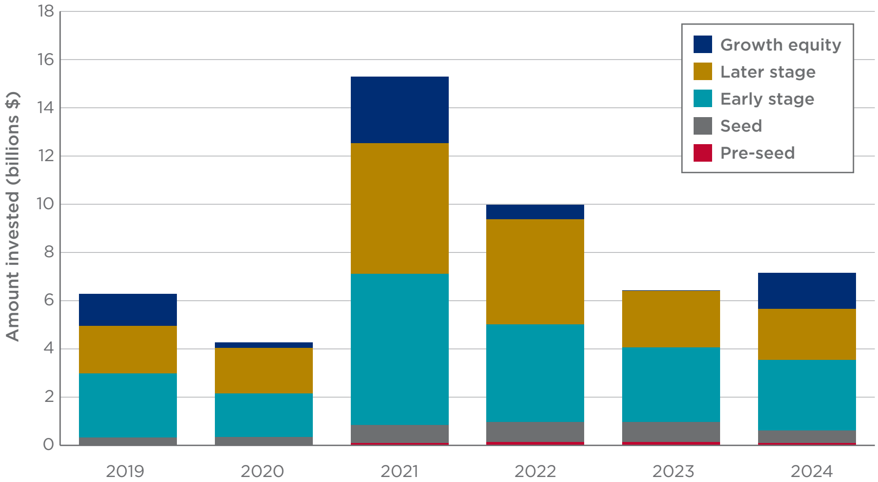
The Business Development Bank of Canada (BDC) also plays a large role in supporting startups through direct and indirect VC financing (BDC Capital, n.d.). For example, it has six direct-support funds with different goals, focusing on seed-stage funding, sustainability, climate tech, women entrepreneurs, industrial innovation, and growth. Combined, these funds make up over $2 billion in financing.

Canada experienced a decrease in VC funding in 2020

A large increase in VC funding occurred in 2021 in Canada, the United States, and globally (Figure 5.1). In Canada, this was preceded by a decline in funding in 2020 that was not as evident elsewhere in the world (CVCA, 2023). However, both Canadian and global levels of VC funding have appeared to stabilize at pre-2020 levels. WIPO found that Canada leads the world in both the number of VC deals received and the number of joint venture/strategic alliance deals from foreign and domestic sources as a percentage of GDP. However, the absolute amount of VC financing available in Canada has been as little as 5% of that of the United States. VC deals in the United States are also substantially larger than those in Canada—the United States routinely raises more than 10 times the amount as Canada with only twice as many deals.

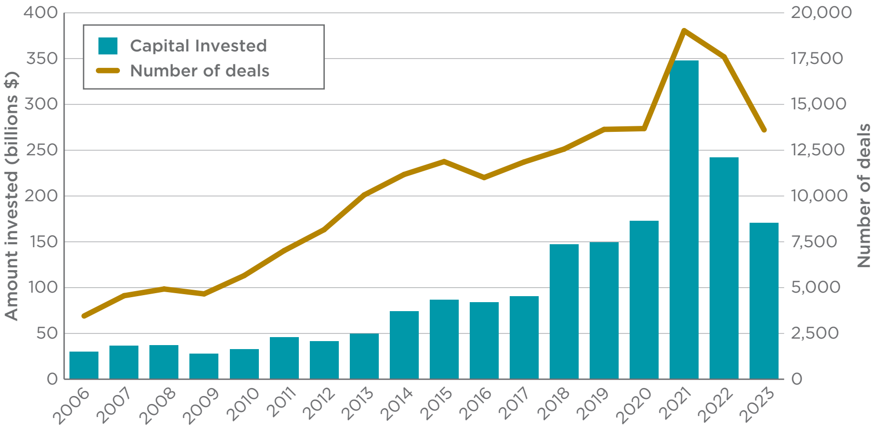
VC funds are typically specialized by investment stage, sector, or geography. These can include public sector funds, private funds (backed by financial institutions, corporations, family offices, or individuals), and corporate funds. Canada has shown significant capital invested in early and later investment stages in recent years (Figure 5.1a), with pre-seed and seed capital comprising only a small fraction of the total capital deployed. However, year over year, these catalytic investments made up a smaller fraction of total investments compared with global and U.S. levels. Likewise, Series C and mega rounds worth over $250 million made up over half of global investments each year compared with a more modest representation of “later stage” and “growth equity” investments in Canada.

(A)



Data source: CVCA (2025a)

(B)

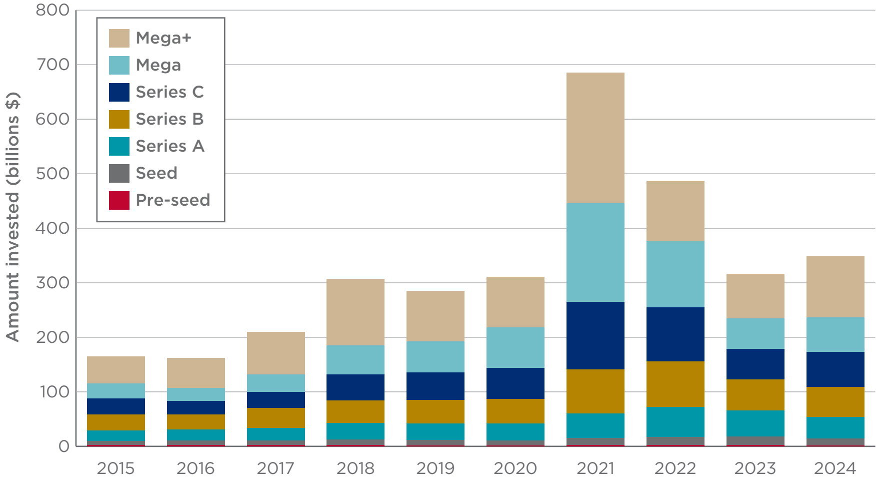


Data source: NVCA (2024)

Figure 5.1 VC investment activity

Panel (A) shows Canadian VC investment activity by stage, 2019–2024. Panel (B) shows VC invested between 2006 and 2023 by U.S. firms. Panel (C) shows global VC investment activity by stage, 2015–2024. VC investments in Canada, the United States, and globally increased dramatically in 2021, followed by a return to pre-2021 levels in subsequent years. Canadian investments were less than 10% of U.S. investment in most years.

(C)



Data source: Dealroom.co (2024)

Figure 5.1 VC investment activity (continued)

Panel (A) shows Canadian VC investment activity by stage, 2019–2024. Panel (B) shows VC invested between 2006 and 2023 by U.S. firms. Panel (C) shows global VC investment activity by stage, 2015–2024. VC investments in Canada, the United States, and globally increased dramatically in 2021, followed by a return to pre-2021 levels in subsequent years. Canadian investments were less than 10% of U.S. investment in most years.

VC funding comes from a variety of domestic investors (Box 5.2), but Canadian firms also receive significant funding from foreign entities, predominantly from the United States (Figure 5.2). Given the limited amount of VC funding available in Canada and the need for high-growth firms to access global markets, emerging companies often actively seek foreign investors, particularly from the United States. However, the panel notes that, as of 2025, uncertainty about the future of trade between Canada and the United States could threaten the availability of this financing.

Box 5.2 Top domestic VC investors, 2024

Canada's VC ecosystem includes a variety of funds from across different sectors, focusing on different stages of the company lifecycle. The most active funds in 2024 by number of deals were two government funds and a private angel group: BDC Capital ($1.2 billion over 76 rounds), EDC ($931 million over 46 rounds), and Golden Triangle Angel Network ($90 million over 43 rounds). The most active pension, retail, corporate, or other public fund was Desjardins Capital Markets ($152 million over 21 rounds), which ranked 7th overall. By magnitude of investment, BDC Capital and EDC ranked first and second again, followed by Nvidia, which provided $903 million in investments over only three rounds.

CVCA (2025a)

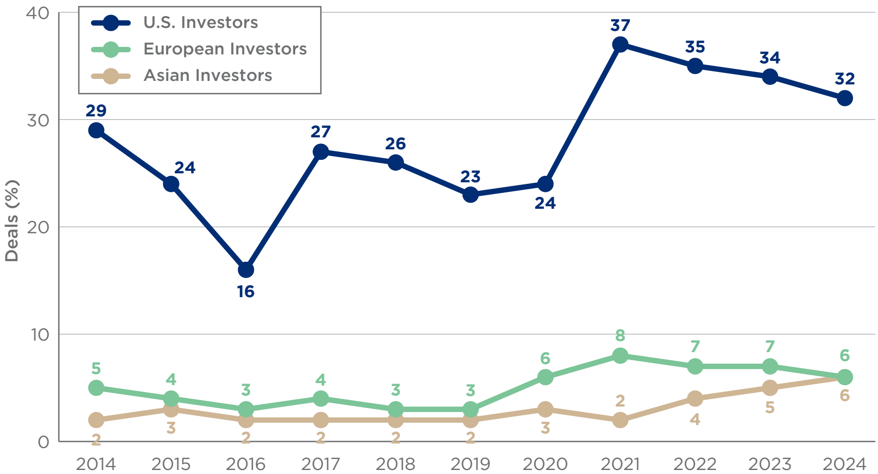


Figure 5.2 Percentage of VC deals with U.S., European, and Asian investors, 2014–2024

A considerable fraction of VC deals were made by U.S. investors between 2014 and 2024, reaching as high as 37% in 2021.

ICTs attract the vast majority of VC deals in Canada

ICT has consistently been the top sector for VC funding in Canada, accounting for over half of all deals since at least 2017 (CVCA, 2025a). Between 2017 and 2021, the CVCA category of life sciences (Box 5.3) ranked second in VC deals, surpassed by clean tech only in 2022 (Figure 5.3). Though the number of agribusiness deals was often comparable to the number of clean tech deals in this period, the amounts invested were generally much smaller. These sectors can be further broken down by type of technology. For instance, between 2015 and 2024, over 60% of ICT investments went to internet software and services, with a smaller amount going to non-internet and mobile software. In life sciences, investments in therapeutic drugs and biologics accounted for anywhere from 60–80% of the total by year, followed by smaller amounts in eHealth and ICTs. Clean tech investments typically focused on recycling and advanced materials, while agribusiness largely went to advanced agriculture and agri-biotechnology in most years (CVCA, 2025a).

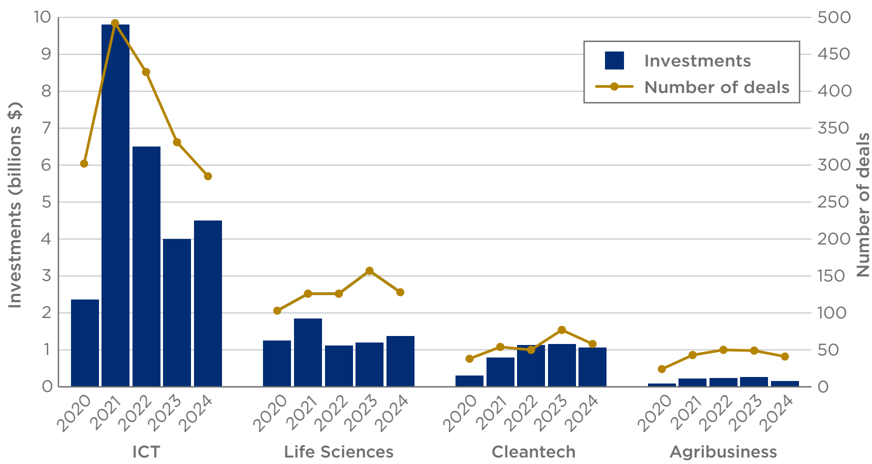


Figure 5.3 VC investment by sector, 2020–2024

ICT firms attract most VC investment in Canada, followed by life sciences, clean tech, and agribusiness firms.

Box 5.3 Life sciences in Canada

Canada's life sciences sector, especially in therapeutics, has seen significant growth. VC investment has surged from $122 million in 2013 to $842 million in 2024, with notable billion-dollar mergers and acquisitions (M&As) and initial public offerings (IPOs) highlighting the sector's global competitiveness. Therapeutics specifically accounted for 42% of companies and 78% of VC deal value during this time. However, Canadian investor participation declines sharply as companies scale, with domestic funds lacking the size and capacity to support later-stage growth. As U.S. investors fill this gap, over 75% of returns from top exits go to international firms—leading to a loss of economic returns and intellectual property control for Canada.

(Azzi *et al.*, 2025)

VC funding varies year over year and by geographic location—large funding rounds can distort the totals raised in certain CMAs. While the distribution of VC across Canada is variable, consolidation is occurring in the top three CMAs. In certain years, companies in Toronto and Montréal attracted more than half of all VC funding in Canada, and Vancouver rounded out the top three, with increasing concentration around these hubs over time (Figure 5.4). This type of urban concentration is also evident in the U.S. innovation hubs like Silicon Valley and Boston.

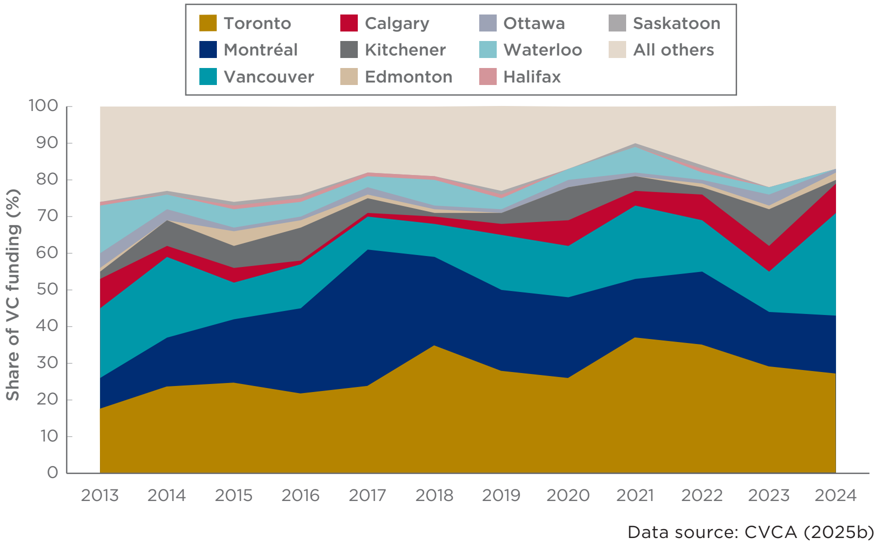


Figure 5.4 Share of VC funding by top CMAs, 2013–2024

VC funding was relatively consistent across CMAs in Canada between 2013 and 2024. Toronto and Montréal swapped the lead position in terms of having the highest share of VC funding.

5.2.3 Private Equity

While VC reflects early-stage innovation capacity, PE signals the ability to scale and consolidate innovative firms. In this sense, PE activity is both a distinct indicator of innovation performance compared with VC investment and a related one.

In 2024, following a weak period, PE investment in Canada experienced a substantial increase, with $27.5 billion over 658 deals (comparable to 2018 levels) (CVCA, 2025c). Privatizations played a major role in 2024, with 14 companies going private, accounting for $15.4 billion or 56% of total PE dollars invested—the highest value on record for privatizations in Canada (CVCA, 2025c). Additionally, eight mega deals (>$500 million) totalling $19 billion took place in 2024, exceeding the combined total of such deals in 2022 and 2023. Despite this increase in large transactions, smaller deals (<$25 million) remained the primary focus, representing 84% of all deals with disclosed values (Figure 5.5). Investments in the ICT sector amassed the most dollars invested in 2024, with $15.3 billion across 117 deals, while investments made in the consumer and retail sector followed with $4.1 billion invested across 59 deals (Figure 5.6).

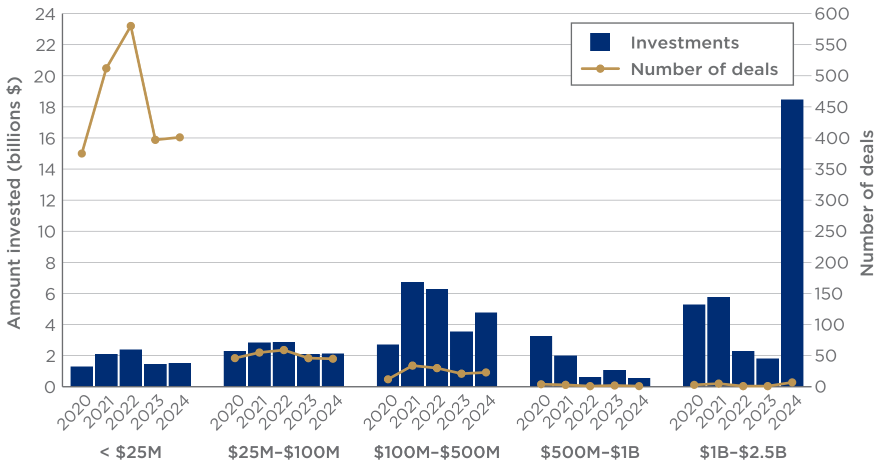


Figure 5.5 PE activity by deal size, 2020–2024

PE funding generally experienced maximums in 2021 or 2022, and generally fell to pre-2021 levels afterwards, except for deals greater than $1 billion, which reached a maximum in 2024.

The panel notes that, as the baby boomer generation of business owners reaches the age of retirement, it is possible that PE will become even more important in sculpting Canada's STI ecosystem. If Canadian investors do not actively participate or are not able to compete with foreign investors (mainly from the United States), many successful businesses could leave the country. Likewise, Canadian ownership may be lost through roll-up strategies[22] that endeavour to defragment various sectors in Canada.

22 For example, VetStrategy, one of Canada's largest networks of veterinary hospitals, is backed by the PE firm Berkshire Partners and National Veterinary Associates, a U.S.-based consolidator with a presence in Canada.

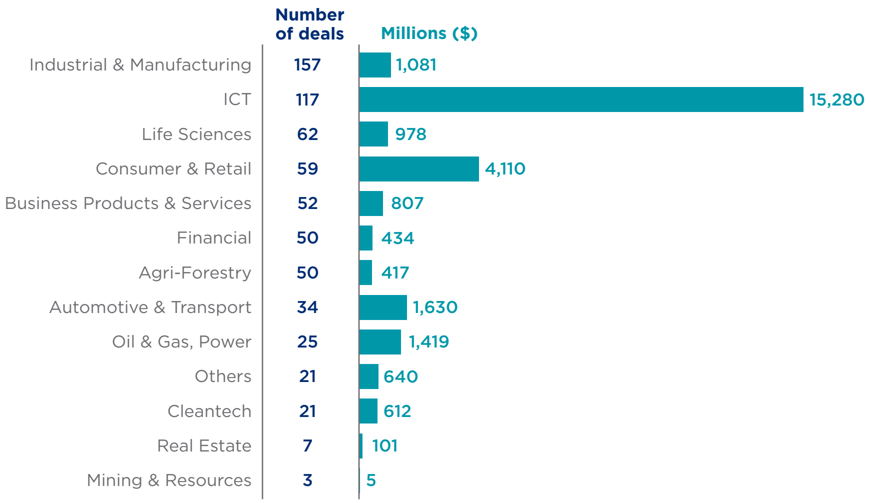


Figure 5.6 PE activity by sector, aggregated between 2020 and 2024

ICT firms received the most PE funding by a wide margin, followed by consumer and retail, automotive and transport, and oil and gas, power.

5.2.4 Mergers and acquisitions and initial public offerings

In 2024, Canadian PE investors realized $6.7 billion across 86 exits (Figure 5.7), continuing a three-year upward trend in exit activity (CVCA, 2025c). However, no IPO exits were recorded in 2024, indicating a persistently weak IPO environment for the third year in a row. Secondary buyouts accounted for $4.7 billion (70.6%), with 22 such deals averaging $213.9 million per exit, well above the overall exit average of $77.5 million. This reflects strong demand for mature, PE-backed firms and signals that firms are holding portfolio companies private longer before exiting.

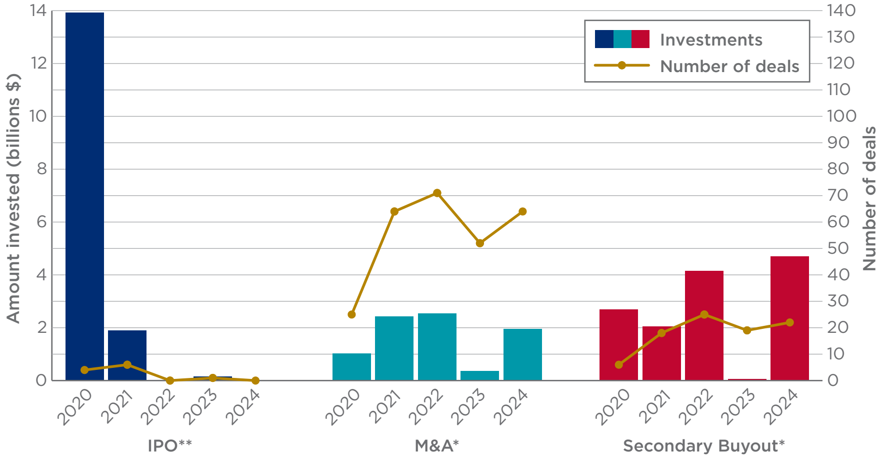


Figure 5.7 IPOs, M&As, and secondary buyouts in Canada, 2020–2024

Number and magnitude of IPOs, M&As and Secondary Buyouts between 2020-2024.

