April 2017

710-151 Slater Street
Ottawa, Ontario
K1P 5H3

613-233-8891
csls@csls.ca

CENTRE FOR THE STUDY OF LIVING STANDARDS

Are Trends in Patenting Reflective of Innovative Activity in Canada?

Jacob Greenspon and Erika Rodigues

CSLS Research Report 2017-02

April 2017

Are Trends in Patenting Reflective of Innovative Activity in Canada?

Abstract

This report sheds light on trends in Canadian innovation as indicated through patenting. Central to these recent trends is an apparent paradox: the number of patents granted to Canadians, an output indicator of innovative activity, has increased substantially between 2000 and 2014 despite decreased business sector expenditures on research and development, a crucial input to innovation, in the same period. This report examines this issue and provides several potential explanations as to why this is the case, the strongest being that the divergence between trends in patenting and R&D expenditures is caused by greater efficiency of research processes and an increase in strategic filings of patents. Furthermore, this report documents recent trends in patenting activity in Canada from several sources and compares trends across different technologies. Patenting trends are also used to give a regional perspective on innovation by tracking the level of innovative activity occurring in provinces and census metropolitan areas.

Are Trends in Patenting Reflective of Innovative Activity in Canada?

Table of Contents

Are Trends in Patenting Reflective of Innovative Activity in Canada?

Executive Summary

This report seeks to shed light on trends in innovation in Canada as indicated through patenting. It explores data on the number of patents granted to Canadian inventors by intellectual property (IP) offices in Canada, the United States, Japan, and the European Union. Also examined are trends in the number of patents granted by different technological categories and industrial sectors, as well as the number of patents granted to Canadians by province and by census metropolitan area (CMA). Finally, the report focuses on an apparent paradox between increases in the number of patent grants, an output measure of innovative activity, that have far outpaced stagnant R&D expenditures, an input measure of innovation, and especially a decline in business enterprises expenditure on R&D (BERD).

Canada has generally seen an increase in the number of patents granted to its resident inventors in recent years, although this is not true across all intellectual property offices for which patent data are examined in this report. Typically, over half of the patents granted to Canadian residents are related to information and communication technologies (ICT), which suggests that innovative activity in Canada is more concentrated in the ICT sector than in other OECD economies. Ontario is a leader among the provinces in the number of patents granted to its residents, receiving the most patents in both absolute and population-normalized terms across most IP offices. Ontario's leadership in patent grants is no surprise considering data on the number of patent grants by CMA: 8 of the 10 CMAs that received the most United States patents per 100,000 residents in 2012 are located in Ontario. In particular, Kitchener-Waterloo and Ottawa-Gatineau receive many more patents per 100,000 residents than other CMAs.

Several explanations for the recent paradox of decreasing R&D spending and increasing patent grants are examined. The report concludes that the paradox is most likely caused by greater efficiency of research processes and an increase in strategic filings of patents, although changes to the patenting administrative and regulatory systems could also play a part.

Measuring Innovative Activity in Canada through Patents Granted to Canadian Residents

Patenting trends provide an indicator of innovative activity that quantifies the direct outputs of innovative activity. There are several available measures of innovative activity: Total Factor Productivity (TFP), an outcome of innovation; and surveys of firms' new technologies, processes, or products, a more qualitative output measure of innovation. There are also alternative methods of intellectual property protection such as trade secrecy that firms may use to avoid the expensive process of obtaining a patent for only a limited period of protection.

Nonetheless, patents are a well-established and widely used measure of innovative activity. This report examines trends in patent grants to measure levels of innovative activity because these data are more extensively available, particularly by technology, by province, and by CMA. This report also describes some limitations with measuring innovation through patent volumes, such as that not all inventions are patented, not all patents have economic value, and others.

In order to track trends in innovative activity as indicated through patents, this report examines trends in the number of patents granted to Canadian inventors by the Canadian Intellectual Property Office (CIPO), the United States Patent and Trademark Office (USPTO), and the Triadic Family (consisting of the USPTO, the Japan Patent Office (JPO) and the European Patent Office (EPO)). These three sources of patents are utilized as they provide different perspectives on the level of innovative activity in Canada.

The number of patents granted by the Canadian Intellectual Property Office to Canadian residents provides an indication of Canadian innovative activity that will be applied in Canada. However, one limitation of using these data is that Canadians apply for fewer CIPO patents than USPTO patents, illustrating that a focus solely on CIPO patents underestimates the level of innovative activity in Canada. Therefore this report also utilizes data on the number of patents granted to Canadians by the USPTO. This helps improve the use of patents as an indicator of innovative activity, as a higher number of innovations are accounted for. This report also uses data on the number of triadic patents granted to Canadians. Triadic patents are argued to present the best indication of innovative activity in a country since inventions receiving triadic patents tend to be of high quality. This is because triadic patents are costly to obtain and inventors would only pursue them if they deemed the benefits of obtaining this type of patent as outweighing the associated costs. However, data on triadic patents are more difficult to obtain, as there is no single patenting office granting these patents.

Major Patenting Trends

The number of patents granted to Canadians by CIPO and USPTO increased substantially between 2000 and 2014, while the number of triadic patent grants fell slightly from 2000 to 2011. The number of patents granted annually by CIPO experienced the greatest increase between 2000 and 2014 out of the three sources of patents discussed, nearly tripling and increasing 7.3 per cent annually from 1,117 patents in 2000 to 2,984 patents in 2014. However, while the number of patents granted by CIPO to Canadian residents has increased substantially in recent years, the number of patent applications filed at CIPO by Canadian residents has remained stagnant, increasing from 4,187 patents in 2000 to only 4,198 patents in 2014. Furthermore, in 2014 the vast majority of CIPO patents continued to be granted to non-residents (87.4 per cent) rather than Canadian residents (12.6 per cent), although the share of CIPO patents granted to Canadian residents has more than doubled in size from a low of 6.2 per cent in 1982.

There are more patent applications filed by Canadian inventors at the USPTO than at CIPO, likely due to the larger potential U.S. market. The number of patent applications filed by Canadians at the USPTO nearly doubled in this period, from 6,809 applications in 2000 to 12,963 patents filed in 2014. There was also over twice as many USPTO patents granted to Canadian inventors in 2014, 7,042 patents, compared to the 3,419 patents granted to Canadian residents by the USPTO in 2000. Canada leads all G7 countries in growth of USPTO patents granted to its residents between 2000 and 2014.

Triadic patents are often considered high quality inventions because they are costly patents to obtain. Trends in the number of triadic patents granted to Canadian inventors generate a far different picture of innovative activity in Canada than that presented by CIPO and USPTO patenting activity. After increasing by 111 per cent between 1990 and 2000, from 290 patents to 612, between 2000 and 2011 the number of triadic patents granted to Canadians decreased to 576 patents, a contraction of 5.9 per cent per year. This compares to growth of 92.5 per cent at CIPO and 46.7 per cent at the USPTO in the number of patents granted to Canadian residents during the same period.

Patenting Trends by Technology

At the national level most innovative activity in Canada as indicated through patent grants has occurred in technologies and industries related to information and communication technologies (ICT). Depending on the measure used to assign geographic origin to patents and the precise definition of ICT, between 51 to 57 per cent of the patents granted to Canadian residents in 2012 by the USPTO were classified as ICT patents, and this share rose to 59.4 per cent in 2014.

Several different technological and industrial classifications for patents are examined in this report. When USPTO patent grants are classified by their North American Industrial Classification System (NAICS) manufacturing sector of final use, the number of patents granted to Canadian inventors was highest between 2000 and 2012 for ICT-related sectors such as computer and electronic products, in terms of both number of patents issued and growth rates. In 2014, 34 per cent of patents issued to Canadians by the USPTO and categorized under the International Patent Classification (IPC) system were granted to physics related innovations and about 27 per cent of patents were granted to innovations related to electricity. Finally, the boom in patent grants to Canadians at both the USPTO and CIPO was fueled by inventions patented in medical technology, digital communications, computer technology, and IT methods for management. However, Canadian residents were granted more patents only at CIPO for inventions classified under measurement, civil engineering, and engines, pumps and turbines. Likewise, Canadian residents were granted more patents at the USPTO for inventions related to telecommunication and audio-visual technology, suggesting the possibility that Canadian inventors find it more useful to patent-protect their ICT inventions in the United States than in Canada.

Patenting Trends by Province and by Census Metropolitan Area

Ontario, Canada’s most populous province, leads all provinces in the number of USPTO and triadic patents granted to its resident inventors, even with patent counts normalized to provincial populations. Inventors resident in Ontario were granted 30.4 USPTO patents per 100,000 residents in 2012 and 3.6 triadic patents per 100,000 residents in 2008 (the most recent year for which data is available). Ontario, with 38.6 per cent of Canada’s population in 2012, in fact punches above its weight in terms of the number of patents granted to its residents as it receives at least half of all patents granted to Canadians from each intellectual property office

However, Alberta ranks first in the number of CIPO patents granted to its inventors when patent counts are normalized to population size. Albertan inventors were granted 12.9 patents per 100,000 residents in 2014, while Ontario received the second most (11.1 patents per 100,000 residents), Saskatchewan the third most (6.68 patents per 100,000 residents) Québec the fourth most (6.34 patents per 100,000 residents) and British Columbia ranking sixth, with its inventors granted only 4.7 patents per 100,000 residents in 2014. British Columbia performs relatively better for patents from the USPTO, which granted its inventors 18.8 patents per 100,000 residents in 2012, and in triadic patents, as its inventors were issued 2.87 patents per 100,000 residents in 2008.

One explanation for these differences could be that the patent-driving industries in each province have differing levels of exposure and integration with foreign markets. Alberta, by receiving a comparatively higher number of CIPO patents among provinces than USPTO or triadic patents, may have patent-driving industries primarily focused on serving the domestic market (such as technology developed specifically for the Alberta oil and gas industry), compared to more export oriented patent-driving industries in Ontario, British Columbia, and Québec. For example, Ontario residents were granted a very high number of ICT patents by the USPTO—even in population-normalized terms Ontario received nearly twice as many ICT patents as the next highest province, British Columbia and over three times as many patents as Québec in 2012.

Ontario's dominance in ICT patenting is mainly based on the high number of ICT patents granted by the USPTO in 2012 to inventors from three cities: Kitchener-Waterloo (820 patents, 89 per cent of its total patent grants), Toronto (363 patents, 20 per cent of its total grants), and Ottawa-Gatineau (311 patents, 30 per cent of its total grants). Across all technologies, eight of the ten CMAs whose residents were granted the most patents in population-normalized terms are located in Ontario, with Vancouver and Sherbrooke, Québec the only exceptions. In 2012, Canada's largest city, Toronto, led the country in USPTO patents granted to inventors with 1,785 patents—equal to 26.2 per cent of the total number of USPTO patents granted to Canadian residents. However, Kitchener-Waterloo, Ontario led Canada's CMAs in both recent growth in UPSTO and triadic patents as well as in the number of patents granted per 100,000 residents. Data on CIPO patents at the CMA level are not publicly available from CIPO.

Input-Output Paradox: Divergent Trends in R&D Expenditures and Patenting

An additional measure of innovation is research and development (R&D) expenditures, a crucial input to innovation. As mentioned above, this report tracks levels of innovative activity by examining trends in patenting because patents serve as a well-established output indicator of innovation. Central to these recent trends in patenting is an apparent paradox: while business sector expenditures on research and development—a crucial input to innovative research—decreased between 2000 and 2014 (the last year for which patent data are available), the number of patents granted to Canadian residents—an output indicator of inventive research—has increased substantially in the same period. This is puzzling because a decrease in inputs to innovative research would be expected to lead to a decrease in outputs produced by that research. Instead, R&D expenditures have diverged from trends in the number of patents granted.

Between 2000 and 2014 real business enterprise expenditure on research and development (BERD) decreased by 6 per cent and real total expenditures on R&D increased by 14 per cent (in 2007 prices). However, in the same period, the number of patents granted to Canadians by CIPO and USPTO increased significantly (by 167 per cent and 102 per cent, respectively). Although patent applications at CIPO by Canadian residents increased by only 0.3 per cent between 2000 and 2014, in line with the trends in R&D expenditures, patent applications at the USPTO increased by 90 per cent over the same period. The number of triadic patents granted to Canadians also fell, by 6 per cent, between 2000 and 2011, in line with the decline in BERD. One possibility is that the decrease in inputs to innovation mainly impacted the output of high-quality inventions that typically receive triadic patents, but further quantitative research is needed to support that conclusion.

This report examines six potential explanations for this paradox, but finds that several do not have sufficient evidence. First, the observed divergence may be due to lags in the causal relationship between R&D spending and patenting over time, such that not enough time has passed for the decrease in R&D spending to result in fewer patents. The divergence may also be caused by changes to the patent administration system, such as revisions to the patent regulatory regimes or the ability of patent offices to process patent applications. Alternatively, it is possible that the divergence is caused by the average quality of patent applications increasing, perhaps due to firms filing more applications for inventions that have already received patents in other jurisdictions. A higher number of strategic patent filings—patents applied for by firms for reasons other than securing a monopoly over the profits of their invention—may have led to an increase across some patent counts. Finally, increases in the efficiency of R&D spending because of improved technologies, or shifts in R&D spending from sectors with low patent-to-R&D ratios to higher patent-to-R&D ratios could have allowed patent volumes to increase with less R&D spending inputted. Differing trends in the number of patent grants and patent applications shed some light on these explanations.

