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Innovation in focus: Exploring trends in the development of advanced technology through patent applications

by **Dominique Gagnon**

Abstract

This article explores trends in patent applications made by Canadian-resident businesses for advanced technologies from 2001 to 2019, drawing on Eurostat's aggregation of high-tech patents. Approximately one-third of applications fall under high-tech categories, the bulk of which were associated with Communication, Computer, and Automated business equipment technologies. While these fields saw growth until 2012, a subsequent decline occurred, notably in Computer and Electronic Product Manufacturing. Biotechnology, Semiconductors, and Lasers showed limited dynamism, while aviation technology applications surged by nearly twentyfold over the period. Examining innovation outputs based on the multinational status of applicants, we find Canadian Multinational Enterprises (MNEs) demonstrated superior intellectual property generation with 4 in 5 high-tech patent applications originating from Canadian-controlled entities.

Context

Advanced technologies play a pivotal role in the economic development of a highly industrialized nation such as Canada. The constant evolution of technology impacts high-tech businesses as they strive to maintain their position at the forefront of innovation, playing a crucial role in shaping the future of industries and societies alike. Embracing and harnessing advanced technology not only fuels economic growth but also elevates a nation's productivity and global competitiveness.

The patent system can be a key driver for technological advancement. Through the provision of exclusive rights over the exploitation of newly developed technologies for a specified period, this system incentivizes businesses to engage in innovative endeavors. Supporting this notion, research by Abbes, C., Baldwin, R., & Leung, D. (2022b) reveals that Canadian-resident enterprises that filed for a patent were 7.5% more likely to experience high employment growth and 12.9% more likely to experience high revenue growth than their "non-filer" counterparts.

Beyond its primary function to protect an organization's creative investments, the patent system also facilitates the collection of data related to technologies. Analyzing patent statistics becomes instrumental in understanding the maturity levels of distinct technologies and unveiling emerging trends within the national technological landscape. By meticulously scrutinizing technology-related patent applications alongside the count of applicants, whether research initiatives exhibit concentration or dispersion can be effectively discerned. Furthermore, the analysis of patent statistics also helps in identifying regional proficiency in specific technology sectors in a national context.

The data for this analysis come from the Canadian Patent Research Database (CPRD), which is built by linking the European Patent Office's (EPO) Worldwide Patent Statistical Database (PATSTAT) with other administrative data holdings at Statistics Canada. Abbes, C., Baldwin, J.R., Gibson, R., & Leung, D. (2022a) have outlined the methodology employed in the development of the CPRD. Additionally, their work sheds light on the evolving trends in patent applications made by Canadian-resident businesses from 2001 to 2015. Notably, they observe a rise in applications from small firms in the service industry, contrasting with a decline in applications from large manufacturing firms during the same period. Gibson R. and Leung D. (2023) further contribute additional insights into methodological enhancements made to the database. Notably amongst those, the CPRD now includes all firms that file for patent applications rather than solely the first business on each application, the improved linkage rate further ensures completeness, and the series have been refreshed to include activity up to 2019.