*Includes transactions with undisclosed values

**IPO valuation

In the United States, similar dynamics are playing out. IPO markets have also been sluggish, though there were some signs of recovery in 2024 with high-profile tech IPOs, unlike Canada's complete IPO drought (Guevarra *et al.*, 2025; Kupec, 2025). PE exits in the United States have seen higher volumes and values overall, but the preference for secondary buyouts and delayed IPOs aligns with Canadian trends, reflecting caution, valuation uncertainty, and extended holding periods.

5.3 Data limitations

An analysis of Canada's access to early-stage financing is new to this iteration of the *CCA State of STI in Canada* series and only provides a glimpse of the complicated and interconnected network of startups and investments. However, this report points to several areas that would benefit from additional data and analysis. As previously noted, scale-ups can be defined in different ways, and additional data on their development in different sectors would help inform strategies for effectively supporting these companies. Furthermore, higher resolution and time-series data on growth and financing trends at the CMA and company levels would help clarify the nature of the startup environments across Canada. Future work could explore financing gaps in strategic sectors, as well as possible interventions to alleviate them, consistent with efforts by governments elsewhere.

6

Publications

Chapter findings

- Canada produced 3.6% of the world's research publications by full counting between 2012 and 2023 (ranked 9th, down from 7th in the 2018 CCA assessment) and 2.4% by fractional counting (ranked 11th, down from 9th).
- Canada increased its publication output by 9% between 2012–2017 and 2018–2023 (up from 14th to 12th), but this growth was far surpassed by high-growth countries such as China, India, and Russia.
- Canada maintained its international standing of 6th place for overall research impact, as determined by citations.
- The share of publications that researchers in Canada authored with an international collaborator increased from 44% in the previous assessment to 53%, well above the world average.
- Public health and health services, clinical medicine, and ICTs are three of the most prominent fields of growing strength in Canada in terms of specialization and citation-based impact.

Bibliometric data are often used to measure research outputs (e.g., number of publications, areas of growth, research impact as measured by citations) and to characterize the research environment in terms of various forms of collaboration. Many bibliometrics are measures of research output as a result of research spending (largely by the higher education sector) and other inputs discussed in Chapter 3. They are also important inputs to the wider innovation economy, signalling knowledge generation and talent development. While bibliometric analysis is the standard method of measurement, the panel notes that publications and citations are imperfect indicators with a variety of complications, including methodological and ethical issues (e.g., issues with database curation, citation gaming) (Põder, 2022; The Open University, n.d.). However, as bibliometrics are readily available and relatively simple to aggregate, they are a useful source of data for assessing Canada's research performance and trends.

A bibliometric analysis was commissioned by the CCA and performed by Science-Metrix using the Scopus database. Unless otherwise noted, data and analyses discussed in this chapter are drawn from the Science-Metrix (2024) report, which builds on and extends work done in previous *CCA State of STI in Canada* assessments, and is available on the CCA website.

6.1 Methodology and terminology

Canada's publication output by scientific field can be assessed by considering number of publications, citation-based impact, and growth. These values are compared with global averages as well as with comparable countries, and used to identify fields of high performance and expertise. Collaboration metrics are also derived from author affiliations and are used to quantify international, regional, and sector-based collaborations. The indicators used throughout this chapter are described in Tables 6.1 and 6.7.

Table 6.1 Bibliometric indicators used in this study and Canada's overall rank

Indicator	Description	Canada's rank
Number of publications	Number of publications tracks how many publications an entity produced over a given period and can be presented in whole/full and fractional counts. With **full counting (Full)**, each publication is counted once for each listed author; if a publication is co-authored by two researchers from different countries, the publication will be counted once for each country. **Fractional counting (Frac)** credits each co-author and associated entity with a fraction of a publication, all of which sum to a whole count.	**Full = 9th** **Frac. = 11th**
Specialization Index (**SI**)	**SI** measures the relative research intensity in a specific field. An SI score greater than 1.0 means that a larger fraction of publications were produced in a given field by an entity than by the rest of the world. An SI score below 1.0 means that less research is produced in a field than expected based on the world average.	**Varies by field**
Growth Rate (**GR**) and Growth Index (**GI**)	**GR** corresponds to the percentage change in total publication output between two periods (e.g., 2012–2017 and 2018–2023); a GR score of 1.09, for example, indicates the output increased by 9% between the two periods. **GI** score measures the growth of publications between two periods of time relative to the growth of a reference entity (e.g., the world). For example, if Canada's GR is 1.09 and the world's GR is 1.37, Canada's GI=(1.09/1.37)=0.8, which is below 1.0, meaning that its publication output in that field is growing slower than the world average.	**GR, GI = 12th**
Average Relative Citation (**ARC**)	**ARC** measures the impact of publications produced by a given entity as reflected in citations. An ARC score over 1.0 indicates that the entity's publications are more highly cited than the world average. ARC scores are normalized by publication type, year, and field of research.	**ARC = 6th**
Highly Cited Publications (**HCP10%**)	**HCP10%** counts the percentage of publications an entity has in the top-cited 10% of publications identified within a field for a given period. A value above 10% indicates that the entity has more highly cited publications than expected based on its share of all publications in that field.	**HCP10% = 6th**

6.2 Research productivity: Publishing output and growth

Previous iterations of this report show Canada to be an active and impactful generator of research. Canada continues to demonstrate strength in research-based publishing; however, its production is slipping according to several metrics.

Canada's rank in production of research publications has dropped since the previous report

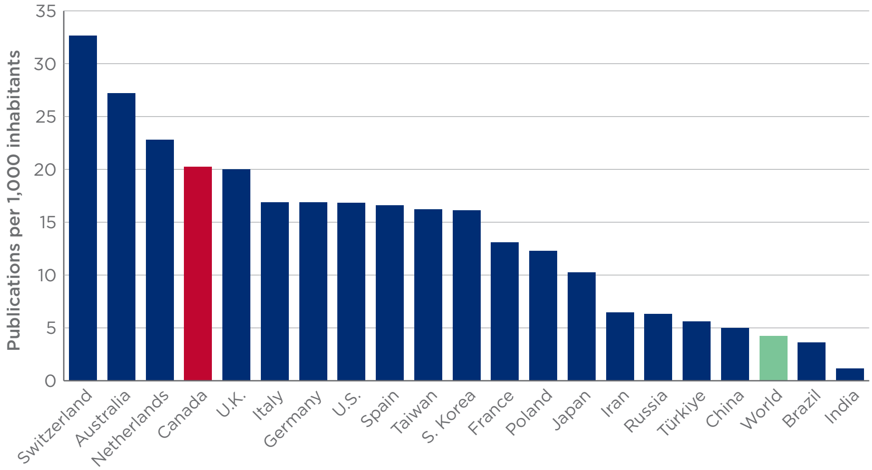
In terms of the number of publications (full counting), Canada was 9th in the world between 2012 and 2023, dropping from 7th in the 2018 report. According to fractional counting for that same period, Canada slipped from 9th to 11th globally, overtaken by Russia and South Korea (Table 6.2). This difference between full and fractional counting highlights Canada's active international collaboration (Section 6.5). While Canada does not have the highest publication output in the world, it does maintain a world-class level of research output per capita (Figure 6.1).

Table 6.2 Research performance of the top publishing countries, 2012–2023

Rank (Frac)	Country	Frac	% of World (Frac)	Full	% of World (Full)	GR (Frac)	ARC	HCP10%
	World	**34,147,501**	**100**	**34,147,501**	**100**	**1.37**	**1.00**	**10.0**
1	China	7,064,285	20.7	7,743,955	22.7	1.91	0.96	10.0
2	United States	5,726,880	16.8	7,259,342	21.3	1.05	1.29	13.7
3	India	1,692,773	5.0	1,897,047	5.6	1.81	0.78	7.1
4	Germany	1,404,636	4.1	2,034,495	6.0	1.07	1.07	10.8
5	United Kingdom	1,369,075	4.0	2,189,647	6.4	1.05	1.30	14.0
6	Japan	1,279,154	3.7	1,537,881	4.5	1.00	0.73	5.9
7	Italy	996,326	2.9	1,365,995	4.0	1.27	1.07	10.8
8	Russia	907,449	2.7	1,050,773	3.1	1.88	0.38	2.1
9	France	894,186	2.6	1,361,072	4.0	0.94	0.96	9.4
10	South Korea	833,106	2.4	999,840	2.9	1.23	0.89	8.1
11	**Canada**	**812,794**	**2.4**	**1,227,990**	**3.6**	**1.09**	**1.17**	**11.8**
12	Spain	802,787	2.4	1,130,522	3.3	1.22	0.95	9.1
13	Brazil	764,250	2.2	919,935	2.7	1.31	0.70	5.4
14	Australia	725,044	2.1	1,115,923	3.3	1.12	1.26	13.4
15	Iran	586,981	1.7	671,012	2.0	1.51	0.88	8.7
16	Türkiye	479,948	1.4	568,450	1.7	1.42	0.72	6.1
17	Poland	450,466	1.3	572,020	1.7	1.27	0.65	4.6
18	Netherlands	418,493	1.2	696,637	2.0	1.06	1.38	15.2
19	Taiwan	379,267	1.1	471,533	1.4	0.95	0.86	7.7
20	Switzerland	290,001	0.8	539,743	1.6	1.09	1.33	14.5

Data source: Science-Metrix (2024)

The top 20 publishing countries by fractional counting. Colour coding indicates performances above (green) or below (red) the world level.



Data source: Science-Metrix (2024)

Figure 6.1 Publications per capita for the top 20 producing countries, 2012–2023

In this figure, the publication output of each country is divided by its population; a higher number signifies more publications per person in a given country. However, this does not account for the number of researchers in each country.

Canada's growth in research output was below the global average, but has increased since the previous report

Among the top 20 publishing countries, Canada ranks 12th in GR and is in a similar position as countries such as the United States, the United Kingdom, the Netherlands, Germany, Switzerland, and Australia, while falling behind China, India, and Russia. Canada's GR is consistent with countries that have historically led in research publishing, while being surpassed by high-growth countries with exceptionally high GR values. Among the top 20 publishing countries, only five have a GI higher than 1.0, meaning that only five exceed the global GR. This is because the high output and growth of China, India, and Russia raise the global GR substantially.

6.2.1 Research impact: Citation metrics

Canada exceeded the global level on all citation metrics, maintaining its ranking (6th) from the 2018 CCA report

ARC is one way to quantify citation-based research impact. Canada ranks 6th, below the Netherlands, Switzerland, the United Kingdom, the United States, and Australia. While high globally, Canada's ARC in fact decreased from 1.20 between 2012 and 2017 to 1.12 between 2018 and 2021. Looking at the top decile of highly cited publications, Canada's HCP10% again ranks 6th with 11.8%, compared with the defined baseline of 10%. These metrics suggest that Canadian publications are quite impactful.

6.2.2 Publications by sector

The academic sector produces more publications in health sciences, applied sciences, and natural sciences, with a smaller fraction of publications in economic and social sciences, and arts and humanities. The government sector, however, produces roughly equal numbers of publications in natural sciences and health sciences, while the private sector largely focuses on natural sciences. As expected, the medical sector overwhelmingly produces health sciences publications. Of all sectors, academic institutions are the only ones that produce a significant number of arts and humanities publications.

6.3 Research by domain and field

By applying the indicators in Table 6.1 to Canada's publications in specific domains and fields, it is possible to determine areas of expertise and specialization; these results are shown in Table 6.3. Domains and fields were determined using a hybrid model that considers the topical classification of journals in which works were published (Box 6.1). Notably, there can be significant delays between a project's initiation and any measurable output, and these delays differ from field to field.

Table 6.3 Canada's research performance by domain and field of research, 2012–2023

Domain/Field	Frac	GR (Frac)	SI	ARC	HCP10%
All domains	**812,794**	**1.09**	**1.00**	**1.17**	**11.8**
Applied sciences	**243,236**	**1.04**	**0.86**	**1.25**	**12.6**
Agriculture, fisheries & forestry	26,201	1.04	1.01	1.24	12.7
Built environment & design	9,223	1.26	1.17	1.06	9.8
Enabling & strategic technologies	59,023	1.07	0.69	1.20	12.5
Engineering	71,931	0.96	0.90	1.22	12.3
Information & communication technologies	76,858	1.08	0.92	1.44	14.0
Arts & humanities	**27,508**	**1.14**	**1.29**	**1.17**	**12.1**
Communication & textual studies	10,803	1.18	1.26	1.23	12.7
Historical studies	7,571	1.10	1.07	1.13	11.9
Philosophy & theology	7,367	1.13	1.56	1.13	11.7
Visual & performing arts	1,767	1.04	1.84	1.10	10.8
Economic & social sciences	**69,533**	**1.16**	**1.31**	**1.03**	**10.2**
Economics & business	24,939	1.25	1.13	1.04	10.4
Social sciences	44,594	1.20	1.44	1.03	10.1
Health sciences	**322,229**	**1.15**	**1.26**	**1.18**	**12.1**
Biomedical research	54,576	1.03	1.12	1.05	10.6
Clinical medicine	191,825	1.16	1.12	1.24	13.0
Psychology & cognitive sciences	30,179	1.15	2.04	1.04	9.8
Public health & health services	45,649	1.31	2.14	1.14	11.5
Natural sciences	**150,288**	**1.01**	**0.76**	**1.12**	**11.1**
Biology	30,194	1.01	1.05	1.16	12.0
Chemistry	29,241	0.98	0.59	1.11	11.1
Earth & environmental sciences	32,138	1.16	1.05	1.05	9.8
Mathematics & statistics	14,908	1.07	0.80	1.11	9.5
Physics & astronomy	43,807	0.93	0.61	1.16	12.1

Data source: Science-Metrix (2024)

Colour coding indicates performance above (green) or below (red) the world level.

6.3.1 Publication counts and growth

Canadian publications are concentrated in health sciences, followed by applied sciences and natural sciences

Canada is most productive in health sciences, followed by applied sciences and natural sciences, distantly followed by economic and social sciences and arts and humanities. However, these results should be interpreted with care. The Scopus database is known to have less coverage of humanities, arts, and social science (HASS) subjects (Mongeon & Paul-Hus, 2016).

Box 6.1 Domain and field classification

For consistency with previous reports in this series, Science-Metrix used a three-level system of classification resulting in 5 domains, 20 fields, and 174 sub-fields (full results are available in Science-Metrix (2024)). This system assigns journals to sub-fields based on Scopus data; while most journals were classified algorithmically, some (e.g., nanotechnology, biotechnology, education, nursing) were manually categorized. The classification was further enhanced by reclassifying papers from multidisciplinary journals at the paper level. For this report, a hybrid model is used: general journals are classified at the paper level.

Alternative classification schemes are also emerging. For example, OpenAlex—a free, open-source catalogue of more than 250 million scholarly works from 250,000 sources—uses a generated classification system that takes into account information about the work, including title, abstract, source (journal) name, and citations (OpenAlex, 2024). The results lead to around 4,500 "topics" (versus 174 sub-fields). Bibliometrics using OpenAlex are explored in a supplemental paper available on the CCA website, which show additional results regarding Canada's expertise in academic publishing at the topical level (on account of the different classification scheme), but converging to comparable results at the domain level (Larivière *et al.*, 2025). Among the results, this analysis shows that Canada demonstrates above-average research activity in health sciences and social sciences, alongside strong performance across a broad range of disciplines including Arctic research. This aligns with the needs of Canada's public healthcare system and aging population, and its excellence in Arctic research reflects its geographic position and the importance of the integration of Indigenous knowledge.

Economic and social sciences, health sciences, and arts and humanities show the largest growth in publication output

While Canada shows significant growth in economic and social sciences, health sciences, and arts and humanities, Canada's GI in these fields is comparable to its all-fields GI and lower than 1.0, signifying slower growth than the global average.[23] Canada's strong output in social sciences and arts and humanities is biased by the fact that Scopus largely indexes English publications, excluding many publications in other languages (Section 6.6).

6.3.2 Citation-based impact and research intensity

Economic and social sciences, arts and humanities, and health sciences show the highest SI with notable highlights in public health and health sciences, psychology and cognitive sciences, and visual and performing arts. Fields with low specialization include chemistry, physics and astronomy, and enabling and strategic technologies. Fields with high SI are where Canada has a proportionally higher output than that of the rest of the world. Canada cannot be specialized in everything, of course; a lack of specialization in one field will be made up for by other fields.

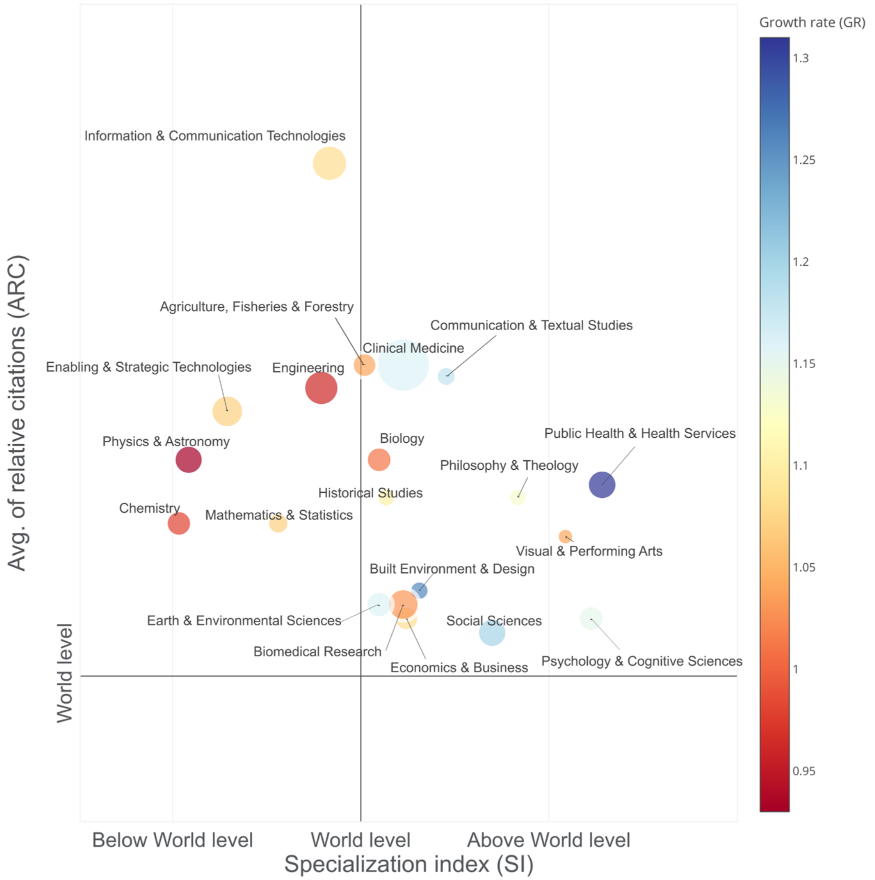
Applied sciences is particularly impactful, with a focus on ICTs and agriculture, fisheries and forestry. Health sciences is the second-most impactful domain, followed by arts and humanities; respectively, these include clinical medicine and communication and textual studies as high-impact fields.

6.3.3 Growing fields of strength

Canadian expertise is growing in public health and health services, clinical medicine, and ICTs

The indicators used above describe the state of Canadian research in a global context between 2012 and 2023; considering these indicators in aggregate, it is possible to illuminate which sub-fields appear to be growing areas of strength. Figure 6.2 shows ARC plotted against SI on an axis normalized by the global values for each field of research described in Table 6.3. The results show that most fields are above the x-axis, signifying the high citation impact of Canadian research in general.

23 Scopus undertook a significant book indexing project in 2015, which increased its coverage of HASS disciplines (Scopus, 2015). It is possible that, for this reason, the GR of the arts and humanities and economic and social sciences disciplines exhibit stronger growth than Canada's average GR. This hypothesis is consistent with these two domains' lower GI values, which compare Canada's GR to that of the world level. This means that GRs for other countries were also high, suggesting systematic growth in these fields globally.



Data source: Science-Metrix (2024)

Figure 6.2 Positional analysis of Canada's fields of research, 2012–2023

ARC is plotted against SI on an axis normalized by the global values for each field of research described in Table 6.3. This divides the figure into four quadrants, defining areas of high and low specialization and impact. GR is included using colour—data plotted in blue represent high growth, while red represents slow or negative growth. The bubble size reflects the total publication output of each field.

Table 6.4 lists 11 sub-fields that show Canada's potential growing areas of strength compared with those of the top 20 publishing countries listed in Table 6.2. To make this comparison, a composite indicator was used. Most of these growing sub-fields are in public health and health services and clinical medicine. Between the periods of 2000–2011 and 2012–2023, Canada decreased in global ranking in 7 of the 11 identified sub-fields, reflecting its below-average growth in nearly all fields and the composite indicator's incorporation of SI as a component of these rankings. In contrast, ornithology increased from 4th to 1st globally, while substance abuse increased from 4th to 2nd, gerontology remains 4th, and ophthalmology and optometry went from 8th to 6th.