This report concludes that increases in the efficiency of R&D spending and a greater propensity for Canadian inventors to file for strategic patents are the most likely potential explanations behind this divergence. Changes to the patent administration system and recent regulatory changes, in particular the implementation of the Patent Prosecution Highway (PPH), may have also enabled patent volumes to increase beyond trends in R&D expenditures. Recent increases in patent grants at CIPO and USPTO could also be caused by these offices' efforts to improve patent application examination capacity; however, those changes cannot explain the increase in the number of patent applications at the USPTO. Finally, although parts of the explanation regarding increased efficiency are difficult to prove, it seems likely that the advancement of ICT and other technologies in the past two decades has increased the productivity of research processes and thus R&D spending. Further research is needed to confirm exactly what has caused the growing gap between R&D expenditures and patent grants.

Are Trends in Patenting Reflective of Innovative Activity in Canada?

List of Tables

List of Charts

List of Boxes

Are Trends in Patenting Reflective of Innovative Activity in Canada?

I. Introduction and Background[1]

Innovation is a crucial driver of economic growth. As Canada explores how to strengthen economic growth in the context of an aging population and a rapidly shifting industrial landscape, spurring innovation has emerged as a key priority for governments. The 2017 federal government budget, released on March 22, contains several initiatives focused on stimulating innovation in Canada such as a venture capital finance program, funding for industrial clusters, and a modernizing of Canada's intellectual property strategy.

This focus on spurring innovation elicits questions of how innovation is measured. There are several available indicators of innovative activity, yet no consensus on which is best. Growth of total factor productivity (TFP) is an outcome of innovation, but its credibility as a measure of technological progress is questionable; while several innovative technologies have been developed over the past 30 years, TFP growth in Canada was essentially flat over the 1985-2015 period.[2] An alternative approach to measuring innovative activity is examining inputs devoted to innovation, such as gross expenditures on research and development (R&D) or the number of workers employed in R&D. A third approach is to measure specific outputs, for example, through surveys asking firms if they have adopted new technologies, processes, or products.[3] However, while such surveys provide valuable qualitative data, they are often quite limited by time period and to only a few industrial sectors (Taylor, 2016: 327).

Patenting trends provide an indicator of innovative activity that quantifies the direct outputs of innovative activity.[4] Patented technologies also represent an input which will typically only generate value if adopted and used by firms. The process of filing a patent is costly, so the fact that firms obtain them suggests that they believe that these inventions will be valuable to someone. In this report, trends in the number of patents granted to Canadian residents are used to shed light on trends in innovative activity.

---

[1] This report was written by Jacob Greenspon and Erika Rodrigues, under the supervision of Andrew Sharpe. We would like to thank Pierre Therrien, Elias Collette, Daniel Schwanen, Craig Alexander, Bert Waslander, John Lester, Alexander Murray, Matthew Calver, Dieter Kogler, and officials from both Innovation, Science and Economic Development Canada and from the Canadian Intellectual Property Office for detailed comments on earlier drafts of the report. Email: jacob.greenspon@csls.ca

[2] Statistics Canada's official index of business sector TFP (available in CANSIM Table 383-0021) was equal to 98.3 in 1985 and 98.9 in 2015. TFP growth is influenced by many economic forces other than technological progress. See Murray (2016) for a comprehensive discussion of the measurement and interpretation of TFP.

[3] For an overview of such surveys of firms' innovation see Gault (2003).

[4] The patent literature typically labels the object of a patent an invention, patented by an inventor, rather than innovation patented by an innovator. However, since the focus of this report is on innovative activity and given that patents can be filed for improved products and processes and not solely for original creations, both invention and innovation are used interchangeably in this report.

Inventors are granted patents for innovations that have been deemed by the issuing intellectual property office to be sufficiently inventive.[5] Patent offices evaluate applications on the criteria of the invention being novel (that it is significantly different from existing technologies), non-trivial (that it would not be an obvious innovation to someone skilled in the relevant technologies), and useful (that it has potential commercial value) (Taylor, 2016: 323). However, these are broad standards to meet. Therefore, more exact criteria for patent application examination (for example, whether strings of genetic code can be patented) are determined by legislation and judicial decisions. This ensures that patents are only awarded to inventions that are considered truly innovative.

The reason governments grant patents to inventors is to solve a positive externalities problem that emerges around the production of innovations. Consider the counterfactual scenario where it is not possible for a firm to patent its inventions. After a costly research and development (R&D) process within a firm, the resultant innovations can be considered a non-rivalrous and non-excludable public good because, assuming the invention is easy to reverse engineer and replicate, the innovating firm cannot prevent other firms from replicating, and profiting from, that innovation. However, use of the innovation by other firms will reduce the profits that the innovating firm receives from its invention, thus lowering the return it receives on its R&D investment. Since the innovating firm receives a lower (or no) return on its investment, it will have less incentive to innovate and will under-produce innovations. As noted by Arrow (1962), innovation will be undersupplied if government does not intervene to help innovating firms recoup R&D investments. The patenting system therefore restricts the transferability of innovations and renders them rivalrous goods, allowing innovating firms to uniquely profit from their inventions and thus incentivizing innovation by the patent-holder. However, these patent monopolies must be temporary in order for society to benefit from the dissemination and subsequent improvement of patented innovations.

Therefore in order to incentivize the creation of new innovations that can still be disseminated through society, patent governing bodies grant firms patents which provide temporary exclusive rights (usually 20 years from the filing date) to an innovation (Hall and Harhoff, 2011). In exchange for a temporary monopoly, patent holders disclose details of their innovation as well as any previous research that led to the creation of said innovation to the public (Brydon *et al.*, 2014). This structure is aimed at rewarding innovative activity while simultaneously disseminating new knowledge that can lead to further innovations. Once the patent has expired, those who are 'skilled in the art' may replicate the innovation or modify it, thereby allowing for wider diffusion of the innovation and potentially improving upon it (Hall *et al.*, 2012). Moreover, a patent holder may issue a license[6] to a party that discovers an alternate

[5]There are in fact three types of patents: utility patents, for invented processes, machines, articles of manufacture, and compositions of matter; design patents, for ornamental designs for an article of manufacture; and plant patents, for invention or discovery of new varieties of asexually reproducing plants (USPTO, 2012:5). This report focuses on utility patents because they cover the tangible and intangible inventions that make up most innovative activity, have the most extensive data in terms of time, geography, and technology, and vastly outnumber other patent types (for example the USPTO granted 300,677 utility patents in 2014 compared to 23,657 design patents and 1,072 plant patents). Taylor (2016:362) concludes "most econometric analysis of patent data is confined to utility patents."

[6] A patent license allows the owner of the license to use the invention or process in a way that would otherwise infringe on the patent. In return, the patent holder may receive royalties. It is important to note that the license does not transfer ownership of the patent. See OECD (2006) for further discussion.

Box 1: Measuring Innovation by Patent Applications versus by Patent Grants

There are two measures of a national patent counts: the number of patent applications filed, and the number of patents actually granted. There is no scholarly consensus on which measure is the better indicator of innovative activity, and different authors rely on one or the other measure. For example Brydon *et al*. (2014), Rafiquzzaman and Whewell (1998), and the Global Innovation Index (Cornell University *et al*., 2016) use patent applications as a measure of innovation. On the other hand, Taylor (2016), Sung *et al*. (2013), and others measure innovative activity by the number of patents granted. Nagaoka *et al*. (2010: 1087) argues that due to differences in the level of information automatically disclosed in patent applications, in the United States volumes of patent grants are commonly used as an indicator of inventive activity while patent applications are typically used in Europe and Japan. This report primarily examines trends in patent grants to measure levels of innovative activity because these data are more extensively available, particularly by technology, by province, and by CMA. As well, although it can be assumed that all inventions for which a patent application is filed must be presumed significantly innovative upon filing (as otherwise the inventor would not have incurred the costs of filing an application), compared to patent applications the number of patent grants represents a rough form of quality-adjusted data as these inventions have been judged by examiners from the intellectual property office issuing the patent as sufficiently inventive to merit a patent. Nonetheless, this report utilizes data on patent applications where available in order to further inform the trends in data on numbers of patents granted.

use for their innovation or a use that the patent holder is not in a position to put into practice (Nelson and Mazzoleni, 2007).[7] The discoveries of these alternate uses are usually made possible by the information contained in a patent, thus illustrating the social benefits patents carry relative to non-disclosure of inventions through 'trade secrets' protection.

Given these incentives for patenting innovations, patent trends can therefore serve as a proxy measure of innovative activity. In order to track trends in innovative activity as indicated through patents, this report examines volumes of patented inventions at the Canadian Intellectual Property Office (CIPO), the United States Patent and Trademark Office (USPTO) and inventions granted triadic family patents (that is, identical patents filed at the USPTO, the Japan Patent Office (JPO) and the European Patent Office (EPO)). Primary patent data sourced directly from these offices are complimented by secondary data from international patenting organizations. This report draws comparisons between Canada and other OECD countries, as well as within Canada between provinces and between Census Metropolitan Areas (CMAs).

The remainder of the first section provides a brief introduction of using patents as an indicator of innovation, the methodology of the sources from which patent data was taken, and the limitations associated with using patents as an indicator of innovative activity. Section 2 discusses trends in the three sources of patents at the national level in Canada. Provincial patenting trends are discussed in Section 3. Section 4 reviews patenting trends at the CMA level in Canada. Section 5 examines the puzzle of increasing numbers of patents being granted to Canadians despite decreases in research and development expenditures. Section 6 presents an

[7] This can be the same use as that of the original patent holder. For example, a patent holder may lack the financing, resources, or expertise to mass produce an invention, but could issue a license to a firm which is not constrained in these ways.

agenda for future research related to patents and innovation. Finally, the conclusions of this report are discussed in Section 6.

A. Potential Factors behind Patenting Trends

There are three broad factors which determine levels of patenting activity: innovative activity, the direct costs and benefits of patenting, and the opportunity costs of patenting versus alternative intellectual property protection methods. Although this report focuses on patents as an indicator of innovative activity, it is important to note other factors that can influence annual flows of patent applications.

Innovative activity drives patenting because a patent grant indicates that a new idea or invention has been created. If the direct costs and benefits and the opportunity costs of patenting are constant, changes in the volume of patent grants indicate a higher (or lower) level of innovative activity in the economy. Generally, patents serve as an appropriate indicator of innovative activity. However, there are several limitations to this approach, which are discussed in the next section.

The direct costs and benefits of patenting refer both to the monetary and non-monetary[8] costs and benefits intrinsic to the legal and bureaucratic processes of filing a patent. For example, if patent laws were changed to make the process of filing a patent more burdensome, or if patent application fees (or associated fees for patent lawyers or agents) were raised, applicants would be less likely to file a patent application. Similarly, efforts to reduce costs associated with patenting, such as streamlining bureaucratic procedures around filing a patent application, would likely result in an increased volume of patent applications. Changes to direct benefits of patenting, such as modifying the length of the period of exclusive rights, would have similar effects.

There have been two notable recent reforms of the patenting process in Canada that shifted the intrinsic costs of patenting. The 1987 reform of the *Patent Act* introduced maintenance fees[9] to CIPO patenting system, and thereby increased the direct costs of a successful patent application. In contrast, the 2014 *Patent Act* amendment (whereby Canada ratified the international *Patent Law Treaty)* reduced much of the administrative burden of holding a patent, for example by lifting certain requirements regarding representation that limited who could pay maintenance fees on a patent, and thus decreased the direct costs.[10]

The opportunity costs of patenting refer to the relative costs and benefits of patenting compared to alternative methods of intellectual property protection that give inventors exclusive rights to profits from their invention. Instead of protecting their intellectual property through filing a patent, which is expensive to obtain and has a limited duration of protection, an inventor may opt to engage in trade secrecy and protect a new invention or process through confidentiality agreements (Hall *et al.*, 2012). In contrast to patents, secrecy has the potential to

[8] For example, time or stress.

[9] Maintenance fees, as outlined in CIPO's 'Manual of Patent Office Practices' refers to renewal fees which are to be paid at prescribed periods in order to keep a patent in effect.

[10] Amendments to the *Patent Act* may be viewed at the following URL: http://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/wr03892.html.

protect a new innovation indefinitely and at a lower cost, although without the legal guarantee of patent protection. Because a secret benefits only those who know of it, the circulation of new ideas is stalled and knowledge spillovers will not occur.

An alternative to intellectual property protection is open source innovation, whereby the innovator freely releases developmental information, such as blueprints, and allows anyone to apply the innovation without restriction.

If trade secrecy and other alternatives to patenting become more attractive (for example, through technology changes that better facilitate the security of trade secrets) then filing a patent becomes a relatively less attractive option. We may then expect to observe less patenting.

B. Limitations of Using Patents as an Indicator of Innovative Activity

When assessing the level of innovation in a country through examining patent trends, it is important to keep in mind that a larger number of patents may not necessarily indicate a higher level of innovative activity (and vice versa). Several other factors can complicate this correlation and limit the ability of patents to serve as an indicator of innovative activity.