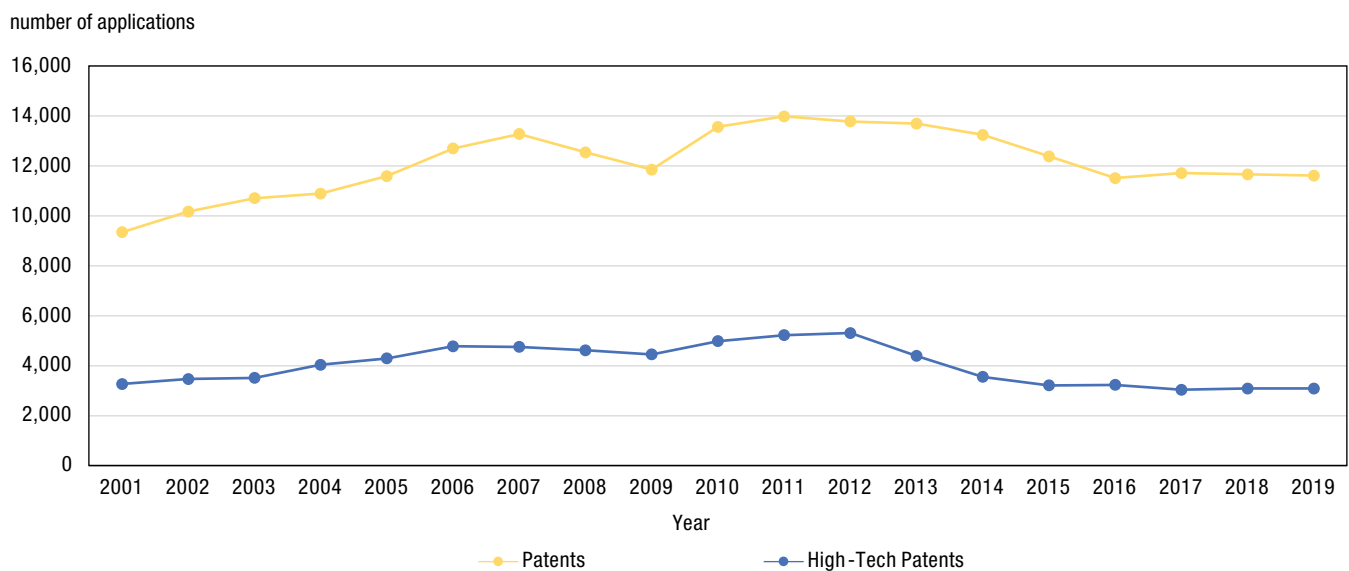
This article utilizes patent application statistics from Canadian-resident enterprises, spanning the years 2001 to 2019, to pinpoint trends in the development of key technologies in Canada, focusing on a basket of high-tech (H-T) patent applications utilizing Eurostat aggregation of high-tech patents. This aggregation employs the International Patent Classification (IPC) subclass to categorize applications into six advanced technology groups: **Computer and automated business equipment, Aviation, Lasers, Semiconductors, Communication technology, and Biotechnology**. For the purpose of this analysis, the CPRD is further linked to Activities of Multinational Enterprises (AMNE) data to identify multinational enterprises (MNEs).

High-Tech patent applications accounted for a third of all patent applications made by resident enterprises in Canada between 2001 and 2019

Overall patent applications in Canadian-resident enterprises saw a robust expansion from 2001 to 2007 (+42.1%) which was followed by a contraction (-10.7%) during the 2008-2009 financial crisis. Applications recovered between 2009 and 2011 (+18.0%) but again experienced a period of decline in the years that followed, bottoming out in 2016 (-17.7%).

High-tech patent applications constituted a substantial portion of overall patent applications from 2001 to 2019, averaging 33.1%. This proportion reached a peak of 38.6% in 2012 before receding to 26.6% in 2019. There was a substantial growth in high tech applications from 2001 to 2006 (+46.0%), followed by a moderate reduction from 2006 to 2009 (-6.7%) leading to another period of growth until the peak of 2012 (+19.2%). However, a substantial departure from the earlier growth trajectory followed the peak with applications dropping by 41.9% between 2012 to 2019.

Chart 1
Patent Applications of Canadian-resident businesses – 2001–2019



Source: Canadian Patent Research Database (CPRD).

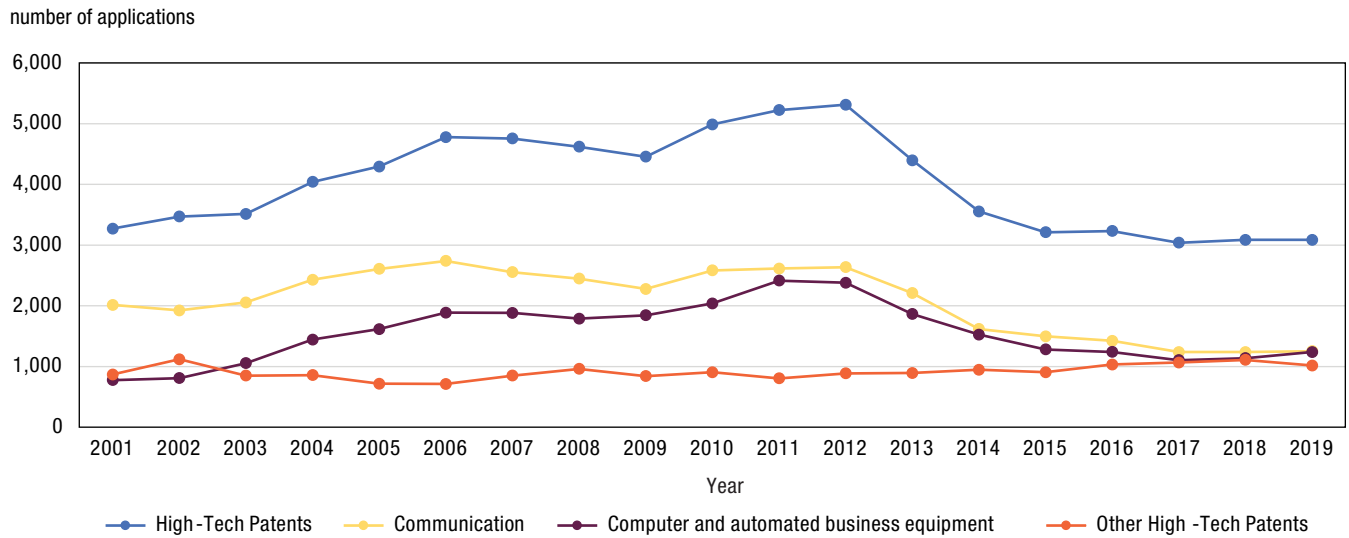
Communication, Computer, and Automated business equipment technologies account for most of the growth and subsequent decline in high-tech applications between 2001 and 2019.