Table 6.4 Canada's research performance in 11 growing sub-fields of strength, 2012–2023

Field	Sub-field	Full	GR	SI	ARC	HCP10%	Composite ranking	
							2000–2011	2012–2023
Biology	Ornithology	1,344	0.96	2.38	1.48	17.7	4	1
Public health & health services	Substance abuse	5,440	1.89	2.72	1.07	12.0	4	2
Public health & health services	Gerontology	3,692	1.49	2.42	1.02	8.9	4	4
Clinical medicine	Respiratory system	8,451	1.09	1.52	1.32	14.1	2	4
Clinical medicine	General & internal medicine	26,308	1.48	1.07	1.78	19.7	2	3
Public health & health services	Epidemiology	3,317	1.01	2.05	1.08	10.4	3	5
Clinical medicine	Psychiatry	16,635	1.36	1.85	1.12	11.1	6	7
Clinical medicine	Emergency & critical care medicine	6,149	1.24	1.80	1.23	12.5	5	6
Clinical medicine	Dermatology & venereal diseases	3,808	1.29	0.69	1.30	12.9	7	10
Clinical medicine	Environmental & occupational health	1,248	1.09	1.18	1.29	13.2	5	7
Clinical medicine	Ophthalmology & optometry	4,671	1.26	0.77	1.02	9.0	8	6

Data source: Science-Metrix (2024)

Composite ranking corresponds to Canada's ranking among the top 20 publishing countries, based on Science Metrix's composite index. A full description is available in Science-Metrix (2024). Colour coding indicates performance above (green) or below (red) the world level.

6.3.4 Critical technologies

The Australian Strategic Policy Institute identified 64 critical technologies that can significantly affect a country's economic prosperity, social cohesion, or national security (Gaida *et al.*, 2023). Of these technologies, Table 6.5 identifies those for which Canada ranks among the top eight publishers of highly cited research papers. Of the six identified AI technologies, Canada ranks 7th globally in natural language processing; other technologies include data analytics, adversarial AI, algorithms and hardware accelerators, machine learning, and integrated circuit design and fabrication. By this metric, Canada shows considerable strength and impact in 26 of the 64 identified technologies. This list overlaps significantly with Canada's Sensitive Technology List, which includes topics such as quantum technologies, advanced sensing and surveillance, energy technologies, and AI (GC, n.d.). The same study found that China leads the world in high-impact research publications in 57 of 64 different critical technologies (e.g., machine learning, biological manufacturing), with a high risk of monopolization in 24 of these technologies (Gaida *et al.*, 2023).

Table 6.5 Global ranking for select technologies where Canada ranks in the top 8 of the world

Technologies	HCP10%	Global rank
AI		
Natural language processing	2.7	7
Advanced ICT		
Advanced radiofrequency communication	4.1	6
Advanced undersea wireless communication	2.1	8
Distributed ledgers	2.9	8
Protective cyber security technologies	3.5	7
Advanced materials and manufacturing		
Advanced protection	2.3	7
Coatings	2.1	6
Critical minerals extraction and processing	2.1	7
High-specification machining processes	1.8	7
Biotechnology, gene technologies & vaccines		
Genetic engineering	1.8	8
Vaccines and medical countermeasures	2.8	7

(continues)

(continued)

Technologies	HCP10%	Global rank
Defence, space, robotics & transportation		
Advanced aircraft engines	1.8	7
Autonomous systems operation technologies	3.5	6
Small satellites	3.8	5
Space launch systems	6.4	5
Energy & environment		
Directed energy technologies	2.5	7
Electric batteries	2.0	6
Quantum		
Post-quantum cryptography	2.8	6
Quantum communications	2.7	8
Quantum computing	3.5	6
Sensing, timing & navigation		
Atomic clocks	2.2	8
Inertial navigation systems	3.7	4
Photonic sensors	1.8	8
Satellite positioning and navigation	2.5	8
Sonar and acoustic sensors	2.6	6
Unique AUKUS technologies		
Electronic warfare	2.8	6

Data source: Gaida *et al.* (2023)

HCP10% refers to the percentage of Canada's papers in a given field that rank in the top 10% of highly-cited papers globally.

AUKUS refers to the trilateral security partnership among Australia, the United Kingdom, and the United States.

6.4 Regional and institutional trends

Universities are at the core of Canada's research output, as measured by publications. Government, industry, and colleges also produce peer-reviewed publications, albeit at a much lower rate. For the most part, regional trends closely follow institutional trends. Provincial and territorial data are available in Science-Metrix (2024).

6.4.1 Research performance by institution

Of Canada's top 45 publishing institutions, only 6 are non-academic (NRC, Agriculture and Agri-Food Canada, Natural Resources Canada, Provincial Health Services Authority in British Columbia, Environment and Climate Change Canada, and Fisheries and Oceans Canada). Of the academic institutions (which include their affiliated hospitals and clinics), four produce far more publications than the rest. University of Toronto leads with 12.4% of Canada's total output, followed by University of British Columbia (7.0%), McGill University (5.7%), and University of Alberta (5.6%). By comparison, the top non-university institution by publication count is NRC, ranking 27th with 6,246 publications—just 0.8% of Canada's total output.

Institutions with the highest growth rate are generally not among the top 25 publishing universities

Most Canadian institutions increased publication output between 2012–2017 and 2018–2023; however, only Lakehead University (38th by number of publications) had a GR on par with the global average. After Lakehead, institutions with the highest GR were École de technologie supérieure, Université du Québec à Trois-Rivières, Ontario Tech University, and Brock University, all of which had relatively low initial publication outputs. Within the top 25 institutions by publication count, University of Guelph, Memorial University of Newfoundland, and York University showed the largest growth.

Most top-publishing institutions have output more impactful than the world average; the highest citation-based impact scores correlate strongly with international collaboration

Nearly all of the top 45 publishing institutions in Canada exhibit high citation-based impact scores. University of Toronto leads with the highest ARC score (1.34), while University of British Columbia, University of Waterloo, McMaster University, and École de technologie supérieure all have an ARC score above 1.30. For these institutions, aside from École de technologie supérieure, a high ARC also corresponds to a high international collaboration rate, which is greater than 52%.

6.4.2 Research performance by census metropolitan area

Because research-intensive universities are the main producers of publications, it is not surprising that the top-performing CMAs largely correspond to the location of top-producing universities (Table 6.6). For example, the top three CMAs (Toronto, Montréal, and Vancouver) are home to the institutions that publish the most. However, despite University of British Columbia out-publishing McGill University, Montréal out-publishes Vancouver by a significant margin. This likely reflects Montréal's higher density of research universities compared with Vancouver's. The next most active CMAs are Ottawa–Gatineau and Edmonton. Taken together, these five CMAs account for nearly half of all Canadian publications. CMAs with lower publication outputs generally experience higher growth but lower impact, except for Quebec City, which shows both high growth and impact. Its high GR has enabled it to move from 11th place among top-publishing institutions in 2012 to 8th place in 2023, all while maintaining a relatively high impact. Kitchener–Cambridge–Waterloo is Canada's most impactful CMA (as measured by the citation impact of its publications), followed by Toronto, Vancouver, Calgary, and Montréal, though several others have a publication impact above the world average.

Table 6.6 Research performance of select Canadian CMAs, 2012–2023

Entity	Frac	GR (Frac)	ARC	HCP10%	Private (%)	Govt (%)
World	**34,147,501**	**1.37**	**1.00**	**10.0**	**8.0**	**14.9**
Canada	**812,794**	**1.09**	**1.17**	**11.8**	**9.3**	**16.4**
Toronto	118,644	1.12	1.31	13.7	11.6	15.6
Montréal	108,370	1.04	1.19	12.3	9.7	17.7
Vancouver	64,228	1.04	1.29	13.8	11.4	24.8
Ottawa-Gatineau	50,958	1.11	1.15	11.1	9.8	32.5
Edmonton	44,266	1.10	1.17	11.9	9.1	18.3
Calgary	31,023	1.15	1.20	11.8	12.8	14.4
Kitchener-Cambridge-Waterloo	29,028	1.09	1.32	14.2	9.5	13.1
Winnipeg	19,494	1.08	1.05	10.3	8.8	23.3
Halifax	18,176	1.08	1.08	10.9	7.8	22.8
Quebec City	17,485	1.24	1.12	11.3	9.7	25.1
Saskatoon	15,671	1.09	0.99	8.9	8.8	24.6

Data source: Science-Metrix (2024)

Colour coding indicates performances above (green) or below (red) the world level.

6.5 Collaboration

Researchers in Canada show high rates of international collaboration. In some cases, they may collaborate with entities outside Canada to gain access to expertise or specialized infrastructure. In others, international colleagues may be better positioned to obtain funding or elevate the attention the research receives internationally. Measuring a country's international collaboration can provide a deeper understanding of its approach to research and its relationship with the international research community. In this section, collaborations are measured using the indicators in Table 6.7. The results are aggregated in Table 6.8.

Table 6.7 Collaboration-based bibliometric indicators used in this study

Indicator	Description
International Collaboration Rate (**ICR**)	**ICR** is the percentage of publications on which a country collaborates with a foreign partner, determined by author affiliations.
Probabilistic Affinity Index (**PAI**)	**PAI** measures the relationship strength of two countries while taking into account each country's relative publication output. Values above 1.0 represent stronger relationships, while numbers below 1.0 represent weaker relationships.
(**PAIasym**), Canada Leads/ Participates	**PAIasym** attempts to account for whether an entity leads or participates in a publication by considering who is listed as the corresponding author. Additional methodological details can be found in Science-Metrix (2024).

Slightly more than half of Canada's publications were international collaborations, often with the United States, Iran, China, and Australia

As detailed in previous iterations of this report, researchers in Canada continue to be very active internationally, collaborating on 53.2% of all publications between 2012 and 2023, compared with the world average of 40.2%. This puts Canada in the same range as countries such as Australia, France, Germany, and the United Kingdom, with significantly more collaboration than China, Japan, and the United States. It is worth noting that a high or low collaboration rate is not necessarily good or bad. In some cases, countries with larger populations have lower international collaboration rates because there are more opportunities to collaborate domestically; however, there also appears to be a correlation between citation-based impact indicators and international collaboration. That said, the United States does not follow the latter trend, exhibiting a low collaboration rate and high citation-based impact.

Despite having one of the lower international collaboration rates, the United States remains Canada's most prominent research partner, followed by Iran, China, and Australia, as measured by PAI. However, due to funding cuts to U.S. research, there is concern about the future of Canada–U.S. research partnerships (Buckley, 2025). Global relations also impact collaborative opportunities; for instance, several Chinese and Iranian institutions (85 and 12 out of 103 institutions, respectively) have been identified by the Government of Canada as posing research security risks (ISED, 2023b).

Canada plays a prominent role in leading international research partnerships

Canadian-affiliated researchers tend to lead collaborations among 14 of the 19 countries assessed (according to PAI_{asym}, listed in Table 6.8), except for Brazil, France, Iran, Switzerland, and Türkiye. Of these five, Iran is the only country with which Canadian-affiliated researchers have a particularly high affinity for collaboration, meaning that the other four countries are less frequent collaborators. Collaboration asymmetry was assessed by comparing whether Canada-affiliated researchers were considered the corresponding author on any given publication. If the corresponding author is Canada-affiliated, it was assumed that Canada leads the collaboration.

Canadian research is at the same level of interdisciplinarity as the world average

Interdisciplinary research has the potential to break down barriers between subjects, lead to high-impact discoveries and solutions to complex problems, and stimulate innovation (Brown *et al.*, 2015; Sun *et al.*, 2021; Hu *et al.*, 2024). Between 2012 and 2023, Canada published an average number of interdisciplinary research papers across all subjects compared with the world level, based on both reference lists and author lists.

Table 6.8 Collaboration trends among the world's leading countries in all fields of research, 2012–2023

Rank (Frac)	Country	Frac	% of World output (Frac)	ICR	PAI	PAIasym (Canada leads)	PAIasym (Canada follows)
	World	**34,147,591**	**100**	**40.2**			
1	China	7,064,285	20.7	19.1	1.51	1.19	0.73
2	United States	5,726,880	16.8	36.0	1.95	2.24	1.84
3	India	1,692,773	5.0	20.4	0.83	0.75	0.74
4	Germany	1,404,636	4.1	50.6	0.88	0.70	0.66
5	United Kingdom	1,369,075	4.0	57.6	1.09	0.98	0.91
6	Japan	1,279,154	3.7	28.5	0.93	0.76	0.64
7	Italy	996,326	2.9	46.3	0.79	0.61	0.58
8	Russia	907,449	2.7	23.0	0.60	0.48	0.36
9	France	894,186	2.6	54.9	1.14	1.06	1.11
10	S. Korea	833,106	2.4	29.3	0.78	0.66	0.65
11	**Canada**	**812,794**	**2.4**	**53.2**			
12	Spain	802,787	2.4	48.0	0.73	0.53	0.53
13	Brazil	764,250	2.2	32.0	1.18	1.23	1.41
14	Australia	725,044	2.1	55.7	1.35	1.31	1.23
15	Iran	586,981	1.7	26.7	1.77	1.79	2.18
16	Türkiye	479,948	1.4	24.8	0.64	0.57	0.68
17	Poland	450,466	1.3	33.1	0.64	0.56	0.53
18	Netherlands	418,493	1.2	61.5	0.96	0.81	0.74
19	Taiwan	379,267	1.1	27.7	0.74	1.08	0.58
20	Switzerland	290,001	0.8	68.9	0.92	0.78	0.81

Data source: Science-Metrix (2024)

Colour coding indicates performance above (green) or below (red) the world level, or not calculated (grey).

6.6 Data limitations

As noted above, results in this chapter are based on a bibliometric study of the Scopus database; this allows for a highly informative analysis of academic publishing trends across the world. However, there are limitations. While the Scopus database is vast, it systematically undercounts HASS disciplines and non-English publications. This reflects subject-specific publishing tendencies, since HASS subjects do not publish in peer-reviewed journals to the same extent as the health, applied, and natural sciences, leading to fewer HASS publications being indexed. One way to address some of these shortcomings is to compare results with databases with wider coverage, such as OpenAlex. This was done in a paper commissioned by the panel (Larivière *et al.*, 2025) and found general convergence with the results from Scopus. Additionally, publication trends can also vary considerably among fields of study, making direct comparison across the wide range of topics included in Scopus challenging. It also largely relies on metrics that approximate impact such as citations, which can be discipline-dependent and do not directly probe the usefulness or innovative value of a publication. Finally, impact derived from academic publications can also be found in policy documents, which was not explored in this iteration of the report. However, preliminary results using the Overton database were explored in a CCA-commissioned paper by Claveau *et al.* (2025) which found around 35% of federal policy documents citing scholarly work, with the age of cited research increasing over time.

7

Patents

Chapter findings

- Canada has experienced growth in patenting. While this growth has been slower than the global average, Canada's patents are generally quite impactful, according to citation-based metrics.
- Canada has a dramatic outflow of patents, which could be linked to a variety of causes, including poor domestic absorptive capacity for innovation or the dominance of foreign firms performing R&D.
- Broad fields such as electrical engineering and mechanical engineering account for the largest number of patents in Canada, though patenting in the former is shrinking while growing in the latter. Patenting in instruments has shown some of the highest growth.

Intellectual property rights—such as patents, copyrights, and trade secrets—are tools to support innovation and economic growth (Gallini & Hollis, 2019; Borges, 2025). They provide a stable framework that turns ideas into valuable assets, enabling investment, collaboration, and market participation, especially for small businesses and startups. They also facilitate downstream innovation by promoting knowledge sharing and technical standardization. Patent metrics can be collected to generate insights into a variety of factors related to innovation. Many granted patents can be telling of an active and innovative economy. For startups, patents can be attractive if not necessary assets that investors look for (though evidence suggests that the ownership of patents does not necessarily signal the quality of a technology (Hoenig & Henkel, 2015)). Likewise, the fields in which patents are granted can identify potential areas of expertise in an economy, while the location of invention and ownership can signal particularly active geographical regions. Patents, like research publications, are also citable documents, allowing for the measurement of citation-based impact metrics; however, the panel notes that citations of academic publications and citations of patent documents do not signal the same thing and, in the case of patents, are difficult to interpret (Gambardella *et al.*, 2007). Other metrics that quantify the flow of IP can be developed to understand whether regions are importers or exporters of patents (Box 7.1). For a description of the indicators used in this chapter, see Table 6.1.

Box 7.1 Flow of IP

Typically, when a patent is filed, both the inventor and the assignee or owner are reported. In some cases, these can be the same entity, but, in general, the inventor and assignee are not the same. By comparing the location (usually via affiliation) of the inventor and assignee, it is possible to determine the *flow* of IP—whether an entity *generates* or *collects* more IP. For example, for a country to exhibit a negative IP flow (e.g., Canada), it must own the rights to fewer patented inventions than it produces. Conversely, a positive IP flow means that a country owns more IP than it generates.

Although a negative IP flow indicates that a higher proportion of IP developed in Canada is not retained in Canada, it is not necessarily a problem. For instance, Israel is known as a small but highly innovative country, yet it has the most negative IP flow among the countries measured, suggesting an active export economy for IP. The panel notes that, in the case of Canada, a negative IP flow may signal poor domestic absorptive capacity for innovations (perhaps reflecting the large number of multinational companies performing R&D in Canada), that Canadian firms have foreign subsidiaries where IP is stored for tax purposes, or signal merger and acquisition activity, among other potential explanations. In other words, many reasons could account for Canada's outward flow of IP, pointing to an important area for future work. However, the panel notes that it is to whom a patent is licensed that determines who gets to implement an invention—a metric that is not available in this technometric analysis.

Patent data were collected from PATSTAT and PatentsView, covering patents filed at the USPTO and EPO. Companies will often file patents for the same invention in several markets to better protect their IP; triadic patents—those filed at the USPTO, EPO, and Japan Patent Office—or patent family approaches, are often used for the most promising inventions. EPO data were not included in previous iterations of this report, but expand coverage and understanding of Canada's patenting trends globally. Because Canada predominantly applies for patents at the USPTO (58,496 patents at the USPTO during 2012–2023 compared with 12,931 at the EPO during 2011–2022), the panel uses USPTO results as a baseline, supplemented by EPO results where useful. However, the panel notes that this bias in the choice of market may present Canadian innovation as more dynamic than it might be in terms of global performance. Full results for both offices can be found in Science-Metrix (2024).

The following sections analyze the patenting trends of the top 20 leading countries based on patents granted[24] between 2012 and 2023 by the USPTO and between 2011 and 2022 by the EPO. At the time of analysis, data at the EPO were incomplete for 2023. As for which office most Canada-associated inventors file patents at (with at least 50% of authors residing in Canada), one study found that, between 2001 and 2016, almost three-quarters[25] (73.5%) were at the USPTO, compared with 55.9% in Canada and 24.7% at the EPO (Blit & Earle, 2022). That said, only a small fraction of businesses in Canada own any type of IP, including trademarks, patents, copyrights, and industrial designs (17.5% within Canada and 5% outside of Canada) (GACG, 2024).

7.1 Global patent activity

Table 7.1 shows the global output of patents granted at the USPTO based on the location of assignee.[26]

24 The panel notes that inventor location is another variable that could be investigated further, as assignee location is a more direct metric relating to commercialization while inventor location may provide more insight into knowledge generation related to patents.

25 Patents can be filed at multiple offices; roughly 50% of patents were filed at only one office (Blit & Earle, 2022).

26 Full and fractional counting can be done based on assignee. However, patents are often assigned to single entities (such as businesses rather than lists of co-authors), so full and fractional counting tend to result in similar values; as such, fractional counting is reported throughout this chapter.

Table 7.1 Patents filed at the USPTO by select countries, 2012–2023

Country	Frac	Patents per 1,000 pop.	IP flow	GR	ARC
World	**3,743,285**	**0.46**	**0**	**1.13**	**1.00**
United States	1,861,816	5.47	7	1.13	1.33
Japan	603,239	4.85	1	0.92	0.54
South Korea	237,718	4.60	3	1.28	0.65
Germany	178,051	2.14	-8	1.02	0.63
China	165,211	0.12	-13	2.78	0.59
Taiwan	136,760	5.85	-1	0.96	0.71
France	71,328	1.04	-8	0.94	0.57
Canada	**58,496**	**1.46**	**-28**	**1.05**	**1.00**
United Kingdom	53,408	0.78	-34	1.26	0.90
Switzerland	47,400	5.34	51	1.19	1.23
Netherlands	42,497	2.32	40	1.07	0.97
Sweden	38,450	3.61	15	1.11	0.77
Israel	28,634	3.01	-40	1.38	1.16
Italy	24,106	0.41	-28	1.18	0.59
Singapore	19,166	3.26	63	1.26	0.78

Data source: Science-Metrix (2024)

Colour coding indicates performances above (green) or below (red) the world level.

7.1.1 Patents granted

Canada ranks 8th in patents granted by the USPTO and 13th by the EPO, but its growth is below the world average

According to USPTO data, Canada generates 1.6% of the world's output, ranking 8th, below France and above the United Kingdom. At the EPO, Canada ranks 13th (1.1% of the world output). Canada's GR at the USPTO from 2012 to 2023 fell below the global average, ranking 15th out of 20 countries. That GR puts it in the realm of countries such as Germany and the Netherlands, falling far behind leading countries, such as the United States, South Korea, the United Kingdom, and Israel.

The average GR of *all* countries patenting at the EPO was higher than the average at the USPTO by the end of 2023. This was also true of the GR of nearly every top-20 patenting country at the EPO. Again, China's GR far surpassed that of all other countries; however, it exhibited a relatively modest patent output (7th). Much like its GR at the USPTO, Canada's GR at the EPO fell below the global average, ranking 14th.

Canadian patents have comparatively high citation-based impact but are less impactful than U.S. patents

The ARC score of Canadian patents at the USPTO was on par with the global median. While this measure can be a proxy for impact, the panel notes it is a much better metric describing the *activity* in an industry; citations on patents signify interest in a topic but do not account for the use, sale, licensing, or renewal of patents—all of which could provide a more robust understanding a patent's impact. That said, the top six patent-producing countries (after the United States) all scored significantly below the global average, with only 3 out of 15 countries (Switzerland, Israel, and the United States) exceeding an ARC of 1.0. At the EPO, Canada scores higher on impact, ranking in 7th place. It follows behind the United States, Germany, and Switzerland, and further behind Israel, Denmark, and Austria.