One issue is that patented inventions vary greatly in terms of their contribution to innovation. While some patented inventions are innovative technological breakthroughs that are extensively utilized, others have few applications or may not be applied at all. However, macro data on the total number of patents issued by a given intellectual property office count equally all granted patents that pass the same basic threshold of innovation, regardless of how significant an impact the invention later has. Quality-adjusted measures of patent data are possible, by measuring the citations received by a patent or the revenue generated from a patented invention, but these types of data are not sufficiently available from multiple patent offices to measure historical trends in patenting. Moreover, quality-adjusted data based on the usage of patents (such as commercial application or citation by subsequent patents) are biased against more recently granted patents as less time has passed since their issuance for these patents to be commercially applied or cited by others.

There are also issues concerning tracking trends in patenting over time. Changes over time to intrinsic costs of patenting (related to patent laws and regulations) affect the incentive to patent by increasing or reducing the cost of filing a patent and thus altering the level of perceived benefit from the innovation that the firm requires to justify incurring the patent costs. Similarly, extrinsic costs of patenting—the opportunity costs of patenting relative to alternative intellectual property protection methods—may change over time and cloud the relationship between patent levels and innovative activity by increasing or reducing the opportunity costs of patenting. Annual patent counts can be misleading because the number of patents granted in a given year does not necessarily reflect innovative activity in the year of the grant, but rather reflects the output of innovative activity in previous years when the innovation was developed. This is illustrated by the 'lag time' it takes for a patent to be granted after initially being filed (a duration of a few years, depending on the filing office) as well as the lag between the start of research on an invention and the date the patent application is filed. In addition, the number of patent grants in a given year (as opposed to applications) can be misleading if the intellectual property office granting the patents has recently increased its capacity to examine patent applications because a subsequent increase in patent grants may primarily reflect a shorter lag time for processing patent applications due to the increased examination capacity.[11]

Furthermore, comparing the number of patent grants across different intellectual property offices can often be misleading. Since patent laws and filing processes typically differ between patent jurisdictions, intrinsic costs to patenting also differ, and hence the incentive to patent a given innovation may differ across patent offices. Therefore, for international comparisons it is better to compare filings at one patent office by residents of different countries, rather than comparing volumes of patents granted to residents of various countries by their domestic patent offices.

The increasing propensity for inventors to file patents outside their country of residence also creates issues for patents to serve as an indicator of domestic innovation. Canadian inventors have a low propensity to file for patents within Canada (at CIPO) compared to at foreign patent offices,[12] mainly due to higher potential profits in larger foreign markets. In addition, the total number of patents granted in Canada overstates the level of innovative activity in the country as it includes grants to both foreign and domestic inventors and therefore does not reflect solely domestic innovation in Canada. Moreover, many patents are filed jointly by both Canadian and foreign inventors. Different data sources take different approaches to allocating patents to each country, but some counts may overstate the amount of innovation occurring in Canada (if, for example, listed Canadian inventors played a relatively minor role) or understate it (such as for some measures that only consider the first listed inventor, which will likely exclude some patents with Canadian inventors). However, there is no documented bias regarding the order Canadian inventors are listed on patent applications, so the aforementioned overstating and understating effects are assumed to be symmetrical.

Finally, patents serve as a better indicator of aggregate innovation in a country or province rather than in specific sectors of the economy or firms (Taylor, 2016: 323). Some technological sectors and firms may rely more on patents to protect innovations than others, for example because some technologies are more easily protected by trade secrecy (Pavitt, 1988). Research by the USPTO (2012) on the number of USPTO patents associated with manufacturing North American Industry Classification System (NAICS) codes found that ICT-related NAICS codes were granted a high number of patents relative to employment levels in each NAICS code sector. Research in this report employing the same methodology for Canadian data, summarized

[11]For example, consider a patent office that consistently receives 1000 patent applications per year. The quality of patent applications and examination standards do not change, so the granting rate remains stable each year. After an average three year lag period during which patent applications are examined, each year 1000α patents are granted (where $\alpha < 1$). Consider if in year t the patent office then hires more examiners to process patent applications and thus reduces the lag period to 2 years. If the volume of applications remains stable at 1000 patent applications per year and the granting rate is unchanged, then in $t+2$ (i.e. two years after the patent office increased its number of examiners) the number of patent grants will have increased to 1000β, where $\beta = \frac{2}{3}\cdot\alpha$. The increase in patent grants at this office from 1000α in year t to 1000β in year $t+2$ is therefore caused only by an increase in the patent office's capacity to examine patent applications, not an increase in innovative activity or relaxation of examination standards.

[12]Brydon *et al.* (2014) report that 82 per cent of patent applications by Canadian inventors are filed at intellectual property offices outside Canada.

in Appendix Table 9, found similar results for USPTO patent grants to Canadians by manufacturing NAICS codes. This suggests either that patent-based measures of innovation may be biased towards some sectors that are more reliant on patents for intellectual property protection, or alternatively that these sectors are more innovative per employee than other sectors.

Despite these limitations, patents remain a widely-used indicator of innovative activity. Patenting trends provide a wide-ranging quantitative measure of innovation and therefore avoid the pitfalls of relying on a purely input-based indicator (such as R&D spending that never leads to an innovation) or a qualitative output measure (where, for example, there may be sampling or reporting issues with surveys of firms' innovative activity). Data on patent applications and grants are also widely available from various patent offices and typically broken down into technological categories, which show the sectors which played the most important role in changing patent counts. Patents are a frequently employed indicator of innovation and "have been used as a basis for the economic analysis of innovative activity for almost a century"(Taylor, 2016: 323).

C. Methodology of Sources

This report relies on primary-source data from the Canadian Intellectual Property Office (CIPO) and United States Patent and Trademark Office (USPTO), as well as secondary-source data from four organizations that collect patent data directly from patent filing offices: the World Intellectual Property Organization (WIPO), the Five IP Offices (IP5), the Institut de la statistique du Québec (ISQ), and the OECD Patent Statistics database.

The number of patents attributed to a country or geographical region may be counted in different ways by each office in the case of collaboration by inventors from different jurisdictions. Sung *et al*. (2014: 582) describe the three different methods of assigning residency to a patent with inventors from multiple countries: whole counts, where each country is attributed one patent; first country, whereby only the country of origin of the first listed inventor is attributed a patent; and fractional counting, where patents are partly attributed to each country on the basis of how many inventors they have listed on the patent. Additionally, different patent offices may provide their annual patent statistics on the basis of application date, granting date, or priority date.[13]

The Canadian Intellectual Property Office is the operating body responsible for administering and processing patents in Canada. CIPO's Annual Reports contain data on the number of patents granted in Canada. While CIPO has an extensive on-line database of patents that allows users to view original patent documents ranging from 1869 to the present, general statistics on patents granted to residents by province can only be found in their annual reports. Currently, only reports for 2012-2013, 2013-2014 and 2014-2015 are available on the CIPO

[13] Priority date refers to date of the first patent application made for an invention at an office, which is the considered the filing date for later patent applications for the same invention at other offices, as long as the application is filed within 12 months of the first application filing and all offices are in member countries of the Paris Convention for the Protection of Industrial Property (World Intellectual Property Organization, n.d.).

website. This report uses patents granted on the basis of province of residence. Earlier national data on the number of patents granted by CIPO are available through WIPO. However, earlier provincial data are unavailable online from CIPO and WIPO.

Data for annual counts of United States Patent and Trademark Office (USPTO) patent applications and grants to Canadian residents are sourced directly from the USPTO. These data are released in calendar year reports by the USPTO Patent Technology Monitoring Team. The USPTO assigns an origin to each patent based on the residence of the first-named inventor.[14] For example, if a Canadian resident and a resident of another country collaborated on an invention and the Canadian resident was listed second on the patent document, the USPTO will attribute the patent to the other inventor's country of residence.

WIPO is a global forum for intellectual property services and information based in Geneva, Switzerland.[15] This organization is an agency of the United Nations with 188 member states. Data on patents at various filing offices (the office at which a patent application is first submitted) from 1980 to 2014 are available. For the purpose of this report, data collected by WIPO from the Canadian filing office (CIPO) are used, in particular, total patents granted to Canadian residents and patent grants by technology, as well as data collected by WIPO from the United States Patents and Trademarks Office (USPTO) on USPTO patents granted to Canadians by technology. Like the USPTO, when attributing a patent to a resident based on his or her country of origin, WIPO only considers the country of origin of the first named applicant (or inventor) on the patent document.[16]

Data in this report are also sourced from the Five IP Offices (IP5 Offices), a forum of the five largest intellectual property offices that works to improve the examination process of patent applications.[17] When accounting for the number of patents issued to the residents of any given country, IP5 Offices only considers the residence of the first applicant listed on the patent when attributing a patent to a certain country.

Data from the Institut de la statistique du Québec (ISQ) are used to obtain data on the number of USPTO and triadic patents granted to Canadian residents by province and CMA of residence. The data gathered by ISQ were compiled by the Observatoire des sciences et des technologies (OST) from the OECD and USPTO databases (Institut de la statistique du Québec, 2015). For provincial and CMA measures the ISQ assigns patents by whole counting, meaning that a single patent can be attributed to more than one province or CMA if that patent has inventors from different provinces or CMAs. For example, if a patented invention was created by four inventors—one from Ontario, one from Québec and two from Alberta—the patent is

[14] This information is listed at the beginning of each patent report. See, for example, United States Patent and Trademark Office (2015).
[15] Background material about the WIPO is available at the following URL: http://www.wipo.int/about-wipo/en.
[16] See the WIPO glossary, available at the following URL: http://www.wipo.int/ipstats/en/statistics/glossary.html.
[17] The five largest IP offices are the USPTO, EPO, JPO, the Korean Intellectual Property Office (KIPO) and the State Intellectual Property Office of the People's Republic of China (SIPO).

counted once in Ontario, once in Québec and once in Alberta. To avoid double counting, for the Canadian total, the patented invention is only counted once instead of three times.[18]

The Organization for Economic Co-operation and Development (OECD) maintains a database of patent statistics through its online statistical site. Data from the OECD are used for comparative purposes to observe international trends in the number of USPTO and triadic patents by country. However, comparison of patenting trends across offices is limited because while the USPTO and WIPO attribute each patent to a single country, based on the origin of the first listed inventor, the OECD database assigns residency of a patent based on fractional counting, meaning a single patent is attributed to multiple countries by fraction of how many inventors listed on the patent originated from each country. For example, a patent co-invented by 1 French resident, 1 American resident and 2 Canadian residents will be counted as ¼ of a patent for France, ¼ for the USA and ½ patent for Canada (OECD: 2009).

Most intellectual property offices, including the EPO, the JPO, and CIPO, award patents on a first-to-file basis, where the patent is granted to the first inventor who files a patent for an invention, even though they may not be the first person to create the invention. Since the passage of the *America Invents Act* in 2013, the USPTO has also awarded patents on a similar first-inventor-to-file system (American Intellectual Property Law Association, n.d.).[19] Patent applications list the names and addresses of both the inventor(s) and the assignee/patent holder(s), leading to two different ways patents can be counted: either by the inventor(s)'s place of residence or the assignee/holder(s)'s place of residence. Moreover, the time it takes to grant a patent after filing differs between patent offices and the type of invention being patented.

D. Patent Assignments by Inventor and by Assignee

There are two different counts of how many patents are issued to residents of a certain country, province, or CMA: the number of patents issued to inventors resident to that jurisdiction, and the number of patents issued to resident assignees. The term ‘inventor’ refers to the inventor listed on the patent, whereas the term 'assignee' refers to the holder of the rights to use and commercialize the invention. Counts by each measure may differ if, for example, a Canadian inventor files a patent while working for an American firm that retains ownership of the patent. While both counts offer useful information, this report focuses on trends in the number of patents granted to Canadian inventors because, as explained by Sung *et al*. (2014: 580), “whilst assignment by inventor country reflects the inventive activity of a given country, the assignment by assignee country shows the market allocation strategy of companies.”

Although this report focuses on the level of innovation in Canada and thus relies on patent counts by inventor, it is worth noting that the number of USPTO and triadic patents granted to Canadian inventors consistently exceeds the number of patents granted to Canadian assignees. For example, in 2012, the number of inventions patented at the USPTO that listed

[18]This can be seen for example in the number of triadic patents awarded to inventors in each province in 2001 (Appendix Table 4). The provincial figures sum to 946 patents while nationally only 916 patents were issued, meaning that up to 30 patents were the result of collaboration from inventors in different provinces.
[19]American Intellectual Property Law Association. Summary of the America Invents Act. http://www.aipla.org/advocacy/congress/aia/Pages/summary.aspx

Canadians as inventors was 6,812 while that same year, Canadians held the rights to use and commercialize only 4,335 patented inventions (Appendix Tables 12 and 21). Furthermore this gap is growing: between 2000 and 2012, Canada experienced an average annual growth rate of 2.5 per cent in the number of patents awarded to Canadian assignees, half of the growth rate of the number of inventors granted USPTO patents. The percentage of patents invented by a Canadian but owned by a foreign assignee increased from 15 per cent in 2000 to 36 per cent in 2012, the highest rate in the dataset dating back to 1980.[20] Similarly, the percentage of Canadian-invented triadic patents owned by foreign assignees increased from 22 percent in 2000 to 39 per cent in 2008 (the most recent year for which data are available). Data on patent grants to Canadian assignees is included in Appendix Tables 21, 22, and 23.