Patent applications for Computer and Automated Business Equipment, as well as Communication Technology, accounted for the largest portion of high-tech patent applications from 2001 to 2019. They were also responsible for most of the growth in high-tech applications from 2001 to 2012 and the subsequent decline. The variation in applications for these two technology groups was chiefly driven by the Computer and Electronic Product Manufacturing sector, paralleling the rise and fall of Canada’s lead in mobile device manufacturing.

From 2002 to 2006, communication technology patent applications experienced a robust annualized growth rate of 9.2%. The development of these technologies slowed from 2006 to 2009 with applications declining at an annualized rate of -6.0% but recovered in the aftermath of the financial crisis with applications posting an annualized rate of 5.0% from 2009 to 2012. Concurrently, computer and automated business equipment technology patent applications exhibited an annualized growth rate of 23.6% between 2002 and 2006, rapidly catching up to the level of communication technology applications. Despite a modest decrease of 5.2% from 2006 to 2008, computer and automated business equipment technology again outpaced the growth in applications for

communication technologies during the recovery, showcasing an annualized growth rate of 8.9% between 2009 to 2012. However, the years following 2012 presented challenges, with both communication technologies and computer and automated business equipment technologies witnessing a rapid reduction in patent applications, particularly from the Computer and Electronic Product Manufacturing sector.

Chart 2
High-tech Patent Applications of Canadian-Resident Businesses – Selected Technology Domains – 2001–2019