7.2 Patent activity by census metropolitan area

By assessing inventor and assignee address fields, patents can be characterized by their associated city or CMA. Table 7.2 and the following sections show results for the top patenting CMAs in Canada at the USPTO. Additional information about Canada's top 50 cities at both the USPTO and EPO are available in Science-Metrix (2024).

Halifax, Saskatoon, and Montréal showed substantial growth in patenting activity

The top patenting CMAs in Canada are Toronto, Kitchener–Cambridge–Waterloo, Montréal, Vancouver, and Ottawa–Gatineau. These are similarly ranked at the EPO, except for Kitchener–Cambridge–Waterloo, which ranks 1st; this is despite losing a major source of patenting activity (RIM/Blackberry), a loss reflected differently in the GR at the USPTO and EPO.

Table 7.2 Patents filed at the USPTO by select Canadian CMAs, 2012–2023

Region	Frac	IP Flow	GR	ARC
World	**3,743,285**	**0**	**1.13**	**1.00**
Canada	**58,496**	**-28**	**1.05**	**1.00**
Toronto	11,645	-35	1.30	1.03
Kitchener–Cambridge–Waterloo	9,462	47	0.45	0.95
Montréal	6,928	-24	1.53	0.93
Vancouver	5,491	-35	1.30	1.29
Ottawa–Gatineau	3,626	-65	0.80	0.94
Calgary	3,360	-18	1.30	0.92
Edmonton	1,358	-37	1.08	0.85
Quebec City	1,184	-19	1.23	0.94
Halifax	811	69	3.37	1.53
Saskatoon	753	-11	1.89	1.26
Winnipeg	721	-9	0.98	0.77
Moncton	172	35	0.92	0.64

Data source: Science-Metrix (2024)

Colour coding indicates performances above (green) or below (red) the world level.

Considering that innovation is largely driven within metropolitan areas, it is not surprising that the GR of the top-performing CMAs is higher than Canada's average GR. Two exceptions, though, are Kitchener–Cambridge–Waterloo and Ottawa–Gatineau. The former had a precipitous drop in patent activity likely corresponding to changes at RIM/BlackBerry in Waterloo (shrinking considerably and focusing on licensing of their software and designs); interestingly, this is not reflected in the EPO data (Seth, 2025; StockAnalysis, n.d.). In the case of Ottawa–Gatineau, the slowing of patenting activity is observed at both patent offices, possibly linked to the slow dismantling and eventual loss of Nortel between 2009 and 2013 (CBC, 2013). CMAs exhibiting substantial growth at the USPTO include Halifax, Saskatoon, and Montréal, with Toronto, Vancouver, Calgary, and Quebec City also above the Canadian average.

Patent activity in Vancouver, Halifax, and Saskatoon exhibit high citation-based impact

Citation-based impact is moderate at the CMA level, with only a few reaching an ARC above 1.0. These include Vancouver, Halifax, and Saskatoon. Patents attributed to Moncton and Winnipeg have the lowest impact. Most CMAs have ARC values in the range of 0.85 to 0.95.

While Canada generally exhibits negative IP flow at the national and provincial/territorial levels, some CMAs have broken from this trend. Halifax and Moncton had positive IP flows by the end of 2023. Generally, CMAs exhibited IP flows around the mean of -28%. Of note, however, was the particularly dramatic outward IP flow from the Ottawa–Gatineau region.

7.2.1 Most active patenting organizations

The top 25 patenting organizations in Canada are mainly private companies and only include four post-secondary institutions (University of Toronto, University of British Columbia, McGill University, and University of Alberta) (Table 7.3). It is worth noting that not all post-secondary institutions operate in the same way with respect to patent ownership policies (see Box 7.2). Some will, by default, gain ownership of patents generated by their researchers, while others will allow the inventor to retain ownership. Still others have negotiated or joint ownership policies (Thon, 2018). Because these disparate policies affect who is listed as the assignee of any given patent, it is difficult to determine how active post-secondary institutions in Canada are as generators of IP. In the panel's opinion, this is a significant challenge to understanding the STI ecosystem in Canada compared to other countries, such as the United States, where patents are generally owned by the institutions where they are produced (GC, 2021). However, the panel also notes that patents owned by universities score lower on citation-based impact metrics, which may suggest that patents without immediate utility remain under institutional control rather than end up with companies intent on adopting these new ideas.

Box 7.2 Post-secondary institution IP policies

For patents originating in academia, institutional rules around ownership have the potential to create substantially different outcomes across institutions. Canada's regime differs from successful policy models in Israel, the United States, and elsewhere. Inventor-owned and institution-owned policies have different strengths and suitability depending on research sector, access to capital, and other factors; there appears to be no consensus in Canada on which policies are the most effective. Evidence suggests that support for academic inventors—even before spinoff ventures are formed—significantly influences venture survival and success, suggesting that early technology transfer office support, entrepreneurial capabilities, and IP-related training can be effective (Thomas *et al.*, 2020; Park *et al.*, 2022, 2024b). Particularly for institutions with university-ownership policies, technology transfer offices are in a position to influence patent creation but often struggle with narrow notions of what success looks like and a lack of funding to provide more fulsome support (Bubela & Caulfield, 2010; Breznitz *et al.*, 2022; Maxwell, 2023; Huson & Morck, 2024).

The panel notes that this is a complex issue and focusing on patent ownership in isolation provides an incomplete and potentially misleading perspective on Canadian performance. NSERC's Idea to Innovation (I2I) grants support the development of technologies emerging from post-secondary institutions and the transfer of these innovations to Canadian firms (NSERC, 2025). The Lab2Market program works with graduate researchers to support entrepreneurship and the commercialization of research (Lab2Market, n.d.).

Table 7.3 Technological performance of the top 25 Canadian patenting organizations, 2012–2023

Organization	Frac	GR	ARC
Canada	**58,496**	**1.05**	**1.00**
RIM/BlackBerry	7,404	0.23	0.78
Pratt & Whitney	1,624	2.74	1.07
Magna	720	1.28	1.25
OpenText	654	10.08	1.75
University of Toronto	648	1.48	0.71
ATI Technologies	600	0.88	0.48
TD Bank	498	23.90	0.73
CNH Industrial	495	1.59	0.95
Conversant Intellectual Property Management	397	0.16	0.65
Omachron	371	7.43	1.03
University of British Columbia	335	1.16	1.09
Bombardier Recreational Products	322	1.57	1.50
Ignis Innovation	273	1.27	1.72
National Research Council Canada	254	0.76	0.71
WiLAN	211	0.21	0.84
Avigilon	206	1.99	1.04
Bombardier	197	5.55	0.78
McGill University	194	0.82	0.69
University of Alberta	187	0.73	0.30
D-Wave Systems	186	1.32	2.73
ViXS Systems	178	0.05	0.45
Geotab	169	17.78	2.37
Mitel Networks	163	0.61	0.52
Husky	153	0.65	0.72
BCE	153	0.56	0.30

Data source: Science-Metrix (2024)

Colour coding indicates performances above (green) or below (red) the world level.

7.3 Canada's patent activity by technological domain

Canada's patenting performance can also be explored in the context of the technological domain and field. Patents were classified by Science-Metrix across 5 domains (chemistry, electrical engineering, instruments, mechanical engineering, and other fields) and further broken down into 35 fields (Table 7.4). During the patent application process, inventors are required to assign technological fields to their applications (which are ultimately decided by patent examiners); these fields are not mutually exclusive, and a given application could be cross-categorized in multiple fields. For this section, results from the USPTO are used exclusively.

Electrical engineering accounts for the largest number of patents across Canada

Electrical engineering patents represented the highest percentage (39.2%) of Canada's patent output at the end of 2023; however, it was one of two domains that exhibited a declining GR, along with instruments. Mechanical engineering followed (20.5%), with chemistry and instruments reaching roughly the same level of output (14.3% and 14.7%, respectively). Other fields, which includes civil engineering, furniture and games, and other consumer goods, trailed at 11%. As was the case in the previous CCA report, computer technology (11.5%) and digital communications (11.3%) accounted for the largest number of patents at the field level. Telecommunications (4.2%) dropped considerably from the previous report, where it accounted for 8.2% of Canada's patent output. Fields showing a higher GR than Canada's average included food chemistry, engines, pumps and turbines, IT methods for management, and medical technologies. Telecommunications, basic communications processes, and digital communications had the lowest GR.

The most impactful fields by citation were found in the chemistry domain

Although mechanical engineering had the highest ARC out of the five domains, the top three fields based on ARC were found in chemistry (micro-structural and nano-technology, macromolecular chemistry and polymers, and materials, metallurgy). The lowest-performing fields were distributed across domains (medical technology, analysis of biological materials, and other special machines).

Table 7.4 Technological performance in Canada by field, 2012–2023 (USPTO)

Domain/Field	Frac	IP flow	GR	ARC	SI
All domains	**58,496**	**-28**	**1.05**	**1.00**	**1.00**
Chemistry	**8,383**	**-23**	**1.10**	**0.98**	**1.05**
Basic materials chemistry	815	-33	1.05	0.94	1.00
Biotechnology	1,198	-16	0.93	0.86	1.16
Chemical engineering	1,209	-19	1.34	1.01	1.35
Environmental technology	805	-10	1.26	0.97	1.60
Food chemistry	345	-65	2.11	0.93	1.00
Macromolecular chemistry, polymers	268	-52	1.07	1.30	0.48
Materials, metallurgy	556	-16	1.19	1.20	0.98
Micro-structural & nano-technology	161	-19	0.87	1.61	0.73
Organic fine chemistry	771	-16	0.95	1.09	0.82
Pharmaceuticals	1,778	-11	0.94	0.86	1.22
Surface technology, coatings	476	-21	1.37	0.95	0.77
Electrical engineering	**22,937**	**-39**	**0.81**	**0.99**	**0.83**
Audio-visual technology	1,947	-27	0.84	1.13	0.68
Basic communication processes	527	-57	0.54	1.22	0.63
Computer technology	6,701	-45	1.00	0.97	0.81
Digital communications	6,606	-39	0.62	0.92	1.21
Electrical machinery, apparatus, energy	2,538	-28	1.14	1.04	0.70
IT Methods for management	1,575	-27	1.47	0.85	1.20
Semiconductors	573	-23	1.03	1.07	0.18
Telecommunications	2,469	-37	0.41	1.00	1.17
Instruments	**8,605**	**-25**	**1.39**	**0.96**	**0.86**
Analysis of biological materials	485	-17	1.28	0.79	1.40
Control	1,424	-24	1.43	1.11	1.10
Measurement	2,552	-26	1.31	1.18	0.99
Medical technology	3,321	-15	1.47	0.69	0.93
Optics	823	-50	1.40	1.23	0.38

(continues)

(continued)

Domain/Field	Frac	IP flow	GR	ARC	SI
Mechanical engineering	**11,986**	**-13**	**1.27**	**1.09**	**1.28**
Engines, pumps, turbines	1,912	-12	1.72	1.21	1.42
Handling	1,353	-13	1.20	1.24	1.36
Machine tools	840	-14	0.99	0.95	1.02
Mechanical elements	1,545	-17	1.23	1.04	1.19
Other special machines	2,354	-8	1.12	0.80	1.75
Textile & paper machines	242	-40	0.79	1.04	0.37
Thermal processes & apparatus	747	-11	1.28	1.09	1.50
Transport	2,994	-13	1.34	1.17	1.23
Other fields	**6,422**	**-16**	**1.24**	**0.95**	**2.00**
Civil engineering	3,590	-16	1.23	0.85	2.80
Furniture, games	1,797	-17	1.31	1.05	1.64
Other consumer goods	1,035	-15	1.17	1.08	1.23

Data source: Science-Metrix (2024)

Colour coding indicates performances above (green) or below (red) the world level.

7.4 Data limitations

Like bibliometrics, technometrics are a useful, quantitative tool to assess invention output. However, there are limitations to this type of analysis. As discussed above, the analysis in this chapter largely relies on patents filed at the USPTO and, to a lesser extent, the EPO. While this leaves out other global markets, it accounts for the majority of patents filed by Canadian entities, potentially showing Canadian innovation as more active than it is across the rest of the world. While the inclusion of the EPO expands on analysis from previous reports, the panel notes that future work could benefit from a patent search that includes other foreign markets. Additionally, the analysis focuses on the location of the assignee rather than the inventor. Both analyses are valid, but they differ in their emphasis. The assignee location metric highlights the importance of a patent's final location, whereas the inventor location metric more accurately describes local innovation and R&D activities. In many cases, Canadian inventors working for foreign multinational firms with labs in Canada will have their work assigned to the foreign company. Future work could focus on the differences between inventor/assignee locations, which are also reflected in the flow of IP.

Another limitation in this analysis relates to impact. Citation-based impact measures are useful in illuminating the activity of and the interest in a certain type of invention or field. However, they do not describe the use of patents, nor quantify activities such as patent renewals, transfers, or sales. Likewise, the use of patents—including protecting, licensing, or applying patented ideas—can vary from field to field. Finally, while patenting is one way to protect ideas and can reveal innovation activity in an area, many fields rely on trade secrets and other techniques to safeguard their IP.

8

Innovation Performance

Chapter findings

- Innovation by Canadian businesses has decreased noticeably in recent years, even as expenditures on innovation activities have increased over the same period.
- In 2022, the most innovative industries in Canada included ICT services and manufacturing, scientific research and development services, pharmaceuticals, and other manufacturing.
- The acquisition, development, and use of new technologies have substantially decreased in recent years, particularly among SMEs. The most commonly cited reason for not using advanced technologies—by a wide margin—is that they are not viewed as applicable or necessary for the business.
- The most significant, persistent obstacles to innovation for firms in Canada are uncertainty, risk, and a lack of skills. Obtaining or enforcing IP is generally not considered to be a significant obstacle to innovation for most Canadian businesses.

Innovation is the process of creating or implementing new ideas, technologies, or methods that result in new or improved products or processes (OECD & Eurostat, 2018). It is distinct from *invention* because innovation inherently involves the adoption, diffusion, or use of new or improved products and processes, not simply their creation. Similarly, although R&D can be an input to and driver of innovation, much innovation can be unrelated to R&D. Innovation is a key driver of increased productivity and economic growth. Through innovation, countries can create new jobs and new businesses, address social and environmental challenges, and improve quality of life and living standards (OECD, 2015b).

Canada ranked 14th in the world for innovation in 2024, according to WIPO's Global Innovation Index. By contrast, the United States ranked 3rd. This is Canada's best ranking since 2014 but the second-lowest in the G7 (ahead of Italy). Relative to other countries, Canada leads in both number of VC recipients and number of joint venture/strategic alliance deals (1st in each)[27] and has a high ranking in quality of universities (4th), impact of scientific publications (4th), university–industry collaboration (5th), research talent in the business

27 While Canada ranks first in the *number* of VC recipients and deals, it ranks 10th for the *value* of VC investment (Section 5.2.2).

sector (8th), and IP payments (9th). Canada ranks less favourably in gross capital formation (63rd), foreign direct investment inflows (63rd), expenditures on education (66th), ICT use (68th), ecological sustainability (72nd), and labour productivity growth (102nd), as well as IP measures related to intangible assets such as trademarks (77th) and industrial designs (89th) (WIPO, 2024). Canada ranked above the United States in the strength of its institutions, human capital, research, and infrastructure, but below it with respect to market and business sophistication, as well as knowledge, technology, and creative outputs.

Some of these rankings differ slightly from similar rankings presented elsewhere in this report due to differences in data sources, methodologies, and sets of comparator countries. However, there is broad alignment regarding both Canada's strengths (research, talent, and cross-sectoral collaboration) and weaknesses (productivity, technology use, and financing).

Notably, firms in Canada tend to self-report very high levels of innovation, to the extent that in 2020 Canada ranked 1st in the OECD for proportion of innovative firms (OECD, 2024f). However, in the view of the panel, these data are questionable as it is doubtful that Canada leads the world in the proportion of firms that are innovative based on the assessed indicators (Section 8.4).

8.1 Trends in Canadian innovation

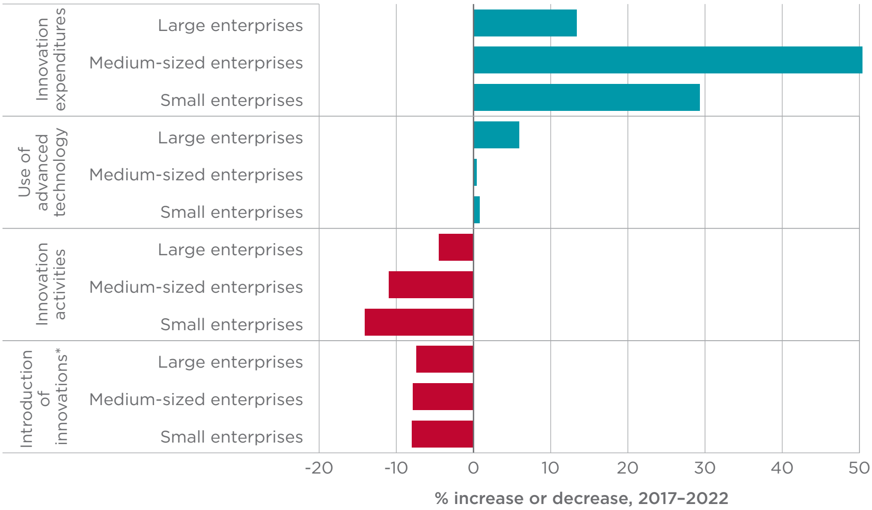
There are a variety of ways to measure innovation (Munro & Lamb, 2025). Beyond examining inputs such as national R&D expenditures, education, and personnel (Chapter 3) and outputs such as publications and patents (Chapters 4 and 6), another approach to measuring innovation that is common internationally is through surveys that directly ask firms about their innovation activities and performance. This may include asking whether the firm introduced new products or processes into the market or in their organization, or about particular types of innovation activities undertaken by the firm (e.g., R&D, software development, design work, IP activities). However, because these surveys are based on self-reported data, they may be less objective indicators of innovation, especially with respect to international comparability (Section 8.4). Nevertheless, they can still offer important insights and provide benchmarks for identifying trends over time. The data in this section are based on Statistics Canada's Survey of Innovation and Business Strategy (SIBS) and Survey of Advanced Technology (SAT), unless otherwise indicated. These surveys differ with respect to their coverage by firm size and industry; for details, see StatCan (2023l,m).

There has been an overall decline in innovation among firms in Canada

Between 2017 and 2022, there was a decline in the proportion of firms in Canada that introduced innovations (from 80% to 72%) and that undertook innovation activities (60% to 47%) (Figure 8.1)—a trend across nearly all industries. There was also a 39% increase in average innovation expenditures ($1.5 million to $2 million, adjusted for inflation in 2020 constant dollars) over this period, while use of advanced or emerging technologies remained relatively unchanged (46% to 47%). This disconnect between increasing expenditures and decreasing introduction of innovations may reflect a more general phenomenon—declining research productivity—that results in innovation becoming harder to achieve (Bloom *et al.*, 2017).

The COVID-19 pandemic presented significant obstacles to innovation between 2020 and 2022, which contributed to a drop in innovation activities over that period (StatCan, 2024x). However, an even larger decrease in innovation activities occurred before the pandemic, from 2017 to 2019. This decline in innovation was more acute among SMEs than it was in large enterprises, which increased their use of advanced or emerging technologies more than SMEs. However, SMEs increased their average innovation expenditures at a faster rate than large enterprises, reflecting the shift in Canada's industrial R&D expenditures toward SMEs that was noted in Section 4.3.1.[28] Across nearly all industries, large enterprises (>250 employees) undertook innovation activities at a considerably higher rate than SMEs.

28 Because industry and firm size coverage differ between the SIBS and RDCI survey instruments, as well as differences in data collection methodology, data on innovation activities and expenditures among smaller firms do not precisely reflect the data on R&D expenditures among smaller firms presented in Section 4.3.1.