Inventors of a patented invention do not necessarily have the right to use and commercialize their invention unless they are the holder of the patent. If they assign the patent to another entity such as a company or another individual, they no longer have the right to use or commercialize the invention they created unless they obtain permission to do so. Therefore despite the growing numbers of Canadian inventors who have inventions patented at the USPTO, the smaller, and slower growing, number of patents granted to Canadian assignees suggests that Canada may be unable to commercialize these inventions and profit from the increased innovative activity.

II. Patent Trends at the National Level in Canada

This section focuses on patent trends at the national level as an indicator of innovative activity in Canada by examining the number of patents granted to Canadian inventors by CIPO, the USPTO and the triadic family patent offices. Patent trends in Canada are also compared internationally with the G7 and OECD countries.

Canadians are granted more patents from the USPTO than from CIPO and triadic patent family offices. While the number of patents issued to Canadians from all three sources has increased significantly since 1980, recent trends are more divergent. The number of patents granted by CIPO and by the USPTO both increased between 2000 and 2014, but the number of triadic patents granted to Canadians decreased from 2000 to 2011 (the most recent year for which data are available). Canada led the G7 countries in growth of triadic patents between 2000 and 2008 but Canadian inventors then suffered the largest decline among the G7 in the number of triadic patents granted between 2008 and 2011.

[20] See Appendix Tables 12 and 21. The percentage of patents invented by a Canadian but owned by a foreign assignee was calculated as one minus the ratio of the number of assignee patents granted to Canadians in a given year to the number of inventor patents granted to Canadians in the same year. Note that this calculation somewhat understates the share of Canadian-invented patents that are owned by non-Canadians since it assumes that all Canadian-owned patents are Canadian-invented.

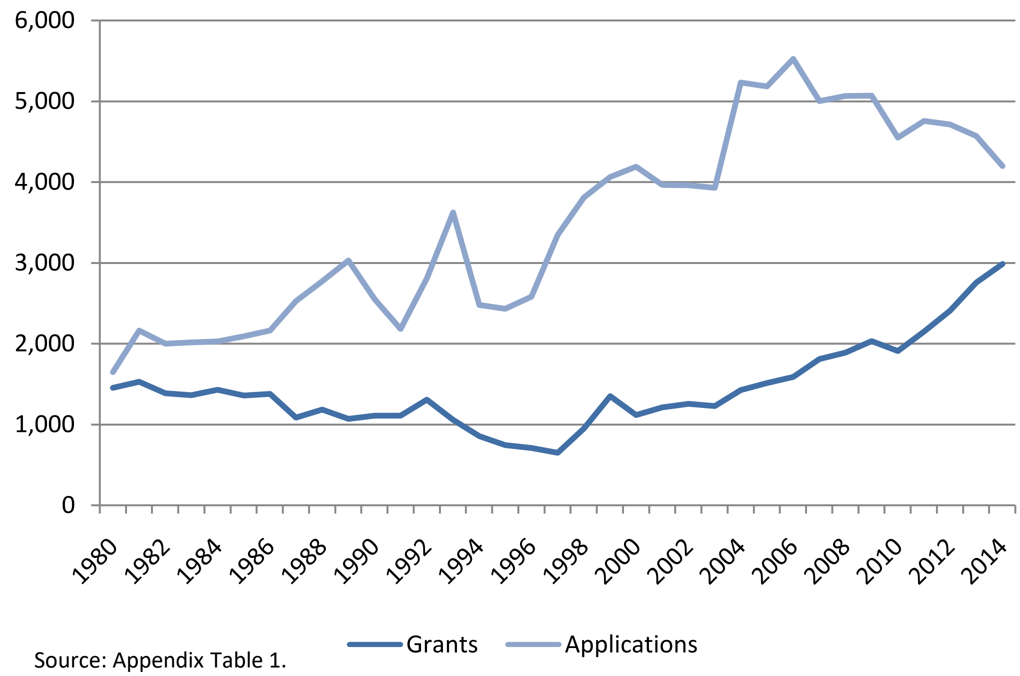
A. Patenting Activity by Canadians at the Canadian Intellectual Property Office

The Canadian Intellectual Property Office (CIPO) is the authority for granting patents within Canada, to both Canadian residents and foreigners (non-residents).[21] Table 1 includes the number of CIPO patents granted and applied for by Canadian residents from 2000 to 2014, and select earlier annual counts.[22] Chart 1 presents the data on CIPO grants and applications by Canadian residents between 1980 and 2014.

i. Patents Granted by the Canadian Intellectual Property Office

The number of CIPO patents granted to Canadian residents has grown considerably in the past 15 years, and the number of patents granted in 2014 is double the number of CIPO patents granted to Canadians in 1980. However, the number of patents granted to Canadians by CIPO decreased dramatically, by 55 per cent, between 1980 and 1997. Lo and Sutthiphisal (2009) suggest that one reason for this decrease is the 1987 *Patent Act* reform of the Canadian patent regime that replaced the first-to-invent rights system with a first-to-file system and, more importantly, introduced maintenance fees for all new CIPO patents. Maintenance fees increased the direct cost of patenting, especially as the fees increased at the later stages of a patent's lifespan. Consequently, between 1987 and 1989 patent applications to CIPO temporarily surged

Chart 1: Number of CIPO Patent Grants and Applications to Canadians, 1980-2014

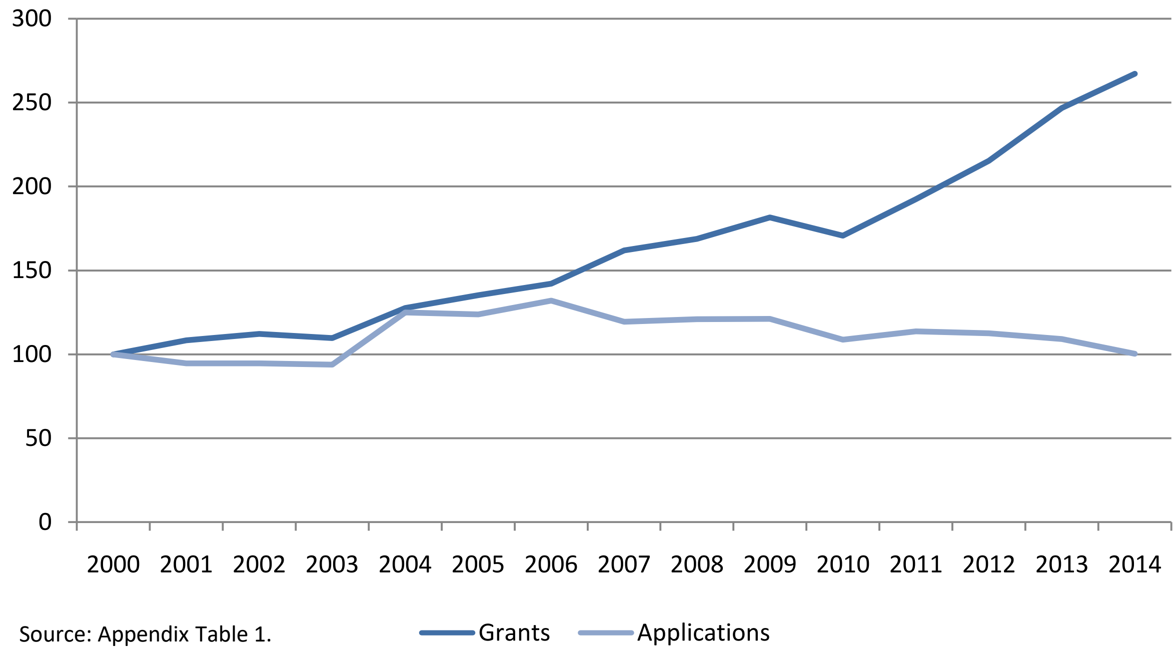


Source: Appendix Table 1.

[21] This report uses patents as an indicator of innovative activity in Canada and therefore focuses on CIPO patents granted to Canadian residents. However, foreign residents continue to receive many more CIPO patents than Canadians. For example, in 2014 foreign residents were issued 20,765 patents, compared to 2,984 for Canadians. Data on CIPO patent grants and applications by non-residents are included in Appendix Table 2.

[22] Complete data from 1980 to 2014 are included in Appendix Table 1.

Chart 2: Number of CIPO Patent Grants and Applications by Canadian Residents, 2000-2014 (2000=100)



Source: Appendix Table 1.

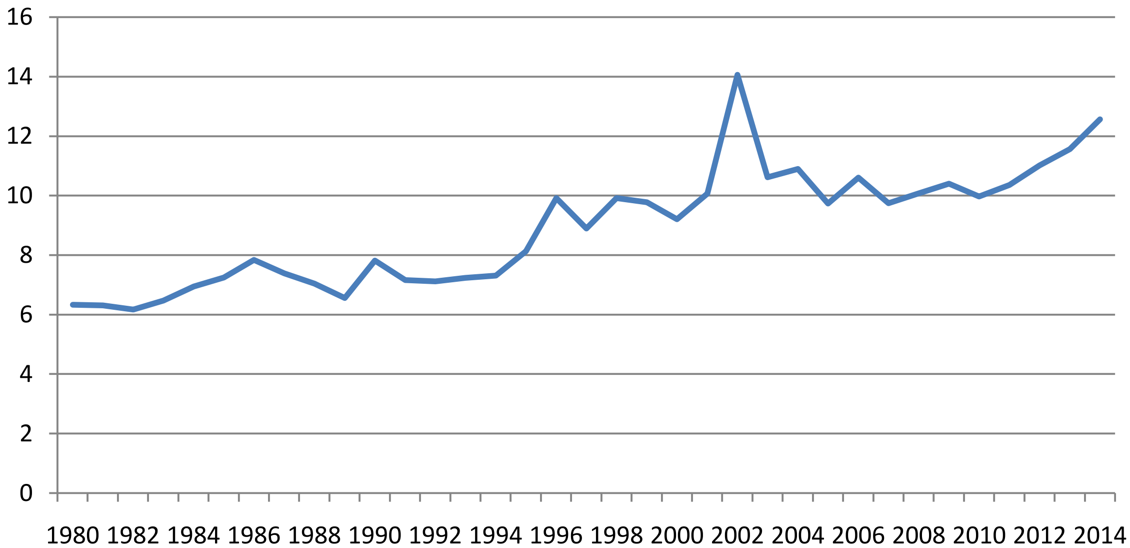
as inventors rushed to file patent applications before the new law came into effect (Lo and Sutthiphisal, 2009).[23] After 1989, the volume of both CIPO patent applications and grants decreased, perhaps due to inventors of lower valued inventions being less likely to pay the higher maintenance fees when the costs of maintaining a patent were likely to outweigh the benefits.

Chart 2 presents recent trends in the number of patent grants and applications to CIPO by Canadian residents. After the decline in patent grants from 1980 to 1997, the number of patents granted to Canadians by CIPO increased by 167 per cent between 2000 and 2014.[24] Growth of CIPO patents granted to Canadians accelerated after 2010; patents grew by 70.6 per cent (or 5.5 per cent per year) over the 2000-2010 period, then by 56.6 per cent (or 11.9 per cent per year) over the 2010-2014 period.

Chart 3 presents the share of total CIPO patents granted to Canadians (rather than foreign residents) between 1980 and 2014. Canadian residents have consistently been granted far fewer CIPO patents than non-residents. The much larger share of non-resident CIPO patents illustrates that Canada is an importer of technology, suggesting that Canadians benefit greatly from the diffusion of foreign technologies (Rafiquzzaman and Whewell, 1998). In 2000, the share of total CIPO patents granted to Canadian applicants was 9.2 per cent, while the share of total CIPO patents granted to foreign applicants was 90.8 per cent. In 2014, the share of CIPO patents to Canadian applicants rose to 12.6 per cent, doubling from the share of CIPO patents issued to

[23] Although the *Patent Act* reform bill was passed on May 6, 1987, the amendment did not come into effect until October 1st, 1989.
[24] Growth in the number of CIPO measured between the 1997 trough and 2014 is 361 per cent.

Chart 3: Per Cent Share of Total CIPO Patents Granted to Canadian Residents, 1980-2014



Source: Table 1.

Canadian residents in 1980. The recent increase in the resident share of patents is due to its higher annual growth rate of 7.3 per cent between 2000 and 2014, compared to annual growth of 4.6 per cent for non-residents over the same period. However, in 2014 non-residents were still granted 7 patents for every patent granted to Canadian residents.

ii. Patents Applications to the Canadian Intellectual Property Office

The number of patent applications filed at a particular intellectual property office can also be used as an indicator of innovative activity. Although only granted patents represent innovations that have been deemed by CIPO sufficiently innovative to meet their criteria of novelty, non-obviousness, and practical utility, patent application counts include innovations outside CIPO's "narrower" criteria, such as patents that consist of only a theorem or abstract principle (Brydon *et al*., 2014:3). As well, a patent application demonstrates that the innovation is significant because the inventors determined themselves that the benefit they would receive from their patented innovation sufficiently exceeded the intrinsic and extrinsic costs of filing a patent for their innovation. Trends in patent applications are therefore a useful complement to the number of patents granted when quantifying the level of innovative activity.