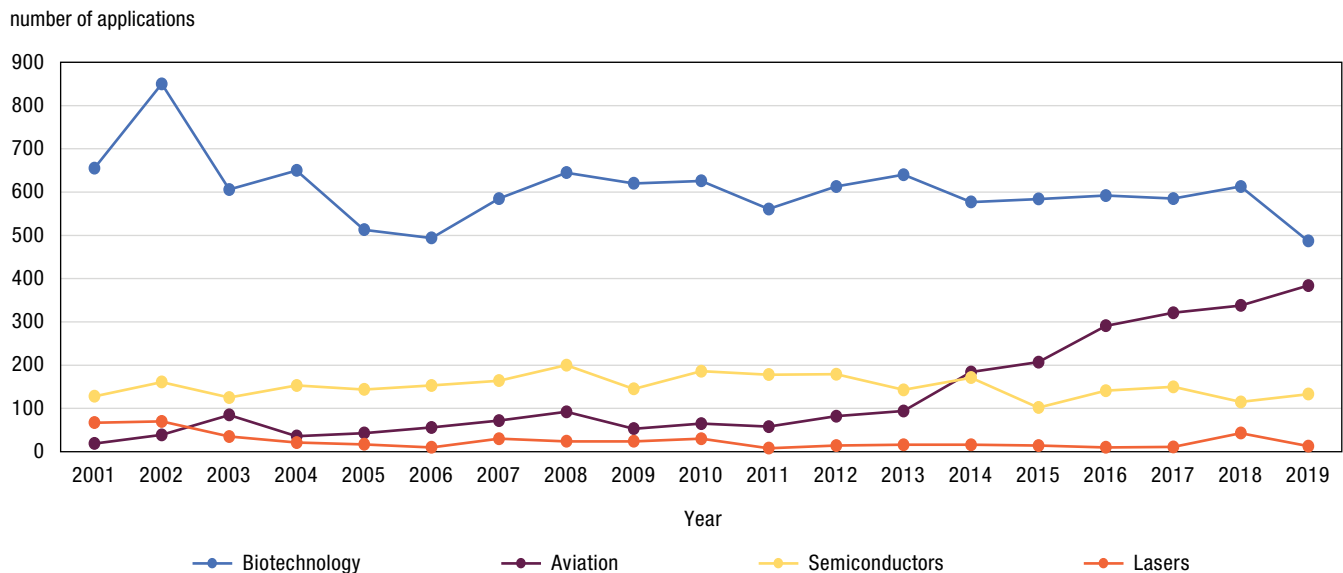


Source: Canadian Patent Research Database (CPRD).

Aviation technology applications converging with biotechnologies after passing both semiconductors and laser technologies applications.

Over the entire examined period, the landscape of high-tech patent applications in Canada reveals distinct trajectories for various technology sectors. Biotechnology patents emerged as the third most common high-tech application, maintaining relative stability at around 600 applications after a decline from a peak of 850 applications in 2002. In contrast, aviation technology applications experienced annualized growth of 18.2% per year. This upward trend resulted in them surpassing laser technology applications in 2003 and semiconductor technologies in 2013. Notably, as of 2019, aviation technology patent applications were just 103 applications shy of overtaking biotechnologies in terms of frequency. Meanwhile, semiconductor technology applications maintained an average of 151 applications per year, reaching a peak of 200 in 2008 and falling to 133 by 2019. Like biotechnology applications, laser technology applications peaked in 2001 and 2002 at 70 applications but have since remained relatively low.

Chart 3
High-tech Patent Applications of Canadian-Resident Businesses – Selected Technology Domains – 2001-2019



Source: Canadian Patent Research Database (CPRD).

Applications for high-tech patents by Canadian-controlled MNEs outpaced those of their foreign-controlled counterparts.

Drawing on data from the Activities of Multinational Enterprises (AMNE) program,¹ the contribution of MNEs in driving high-tech innovation in Canada can be considered. Using 2019 as the reference year, the AMNE program reports the presence of 13,528 Canadian-controlled MNEs, 17,794 Foreign-controlled MNEs, and 2,789,565 Non-MNEs in Canada.

When comparing Canadian-controlled MNEs with their foreign-controlled counterparts, similar intensities in terms of intramural R&D expenditures are observed, with both groups spending around 520 thousand dollars per enterprise. Additionally, there’s a slightly higher intensity in R&D personnel for Canadian-controlled MNEs, with 3.54 R&D personnel per enterprise compared to 3.38 for foreign-controlled MNEs. However, these comparable figures translate to significantly more Gross Fixed Capital Formation (GFCF) in Intellectual Property (IP) for Canadian-controlled MNEs, at 1.37 million dollars per enterprise, compared to 0.77 for their foreign-controlled counterparts. In other words, Canadian MNEs appear to generate more intellectual property assets for a similar level of R&D investment.

1. The Activities of Multinational Enterprises in Canada program describes the characteristics, activity, financial position and performance of multinational enterprises in Canada.

Table 1
Activities of MNEs in Canada, Canadian and foreign MNEs – Selected Statistics – 2019

	enterprises	Total Intramural R&D expenditures	R&D personnel	GFCF of IP
	number	millions of dollars	number of employees	millions of dollars
Canadian-Controlled MNE	13,528	7,003	47,938	18,543
Foreign-Controlled MNE	17,794	9,287	60,184	13,632
Non-MNE	2,789,565	5,630	60,266	14,596

Source: Table 36-10-0356-01 Activities of multinational enterprises in Canada, Canadian and foreign multinationals, as a share of the Canadian economy.

Turning our attention to patent applications, while roughly 1 in 4 applications originating from foreign-controlled MNEs were related to advanced technology, the figure was closer to 1 in 3 for Canadian-controlled MNEs. Furthermore, the majority of high-tech patent applications filed by Canadian-resident enterprises were attributable to Canadian-controlled entities. On average across high-tech fields, when excluding applications related to aviation, as many as 85% of the patent applications originated from Canadian-controlled enterprises. This may be surprising at first, considering that globally, most high-tech companies are foreign-controlled MNEs and that many of them do operate subsidiaries in Canada. This may suggest that, to some extent, these foreign-controlled MNEs may not be carrying out much of their most high-tech R&D in Canada, but instead are focusing on operational activities such as wholesaling and distribution, production and assembly, sales and marketing, lobbying and customer support. Whereas Canada has restrictions limiting foreign control of telecommunications operators and of airline carriers in Canada to a maximum of 20% and 49% respectively, this does not play a significant role in any of the technology fields in focus as neither of these industry groups account for a large share of applications in any of the fields.