Data source: StatCan (2024c,y,z,aa)

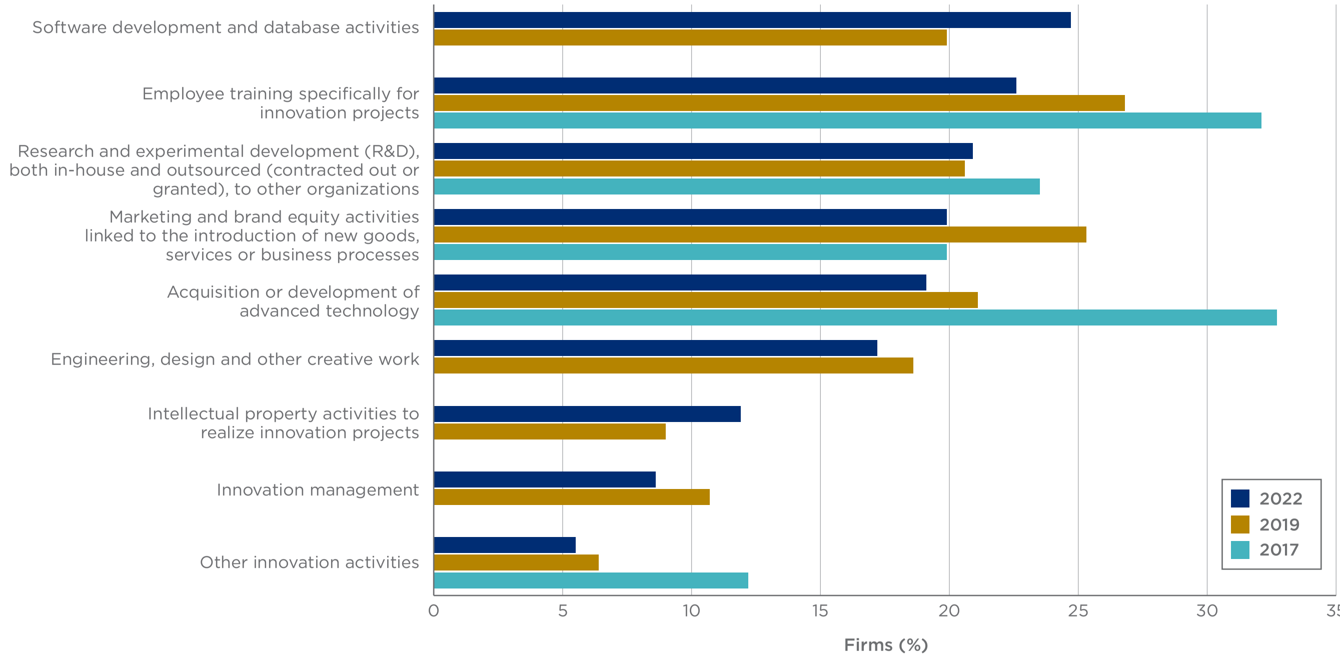
Figure 8.1 Trends in innovation by firm size, 2017–2022

Declining innovation activities and introduction of innovations coupled with increased innovation spending reflect a broader trend of declining research productivity.

Innovation expenditures are adjusted for inflation (2020 constant dollars). Small enterprises are defined as having 20 to 99 employees, medium-sized enterprises 100 to 249 employees, and large enterprises 250 and more employees.

*Data on the *Introduction of innovations* are from 2019 to 2022 only.

Nearly all types of innovation activities decreased between 2017 and 2022; the only types that increased over this period were in software development and database and IP activities (Figure 8.2). The most common innovation activity among firms in Canada in 2022 was in software development and database activities (24.7%), followed by employee training specifically for innovation projects (22.6%), and R&D (20.6%). Innovation management is one of the least-common innovation activities conducted by Canadian firms—practised by only 8.6%—and had among the lowest average expenditures in 2022. Yet innovation management has been identified as a key factor for improving Canada's innovation performance, and for retaining the economic and social benefits resulting from Canada's research strengths, talent, and entrepreneurialism (CCA, 2018b). Moreover, many of the biggest obstacles to innovation for firms in Canada (Section 8.3)—for example, uncertainty and risk—can be addressed through better innovation management.



Data source: StatCan (2024c)

Figure 8.2 Percentage of firms engaged in innovation by activity type, 2017, 2019, and 2022

Activities are ordered by highest-to-lowest percentage of firms engaged in each type of innovation activity in 2022. Data is unavailable for some categories in some years.

Innovation in Canada is led by a small handful of industries

Across all enterprise sizes, the most innovative industries in Canada in 2022—defined here as those with a high proportion of firms both introducing innovations *and* undertaking innovation activities—can be found among three industry types: information and cultural industries; professional, scientific, and technical services; and manufacturing.

As with the R&D strengths identified in Chapter 5, many of the most innovative industries in Canada are involved in different areas of the ICT sector, as well as various types of manufacturing. The pharmaceutical industry also has a relatively high rate of innovation, particularly in its manufacturing sector, while the finance and insurance industry has a high percentage of firms introducing innovations. Unsurprisingly, scientific research, engineering, and related services are also among the most innovative industries (Table 8.1).

Industries based on natural resources, such as forestry, agriculture, mining, and oil and gas tend to have a somewhat lower proportion of firms introducing innovations (51–69%) or undertaking innovation activities (42–48%), which may be more typical of commodity-based industries with lower profit margins. Despite this, both the oil and gas extraction industry and the mining and quarrying industry have very high average annual expenditures on innovation activities compared with other industries ($16.5 million and $5.8 million, respectively).

Table 8.1 Top 30 most innovative industries in Canada, 2022

Industry	Firms undertaking innovation activities (%)	Firms introducing innovations (%)	Average annual innovation expenditures (x $1,000)	R&D intensity (% of revenues)
Computer and peripheral equipment manufacturing and communications equipment manufacturing	92.7	94.6	4,162	10.8
Pharmaceutical and medicine manufacturing	93.9	91.2	10,758	4.0
Software publishers	89.2	92.1	4,141	14.7
Scientific research and development services	93.1	80.9	12,159	20.1
Audio and visual equipment manufacturing and manufacturing and reproducing magnetic and optical media	83.5	90.5		4.0

(continues)

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Industry	Firms undertaking innovation activities (%)	Firms introducing innovations (%)	Average annual innovation expenditures (x $1,000)	R&D intensity (% of revenues)
Navigational, measuring, medical and control instruments manufacturing	94.3	79.3	4,656	7.0
Data processing, hosting and related services	80.1	90.1	10,859	0.9
Other information services	83.9	84.9		0.7
Petroleum and coal product manufacturing	78.8	88.6		0.2
Semiconductor and other electronic component manufacturing	82.8	84.5	2,008	7.0
Motor vehicle plastic parts manufacturing	85.8	78.9		0.8
Medical equipment and supplies manufacturing	79.8	84.7	1,029	1.4
Computer systems design and related services	82.7	81.7	3,972	9.0
Electrical equipment, appliance and component manufacturing	82.2	82.0	2,199	4.1
Aerospace product and parts manufacturing	84.3	76.9		2.4
All other chemical manufacturing	81.5	74.8		2.6
Machinery manufacturing	79.9	76.2	2,598	1.9
Architectural, engineering and related services	73.7	81.4	776	4.0
Pipeline transportation	77.1	77.1		2.5
All other transportation equipment manufacturing	72.4	77.7	897	1.8
Rubber product manufacturing	70.4	78.2	5,571	0.4
Other miscellaneous manufacturing	68.6	79.6		0.7
Pharmaceuticals, toiletries, cosmetics and sundries merchant wholesalers	57.7	90.3	13,278	2.5
Motor vehicle and motor vehicle body and trailer manufacturing	66.1	78.0		0.8
Textile and textile product mills, clothing and leather and allied product manufacturing	67.3	75.8	2,072	2.8

(continues)

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Industry	Firms undertaking innovation activities (%)	Firms introducing innovations (%)	Average annual innovation expenditures (x $1,000)	R&D intensity (% of revenues)
Beverage and tobacco product manufacturing	57.9	84.7	837	0.8
All other plastic product manufacturing	67.2	75.2	795	1.0
Securities and commodity contracts intermediation and brokerage	58.1	84.1	1,993	20.1
Telecommunications	58.8	82.4		14.7
Management, scientific and technical consulting services	60.2	80.7	764	3.7

Data source: StatCan (2024c,r,y,z)

Industries are ordered by the sum of the proportion of firms introducing innovations plus the proportion of firms undertaking innovation activities. Data on average annual expenditures on innovation activities for some industries are not published by Statistics Canada due to concerns about the reliability of the data (grey cells). Industry names are those used by NAICS.

Table 8.1 also includes the R&D intensity of each industry, to highlight the discrepancy between industries that are innovative by being R&D-intensive, and industries that are innovative in other ways. For example, in the ICT sector, computer manufacturing and software publishing are highly innovative and highly R&D-intensive, whereas data processing, hosting and related services is highly innovative, but has a very low R&D intensity.

8.2 Technology adoption

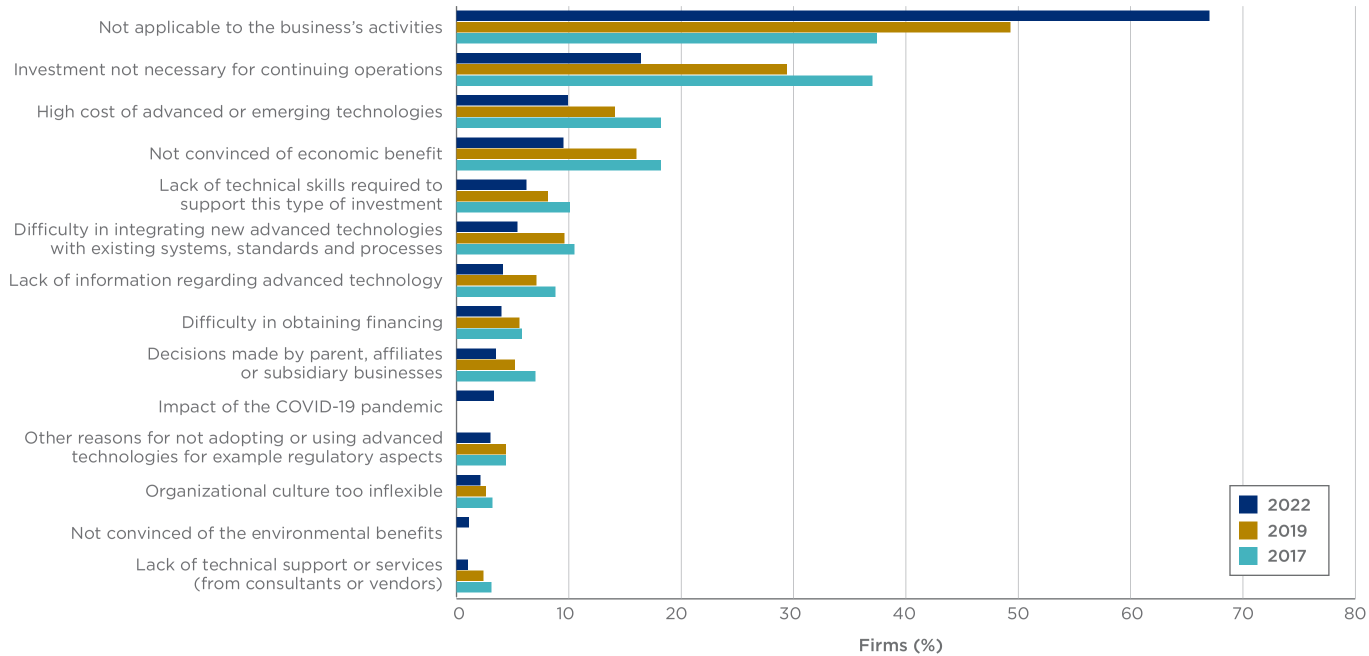
Technology adoption is a driver of innovation (Zhang & Ostertag, 2025). Across all industries and all firm sizes, adopters of advanced technology[29] are more likely to introduce innovations than non-adopters (StatCan, 2023e). However, according to SIBS, rates of technology acquisition are slowing dramatically. While advanced technology development or acquisition was the most common innovation activity in 2017 (32.7% of firms), it dropped to 19.1% by 2022 (StatCan, 2024c). In early 2025, 17.9% of firms indicated that they planned to invest in advanced technologies over the next 12 months, while 60.9% indicated that they do not intend to do so (StatCan, 2025j).

29 Statistics Canada defines *advanced technology* as "a new technology that performs a new function or improves some function significantly better than other commonly used technology" (StatCan, 2023d).

Between 2017 and 2022, the manufacturing industry led in the percentage of firms acquiring or developing new technologies and had one of the smallest decreases over that period (44% to 33%). By contrast, many of the other most innovative industries in Canada had rates of technology acquisition and development in 2017 comparable to those in the manufacturing industry. Still, they experienced significant decreases by 2022, including in the professional, scientific and technical services industry (37% to 15%), information and cultural industry (40% to 9%), and finance and insurance industry (44% to 7%) (StatCan, 2024c). Average firm-level expenditures on the acquisition or development of new technology decreased by 15% between 2017 and 2022 ($850,000 to $723,000, inflation-adjusted 2020 constant dollars) (StatCan, 2024z). Small firms (<100 employees) accounted for more than two-thirds (68%) of all capital expenditures on advanced technology between 2020 and 2022, while large firms (>250 employees) accounted for only 17% (StatCan, 2023f).

Annually, more firms in Canada use advanced technologies than acquire or develop new technologies. Still, fewer than half of all firms (47%) used advanced technologies in 2022, according to SIBS (StatCan, 2024aa), while SAT found that 62% of firms used at least one type of advanced technology (StatCan, 2023g). The most cited reason for not using advanced or emerging technologies—by a wide margin—is that they are not seen as applicable to the business's activities (67%) or necessary for continuing operations (16%) (Figure 8.3). These are also the most commonly cited reasons why businesses do not invest in capital expenditures into advanced technologies (StatCan, 2023h).

These results suggest that Canadian businesses may not feel the need to adopt or use new technology and, more generally, are not incentivized to undertake technology-based innovation. Due to their smaller size and relatively low levels of spending on R&D, Canadian firms often lack the absorptive capacity needed to adopt new technologies (CCA, 2009). An abundant supply of labour and the ability to fill low-skill jobs vacancies with immigration can also reduce the incentive for firms to adopt new technologies (Lewis, 2011; Zhang & Ostertag, 2025). Canada's industrial structure (Section 3.1.2) may also contribute to low rates of technology adoption, insofar as Canada's economy is more concentrated in industries (e.g., natural resources, construction) that have less incentive or need to adopt technology to remain profitable.



Data source: StatCan (2024ab)

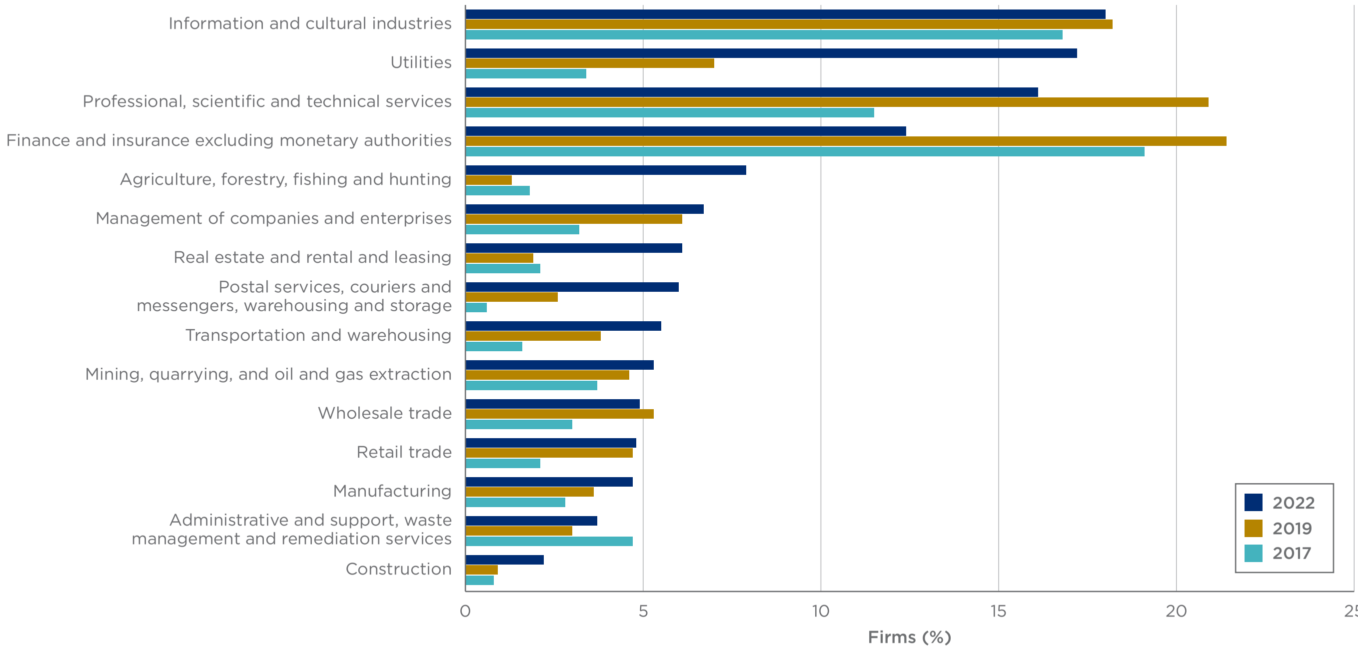
Figure 8.3 Reasons for not adopting or using advanced technologies, 2017, 2019, and 2022

Reasons for not adopting or using advanced technologies are ordered by highest-to-lowest percentage of responses in 2022. Data is unavailable for some categories in some years.

Only a small proportion of Canadian firms use AI technology

As a general-purpose technology, AI has enormous potential to advance R&D, innovation, and productivity across a wide variety of industries and sectors, as well as for STI more generally (Section 2.3). According to SIBS, the use of AI across all industries and firm sizes increased from 4% in 2017 to 6.3% in 2022; according to SAT, 3.1% of firms used AI in 2022 and 2.9% planned to implement AI in the next two years (StatCan, 2023i,j, 2024aa). However, given the dramatic increase in the variety and capabilities of AI tools since 2022, and the considerable interest and attention AI has generated since then, it is likely that these data are outdated and not reflective of the current use of AI by Canadian firms. For instance, the 2025 Canadian Survey on Business Conditions (CSBC) found that 12.2% of businesses used AI over the last year, an increase from 6.1% reported in 2024 (StatCan, 2025k). Similarly, a 2024 survey of SMEs by the BDC found that 66% of respondent businesses reported using at least one AI-powered tool (when prompted with a list of such tools) (Galliot, 2024). However, data from 2023 suggest that Canadian firms have been slower to use generative AI relative to many peer countries (Morning Consult, 2023).

In 2022, use of AI was mainly concentrated in firms related to information and cultural industries (SIBS, SAT = 18%, 13.5% of firms), followed closely by the utilities industry (17%, 10.9%), the professional, scientific, and technical services industry (16%, 8.6%), and the finance and insurance industry (12%, 9.5%) (Figure 8.4). These same industries were found to lead in AI use in the 2025 CSBC, with much higher use rates: information and cultural industries (35.6%); professional, scientific and technical services (31.7%); and finance and insurance (30.6%) (StatCan, 2025k).



Data source: StatCan (2024aa)

Figure 8.4 Percentage of Canadian firms using AI by industry sector, 2017, 2019, and 2022

Industry sectors are ordered by highest-to-lowest percentage of firms using AI in 2022.

According to SIBS, the use of AI declined in the finance and insurance industry, dropping from 19.1% in 2017 to 12.4% in 2022, while increasing in nearly every other industry. However, this reported decline stands in contrast to broader global trends, where these industries are among the most active in deploying AI tools (WEF, 2025). Indeed, according to the Evident AI Banking Index, Royal Bank of Canada was ranked 3rd in the world in 2024 for AI maturity in the banking sector, and all of the "Big Five" Canadian banks[30] were ranked within the top 25 (Evident Insights, 2024). As such, the decline reported by SIBS could reflect shifts in reporting behaviour, definitional ambiguity, or differences in how firms interpret the scope of AI, rather than a true decrease in adoption.

As with all advanced or emerging technologies, the use of AI tends to increase with enterprise size, with the greatest increase in AI use between 2017 and 2022 among large firms (StatCan, 2024aa). According to SIBS, 5.3% of small firms, 8.5% of medium firms, and 16.5% of large firms used AI in 2022 (StatCan, 2024aa), while that usage was 2.7%, 6%, and 11.1%, respectively, according to SAT (StatCan, 2023i). Similarly, the CSBC also found that the use of AI generally increased with firm size in 2025 (StatCan, 2025l), and BDC's survey found that larger SMEs (>100 employees) used AI more than smaller ones, and that adoption rates were higher among younger businesses. According to CSBC, the strongest predictors of a firm using AI are: (i) whether the firm relocated any business or organizational activities or employees from Canada to another country (50.1% of such firms use AI), (ii) whether the firm made investments outside of Canada (48.4%), and (iii) whether the firm exported services outside of Canada (43.1%) (StatCan, 2025l).