Recent trends in the number of patent applications filed at CIPO from 2000 to 2014 are presented in Chart 2. In contrast to the number of patents granted by CIPO, which has increased significantly throughout the past two decades, the volume of patent applications filed at CIPO by Canadian residents is now near the same level as in 2000. Since a peak of 5,522 in 2006, patent applications to CIPO have dropped by 24 percent through the 'Great Recession' and recovery, to a ten-year low of 4,198 in 2014. These recent trends represent a reverse from historical growth in each decade: CIPO patent applications by Canadians increased by 54.7 per cent from 1980 to 1990 and by 64.3 per cent between 1990 and 2000. However, despite growth of 20.9 per cent

Table 1: Number of CIPO Patent Applications, Patent Grants, and Granting Rates (with 4 year lag) for Canadian Resident Inventors, 1980, 1990, 1996, 2000-2014

	CIPO Patents Granted to Canadian Residents	CIPO Patent Applications by Canadian Residents	Granting Rate, With 4 year Lag (%)	Share Granted to Canadian Residents of Total CIPO Patents Granted (%)
1980	1,450	1,648	-	6.33
1990	1,109	2,549	51.3	7.82
1996	709	2,583	25.3	9.92
2000	1,117	4,187	43.2	9.21
2001	1,210	3,963	36.2	10.07
2002	1,253	3,959	32.9	14.06
2003	1,226	3,929	30.2	10.61
2004	1,425	5,231	34.0	10.9
2005	1,511	5,183	38.1	9.74
2006	1,588	5,522	40.1	10.61
2007	1,809	4,998	46.0	9.75
2008	1,886	5,061	36.1	10.08
2009	2,029	5,067	39.2	10.41
2010	1,906	4,550	34.5	9.97
2011	2,150	4,754	43.0	10.36
2012	2,404	4,709	47.5	11.02
2013	2,756	4,567	54.4	11.56
2014	2,984	4,198	65.6	12.56
1984-1989 (average)	1,249	2,435	63.5	7.17
1990-1999 (average)	983	2,987	38.1	8.33
2000-2009 (average)	1,505	4,710	37.6	10.54
2010-2014 (average)	2,440	4,556	49.0	11.09
% or Point Change, 2000-2014	167.1%	0.26%	22.3	3.35
Annual growth rate, 2000-2014	7.27%	0.02%	n.a.	n.a.
Source: Appendix Table 1.				

between 2000 and 2008, the number of applications filed by Canadian residents increased only marginally, by 0.3 percent (11 patent applications), from 2000 to 2014.

iii. Patent Granting Rate at the Canadian Intellectual Property Office

Recent growth in the number of patent grants has far outpaced growth in patent applications. Between 2000 and 2014 the volume of patent applications filed at CIPO by Canadian residents increased by only 0.3 per cent, far below the 167 per cent increase in patents granted to Canadian residents in the same period. Post-recession, from 2008-2014, the number of patents granted to Canadian residents grew by 58.2 per cent despite applications from residents decreasing by 17.1 per cent over the same 6 years. While at any intellectual property office only

Box 2: Calculating the Patent Granting Rate

The patent granting rate estimates the proportion of patent applications that are later granted. The patent granting rate for a particular intellectual property office is calculated as the following:

$$\boldsymbol{Rate_{t+l} = 100 \text{ x } \frac{Number\ of\ Patents\ Granted_{t+l}}{Number\ of\ Patent\ Applications\ Filed_t}}$$

Where *t* is the 'base year' for the annual count of patent applications, and *l* is the lag period (in years) between the date of a patent application being filed and the date of granting, based on the estimated average pendency time reported in the literature.[25] Each intellectual property office has a unique pre-determined value of *l*. However, Eckert and Langinier (2014) note that, even after accounting for the lag in average pendency times, dividing the number of grants by applications provides only a rough estimate of the granting rate, as this measure does not correct for resubmitted or withdrawn applications. The above formula for the patent granting rate therefore results in a lower calculated rate than in much of the literature—for example, Quillen and Webster (2006) exclude rejected applications that have been resubmitted and therefore estimate a granting rate of 97 per cent at the USPTO. Granting rates can also be influenced by factors such as the resources available to patent office examiners and the types of innovation that are being examined. In addition, cross-country comparisons are complicated by different filing strategies at each office, such as applicants applying for several patents for the same invention. See Lemley and Sampat (2008) for further discussion of the methodology and challenges of calculating patent granting rates.

some fraction of the total number of applications filed will be granted patents, this granting rate changes substantially over time.

Changes in the granting ratio over time may be as a result of a variety of factors apart from trends in innovation and others that drive changes in the number of patent applications and grants. One consideration is that the average quality of patent applications may change over time. Patent quality is typically measured using indicators such as the technological scope of patents, the number of backward and forward citations for each patent, and various other indices constructed to estimate patent quality and value.[26] Another possibility is that the behaviour of the patent office may change, due either to changes in their assessment capacity or to changes in their assessment criteria.

Indeed, it is clear that the standards by which CIPO reviews patents have evolved. The Ginarte-Park index of patent protection measures the strength of domestic patent rights based on "coverage (inventions that are patentable); membership in international treaties; duration of protection; enforcement mechanisms; and restrictions (for example, compulsory licensing in the event that a patented invention is not sufficiently exploited)" (Park, 2008:761). The most recent

[25] London Economics, the source used by Eckert and Langinier, measures pendency times as the period between the filing of a patent application and the granting of a patent.

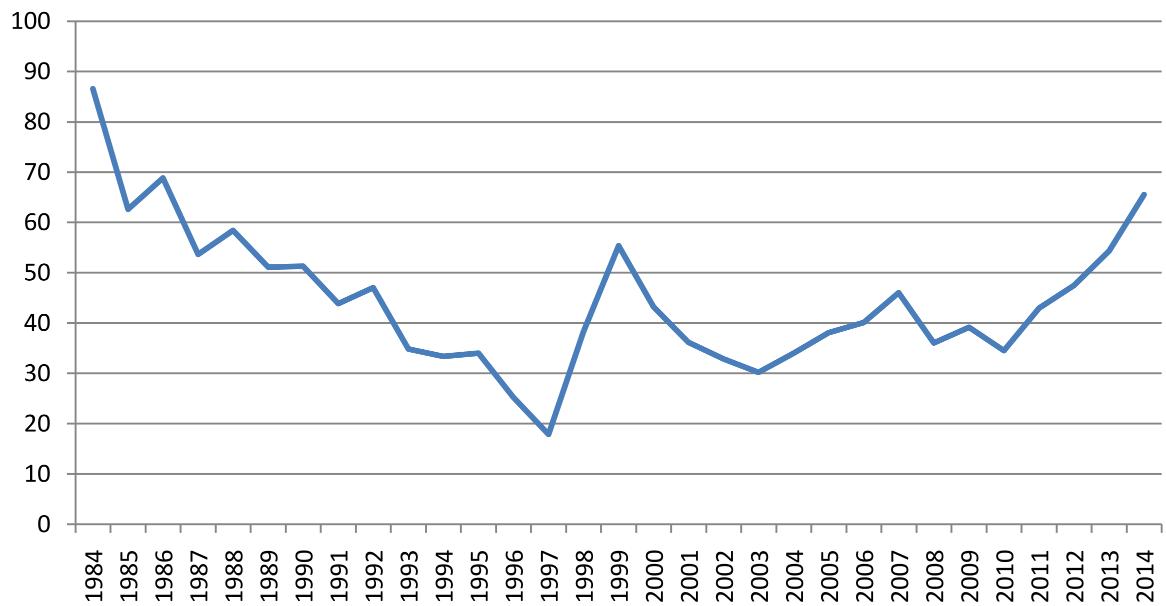
[26] See OECD (2015) for a discussion of measurement of patent quality and value and descriptions of various indicators.

data from the Ginarte-Park index shows Canada improved from a score of 3.28 in 1990 to 4.34 in 2010.[27] (Note, however, that the recent increases in the patent granting rate at CIPO occurred after 2010.) Judicial decisions regarding the proper interpretation of criteria for patentability are a driver of change in patent assessment standards. For example, after the judgment in *Amazon.com Inc. v. Canada (Commissioner of Patents)* [2011], CIPO instructed examiners to broaden the patentable subject matter to include computer-implemented inventions (Canadian Intellectual Property Office, 2013).

Other factors potentially affecting the patent granting rate include changes in the patent pendency time, changes in the rate of withdrawal of applications, changes in the quantity and quality of examiners, and changes in the demand for patents relative to other forms of intellectual property protection.

Chart 4 and Table 1 present trends in the granting rate for Canadian residents at CIPO, taking into account the estimated average four year lag between the initial filing of a patent application and its grant; therefore, the series begins in 1984, rather than 1980 (the earliest year

Chart 4: Per Cent Granting Rate for Canadian Residents at CIPO, 1984-2014 (With 4 Year Lag)



Source: Appendix Table 1.

[27] The index is described in Park (2008) and available at the following URL: http://fs2.american.edu/wgp/www/patent%20index%201960%20-%202010.xlsx.

for which patent application data are available from WIPO).[28] Appendix Table 1 includes complete data on patent granting ratios from 1980 to 2014 for Canadian residents.[29] In 1984, the granting rate was 86.6 per cent. However, CIPO granting ratio for Canadian residents began falling sharply thereafter and, aside for a brief spike in 1999, remained below 50 per cent until 2013. However, the granting ratio for Canadians at CIPO has been on a rapid upward trajectory in recent years, increasing by 31 percentage points from 34.5 per cent in 2010 to 65.6 per cent in 2014, the highest point since 1986.

Prima facie, this recent strong growth in patent grants implies that in the period since the late 2000s recession, the level of innovative activity in Canada has increased substantially. However, the lack of increase in patent applications during this growth period suggests a more complex story. It may be that firms have only applied for patents for their best inventions, for which they were more certain the patent would be granted, and that firms were less likely to take a risk on patenting inventions that were less proven. In addition, the increase in the granting rate could be driven by other factors listed above.

B. Patenting Activity by Canadians at the United States Patent and Trademark Office

Patents issued by the USPTO are widely used to measure and analyze innovation because they are highly sought out by inventors from many countries (Lo and Sutthiphisal, 2009). The USPTO receives a large share of its foreign patents from Canadian inventors in particular, owing to the access they allow to a significantly larger market as well as the close proximity and high degree of economic integration between the two countries (Rafiquzzaman and Whewell, 1998).

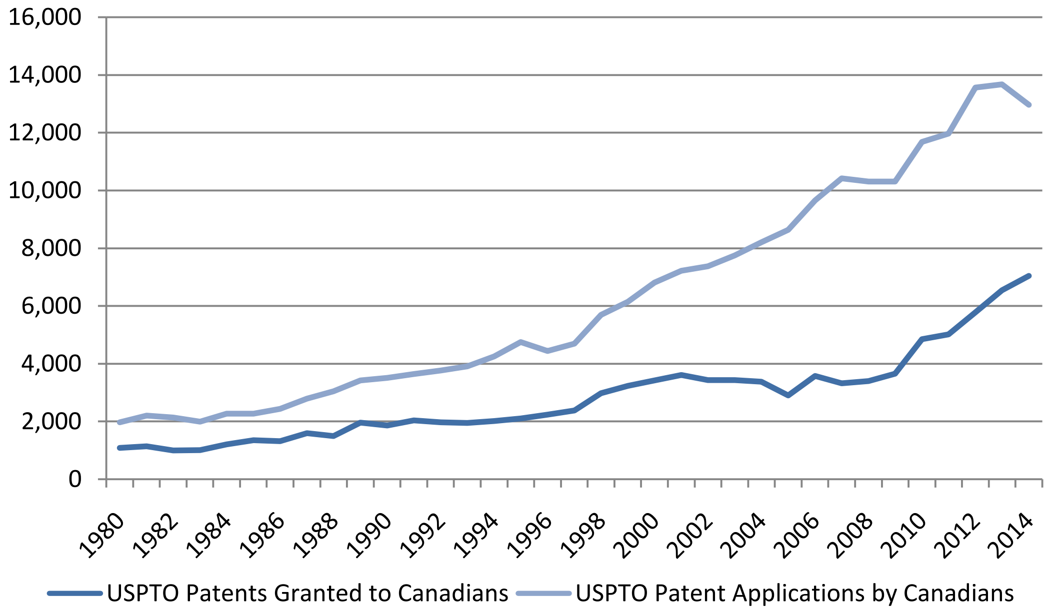
Table 2 presents the number of patents granted to Canadian inventors by the USPTO, Canadian inventors' share of the total number of USPTO patent grants, the number of USPTO patent applications filed by Canadian inventors, and granting rates for Canadian inventors at the USPTO. Annual data from 2000 to 2014 as well as select earlier annual counts and period averages are included in Table 2, while Appendix Table 3 contains complete data from 1980-2014.

i. Patents Granted to Canadians by the United States Patents and Trademark Office

Chart 5 presents recent trends in the number of USPTO patent grants and applications by Canadian residents. Overall the number of USPTO patents granted to Canadian residents has increased significantly between 1980 and 2014, by nearly sevenfold during this time (an increase of 550 per cent). Aside from a period of stagnation between 2000 and 2009, when the number of

[28] Estimate of 4 years is based on Eckert and Langinier (2014), who reported that from 2003 to 2009 the average pendency time at CIPO had increased from 45 months to 52 months.
[29] Appendix Table 2 includes data on the granting rate for foreign residents at CIPO, which are generally positively correlated with the granting rate for residents. However, the rate for non-residents has nearly always exceeded the granting rate for residents: on average, from 1984-2014 the granting rate for non-residents was 5 percentage points higher than for residents.