Conversely, within aviation, foreign-controlled MNEs claimed a majority (52.6%) of applications. This aligns with the broader understanding that the aerospace domain is largely dominated by a few large American and European MNEs that fulfill both commercial and military functions and the riskiest R&D is very often directly financed through budget allocation for National Defense. The critical strategic interests of major powers contribute to shaping a domain influenced by protective policies and actions that limit the ability of Canadian-controlled enterprises to compete in the field, as the recent case of the Bombardier C-Series exemplifies.²

Table 2
Percentage of applications that are H-T and distribution of H-T applications by MNE status – 2019

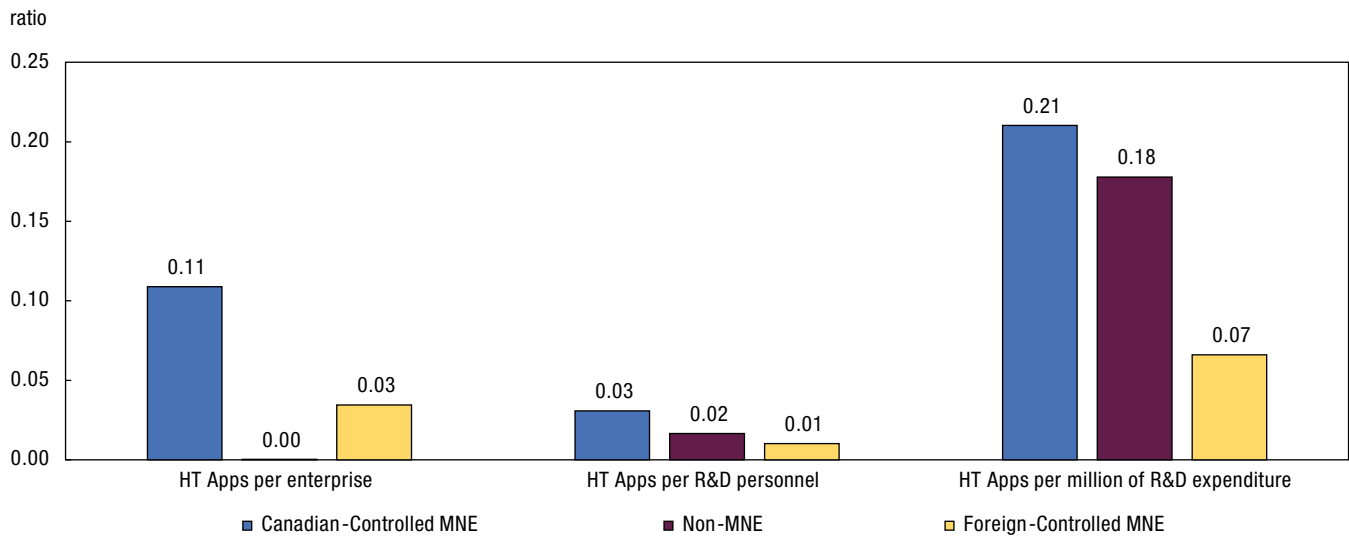
	Canadian-Controlled			Foreign-Controlled
	MNE	Non-MNE	Both	MNE
	percent			
Applications that are H-T by MNE status				
All H-T	32.0	22.1	27.1	25.9
Distribution of H-T applications by MNE status				
All H-T	47.7	32.4	80.1	19.9
Lasers	46.2	30.8	76.9	23.1
Aviation	35.2	12.2	47.4	52.6
Communication	55.0	27.4	82.4	17.6
Biotechnology	28.5	59.1	87.7	12.3
Semiconductors	48.9	44.4	93.2	6.8
Computer and automated business equipment	55.2	30.8	85.9	14.1

Source: Canadian Patent Research Database (CPRD), Table 36-10-0356-01 Activities of multinational enterprises in Canada, Canadian and foreign multinationals, as a share of the Canadian economy.