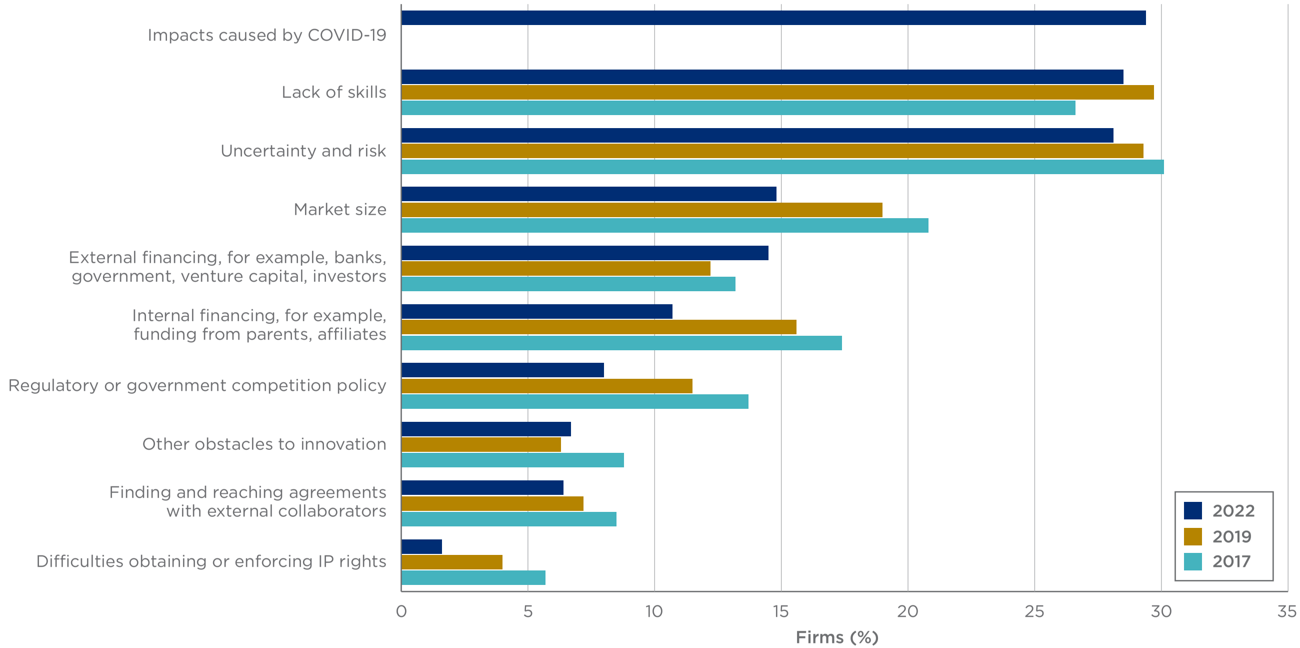
In 2022, the most commonly cited significant obstacles (i.e., obstacles that were rated "moderately significant," "significant," or "very significant" by respondents) to AI adoption among Canadian firms were difficulties in recruiting qualified staff (60%) and difficulties in integrating AI with existing systems and processes (58%). Other obstacles included low returns on investment or long payback periods (57%), lack of employee training (56%), and difficulty determining how AI technology will impact the business (54%) (StatCan, 2023k). According to the BDC survey, among the biggest challenges for SMEs adopting AI in 2024 were a lack of knowledge and understanding about what options and tools are available, concerns about data and privacy, and high costs (Galliot, 2024). According to the 2025 CSBC, 41.2% of firms considered AI to be "not relevant" to their operation (StatCan, 2025k).

30 Canada's "Big Five" banks are, in order of their ranking in the Index: RBC (3rd), TD Bank (9th), Scotiabank (20th), CIBC (22nd), and BMO (24th).

8.3 Supporting innovation in Canada

Since 2022, new challenges have arisen that present obstacles to innovation (Chapter 2). However, the most significant and persistent obstacles reported by firms in Canada from 2017 to 2022 were uncertainty and risk, and lack of skills. Additionally, lack of external financing is a growing obstacle—the only explicitly identified obstacle that increased among survey respondents between 2019 and 2022 (Figure 8.5). Despite relatively few firms engaging in IP-related innovation activities, obtaining or enforcing IP is generally not considered to be a significant obstacle to innovation for most Canadian businesses. The share of firms citing IP as an obstacle declined between 2017 and 2022, while the proportion of firms undertaking IP activities increased between 2019 and 2022 (Section 8.1).

It should be noted that this data does not distinguish between (i) obstacles faced by firms when engaging in innovation activities, and (ii) obstacles faced by firms that deter them from innovating. This distinction is important when developing effective policies to support and encourage innovation (D'Este *et al.*, 2012).



Data source: StatCan (2024ac)

Figure 8.5 Obstacles to innovation for Canadian firms, 2017, 2019, and 2022

Obstacles to innovation are ordered by highest-to-lowest percentage of responses in 2022. Data is unavailable for some categories in some years.

According to SIBS, 34% of firms reported using a government program to support innovation in 2022, a rise from 32% in 2017. The most frequently used and most critical government programs in 2022 were tax credits or incentive programs, training and hiring programs, and grants and contributions programs (StatCan, 2024ad). The survey found that government procurement (Section 9.4.1) is not widely used to support innovation activities, nor was it viewed as among the most critical (StatCan, 2024ae).

8.4 Data limitations

There are a variety of challenges when measuring innovation, from basic definitions to choice of indicators to data lags, gaps, and lack of standardization that create challenges for meaningful comparisons across countries (Munro & Lamb, 2025).

Innovation indices or scorecards, such as WIPO's Global Innovation Index have both benefits and drawbacks. By aggregating a wide range of indicators, they offer a more general and holistic view of national-level innovation that avoids the deficiencies of any specific indicator. However, this high-level view, along with overall rankings, may obscure rather than illuminate differences across countries, or differences in ranking may be overemphasized. Additionally, indices may also rely on some indicators that are of questionable value in assessing innovation performance.

While innovation surveys are based on self-reported data and may be less objective indicators of innovation, they can nevertheless offer important domestic insights and provide benchmarks for identifying trends. However, the panel opted not to use innovation survey data as sources for international comparisons to Canada's innovation performance. Although the OECD collects data on innovation performance by firms in different countries based on innovation surveys such as Canada's SIBS and the European Union's Community Innovation Survey (both based on the OECD's Oslo Manual), international comparability of these data "may be limited due to differences in innovation survey methodologies and country-specific response patterns" (Editors, 2017).

For example, according to the OECD's Science, Technology and Innovation Scoreboard, Canada ranks first in the world for the proportion of innovative firms (83%). One factor that may partially explain Canada's suspiciously high performance is that SIBS only covers firms with more than 20 employees. At the same time, surveys used by most other comparator countries also include firms with 10 to 20 employees. Since firms with more than 20 employees are more than twice as likely to be innovative as those with fewer than 20 employees, the proportion of all innovative firms appears inflated in Canada when compared with other countries (OECD, 2023c). Another factor that may contribute to Canada's inflated innovation performance relative to other countries is the type of industries surveyed. SIBS includes industries that countries using the Community Innovation Survey and similar surveys do not, such as agriculture and forestry, construction, wholesale trade in motor vehicles, legal and accounting services, and professional, scientific, and technical services (OECD, 2023c). The specific wording of the questions asked in each country's innovation survey may also contribute to Canada's inflated innovation performance.

Additionally, innovation survey data is subject to many of the same or similar industry classification challenges mentioned in Section 4.1. For example, the coverage of industries by NAICS code varies in granularity (i.e., from 2–4 digits in codes), and many nascent and emergent industries are not easily defined using NAICS, such as life science and biotechnology, clean tech, and deep tech. Finally, analysis would benefit from additional metrics on technology adoption, including AI adoption.

9

Barriers and Knowledge Gaps

9.1 Human capacity

9.2 Business leadership

9.3 Canada's financial sector

9.4 The public sector

9.5 AI and productivity

9.6 STI ecosystems and society

9.7 Real-time data and analysis

Chapter findings

- In the challenging years ahead, enhanced business R&D and increased adoption of new technologies, particularly AI, can play an important role in reversing Canada's declining economic performance. The financial sector can help by providing domestic financing for promising startups looking to scale into global market leaders while maintaining a footprint in Canada.
- People are at the centre of the STI ecosystem; fostering human talent and wider participation are essential preconditions for greater success.
- Decision-makers in the public sector can contribute to improved performance by creating a more supportive operating environment for researchers and innovators. This is likely to require, *inter alia,* critical review and refinement of regulatory regimes, funding programs, and procurement policies.
- While broad directions for urgent action seem clear, actors across the STI ecosystem also need relevant, real-time data and analysis to inform decision-making. Furthermore, the pace of change is such that better insights into Canada's current performance and opportunities for improvement may well require new frameworks for understanding the STI ecosystem and its connections to broader society.

The panel was asked to provide an update on the status of STI in Canada—following the methodology of past reports in the *CCA State of STI in Canada* series—to inform policy-makers and those in the STI community about how Canada is performing relative to peer countries on key measures, and to highlight emerging areas of opportunity and challenge. The domestic and international contexts have changed since the last iteration of this assessment, and the world has become more complicated as forces of technological disruption, geopolitics, global trade, climate change, and economic transformation collide. Despite these mounting and intersecting challenges, STI remains a global endeavour.

Canada's economy, including its STI ecosystem, is deeply integrated with that of the United States, but this partnership is undergoing massive change—perhaps irrevocably. It will impact the flow of goods, people, and capital, and it will undermine collaboration. Perhaps most importantly, it will undermine confidence. Globally, there are rising sentiments of protectionism; at the same time, however, international trade patterns are firmly established and the deepening of trade ties persists (OECD, 2025i). While Canada grapples with its changing relationship with the United States, it continues to strengthen other trade ties (PMO, 2025). At the same time, Canadian policy-makers need to safeguard domestic research from both a security and IP perspective (SIGRE, 2022; Rühlig, 2023).

The data presented throughout the report reveal important characteristics of Canada's STI ecosystem. This ecosystem is characterized by, on the one hand, high-performing post-secondary institutions, a highly educated workforce, relatively high R&D activity among SMEs, and the presence of innovative MNEs. On the other hand, this ecosystem suffers from having few large Canadian anchor firms, chronically low R&D spending in business and government, limited access to risk capital, a gap between fundamental research and innovation, and poor performance in scaling innovative businesses and retaining them domestically. In the panel's view, many peer nations appear to be doing more to advance their innovation economies. All told, Canada's upstream strengths in research and talent are failing to translate into downstream benefits in terms of economic outcomes.

Many of these characteristics have been understood for some time. However, the STI ecosystem is locally, nationally, and globally connected and shifting in response to new internal and external pressures. Given the fluid situation and shifts in the locus of innovation itself (e.g., intangibles, AI) and limitations in available data, this assessment can only provide a partial picture—but what has come into view is troubling.

Expanding on the charge of the 2018 CCA report, the panel was asked not only to characterize the state of STI in Canada, but also to consider the evidence on barriers and knowledge gaps in translating Canadian strengths in S&T into innovation, wealth creation, and broader benefits to society, as well as strategies to address these barriers and knowledge gaps. This chapter seeks to connect the current performance of the STI ecosystem to the needs and opportunities for improvements, building on the evidence and the panel's expertise.

Specific changes in policy and practice will be subject to debate, and the panel did not formally evaluate the effectiveness of existing programs. However, the panel has no doubt that the collision of multiple challenges and threats today provides a strong impetus for intervention in Canada's STI ecosystem. Addressing these issues will require the involvement of a range of actors and a level of speed and effort that surpasses any seen in recent decades. There will also be a need for a coherent STI strategy, public-private collaboration, adaptive and relevant policies and programs, real-time information, and access to expertise. Above all, effective and efficient execution needs to be coupled with a culture of more rigorous assessment based on timely data collection to evaluate the impact of interventions.

9.1 Human capacity is fundamental to a healthy STI ecosystem

Beyond powering economic growth, Canada's STI talent base provides the agility needed to respond to "waves of creative destruction" (Carayannis, 2013). The country's education system performs well (Section 3.2), but recent challenges underscore the fragility of its funding model, which has become heavily reliant on international student fees in multiple provinces (Section 2.4.4). Moreover, as post-secondary institutions abroad improve their performance, Canada's institutions will be challenged to maintain their leadership positions.

Improved STI performance depends on attracting, educating, retaining, and deploying a highly-skilled workforce

Canada's immigration system was, for a long time, a driving force behind the country's impressive STI talent base (Picot & Hou, 2018). Despite multiple warnings from economists (Blit, 2024; Blit *et al.*, 2024; Oreopoulous & Skuterud, 2024; Workswick, 2024), there has been a shift away from an immigration policy that sought to raise the skill level of the population to one focused on low-skilled workers. That this shift was driven partly by employer lobbying underscores the relative lack of demand for skilled workers in Canada's STI ecosystem. More recently, the government has shifted immigration priorities toward healthcare and social services, education, and the trades (IRCC, 2025). The panel is concerned that the overall effect of these changes will be to reduce the calibre and volume of STI talent being attracted from abroad. Moreover, admitting fewer highly qualified international students to Canadian post-secondary institutions impacts downstream talent and worsens the precarious financial position of many of the institutions that are bright lights in Canada's STI ecosystem.

As part of a highly integrated North American market and as an open trading economy that has historically welcomed many immigrants, Canada has extensive economic and social ties abroad. While immigration has historically supported the development of Canada's STI sectors, the country also contends with a "brain drain," with some of its top talent emigrating to the United States or elsewhere for more appealing career prospects (Spicer *et al.*, 2018). Elective emigration among some of the highest-skilled people is a key factor accounting for income and innovation differences between Canada and the United States (MacGee & Rodrigue, 2024). However, changes in U.S. policy, including cuts to science funding, are creating an opportunity for Canadian employers to attract top talent (Friesen, 2025; Nemer & Quirion, 2025; Sahebzada, 2025). Canada can seize the moment to recruit and retain top talent, but changes in the United States are among many factors shaping employment decisions. In the absence of stronger career prospects, competitive salaries and research funds, infrastructure, and growth in the number of opportunities, long-term outcomes are unlikely to change meaningfully (CCA, 2021).

A more inclusive STI ecosystem could enhance participation, performance, and sovereignty

A diverse STI ecosystem will be more productive and innovative (Lorenzo & Reeves, 2018; Hofstra *et al.*, 2020). Canada is home to a small and diverse population; to be as robust as possible, its STI ecosystem needs to draw from the whole talent pool. Inclusive research funding, financing, procurement, and infrastructure have all been identified as means to build the STI ecosystem (Cukier, 2025).

The CCA, in partnership with SSHRC, hosted a virtual event titled Indigenous Perspectives on Knowledge, Science, Technology, and Innovation in Canada, featuring Indigenous innovators, entrepreneurs, and thought leaders who led a discussion on the challenges and opportunities that Indigenous individuals and communities have when engaging in Canada's STI ecosystem (Section 1.2.3). The speakers described emerging practices to support Indigenous inclusion; in science, more equitable research approaches include compensating Indigenous Knowledge Holders, ensuring reciprocity, and promoting research sovereignty. For example, there is a movement toward research sovereignty and community-directed higher education through the creation of the Haudenosaunee Research Institute at Six Nations Polytechnic (Martin-Hill *et al.*, 2025). This institute is being proposed to support self-determination in the governance of research. Canada's research granting institutions tend to require university affiliations for funding recipients, leading to funding for Indigenous research projects being managed outside of the community. Martin-Hill *et al.* (2025) report that:

> *Research funding being held by non-Indigenous academics housed in university systems outside of the community leads to inequity in knowledge production and creates a scenario where Indigenous communities often make concessions to accommodate the careers and interests of external scholars and their students.*

A Six Nations research institute could also help to convene Haudenosaunee scholars to advance a local research agenda. In the status quo, "for many

Indigenous people, the pursuit of higher education, and research scholarship in particular, often requires leaving their community or reserve, which inhibits long-term capacity building within the community" (Martin-Hill *et al.*, 2025).

The Saskatchewan Indian Institute of Technologies (SIIT) established pawâcikêwikamik, an Indigenous innovation accelerator providing access to technology, training and education, workspaces, mentoring, and microgrants to emerging Indigenous entrepreneurs (SIIT, n.d.). pawâcikêwikamik features a MakerLodge that has supported several emerging entrepreneurs through the provision of access to technologies and guidance. Micrograants have also supported entrepreneurs in purchasing the equipment and supplies needed to pursue business ventures (SIIT, n.d.). In the innovation space, the Indigenous Tech Circle provides a culturally safe space for networking and professional development, offering mentorship, workshops, and events that bring Indigenous innovators together to build capacity and connections (Indigenous Tech Circle, n.d.). Animikii develops technologies that respect Indigenous data sovereignty, recognizing "that technology by itself is not a solution to the pressing issues we face, rather it must be guided by a system of values that promote mutual understanding and equity." Animikii has partnered with the Six Nations Survivors Secretariat, San'yas Cultural Safety training, and the British Columbia Museum Association to provide the technologies that underpin impactful programming (Animikii, 2023, 2025).

To prosper, Canada needs to embrace lifelong learning

Training institutions and firms have a role to play in retooling and upskilling workers to keep pace with changing technologies. The skills and roles sought by the labour market are constantly evolving in response to rapidly changing technologies (Section 2.4.1), and reskilling is key to maintaining an innovative workforce. Business investment in workforce training and development is critical, but expenditures on employee training specifically for innovation projects is low and falling (StatCan, 2024z). Microcredentialling can be effective in maintaining a worker's skills over the span of their career, and colleges and institutes are engaging collaboratively to meet these needs (Gauthier, 2020; Pichette *et al.*, 2021; Tamoliune *et al.*, 2023; CICan, 2025). Ongoing investment is needed to enhance entrepreneurial and business management skills to bring innovations to market successfully. While Canada has a high output of graduates in business, management, and administration, there is a further need for business skills among individuals trained in science to drive innovation management. Effective innovation management requires domain-specific scientific knowledge in addition to managerial skills and experience (Thomas *et al.*, 2020). Educational institutions including business schools and businesses themselves have an opportunity to foster innovation skills in their students, faculty, and employees (CCA, 2018b). Expanding the course offerings, training experiences, and collaboration opportunities offered to STEM and HASS students to include managerial and business opportunities can help to develop more competencies in innovation management to the benefit of both HQP and the Canadian STI ecosystem (CCA, 2018b; OECD, 2022; Bouchard *et al.*, 2023; Khan & Casello, 2023).

Post-secondary institutions can foster entrepreneurial activity across the ecosystem

A narrow conception of the post-secondary institution's role in entrepreneurship may focus on supporting the transfer of research results and IP management. Broader notions encompass the importance of fostering entrepreneurial skills among students and faculty, building deeper connections between the post-secondary institution population and the broader STI ecosystem, and applying entrepreneurial approaches to social as well as economic objectives (OECD, 2022; Abreu & Grinevich, 2024). The concept of the *entrepreneurial university* positions the "university as an institution capable of leveraging its education, research, knowledge exchange and community engagement activities to create and promote entrepreneurial thinking and actions both internally and externally" (Abreu & Grinevich, 2024).

Entrepreneurial activity is on the rise across Canadian campuses, with a 26% increase in the number of new startups reported in 2023 (AUTM, 2024). In the panel's experience, a new generation of faculty members is equally active in entrepreneurial activities. If appropriately supported, this growth in activity could substantially benefit Canada's STI ecosystem. The panel notes that recognizing this important role for post-secondary institutions, and how it is resourced and valued, is vital for the effectiveness of the broader STI ecosystem. University spinoffs have higher long-term survival rates than other new technology-based firms and have the potential to make a greater contribution to the economy, although only a small proportion of university spinoffs grow into large companies (Lawton Smith & Ho, 2006; Thomas *et al.*, 2020; Conceição *et al.*, 2022). Appropriately resourcing technology transfer functions and recognizing patenting and commercialization efforts by post-secondary researchers as part of career advancement could enhance the contribution of post-secondary institutions in the STI ecosystem (Sanberg *et al.*, 2014; Carter *et al.*, 2021; Huson & Morck, 2024).

9.2 Business leadership is essential to improving Canada's STI performance

Historically, Canadian firms were understood to be "as innovative as they have needed to be" (CCA, 2013b). As Canada's STI performance continues to fall relative to comparator countries, and as it faces a new brand of globalization in this era of geopolitical uncertainty, there is no longer the luxury of maintaining a low-innovation equilibrium domestically.

Canada lacks a critical mass of large firms in innovative sectors

Canada's BERD is notoriously low, but some scholars argue that this low R&D investment may be a symptom of a more fundamental problem: few large innovative firms (Section 4.3.1). The relatively high levels of R&D activity among a growing portion of SMEs are not sufficient to offset the lack of large innovative firms. Large firms tend to pay higher salaries and are more likely to adopt new information technologies (Galindo-Rueda *et al.*, 2020; Grekou *et al.*, 2020). A dearth of large, high-productivity firms in Canada relative to the United States is an important factor for explaining diverging incomes and productivity (Leung *et al.*, 2008; MacGee & Rodrigue, 2024).

Adoption relies on adequate corporate and individual absorptive capacity

Low rates of technology use and adoption in business contribute to Canada's weak innovation outcomes. Historically, a lack of competition and a degree of complacency have been identified as key contributors to this poor performance, though evidence on this point is dated (CCA, 2013b; Atkinson & Zhang, 2024). Additionally, data from 2022 indicate that Canadian firms do not see how emerging technologies are relevant to their own operations (StatCan, 2024ab) (Section 8.2). SIBS found that between 2020 and 2022, companies that are most likely to adopt new technologies are those facing greater competition, those using advanced technologies, and multinationals (StatCan, 2024af). Training in innovation management skills can play a role in developing individual and corporate absorptive capacity (CCA, 2018b; Thomas *et al.*, 2024).

Beyond this important role for higher education institutions and the private sector, broader public engagement in STI learning through primary and secondary education, as well as social programs, can also bring about a shift toward a more innovative culture and one that is more likely to adopt new technologies. Fostering "creative insecurity," where firms compete and strive to perform highly, could help augment Canada's performance (Taylor, 2016). Vu and Dobbs (2025) note that "the role of innovation in Canadian society is neither neutral nor fixed." Social acceptance of innovations hinges on trust in both the technology and its creators, and plays a key role in adoption (Wu *et al.*, 2011). Uptake of innovations is shaped by attitude changes and social capital (Micheels & Nolan, 2016; Rogers *et al.*, 2019).

Cultivating regional strengths is a promising strategy for fostering growth

Meissner *et al.* (2017) observe the centrality of networks to most innovation efforts. More than 70% of Canadian patents originate in just five CMAs: Toronto, Ottawa–Gatineau, Vancouver, Montréal, and Kitchener–Cambridge–Waterloo (Kogler, 2025). Geographical clustering has been found to benefit a range of industries. Spencer *et al.* (2010) report that "when industries are located in an urban region with a critical mass of related industries, they tend to have both higher incomes and rates of growth compared with when they are situated in non-clustered settings." Despite the strengths of this approach, there is no overarching formula for establishing and fostering high-performing regions, and the appropriate strategies are sector and context-dependent (Wolfe, 2009; adMare Institute, 2023). However, access to a strong talent base and local institutional supports are both important elements (Wolfe, 2009). The Government of Canada's Global Innovation Clusters program focuses on five areas: digital technology, protein industries, advanced manufacturing, scale AI, and oceans, but does not emphasize geographical proximity (ISED, 2025c).