Chart 5: Number of USPTO Patent Applications and Grants to Canadian Residents, 1980-2014



Source: Appendix Table 3.

USPTO patents granted to Canadians increased by only 6.9 per cent overall, the number of patents granted to Canadian residents has experienced steady upward growth averaging 5.7 per cent per year between 1980 and 2014. Since 2009 there has been a substantial surge in patents issued by the USPTO to Canadians, with the total volume increasing by 93 per cent from 2009 to 2014 to reach a high of 7,042 patents, more than twice the number issued in 2000 (an increase of 106 per cent).

ii. Patent Applications by Canadians at the United States Patents and Trademark Office

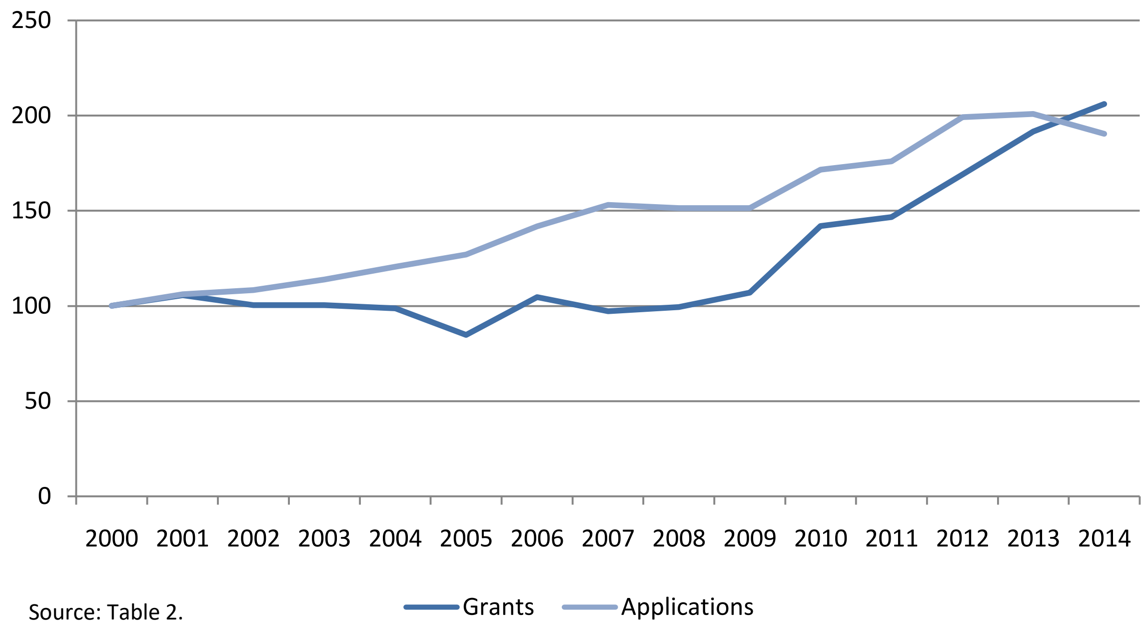
The number of patent applications has followed a similar trend as the number of patent grants, increasing by 558 per cent between 1980 and 2014. Growth in the number of patent applications to the USPTO has also been strong recently, increasing 90 per cent from 6,809 applications in 2000 to 12,963 applications in 2014, representing growth at an average annual rate of 4.7 per cent. Despite this overall strong growth, between 2007 and 2009 the number of USPTO patent applications by Canadians decreased by 1.1 per cent. Since this slowdown, however, growth in the number of patent applications filed by Canadians at the USPTO has picked up again, as the volume of applications increased by 26 per cent from 2009 to 2014.

Table 2: Number of USPTO Patent Grants, Patent Applications, Granting Rates (with 3 year lag), and Share of Total USPTO Patent Grants for Canadian Inventors, 1980, 1983, 1990, 1995, 2000-2014

	USPTO Patents Granted to Canadians	USPTO Patent Applications by Canadians	Granting Rate (With 3 year Lag) (%)	Canadian Inventors' Share of Total USPTO Patent Grants
1980	1,083	1,969	-	1.75
1983	1,002	1,995	50.9	1.76
1990	1,859	3,511	66.6	2.06
1995	2,104	4,745	55.9	2.07
2000	3,419	6,809	72.8	2.17
2001	3,606	7,221	63.4	2.17
2002	3,431	7,375	55.8	2.05
2003	3,427	7,750	50.3	2.03
2004	3,374	8,202	46.7	2.05
2005	2,894	8,638	39.2	2.01
2006	3,572	9,652	46.1	2.06
2007	3,318	10,421	40.5	2.11
2008	3,393	10,307	39.3	2.15
2009	3,655	10,309	37.9	2.18
2010	4,852	11,685	46.6	2.21
2011	5,014	11,975	48.6	2.23
2012	5,775	13,560	56	2.28
2013	6,547	13,675	56	2.36
2014	7,042	12,963	58.8	2.34
1983-1989 (average)	1,415	2,605	64.3	1.8
1990-1999 (average)	2,273	4,480	60.6	2.0
2000-2009 (average)	3,409	8,668	49.2	2.1
2010-2014 (average)	5,846	12,772	53.2	2.3
% or Point Change 2000-2014	106.0%	90.4%	-4.6	0.19
Annual growth rate, 2000-2014	5.30%	4.71%	-	-

Source: Appendix Table 3.

Chart 6: Number of USPTO Patent Grants and Applications by Canadian Residents, 2000-2014 (2000=100)



Source: Table 2.

iii. Patent Granting Rate at the United States Patents and Trademark Office

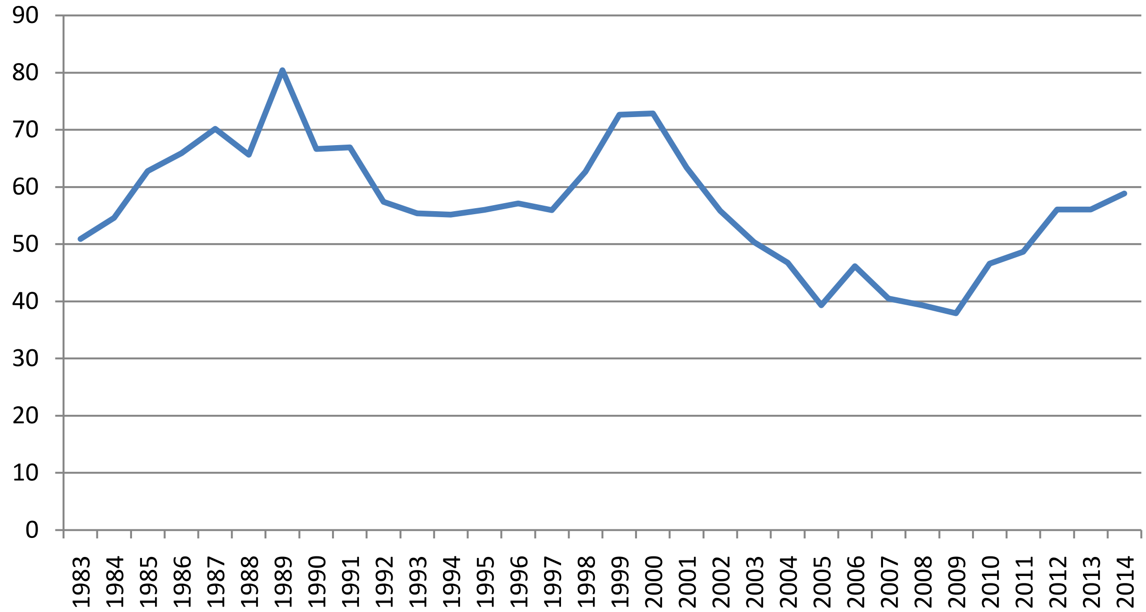
Table 3 includes the annual granting rate at the USPTO, calculated taking into account the estimated 3 year average lag between the application filing date and the granting date of a patent.[30] The USPTO granting rate for Canadian inventors peaked in 1989 at 80 per cent (Appendix Table 3). The next highest point was in 2000, when the granting rate reached 73 per cent. The granting rate declined thereafter until 2009, when the granting rate reached a low of 38 per cent. However since 2009 the granting rate improved, and in 2014 it had increased to 59 per cent, although this was still 14 percentage points less than in 2000.

iv. Comparing National Trends at the United States Patents and Trademark Office

The surge in patenting at the USPTO is not unique to Canadian residents. Eckert and Langinier (2014) note that patent applications and grants have more than doubled in both the US and Europe between 1990 and 2010. The authors note that several potential explanations for this rapid increase have been offered, including higher R&D expenditures and invention rates; an increase in the rate of filing abroad; less stringent examination standards; new patent strategies and management practices; and increased incentives to protect against infringement claims and strengthen firms' bargaining positions following recent legal decisions which have permitted the patenting of software and business practices (Eckert and Langinier, 2014).

[30] The estimate of 3 years is based on Eckert and Langinier (2014), who reported that between 1996 and 2008, the pendency time reported for the USPTO had increased from approximately 20 months to 40 months.

Chart 7: Per Cent Granting Rate for Canadian Residents at the USPTO, 1983-2014 (With 3 Year Lag)

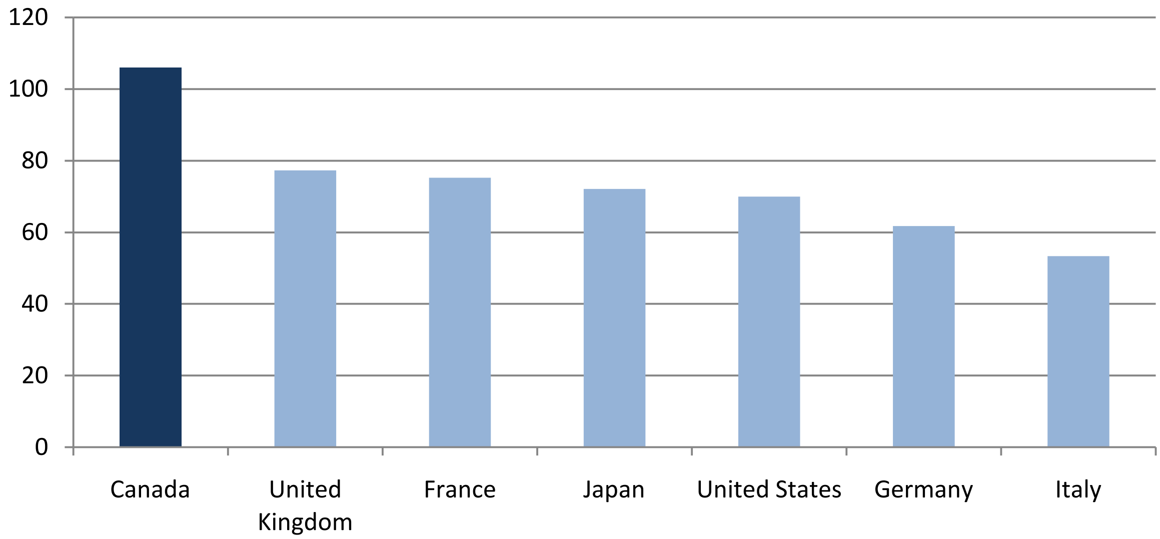


Source: Appendix Table 3.

Chart 8 compares growth in the number of patents granted by the USPTO to G7 countries from 2000 to 2014.[31] From 2000 to 2014, Canada experienced the highest growth in USPTO patent grants among the G7, and was the only G7 country to see a doubling of the number of patents granted to its inventors. All G7 countries suffered a decline between 2000 and 2008 in the number of USPTO patents granted to their inventors (with the exception of Japan). However in the following six years, from 2008 to 2014, all G7 countries experienced rapid growth in the number of patents granted to their inventors between 2008 and 2014, with Canada leading the G7 with an increase of 108 per cent. In absolute terms, however, Canada performs worse. Canadian inventors were granted 7,042 USPTO patents in 2014, fourth most among G7 countries but far behind the first-place United States (144,621 USPTO patents granted in 2014) and second-place Germany (53, 848 USPTO patents).

[31]Complete data on USPTO patent grants to residents of G7 countries are included in Appendix Table 4.

Chart 8: Per Cent Change in Total Patents Granted at the USPTO by Inventor(s)'s Country of Residence and Date of Grant, G7 Countries, 2000-2014



Source: Appendix Table 4.

C. Patenting Activity by Canadians at the Triadic Patent Family Offices

This section examines innovative activity by Canadian inventors as measured by the number of triadic patents issued to Canadian residents. A patent family refers to a set of patents taken in multiple countries to protect a single invention by common inventors, with the priority date of patenting determined by the date of the first patent application.[32] The term 'triadic patent family' refers specifically to a set of patents taken at the European Patent Office (EPO), the Japan Patent Office (JPO) and the United States Patent and Trademark Office (USPTO) to protect the same invention (OECD, 2006).