2. [Bombardier's Steep Descent and the Geopolitics of Aerospace — McGill Business Review.](#)

Extending the analysis to consider enterprise counts, intramural R&D expenditure, and R&D personnel, Canadian-controlled MNEs are observed to outpace foreign counterparts in high-tech applications per enterprise (0.109 vs. 0.034), per R&D personnel (0.031 vs. 0.010) and in terms of high-tech applications per million dollars of R&D expenditure (0.210 vs. 0.066). Conversely, while the large number of non-MNEs across the country, which includes most Small and Medium-sized Enterprises (SMEs), results in a low rate of high-tech patent applications per enterprise, non-MNE enterprises in Canada nonetheless surpassed foreign-controlled MNEs in the rate of high-tech patent applications per R&D personnel (0.017 vs. 0.010) and per million dollars spent in intramural R&D expenditure (0.178 vs. 0.066).

Chart 4
High-tech patent applications per enterprise, R&D personnel and million of dollars spent on R&D – 2019



Source: Canadian Patent Research Database (CPRD), Table 36-10-0356-01 Activities of multinational enterprises in Canada, Canadian and foreign multinationals, as a share of the Canadian economy.

Conclusion

Leveraging Eurostat’s aggregation of high-tech patents to discern trends in patent applications by Canadian-resident businesses for various advanced technologies, our findings reveal that up to one-third of applications between 2001 and 2019 fall in a high-tech category. Predominantly, these applications are associated with Communication, Computer, and Automated business equipment technologies. Although these technologies witnessed notable growth in applications from 2002 to 2012, a subsequent rapid decrease followed led by a reduction in applications from the Computer and Electronic Product Manufacturing sector. Biotechnology, ranking as the third most important technology field amongst domains studied, has shown limited dynamism over the period. The same can be said for Semiconductors and Lasers, which ranked 4th and 5th out of the 6 categories, respectively, in terms of applications. In contrast, aviation technology applications have experienced a remarkable growth between 2001 and 2019, surging nearly 20-fold.

Further examination of the differences in innovation outputs by the MNEs status of applicants, shows that despite comparable intramural R&D expenditures and only slightly higher intensity in R&D personnel compared to their foreign-controlled counterparts, Canadian MNEs appear to generate more intellectual property assets and accounted for significantly more high-tech patent applications in 2019, except for the aviation domain, where foreign-controlled MNEs lead applications by a slight margin. Nonetheless, with up to 80% of all high-tech patent applications originating from Canadian-controlled applicants, further investigation may be warranted to better understand whether differences in innovation outcomes are attributable to variations in the mix and technological intensity of activities conducted by foreign-controlled subsidiaries in Canada vis-a-vis their Canadian-controlled counterparts.

While the innovativeness of the Canadian-controlled businesses in advanced technology segments is positive, the comparatively lower innovation output in advanced technology from foreign-controlled businesses in Canada raises questions and aligns with existing concerns about the potential consequences of foreign acquisitions of Canadian high-tech enterprises. There is a prevalent fear that such acquisitions may ultimately lead to the relocation of their most advanced Research and Development (R&D) activities outside of the country. To delve deeper into this issue, a more comprehensive analysis of patent applications, similar to the one presented here, could offer valuable insights by examining the patterns of patenting in advanced technologies both before and after foreign acquisitions, serving as a crucial step in shedding light on the impact of these transactions.

Finally, it is worth noting that additional patent aggregations and identification methods exist and could be leveraged in future analyses to help shed light on other technology domains of interest.

To learn more about the patent applications made by Canadian-resident businesses:

[Canadian Patent Research Database \(statcan.gc.ca\)](https://www150.statcan.gc.ca/n1/pub/28-263-x/2019001/article/00001-eng.htm)

This paper documents the use of the Worldwide Patent Statistical Database (PATSTAT), a global patent application database created by the European Patent Office, to create the Canadian Research Patent Database at Statistics Canada. Innovation is an important driver of the economy, and patent statistics are recognized as a useful measure of innovative activity. The current version of the Canadian Research Patent Database focuses on the worldwide patent applications of businesses with an address in Canada (Canada-resident businesses). These data are linked to Statistics Canada's administrative data holdings to enable studies on describing patenting trends by Canada-resident businesses and the relationship between the input and output of the innovation process and their impact on firm performance.