9.3 Canada's financial sector could foster innovation through enhanced investment

To reduce reliance on foreign investors, there are growing calls at the political and policy level for Canada's leading pension funds to enhance their domestic engagement in the innovation economy (Wallin & Deacon, 2023; Shufelt & Silcoff, 2024; Silcoff & Bradshaw, 2024; Thompson, 2025a). For example, roughly 12% of the Canada Pension Plan is invested domestically (while nearly half is invested in the United States), but only a fraction of that is in the innovation economy (Thompson, 2025a,b). Current pressures demand expanding engagement of and partnership with the broader financial sector (including banks, insurance firms, other investment firms, wealth management firms, family offices, and foundation endowments) as well as the corporate sector.

Tailored investment can help cultivate growth in key sectors and communities

Through efforts to bolster the availability of domestic venture capital, public sector risk capital programs have attracted more private capital into the sector, but deployment is concentrated in ICT areas (CVCA, 2025a,c; ISED, 2025b).

Encouragingly, a number of new funds are heavily focused on AI and related technologies (Zhu, 2024). Raising capital for life sciences, medical technology, clean tech, robotics, advanced manufacturing, and other deep tech companies remains challenging across all stages of the lifecycle (CVCA, 2025a,c). In the panel's view, these more capital-intensive sectors—in which Canada's research strengths align with global market opportunities—would benefit from tailored funding and support programs, co-designed with potential recipients to ensure relevance. Similarly, in the panel's view, to bolster economic resilience, Canadian investors need to own more of Canada's most promising new companies.

More generally, Canada's innovation economy would benefit from targeting resources to the commercialization of promising advances from its research base, creating robust new companies, and enhancing the innovation capacity of SMEs. This means a strategic review of all relevant programs at the interface of academia and industry, comparing them to best-in-class funding programs globally. The review would ideally encompass performance as it relates to investment in IP protection, de-risking technology, bridging talent to enable effective technology transfer, and pre-commercial funding for nascent companies advancing novel technologies to proof of concept. Given the considerable role of philanthropy in funding Canadian research, there is also an opportunity to explore innovative funding approaches in partnership with a new generation of donors who wish to see Canada's research excellence benefit patients, build new industries, create opportunities for graduates, and tackle complex societal challenges (Gartner, 2024).

Likewise, given Canada's small but diverse population and the high engagement of newcomers in entrepreneurship (Picot & Ostrovsky, 2021), continuing efforts to catalyze funding support for underrepresented founders, not least women, are important (Cukier, 2025). BDC Capital (2024) found that of the general partnerships (investment teams owning venture capital firms) surveyed, more than half (55%) are entirely owned by men, and only 34% were at least 25% owned by women; only 79% of general partnerships reported having investment committees that include at least one woman. At the portfolio level in this sample, only 16% of investee companies had a proportional representation of women (51%). As in other countries, it would be to Canada's advantage to explore creative partnerships among all levels of government as well as industry, community organizations, and private foundations. These efforts could include supporting employment opportunities for members of Indigenous communities in startup companies given that, as Raven Indigenous Capital Partners (2024) observes, "being an Indigenous entrepreneur can lead to unique priorities, grounding and challenges."

9.4 The public sector is a core actor in the STI ecosystem

Policy-makers are concerned about the extent to which value stemming from Canadian innovations ultimately leaves the country (Cockburn *et al.*, 2023; Deacon *et al.*, 2024). Many companies that start off in Canada are ultimately acquired internationally (Shufelt & Silcoff, 2024). In other jurisdictions, governments play important roles in creating the conditions for firm success and retention, and in fostering strategic areas of research and innovation.

9.4.1 Framework conditions

A robust STI ecosystem relies on a mix of supports

Governments face constant demands to support the STI ecosystem and are pulled in multiple directions:

- Direct funding support through grants and loans versus indirect support through the tax system;
- Supply-side support to push new research and innovations forward versus demand-side support to pull new research and innovations into the market;
- Upstream support for basic and applied research versus downstream support for innovation commercialization efforts; and
- Top-down, directed STI priority-setting (e.g., missions, moonshots, picking winners) versus bottom-up, non-directed selection of research questions and innovation priorities by other actors in the ecosystem, including industry.

Since there is no simple solution to balancing these tensions, Canada requires a more robust analytical capacity to understand the implications of these various types of support and approaches, and the most appropriate mix for its changing STI ecosystem. This panel was not tasked with evaluating specific government programs or interpreting prior program evaluations. However, it is the view of the panel that, given Canada's continued poor performance in innovation and the rapid changes taking place globally, the government's full toolbox should be critically re-examined to determine whether current STI funding programs and policies are the most impactful way for bringing about overall improvements to innovation, wealth creation, and broader benefits to society. This re-examination should be underpinned by the outcomes that Canada most wants from STI investments and should re-prioritize resource investments accordingly.

Canada's largest support for business R&D is the SR&ED tax incentive, an indirect program that covers a wide array of activities and sectors, and that provides roughly $3–5 billion in annual tax relief to roughly 20,000 firms (CRA, 2025). The form and degree of dependence on these incentives have been questioned for well over a decade (Jenkins *et al.*, 2011). Direct supports are also important and allow for more tailored interventions; however, only 30% of supports are of this type (Jenkins *et al.*, 2011; OECD, 2025d).

STI supports need to be simplified and client-focused

In a 2021 review of innovation programs in Canada, the Treasury Board Secretariat along with Statistics Canada identified 134 different federal programs that supported business growth and innovation, accounting for about $4.5 billion in federal spending to 33,000 businesses (StatCan, 2021b). Analysts suggest that this diversity of programs is itself problematic, creating a significant administrative burden when it comes to understanding and navigating the complexities of various programs (Jenkins *et al.*, 2011; Wallin & Deacon, 2023). Simplifying the suite of innovation supports on offer to the private sector can provide clarity and focus, and improve their overall performance (Snyder, 2018). In some instances, programs may not be designed to match the needs or capacity of intended applicants, and burdensome application criteria may favour incumbents over startups, or larger firms over SMEs (Deacon *et al.*, 2024). The panel underscores the importance of offering financial support that is relevant, sustainable, predictable, and delivered with the speed and administrative oversight commensurate with market demands and the resources of the applicant base. This friction is evident across the STI ecosystem, including for supports directed to post-secondary institutions, where public sector funders could enhance domestic recruitment and retention efforts, and augment researcher success, by easing the administrative burdens associated with research grant writing (Bouchard *et al.*, 2023).

Government procurement can boost demand for some innovations

Procurement can be a successful demand-side support, potentially improving the efficiency of public spending, influencing the development of innovations, and fostering technology adoption (Jenkins *et al.*, 2011; Mazzucato, 2018; Kundu *et al.*, 2020; Wallin & Deacon, 2023). MacDougall & Mathilakath (2025) decry the failure of big-ticket procurements to support domestic innovation and cultivate domestic strengths and resilience. The United States relies on Other Transactions agreements to enable more flexible contracting with partners that may be needed to support cost sharing and collaboration in innovative R&D (DARPA, 2019; ASPR, n.d.). Canada's Office of the Procurement Ombud has explored the potential for negotiated requests for proposals (NRFPs), which could offer similar flexibilities, and found that these NRFPs could play an important role in some contexts, encouraging innovation, enhancing risk sharing, and improving competition (OPO, 2025). The United States Small Business Innovation Research (SBIR) program has been touted as a promising model for delivering innovation support owing to its risk tolerance, strategic nature, and simplicity (Audretsch *et al.*, 2002). As originally conceived, the SBIR was a program to leverage government procurement as a tool for supporting innovative small businesses. Along with its sister program, the Small Business Technology Transfer (STTR), it supports new technologies using a phased approach, moving from feasibility studies through to commercialization (SBIR & STTR, 2025).

Innovative Solutions Canada shares some features with the SBIR, identifying needs from government departments and then funding the development of proof of concept, prototypes, and testing of private sector solutions, providing a first customer for emerging Canadian innovations (ISC, 2023). British Columbia's Integrated Marketplace is matching innovators with four testbeds (Vancouver International Airport, Prince Rupert Port Authority, Vancouver Fraser Port Authority, and the Provincial Health Services Authority) to develop and test solutions (Pacific Economic Development Canada, 2021; Kirkwood, 2025). Demand for the modernization of procurement practices in Canada is not new, and effective implementation is now critical (GC, 2018).

Harmonization and streamlining can minimize the negative impacts of regulations on innovation

While smart regulation can help spur innovation, the regulatory burdens faced by innovators in Canada can be considerable. Historically, Canada has been perceived as one of the easiest countries in which to do business. However, according to the World Bank, Canada ranked 23rd for ease of doing business in 2020, down from 4th in 2006 (IBRD & WB, 2006; WB, 2020). Analysis by Transport Canada and KPMG found that regulatory requirements rose 2.1% per year between 2006 and 2021, and that this overall accumulation is associated with a 1.7 percentage point decline in GDP and a 1.3 percentage point decline in business sector employment growth (Gu, 2025). In the panel's view, this points to the importance of reconsidering existing regulatory burdens and exploring new approaches appropriate for a more digital innovation economy. In somewhat the same spirit as NRFPs, regulatory sandboxes can provide flexibility and enable experimentation while maintaining essential safeguards (TBS, 2024).

Canadian regulatory requirements that diverge from those in comparator countries may deter businesses from operating in the relatively small Canadian market. Drug approval processes provide a clear example: drug approval times are longer in Canada relative to the United States, and the market is much smaller, which can deter or at least delay drug producers from entering the Canadian market (Rawson, 2018). Harmonized international standards are one means for advancing regulatory modernization (TC, 2023).

IP programs and policies struggle to maintain value domestically

Domestic policy plays an important role in shaping the incentives for patent creation and retention. Many innovation programs require that industry match funding or at least make a meaningful financial contribution, resulting in tension between the needs of industry to act in the interest of their shareholders and the government's desire to retain IP value domestically. The Government of Canada has invested in IP education programs for firms across a range of innovation sophistication and sectors, including IP Assist and Innovation Asset Collective (IAC, n.d.; NRC, n.d.). Additionally, the federal government is considering the creation of a patent box regime[31] intended to incentivize domestic IP retention through preferential tax rates (FIN, 2024). A more strategic approach to resourcing the earliest stages of commercialization of research (where market forces are often less effective) will be critical to building a new generation of globally competitive companies. Given the critical role of IP in the innovation economy, a review of IP policies is warranted to identify the most effective approaches.

9.4.2 Strategic interventions

Strategies to support innovation vary across sectors, but Breznitz (2021) has identified a common element among innovation success stories: local leaders "figured out why and where their agents of innovation were struggling (or in some cases why these agents did not exist) and then devised specific public policies with regard to particular domains in order to solve problems in particular points in the locales' growth cycles."

Focusing on fuelling key areas of strength can be difficult for a national government, where politics often favour spreading resources across the country. Canada's history of industrial support has been neutral and wide-ranging, with a lacklustre impact on innovation and productivity (Asselin, 2022). Given the state of Canada's productivity crisis and the compelling evidence on the advantages of regional ecosystems, the panel feels there is a strong rationale for fostering growth in key sectors at the regional level to achieve a density that

31 A tax incentive program designed to encourage domestic retention of intellectual property by offering reduced tax rates on income derived from patents and other innovations (FIN, 2024).

will position these clusters to compete globally, not just domestically. Box 9.1 explores one such example: applying many of the strategies described in this chapter could support improved performance in the construction sector, to the benefit of society.

Box 9.1 How STI can contribute to housing affordability

Canada faces a housing crisis wherein almost half of the respondents to a national survey reported concerns about housing affordability, and almost 10% reported problems with the suitability or condition of their housing (StatCan, 2024ag). In response, construction demands are high, and the construction sector occupies a growing share of Canada's economy, representing 12.6% of all hours worked and over 7% of GDP in 2024 (Caranci & Marple, 2024; StatCan, 2025h). However, this sector is dealing with low and falling labour productivity; as the sector grows, Canada's overall performance falls in turn (Caranci & Marple, 2024). Low productivity in this sector, combined with project delays due in part to regulation, also drive up the cost of housing, exacerbating the affordability crisis (CMHC, 2023; Perrault *et al.*, 2025). The demand for low-skilled construction workers is reshaping Canada's immigration strategy to favour low-skilled and sometimes temporary foreign workers, thus increasing housing demand and potentially displacing high-skilled immigrants (Mahboubi, 2024).

Many innovations could be deployed to improve labour productivity in the construction sector. For instance, with an increased reliance on alternative building materials or more automated building processes (e.g., modern approaches to modular home construction, including those using AI and agile robotics), the positive impact on Canada's economic growth would be considerable (Schlesinger, 2021; Caranci & Marple, 2024). Greater reliance on new construction technologies could offer co-benefits in terms of sustainability, inclusion, and fostering a high-skilled workforce (Whitzman *et al.*, 2024). Governments could aid in this transformation through streamlined regulations, incentives, supportive public procurement, and updated building codes, while educational institutions could develop centres of research and skills development to modernize the construction sector. Financial institutions, businesses, foundations, and communities could facilitate new funding approaches to support affordability. A new generation of modern

(continues)

(continued)

construction firms could tackle this significant global need in other markets. Ultimately, the private sector would be at the vanguard in working toward enhanced construction productivity.

Data-driven choices by innovation funders can better support specific growth sectors

Current circumstances have brought focused and sectoral strategies into the spotlight, with supporting policies designed to ensure that Canada capitalizes on the value of resulting innovations (Lapointe & Goldsmith, 2024). The panel identified several areas where a more focused approach could deliver better outcomes, and where governments are developing targeted strategies internationally:

- The **life sciences** sector aligns with key strengths in Canada's STI ecosystem, is a strong performer for VC investment, and offers unique potential to leverage AI and data in our health system for competitive advantage (adMare Institute, 2023; Barbosu, 2024; Azzi *et al.*, 2025). The Biomanufacturing and Life Sciences Strategy prioritizes pandemic readiness, domestic vaccine and therapeutics development and production, and broader sectoral growth (ISED, 2021).
- Governments also play an important role in fostering Canada's **clean tech** industry. Serious efforts to confront climate change hinge on major advances in STI. Canada could potentially capitalize on its resource sector, nuclear power sector, and access to critical minerals in order to take a leadership role in clean energy (Asselin, 2024). With the shift toward electrification well underway, countries that lead in the commercialization of supporting technologies—from solar panels to electric vehicles—will boost their competitiveness (Hermann, 2023). Canada has strengths to build on, already being home to 13 of the Global Cleantech 100 companies (The Cleantech Group, 2024).
- **Deep tech**[32] is a domain in which the public role could be critical. The payoffs of deep tech investment are highly uncertain, and the work is capital-intensive well before commercial revenues can be achieved (Maine & Seegopaul, 2016; Briggs, 2025). As such, standard investment mechanisms

32 Deep tech is characterized by "early-stage technologies based on scientific or engineering advances, requiring long development times, systemic integration, and sophisticated knowledge to create downstream offerings with the potential to address grand societal challenges" (Romasanta *et al.*, 2021).

are often a poor fit, so alternative pathways, including non-dilutive public investments in early stages, are needed (Nedayvoda *et al.*, 2021). Examples of deep tech include quantum, robotics, medical technologies, and advanced materials (Romasanta *et al.*, 2021).

9.5 AI has the potential to reverse declining productivity rates

AI represents one of, if not the most, disruptive technological forces of the modern era with impacts across the STI ecosystem (from research to commercialization) and economy. It also has the potential to reverse declining productivity rates (Nicholson, 2024). Canada's early strengths in AI are exemplified by the 2024 awarding of the Nobel Prize in Physics to Geoffrey Hinton, who co-led the pioneering work on artificial neural networks that underpins recent advances in AI, the 2024 Turing Award to Richard Sutton, and the 2018 Turing Award given jointly to Hinton, Yoshua Benjio, and Yann LeCun, formerly a post-doctoral fellow with Hinton (ACM, 2018, 2024; Nobel Prize Outreach, 2024).

However, there are challenges in commercializing AI innovations and integrating them into key economic sectors. The current performance of Canadian AI ventures relative to international peers is mixed, although there are some pockets of strength (Berkow, 2024; Vector Institute, 2025). As AI matures and comes to the market, Canada could benefit from prioritizing widespread AI adoption across multiple industries to achieve significant productivity and efficiency gains. New general-purpose technologies reshape the economy in three distinct waves. First, in the *replace wave*, new technologies displace the old, but the underlying processes and business models stay the same. Second, in the *reimagine wave*, new processes and business models are enabled by new technologies. Finally, in the *recombine wave*, a general-purpose technology "fuses with other technologies to create entirely new ones" (Blit, 2025).

There is extensive evidence of the potential benefits to be gained from the efficiency savings of engaging in AI's replace and reimagine waves, and Canada's efforts should be focused accordingly (Blit, 2025). While the productivity impacts of the replace wave will be meaningful, the effects of reimagining whole industries are much more powerful (e.g., the internet, as a general purpose technology, was used by Amazon to transform retail and by Uber to transform transportation). Four layers of activities supporting AI deployment are identified: infrastructure (cloud computing and hardware, including chips, servers, and networking equipment), models (large language models such as ChatGPT), services (providing an interface for customers to engage with AI models), and applications (using AI across the economy to do things better or differently); these layers are relevant at all stages. Focusing on the applications layer represents an important economic opportunity for Canada (Blit, 2025).

A focused and concerted approach across all sectors is likely needed, including both push and pull incentives; the pull side can include government working with industry to develop initiatives and policy incentives that encourage AI integration in both public and private sectors. AI is not a one-size-fits-all tool and will require expertise to determine the best way to adapt it to key industries, such as manufacturing, natural resources, and ICTs. As an example, AI has been identified as a tool to accelerate biopharmaceutical innovation from drug discovery through to manufacturing (Barbosu, 2024). AI talent development and upskilling through targeted education and training programs will be required to strengthen Canada's workforce. At the same time, AI literacy and training levels are low (KPMG, 2025), and the public reports low levels of trust and high levels of resistance to AI technologies (Edelman Trust Institute, 2024). Encouraging public trust in AI, with policy promoting AI ethics, security, transparency, and accountability, will help ensure broader societal acceptance and maximize the benefits of AI (G7, 2025). Despite the considerable commercial opportunities, the federal government's programs and investments have privileged research over adoption (Blit, 2025).

9.6 Understanding the connection between STI ecosystems and society

Theoretical conceptions of STI continue to evolve (Section 1.2.2), with the linear model giving way to increasingly complex and dynamic frameworks that recognize a wide range of actors and interconnections. In the context of the polycrisis, some of these newer frameworks call for a more explicit centring of societal well-being within STI policy. Tensions between these different approaches can create barriers to policy action.

New STI research and policy frameworks are emerging to support a transformative STI ecosystem

Broadly classified as transformative innovation policies, these frameworks include sustainable innovation policy, mission-oriented policy, and grand challenge programs, among others (Mazzucato, 2018; Haddad *et al.*, 2022). These new approaches often share concepts with adjacent efforts such as responsible research and innovation, highly integrative basic and responsive research, social entrepreneurship, and impact investing (Abreu & Grinevich, 2013; EC, 2013; Whitehead *et al.*, 2020; Agrawal & Jespersen, 2024). Some of these newer frameworks justify policy interventions not only on the grounds of market failures, but also more broadly in response to systemic weaknesses (Weber & Rohracher, 2012; Haddad *et al.*, 2022). Haddad *et al.* (2022) identify five common characteristics of these emerging transformative innovation policies:

- A focus on societal challenges and inclusive growth (e.g., in relation to the United Nations Sustainable Development Goals);
- Innovation is not supported for its own sake, but instead as a means to achieve societal outcomes—STI policy, therefore, exhibits directionality;
- The requisite policy interventions are varied and multiple, across a broad range of policy domains;
- A wider set of societal actors are included, requiring increased attention to governance; and
- All levels of governance are considered, and the roles and needs evolve over time.

New frameworks and approaches can centre societal well-being within local STI ecosystems

Alignment and a common vision among interest-holders is key to creating a thriving regional STI ecosystem (Budden & Murray, 2019, 2025). One or more research universities are often key anchors, but so too are private sector enterprises and government entities; the engagement and strategic alignment of multiple groups are crucial. Successful regional STI ecosystems are characterized by a concentration of not only people but also resources, including expertise, equipment, innovation-friendly customers, and investment capital (Budden & Murray, 2025).

Expanding on the remits of earlier CCA STI assessments, the charge asks the panel to identify barriers and knowledge gaps in translating Canadian S&T strengths into broader benefits for society. Building from MIT's Regional Entrepreneurship Acceleration Program (REAP), which helps regions around the world create and grow STI ecosystems (MIT REAP, 2025), Figure 9.1 shows one conceptualization of how society could be centred within an STI ecosystem. MIT REAP's (2025) innovation ecosystem model features five key groups: corporations, governments, universities and other post-secondary institutions, entrepreneurs, and risk capital. The panel's adaptation also recognizes that society interacts with each of the players in the STI ecosystem.