Compared to patents from a single patent office, triadic patents are typically "higher quality patents, since the cost of filing patents in all of three patent office works as an important screening device" (Nagaoka *et al*., 2010: 1101). Acquiring a triadic patent involves applying to all three intellectual property offices separately. The preliminary filing fee is 280 USD at the USPTO, 14,000 JPY (approximately 130 USD) at the JPO and about 210 EUR (approximately 230 USD) at the EPO.[33] These fees may not seem prohibitively expensive, but they exclude administrative fees, processing fees, professional drawings, and substantial legal fees (OECD, 2009). Quinn (2015) estimates that attorney fees to file for a patent with the USPTO typically

[32] Definitions and further information about various types of patent family are available from the European Patent Office at the following URL: http://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families.html.

[33] The USPTO fee schedule is available at http://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule. The Japan Patent Office fee schedule is available at http://www.jpo.go.jp/cgi/linke.cgi?url=/tetuzuki_e/ryoukin_e/ryokine.htm. The European Patent Office fee schedule is available at http://www.epoline.org/portal/portal/default/epoline.Scheduleoffees. Fees and foreign exchange rates are as of July 21st, 2016.

range from $5,000 to $16,000 depending upon the type and complexity of the invention. A rational actor would not incur these costs in three countries unless he or she expects the innovation to have a market value that exceeds the costs.[34] Thus, triadic patents not only indicate trends in innovative activity, but also emphasize the quality of the innovation. They also highlight the internationalization of the invention and its presence in large markets.

Furthermore, the use of triadic patents as indicators of innovative activity reduces the "home advantage bias" whereby domestic applicants generally have a higher propensity to file for patents in their country of residence (Dernis and Khan, 2004). This allows for a better international comparison of patent trends since patent applicants need to apply and receive a patent from all three offices, not just the office of their country of residence, in order to be considered a triadic patent. In the case of Canadian residents, focusing on triadic patents as an indicator of innovative activity reduces the market size bias prevalent in the high number of Canadian inventors who apply for USPTO patents (Dernis and Khan, 2004). This has a significant advantage over using patents only issued by the USPTO since Canadian inventors appear to prefer filing their first patent applications in the US as opposed to Canada or elsewhere.

i. Triadic Patents Granted to Canadian Inventors

Table 3 details the number of triadic patents granted to inventors resident of Canada from 1985 to 2011.[35] As noted in Section I.C, the OECD patent statistics database employs fractional counting when attributing a country of origin to a patent. Each country with an inventor listed on the patent will be attributed a fraction of the patent equal to the proportion of the total listed inventors who are resident of that country. For example, a patent co-invented by 1 French resident, 1 American resident and 2 Canadian residents will be counted as ¼ of a patent for France, ¼ for the USA and ½ patent for Canada (OECD: 2009). As a result, annual counts may not round to whole numbers.

Canadian inventors were granted 576 patents in 2011, an increase of 180 per cent from 1985. The strongest growth in this period occurred in the mid and late 1990s, when the number of triadic patents granted to Canadian inventors doubled in 7 years, increasing from 305.9 in 1993 to 612.3 in 2000. Most recently, between 2000 and 2011, the number of triadic patents granted to Canadian inventors has decreased by 5.9 per cent. Although growth had slowed throughout the 2000s, the number of triadic patents granted to Canadian inventors only substantially decreased post-recession, with the total volume of triadic patents falling 16 per cent from 2008 to 2011.

[34] While there may be some cost savings in preparing patent applications for three agencies rather than only one (economies of scale), we still expect obtaining a triadic patent to be considerably more costly than obtaining a patent only from the USPTO or CIPO.

[35] Although the OECD database is complete until 2012, the nature of priority date counting—that the number of patents attributed to a country in a given year is the number of patent applications filed that year which were later granted—is biased against more recent years because a higher proportion of these later patents remain under examination. Since the OECD database was last updated with patent data in 2013, the number of triadic patents decreases substantially for all OECD countries between 2011 and 2012.

Table 3: Triadic Patents issued to Canadian Inventor(s), 1985, 1990, 1995, 2000-2011

	Triadic Patents Granted to Canadian Inventors
1985	205.7
1990	290.8
1995	391.2
2000	612.3
2001	634.3
2002	678.4
2003	670.3
2004	736.9
2005	714.5
2006	666.8
2007	681.6
2008	686.5
2009	677.1
2010	553.5
2011	576.1
% Change 2000-2011	-5.92%
Annual growth rate, 2000-2011	-0.55%

Source: Appendix Table 5.

ii. International Comparison of Triadic Patenting Trends

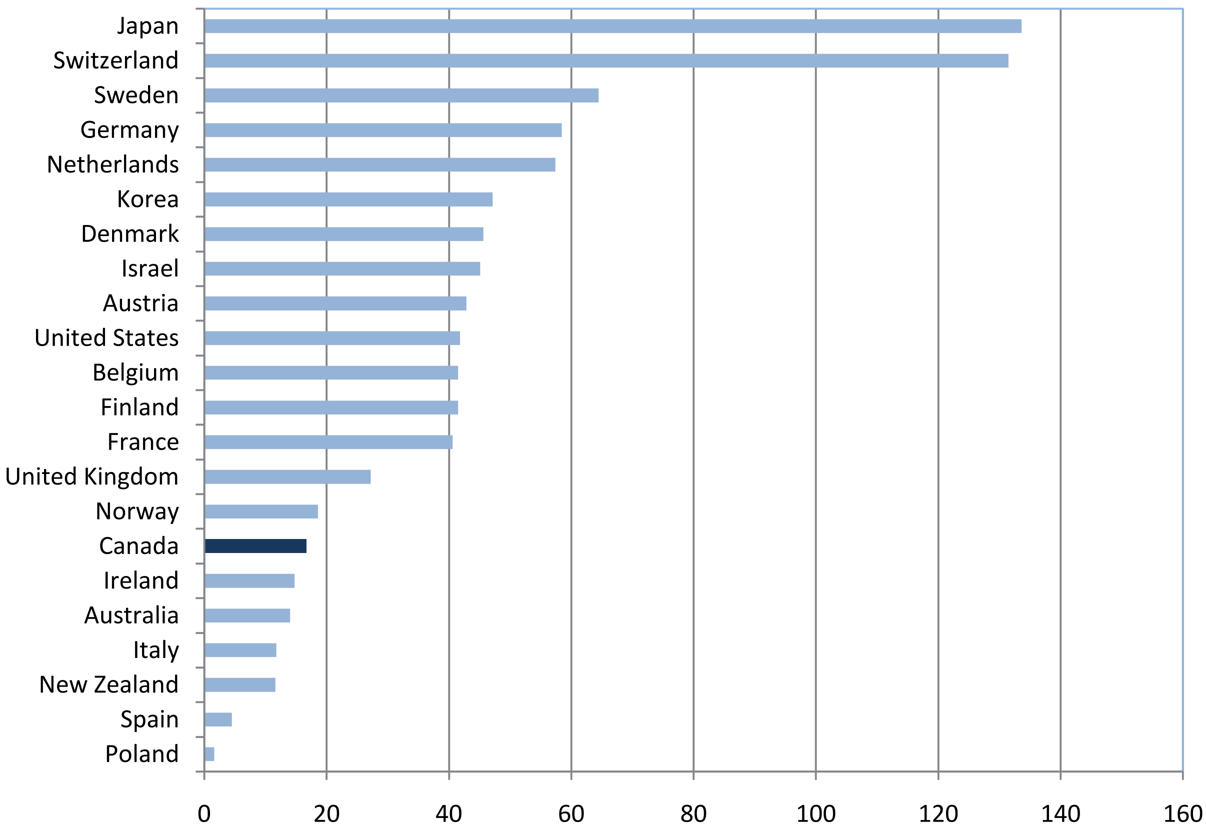
Chart 9 shows the total number of triadic family patents granted per million residents based on the country of origin of the inventor in 2011, the most recent year for which data are available from the OECD. Canada ranked 16th out of the 21[36] OECD countries considered with 16.7[37] patents per million residents, slightly behind Norway (18.6 patents per million residents) and ahead of Ireland (14.8 patents per million residents). Japan and Switzerland generated the most inventions receiving triadic patents per million residents, with 133.6 and 131.5 patents per million residents, respectively, more than double the next highest-ranking country, Sweden (64.5 patents per million residents).

Chart 10 presents the per cent change in the number of triadic patents granted to inventors in each G7 country from 2000-2011. In line with the ISQ data on triadic patents, Canada has experienced negative growth in this period. From 2000-2011 all G7 countries saw their numbers of triadic patents shrink. Canada saw the second smallest decline, of 5.9 per cent,

[36]We do not include 12 of the 34 OECD countries that were granted fewer than 50 triadic family patents in 2011.

[37] This figure does not correspond to the 821 Triadic patents issued to Canadians in Appendix Table 11, but instead to a total of 687 patents. This discrepancy is due to the fact that the data in Appendix Table 11 from the ISQ only attribute the patent to the country of the first named inventor, whereas the OECD data used in Chart 8 utilize fractional counting to attribute countries of origin to the patents. Moreover, data on patents granted by the triadic family from the ISQ are based on granting date, but data from the OECD are based on priority date (the date the patent application was submitted to the first filing office) as opposed to the date the patent was granted. For example, if a patent application was filed in 2000 but granted in 2004, the patent will be accounted for in 2000, not in 2004. OECD data based on the patent's date of grant was unavailable for triadic family patents.

Chart 9: Triadic Patents Granted per Million People by Inventor(s)'s Country(ies) of Residence and Priority Date, Select OECD Countries, 2011

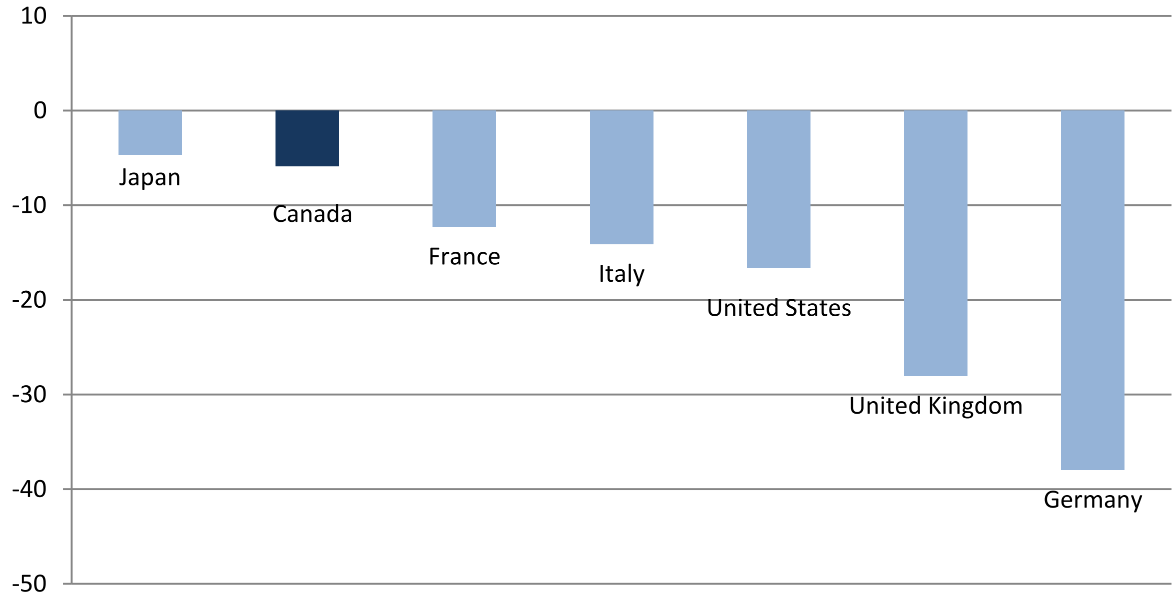


Source: Calculations based on OECD Patent Statistics (http://stats.oecd.org/Index.aspx?DatasetCode=PATS_IPC#) and OECD Population Statistics (http://stats.oecd.org/Index.aspx?DatasetCode=POP_FIVE_HIST).

smaller than only the per cent change for triadic patents granted to Japanese inventors, -4.7 per cent.

However, Canada fares far worse in comparison to other G7 countries when examining only more recent trends in the number of triadic patents. From 2008-2011 Canada experienced a decrease of 16.1 per cent in the number of triadic patents granted to its inventors, the largest decline among G7 countries.

Chart 10: Per Cent Change in Triadic Patents Granted to Inventor(s)'s Country(ies) of Residence and Priority Date, G7, 2000-2011



Source: Calculations based on OECD Patent Statistics (http://stats.oecd.org/Index.aspx?DatasetCode=PATS_IPC#) and OECD Population Statistics (http://stats.oecd.org/Index.aspx?DatasetCode=POP_FIVE_HIST).

D. Comparing Patenting Activity by Canadians across Patent Offices

The inventions produced from innovative activity in Canada may be patented at intellectual property offices around the world. While some Canadian residents opt to patent their inventions only at home with CIPO, many seeking larger markets for their product apply for patents internationally, such as at the USPTO and the other two members of the triadic family patent offices, the EPO and the JPO. Comparing trends in patenting by Canadian inventors at each patent office helps shed light on the factors which drive innovative activity in Canada.