This paper describes the creation of the Canadian Research Patent Database and presents some basic facts from it. It is found that patent activity, as measured by the number of patent applications, has increased slightly by 0.7% per year over the period from 2001 to 2015. Behind this relative stability, there have been stronger increases in patenting by smaller firms with 0 to 19 employees in a number of service industries, and a decline in patenting activity in large firms with 500 or more employees in the manufacturing sector. Some of the technical areas in which patent activity is growing the most include civil engineering, medical technology, IT methods for management, computer technology, transport, thermal processes and apparatus, and mechanical elements.

[Canadian Patent Research Database, 2001 to 2019 \(statcan.gc.ca\)](https://www150.statcan.gc.ca/n1/pub/28-263-x/2019001/article/00001-eng.htm)

This paper provides an update to the work of Abbes et al. (2022a) and to the Canadian Patent Research Database (CPRD). The CPRD was created to study patenting, an important indicator of innovative activity, at the micro level. The CPRD was created by linking selected variables from the European Patent Office's (EPO) Worldwide Patent Statistical Database (PATSTAT), a database on patent applications, to administrative data holdings at Statistics Canada. Originally, the 2018 version of PATSTAT was used to create a CPRD that covered the period from 2001 to 2015. PATSTAT 2021 was used to extend the coverage of the CPRD up to and including 2019. This paper documents the resulting changes in the CPRD.

[Patenting activity of Canadian-resident businesses \(statcan.gc.ca\)](https://www150.statcan.gc.ca/n1/pub/28-263-x/2019001/article/00001-eng.htm)

This article presents initial findings from a new longitudinal database created from administrative data sources to study patenting in Canada. The study of patenting is important, as patenting is a measure of innovative activity and has been linked to positive economic outcomes for firms. Over the 2001 to 2015 period, Canadian-resident businesses increasingly filed patent applications in the United States, and that increase was accounted for by smaller, younger firms in service industries. Patent applications to other patent offices by Canadian-resident business declined over the same period. Technical areas where applications to the United States increased the most include civil engineering, medical technology, information technology methods for management, computer technology, transport, and digital communications. Finally, evidence is presented that suggests, for Canadian-resident businesses, the economic outcomes associated with filing a patent in the United States are similar to those of filing for a patent application in Canada. Once firm and industry characteristics are controlled for, data show that filing for a patent is associated with a 7.5% increase in the probability of experiencing high employment growth and a 12.9% increase in the probability of experiencing high revenue growth.

[Patenting activity of women-owned businesses in Canada \(statcan.gc.ca\)](https://www150.statcan.gc.ca/n1/pub/28-263-x/2020001/article/00001-eng.htm)

This article examines the patenting activity of women-owned businesses and compares it with that of men- and equally owned businesses, and businesses where gender of ownership cannot be determined. It adds to the literature on the gender gap in patenting—most of the focus has been on women as researchers or inventors, and not as business owners. From 2001 to 2019, men-owned businesses accounted for a larger share of patent applications than women- and equally owned businesses, and the gender gap did not narrow over that period. The most striking differences between the men- and women owned businesses that patent were in the propensity to conduct research and development (R&D) and the amount spent on R&D. Men-owned businesses were 16.5 percentage points more likely to have conducted R&D, and, conditional on conducting R&D, spent 70% more. This could help explain why men-owned firms that patent have more applications per firm, and why they have a higher rate of granted applications.

References

Abbes, C., Baldwin, J.R., Gibson, R., & Leung, D. (2022a). [Canadian Patent Research Database Activity](#) (Analytical Studies: Methods and References, No. 42). Statistics Canada. <https://www150.statcan.gc.ca/n1/pub/11-633-x/11-633-x2022005-eng.htm>

Abbes, C., Baldwin, J.R., & Leung, D. (2022b). [Patenting Activity by Canadian Resident Businesses](#). *Economic and Social Reports*, 2(3). <https://www150.statcan.gc.ca/n1/pub/36-28-0001/2022003/article/00005-eng.htm>

Gibson R. and Leung D. (2023), [Canadian Patent Research Database, 2001 to 2019](#), Analytical Studies: Methods and References, <https://www150.statcan.gc.ca/n1/pub/11-633-x/11-633-x2023001-eng.htm>

Eurostat, High-tech industry and Knowledge-Intensive Services Indicators. [Annex 6: High-tech aggregation by patents](#), https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an_6.pdf