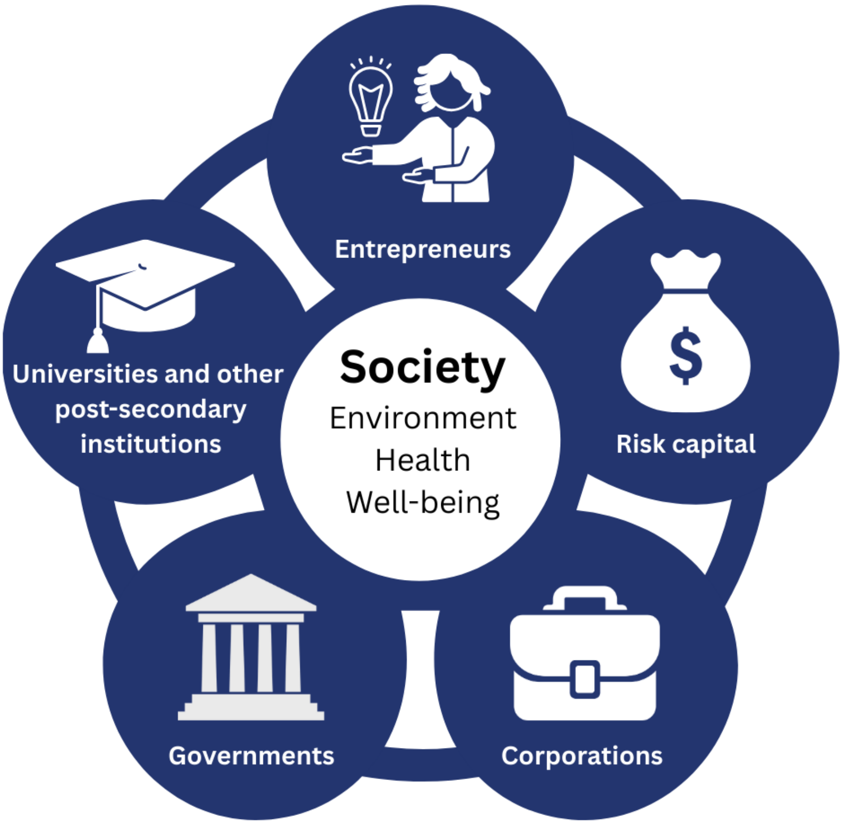


Figure 9.1 Innovation Ecosystem Stakeholder Model

MIT REAP identifies five key stakeholders in the innovation ecosystem: entrepreneurs, universities and other post-secondary institutions, governments, corporations, and risk capital. Societal outcomes are at the centre of contemporary STI ecosystems, and all stakeholders interact with society at large to achieve their goals.

9.7 Decision-relevant, real-time data and analysis are needed to drive improvements

Measuring Canada's performance is essential for strategic decision-making, but measurement challenges are pervasive. These include inconsistent definitions of innovation, lags in data collection and reporting, and a lack of comparable indicators. The shift to intangibles has also complicated measurement (Park *et al.*, 2024a,b; Munro & Lamb, 2025). Furthermore, disaggregated data are needed to understand performance across sectors and how the benefits of STI are being distributed. The panel struggled to draw meaningful insights about key economic sectors using data organized by NAICS codes. Data on training, participation, and leadership disaggregated by gender and racial identity would be policy-relevant, but are generally not available (CCA, 2024c).

This report comes at a critical time for Canada. If the *CCA State of STI in Canada* series is meant to provide evidence and guidance to members of Canada's innovation community, the frequency at which updates are commissioned does not allow for timely analysis. The current data collection frameworks and systems limit the potential for analysis that might empower continuous course corrections. In addition, it is critically important to understand Canada's performance in the context of the changing performance of other countries. In the panel's view, an ongoing assessment program with dynamic dashboards and more frequently updated scorecards would be better able to capture changes in the domestic and international environments, and better able to inform real-time and holistic approaches to emergent events (e.g., pandemics, political shifts, disruptive technological innovations like AI) that occur on timelines much shorter than every six years or so. Continual assessment could also provide more foresight and evidence to better navigate changing conditions. The panel accordingly sees merit in closer monitoring and a program of investigation into key priorities for improving Canada's STI performance, such as:

- Strengthening BERD through collaboratively developed incentives and policy reforms, as well as business leadership;
- Improving knowledge and understanding of the unique needs of Canada's young scaling firms to inform tailored supports;
- Advancing strategic sectors through data systems that recognize their complexity and unique features;
- Strengthening export capacity and improving understanding of challenges and opportunities emerging in shifting supply chains and trade patterns;
- Expanding domestic investment and ownership opportunities, particularly leveraging pension funds;
- Ensuring Canada remains a competitive player in the global economy as a developer and—more importantly—an adopter of AI technology across sectors;
- Bridging the gaps between research, commercialization, and productivity;

- Examining Canada's approach to IP policy including outward flow of IP and tracking metrics related to IP licensing and use, and academic–industry collaborations; and
- Exploring mission-driven R&D initiatives to align innovation efforts with national priorities in order to create wealth and broad societal benefits.

Only by addressing pressing challenges with a strategic and proactive approach, with improved real-time information, and with improved execution and evaluation of chosen strategies, can Canada secure its place in an uncertain global future.

10

Conclusion: Answering the Charge

Over the last 20 years, the CCA has carried out a flagship series of assessments that evaluate Canada's STI performance, the last of which was published in 2018. Recognizing the need for a new examination, ISED (the sponsor) asked the CCA to convene an expert panel to assess the state of STI in Canada, and how Canada compares internationally.

What is the state of science, technology, and innovation in Canada, and how does Canada compare internationally?

Canada is in a productivity crisis, compromising the country's ability to maintain and enhance the standards of living for people in Canada. This is compounded by challenges related to housing affordability, food insecurity, and income inequality. Additionally, rising levels of protectionism and a trade war with the United States, coupled with China emerging as an advanced technology economy, pose further risks to Canada's technological competitiveness and social and economic well-being. In this context, Canada's STI performance matters more than ever. Weak performance will amplify these problems, and strong performance is essential to improving Canada's future.

Canada has enjoyed many successes in science, technology and innovation; several of its post-secondary institutions are ranked among the strongest in the world; its population is highly skilled and educated; and its ICT industry excels. Canada also has world-class research outputs in a variety of scientific disciplines, as well as internationally competitive R&D strengths in several different industries.

Despite these strengths, however, Canada faces daunting challenges and declining performance across many indicators, particularly in business R&D and innovation. Spending on R&D is low and declining in key industries, and Canada is losing ground relative to comparator countries. Canadian post-secondary institutions often struggle to support the transfer of technologies to new companies. Startups struggle to access capital domestically and end up relying on foreign sources. While a revolution in AI is in full swing, bringing potentially game-changing opportunities, Canada's early advantages in AI are slipping away as other countries ramp up their efforts. Canadian firms are slow to adopt new technologies, and the rate of technology adoption is falling over time.[33] Innovation by Canadian businesses has noticeably decreased in recent years,

33 Given the broad nature of the panel's charge as well as time lags inherent in the data series examined, this report cannot give adequate attention to the significant opportunities and challenges that have emerged since 2023 with respect to AI. In the panel's view, priority attention is warranted.

even as expenditures on innovation activities increased over the same period. Similar observations have been noted in previous iterations of this series and by others; however, in the panel's view, the urgency of the situation has now reached a critical level. Without substantial improvements to its STI ecosystem, Canada risks severe economic and social consequences.

The panel notes that the sponsor's charge question and associated sub-questions (in boxes throughout this chapter) are, to some extent, grounded in ways of thinking about STI that may create challenges when it comes to capturing the structure and dynamics of current STI ecosystems. While the panel has endeavoured to present the best data available, many important parts of the STI ecosystem are not measured or are not measurable. As a result, these data ultimately miss key pieces of the STI ecosystem, particularly in relation to innovation. What is often being measured is the *research and invention ecosystem*—roughly, the creation of new knowledge or technology—rather than the *innovation ecosystem*, which involves the use and impact of relevant knowledge or technology.

What are the S&T areas—i.e., scientific disciplines and technological applications—in which Canada excels, and how does Canada compare to peer countries?

Canada excels in several different areas of scientific research, technological invention, and industrial R&D and innovation. However, these areas frequently do not overlap. Table 10.1 shows the fields in which Canada performs well relative to comparator countries with respect to scientific publications, patents, and industrial R&D expenditures.

Table 10.1 Canada's S&T strengths

Publications	Patents	Industrial R&D expenditures
Public Health and Health Services: substance abuse; gerontology; epidemiology **Clinical Medicine:** respiratory system; general and internal medicine; psychiatry; emergency and critical care medicine; dermatology and venereal diseases; environmental and occupational health; ophthalmology and optometry **Biology:** ornithology	**Chemistry:** chemical engineering; environmental technology; materials and metallurgy **Instruments:** control; measurement **Mechanical Engineering:** engines; pumps and turbines; handling; mechanical elements; thermal processes and apparatus; transport **Other:** furniture, games; other consumer goods	**Scientific Research and Development Services** **ICT:** software publishing; provision of ICT services and infrastructure; telecommunications **Publishing and Related Activities** **Manufacturing:** food and beverages; paper and paper products

Publication and patent strengths are based on bibliometric and technometric analyses conducted by Science-Metrix. Publication strengths correspond to those sub-fields with at least 1,000 publications (full counting) in which Canada's GR and GI exceed the world's. Patent strengths correspond to those sub-fields in which Canada's specialization, citation impact, and GRs are nearly at or above the world average. Industrial R&D strengths are based on R&D expenditures by industry, looking at industries in which the intensity and CAGR rank high relative to G7 countries.

The general lack of alignment among Canada's strengths in publications, patenting, and R&D expenditures is due to several factors. The misalignment is exacerbated by data challenges, insofar as the various classification schemes for publications, patents, and industrial R&D sectors are not easily comparable. However, it also points to real issues. The misalignment reflects (in part) the country's industrial structure, the diversity and ongoing evolution of its STI ecosystem, and the transitioning innovation economy, but also highlights Canada's challenges in reaping the benefits of its research strengths through innovation and commercialization. While some variation is to be expected, and while not all research is undertaken with a goal of impacting innovation, the limited overlap among strengths may point to research not well-aligned with industry needs, a lack of absorptive capacity, or structural barriers within the ecosystem.

How are strengths distributed by region and sector across the country?

Canada's top-publishing CMAs largely correspond to the location of its top universities. Five CMAs—Toronto, Montréal, Vancouver, Ottawa–Gatineau, and Edmonton—account for nearly half of all of Canada's publications. However, the presence of a top research university does not always explain differences among CMAs. Although the University of British Columbia leads McGill University in publication output, Montréal significantly outperforms Vancouver, reflecting the combined contributions of McGill, Université de Montréal, and other institutions. Canada's most impactful CMA (as measured by the citation impact of its publications) is Kitchener–Cambridge–Waterloo, followed by Toronto, Vancouver, Calgary, and Montréal, though several others have a publication impact above the world average.

The CMAs responsible for the largest share of patents in Canada are Toronto, Kitchener–Cambridge–Waterloo, Montréal, Vancouver, and Ottawa–Gatineau. Growth in patenting activity is higher than the world average for several CMAs in Canada, including Halifax, Saskatoon, Montréal, Calgary, Toronto, Vancouver, and Quebec City. By contrast, the CMAs with the lowest patent growth relative to the world average are Kitchener–Cambridge–Waterloo and Ottawa–Gatineau, reflecting the loss of large, R&D-intensive firms. For patenting impact, only a few municipalities in Canada—specifically Vancouver, Halifax, and Saskatoon—perform above the world average. Most CMAs have impact values below the world average.

In which S&T areas has Canada shown the greatest improvement / decline in recent years, and why?

Despite an increasing publication output, Canada and many other countries are losing ground to China, India, and Russia. Similarly, between 2012 and 2023, the GR of Canadian patenting at both the USPTO and the EPO fell below the global average, dropping Canada from 14th to 15th place out of 20 comparator countries at the USPTO. Between 2012 and 2023, Canada continued to specialize and produce more highly cited publications in the fields of public health and health services, clinical medicine, and ICTs. However, Canada's patenting activity in telecommunication dropped considerably from the previous report, along with basic communication processes, and digital communications. Patent fields showing a higher GR than Canada's average included food chemistry; engines, pumps, and turbines; IT methods for management; and medical technologies.

Over the past two decades, Canada's R&D has shifted substantially away from manufacturing and overwhelmingly toward services. This shift was largely due to the ongoing deindustrialization of Canada over the past several decades, as well as the decline of several notable R&D-intensive Canadian manufacturing companies such as Nortel, RIM/BlackBerry, and Bombardier. In more recent years, there have been substantial increases in R&D spending in the fields of software engineering and technology, industrial biotechnology, Earth and environmental sciences, and medical and health sciences. In the natural resources sector, R&D spending in mining and quarrying has substantially increased, while decreasing in the oil and gas industry.

Which S&T areas have the potential to emerge as areas of prominent strength for Canada?

Identifying potential emerging areas of strength is difficult, as many areas in which Canada excels are long-established as national strengths. As such, this analysis focuses on the areas in which the GR of publications, patents, and R&D expenditures has increased since the last iteration of this assessment in 2018. Based on the Science-Metrix bibliometric analysis, sub-fields that have shown publication growth include gerontology, respiratory system, general and internal medicine, epidemiology, ophthalmology and optometry, and ornithology. Meanwhile, emerging sub-fields of strength in patenting include food chemistry, control and measurement instruments, engines, and pumps and turbines. Based on an Australian study, Canada shows considerable strength and impact in 26 of 64 critical technologies identified as having the ability to significantly affect a country's economic prosperity, social cohesion, or national security. Importantly, these strengths overlap significantly with Canada's Sensitive Technology List, which includes topics such as quantum technologies, advanced sensing and surveillance, energy technologies, and AI, among others.

In Canada, the fastest-growing business R&D expenditures are in information and cultural industries, which include publishing, media, broadcasting, and internet services; these industries possess an R&D magnitude, intensity, and GR above the average across all industries. R&D expenditures in several natural resource-based industries are also among the fastest-growing in Canada, including forestry, mining, and fishing, hunting, trapping, and aquaculture. Other industries with high R&D spending growth include the manufacturing of motor vehicles, and finance and insurance. In 2021, Canada's R&D intensity in nine strategically important advanced, traded industrial sectors—e.g., aerospace and defence, software and computer services, pharmaceuticals and biotechnology—was much lower than the global average.

How are expenditures in different S&T activities evolving over time in Canada and in relation to peer countries?

Canada's R&D intensity (i.e., total expenditures on R&D as a percentage of GDP) decreased between 2001 and 2022. By contrast, in many peer countries, R&D intensity increased over the same period. Compared to other countries, Canada spends relatively less on business and government R&D and more on higher education R&D. Both federal and provincial/territorial governments increased their funding for R&D performed by businesses between 2018 and 2022, as did foreign sources. At the same time, these governments, businesses, and foreign sources decreased funding for R&D performed in the higher education sector.

Indirect government support for business R&D through tax incentives decreased in Canada between 2000 and 2021, while direct support for business R&D increased. This trend was reversed among OECD countries more broadly, resulting in Canada moving closer to the OECD average of direct versus indirect government support for business R&D as a percentage of GDP.

R&D expenditures in Canadian SMEs have increased relative to large firms in recent years. The proportion of Canada's in-house business R&D expenditures performed by foreign-controlled firms has increased, rising from 30% in 2000 to 38% in 2022. Foreign MNEs significantly outpaced Canadian MNEs and non-MNEs in the growth of R&D expenditures (and personnel) between 2014 and 2022.

How does Canada's distributed science, technology, and innovation ecosystem enable or limit success at various points on the technology development spectrum, including discovery, invention, demonstration, commercialization, and company growth (including the pros and cons of this system)?

Canada's STI ecosystem is widely distributed not only geographically but also across businesses, academic institutions, multiple levels of government (and their departments and agencies), and a wide variety of other organizations, including regional development agencies, financial institutions, incubators and accelerators, and research infrastructures.

In general, Canada's distributed STI ecosystem enables success by supporting supply-side inputs such as basic and applied research, education and skills development, and support for entrepreneurship and startups. However, in the panel's view, coordination and alignment problems as well as a lack of focus on demand-side policy interventions have made it difficult to translate these strengths into the scale-up and growth of innovative domestic firms that remain in Canada. These challenges are compounded by Canada's small and diffuse local market and its lack of absorptive capacity for adopting innovations.

What are the key barriers and knowledge gaps in translating Canadian strengths in S&T into innovation, wealth creation, and broader benefits to society? How can these barriers and knowledge gaps be addressed?

Several features of Canada's STI ecosystem may hinder translating research into innovations that provide economic and social benefits. These features are discussed below.

Difficulty retaining resources and value in Canada: Many companies founded in Canada are later acquired internationally due to limited available domestic financing for early-stage startups or companies looking to scale rapidly. This forces domestic firms to look for foreign investors, largely in the United States. While foreign investment can yield benefits when core activities remain in Canada, it can result in a loss of economic benefits domestically that impede the growth of Canada's STI ecosystem. Furthermore, the average VC deal size in Canada is relatively small compared with that in the United States, and public funding does not always meet the needs of innovative or early-stage companies.

Other sources of funding may exclude smaller companies by requiring matching funds, upfront payments, or a minimum number of employees. Addressing these funding and scale-up challenges may require targeted policies that encourage domestic investment, possibly strengthening the role of pension funds and institutional investors. Additionally, incubators and accelerators have an important role to play in supporting the scaling up of nascent firms.

Canada also has difficulties retaining HQP; this is often referred to as the brain drain. While Canada is successful at attracting foreign talent for post-graduate training, many go on to leave the country for employment opportunities, resulting in a net drain of HQP. However, the changing research environment in the United States may provide an opportunity to attract talent to Canada, given appropriate incentives.

Low rates of technology adoption: Businesses in Canada are slow to adopt new technological innovations. The most commonly-cited reason for not using advanced or emerging technologies and not investing in capital expenditures in such technologies—by a wide margin—is that they are not applicable to the business's activities or necessary for continuing operations. This suggests that Canadian businesses may not feel the need to adopt or use new technology and, more generally, may not have incentives to undertake technological innovation. It has long been noted that Canadian businesses tend to be only as minimally innovative as they need to be due to factors such as Canada's industrial structure or a need for more competition in certain markets. Others note a need for increasing business and innovation management skills among those trained in STEM fields. In the panel's view, the lack of absorptive capacity to utilize innovations is a key barrier to translating Canadian strengths in S&T into innovation and productivity, wealth creation, and broader benefits to society.

A lack of large firms in innovative sectors: Business R&D expenditures are persistently low in Canada and are declining in several key industries. Canada's low business R&D investment may be a symptom of a more fundamental problem: a lack of large firms. The relatively strong R&D performance of Canada's small firms is insufficient to offset the lack of large innovative firms, which tend to pay higher salaries and are more likely to adopt new technologies.

A lack of strategic intervention and focused STI priorities: Simplifying the suite of innovation supports on offer may improve the clarity, focus, and performance of Canada's STI ecosystem. As of 2021, the federal government has reported 134 distinct federal programs providing a combined $4.5 billion in innovation supports to 33,000 businesses. Strategies to support innovation vary across industries. Successful innovation often hinges on identifying specific areas of struggle and establishing tailored policy interventions in response.

In the panel's view, there are several areas where a more focused approach could deliver better outcomes, including life sciences and biotechnology, clean tech, and deep tech. Moreover, these opportunities are not easily captured by traditional measurements of the STI ecosystem.

Data challenges: Measuring Canada's performance is essential for informing decision-making, but data gaps and measurement challenges are pervasive. These challenges include inconsistent definitions of innovation, lags in data collection and reporting, a lack of comparable indicators or taxonomies that track emerging industries, and the shift toward a harder-to-measure, intangibles economy. Traditional bibliometric and technometric analyses provide useful metrics for assessing activity, impact, and expertise, but these are intermediate indicators of innovation. Patent data are used to capture the outputs of research and technology development but patents apply to only a portion of the economy. The panel struggled to draw meaningful insights about key economic sectors using data organized by NAICS code.

There are also critical elements of the STI ecosystem that do not lend themselves to measurement. Traditional STI measurement approaches and frameworks that prioritize economic growth may marginalize or undervalue Indigenous understandings of success. Beyond the need for more and better data and measurement frameworks, there is a need for more capacity in real-time monitoring, assessment, and foresight activities, as well as cross-sectoral dialogues—all of which can provide a more robust means of analyzing emerging industries, technologies, and trends. If the *CCA State of STI in Canada* series is meant to provide evidence and guidance to policy-makers and members of Canada's STI community, the frequency at which these reports are commissioned does not allow for timely analysis. In the panel's view, an ongoing assessment program with dynamically refreshed products would better capture changes in the domestic and international environments, and provide the foresight and evidence needed to navigate changing conditions better.

Closing reflections

While new metrics should be developed, the panel's findings leave no doubt about the need for action. It is clear that Canada still lacks effective approaches to support the development and commercialization—across the continuum from research to deployment—of the most promising areas that could improve national competitiveness and provide greater overall economic and societal benefits.

A high-performing STI ecosystem is essential to the well-being of all people in Canada. Without ambitious and decisive action across the ecosystem to reverse declining performance, Canada’s economy will struggle to provide Canadians with a standard of living they have come to expect. Without improved governance, greater public–private collaboration, and effective execution, Canada’s highly fragmented system will likely continue to underperform. The nation’s ability to deliver quality public health care and education, job opportunities, and affordable housing will be jeopardized. The set of societal challenges Canada faces today surely provides the burning platform needed to drive bold changes.

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