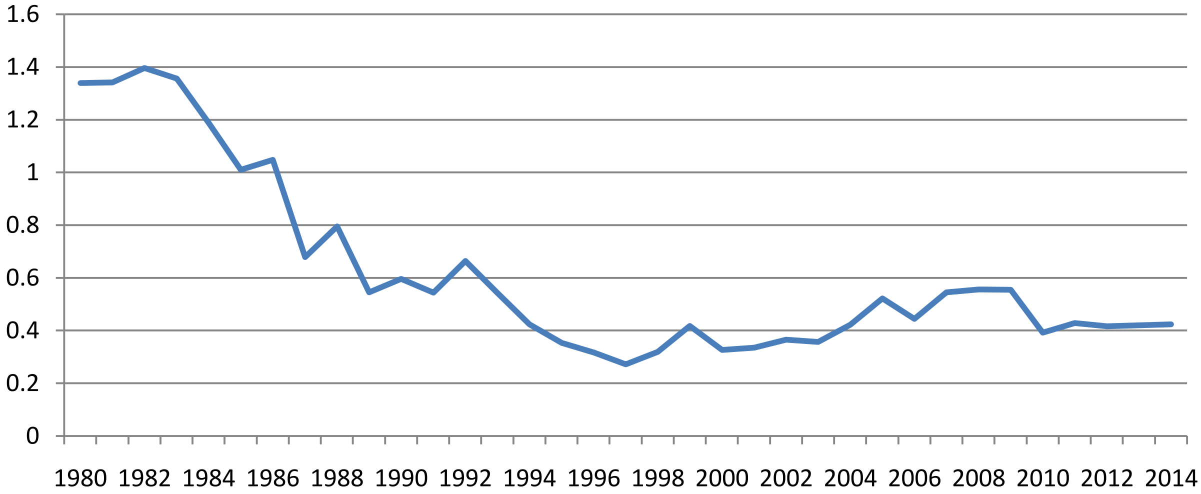
Although the number of patents awarded to Canadian inventors by all three patent offices has increased since 1980, since 1987 there have been far more USPTO patents issued to Canadian inventors than other types of patents. Chart 11 shows the ratio of patents granted to Canadian residents by CIPO versus the USPTO between 1980 and 2014. This ratio has declined since 1982, and since 1986 more Canadian inventors have been granted patents by the USPTO than by CIPO. In 2014, the number of CIPO patents granted to Canadian residents was only 42 per cent of the volume of patents granted to Canadian residents by the USPTO.

In 2008, the most recent year for which comparable absolute volume data are available from all three patent jurisdictions,[38] 3,393 patents were issued by the USPTO to Canadian

---

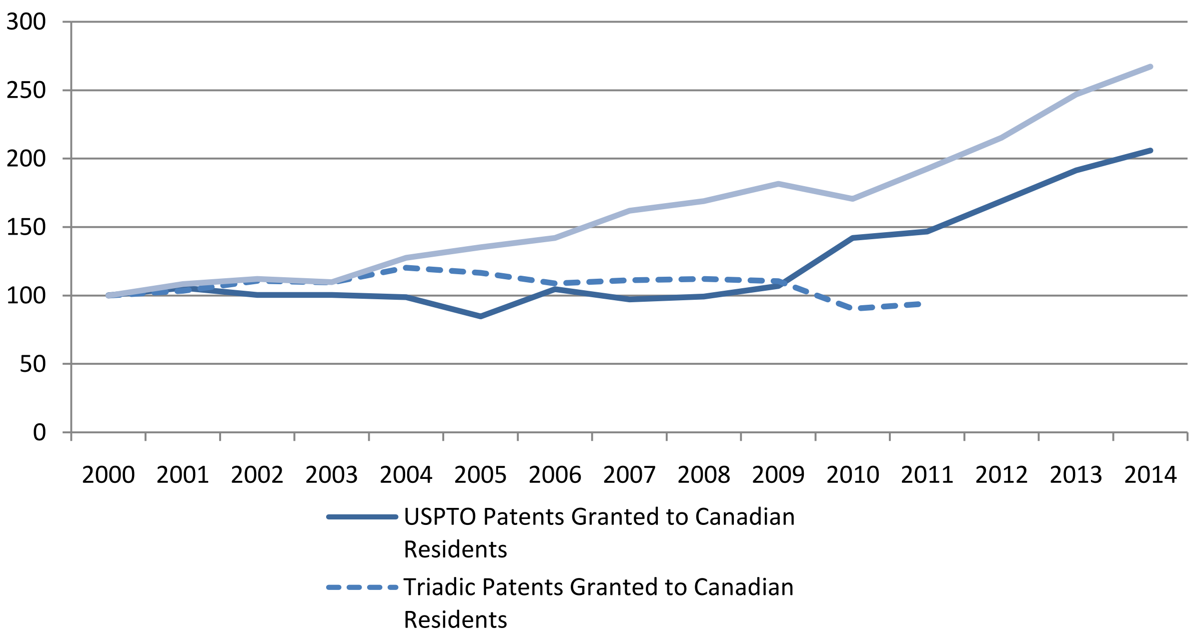
[38]As noted, statistics on triadic patents from the OECD are available only on the basis of fractional counting, rather than the 'first country' counting used for CIPO and USPTO data. Although this does not limit the comparability of growth trends from the three offices, absolute counts of patent grants from each office are not comparable data.

Chart 11: Number of Patents Granted by CIPO to Canadian Inventors versus Number of Patents Granted by the USPTO to Canadian Inventors, 1980-2014



Source: Appendix Tables 1 and 3.

Chart 12: Number of Patents Granted by CIPO, USPTO, and Triadic Patent Family Offices to Canadian Inventors, 2000-2014 (2000=100)



Source: Appendix Tables 1, 3 and 5.

However, data from the ISQ on a first country counting basis for triadic patents granted to Canadian inventors between 1980 and 2008 (included in Appendix Table 11) show that the volume of triadic patents granted to Canadian inventors has historically been far below the number of USPTO and CIPO patents granted to Canadians.

applicants while only 1,886 patents were issued by CIPO to Canadian applicants and only 821 triadic patents were granted to Canadian residents. Chart 12 presents recent trends in the number of patents granted to Canadian residents by each of the three intellectual property offices.

In the last decade for which comparable data are available, growth in CIPO patents outstripped the number of patents granted to Canadian residents by other offices. Between 2000 and 2011 the number of CIPO patents granted to Canadian inventors grew by 93 per cent, compared to growth of 47 per cent in USPTO patents and a 6 per cent decline in triadic patents.

Since 2011, however, there has been a substantial surge in patents issued by the USPTO to Canadians, with the total volume increasing by 93 per cent between 2009 and 2014. In comparison, the number of patents granted by CIPO to Canadian residents has grown by half that amount, 47 per cent, in the same period. Moreover, the number of patent applications filed by Canadians at the USPTO increased by 26 per cent in the same period—in contrast to the 17 per cent decline in patent applications filed at CIPO to Canadian residents between 2009 and 2014. Finally, the USPTO granting rate was lower than CIPO granting rate to Canadian residents in 2014, the most recent year for which data are available, when the USPTO granted 39 per cent of the patent applications filed in 2011 and CIPO granted 66 per cent of the patent applications filed in 2010.

There are several potential explanations for the difference in the number of patents granted to Canadians by the USPTO, CIPO, and triadic patent family offices. Some factors in Canadian inventors' choice of where to patent their innovations could include where the market for their product is located, the probability of their patent application being successful, and different definitions of patentability across each office.

The worldwide trend of globalization and integration in patenting is especially prevalent in Canada, as 82 per cent of patent applications by Canadian residents are filed at foreign intellectual property offices (Brydon *et al.*, 2014: 3). As it has become easier for Canadian firms to sell their products across borders (particularly in the United States) due to changes in technology and more extensive trade agreements, the relative attractiveness of protecting their inventions in larger foreign markets has increased. This correlates with the observed increase in USPTO patents granted to Canadians, though not with the decrease in triadic patents since 2008.

One explanation for differences in the volumes of patents granted by each office is different granting rates at CIPO, USPTO, and the triadic family patent offices. Calculations from Tables 1 and 2 indicate that between 2000 and 2014 patents filed by Canadians at the USPTO had a higher granting rate (51 per cent) compared to the average granting rate at CIPO over the same period (41 per cent), indicating that receiving a patent from the USPTO after the costly and long application process is more likely than from CIPO.

Triadic patents must be granted by the USPTO, EPO, and JPO. Data on triadic patent applications is not available from WIPO, so granting rates for triadic patent applications at the EPO and JPO cannot be calculated like for CIPO and USPTO. However, Quillen and Webster (2006: 653) report that between 1995 and 2004, of the patents already granted by the USPTO, the EPO granted only 72.5 per cent of the same patents (with 5.1 per cent still pending) and the

JPO granted 44.5 per cent of the same patents (with 11.3 per cent still pending). These findings suggest that examination standards at the EPO and the JPO may be higher than those of the USPTO, lending another potential explanation as to why the number of USPTO patents to Canadians greatly outweighs the number of triadic family patents granted.

One reason may be that there is a more expansive definition of patentable subject matter at the USPTO than there is at CIPO (Brydon *et al.*, 2014: 3).[39] For example, as confirmed in the 2002 landmark Supreme Court of Canada ruling in *Harvard College v Canada (Commissioner of Patents)*, CIPO does not issue patents for genetically modified 'higher life forms'.[40] In comparison, the USPTO has a reputation for being broad in its interpretation of whether patented inventions fit the criteria of non-obviousness, usefulness, and novelty (Brydon *et al.*, 2014: 3). Similarly, the EPO does not consider computer enabled inventions (such as software) to be patentable subject matter whereas the USPTO does. Because obtaining a triadic family patent requires obtaining a patent from the EPO, the JPO, and the USPTO, it is likely that patent applications pertaining to innovations in software are patented by the USPTO, but are not applied for at the EPO.

E. Trends in Patenting in Canada by Technology

Successful economies must specialize, which requires innovation to be concentrated in key industries and technological areas. It is thus worth examining which technologies have received the most patents in the past and grown most rapidly in recent years in order to understand the potential they offer for driving future innovation in Canada.

Brydon *et al*. (2014) construct a sectoral innovation index and find that innovative activity as measured by Canadian patent applications has been high in the utilities, construction and computers and electronics sector, relative to other sectors.[41] In addition, there are several sources of data on the types of technologies being patented and the industrial sectors of firms being granted patents. WIPO provides information on the technologies of patent grants to Canadians by CIPO and the USPTO according to a 35 code technology classification developed by several WIPO partner research organizations.[42] Information on USPTO patent grants to Canadian inventors by International Patent Classification (IPC) code is available from the Five IP Offices consortium and presented in this report in the eight aggregated technological classifications. The USPTO also releases information that associates each granted patent with its

[39] A more expansive definition of patentability could be expected to lead to higher granting rate at the USPTO compared to CIPO. However, there are likely behavioural impacts of the more expansive definition when inventors are aware of the difference. That is, inventors will rarely apply for patents at CIPO that they consider likely to be rejected due to the stricter definition of patentability at CIPO.

[40] See *Commissioner of Patents v. President and Fellows of Harvard College*[2002] 4 S.C.R. 45, 2002 S.C.C. 76.

[41] The Brydon *et al.* (2014:6) innovation index measures the annual share of patent applications filed at CIPO by Canadian residents in a certain industry, divided by that industry's share of total CIPO patent applications.

[42] This technological classification system for patents was developed by the Fraunhofer Institute for Systems and Innovation Research (ISI), Observatoire des Sciences et des Technologies (OST), and French patent office (INPI). Each of the 35 codes in the ISI-OST-INPI patent technological classification system contains International Patent Classification (IPC) codes from the eight aggregated IPC codes. See Schmoch (2008) for a detailed description of the ISI-OST-INPI patent technological classification system, concordance between it and the IPC system, and descriptions of the 35 technological classifications.

final use in the economy according to North American Industrial Classification System (NAICS) manufacturing codes. Finally, the ISQ provides data on the number of information and communications technology (ICT) patents granted to Canadian inventors, including by provincial and CMA origin. These patents are classified as ICT inventions based on the IPC system.[43]

Tables 4 and 5 include data from WIPO on recent trends of CIPO and USPTO patents granted to inventors resident in Canada between 2000 and 2014, ranked by the per cent change in patents granted in each technological category between 2000 and 2014.[44] Appendix Tables 6, 7, and 8 include information on the average annual growth rates, percentage contributions to total change, and changes in the number of CIPO and USPTO patent grants for these 35 technological categories in each decade between 1980 and 2014.

Overall, the number of patents granted to Canadians by CIPO has surged since 2000, though the number of patents granted by the USPTO began increasing only after 2010. At both CIPO and USPTO the volume of patents related to information and communication technologies (ICT) have increased in recent years. Patents from these inventions played an important role in the general increase in patents granted by CIPO since 2000 and the USPTO after 2010.

Several of the same technologies have driven the boom in CIPO and USPTO patents since 2010: medical technology (#13), digital communications (#4), and computer technology (#6) all ranked in the top five contributors to the increases in total patents granted by each office. In each of these three categories the number of patents granted by both offices has also grown at very high rates since 1980. IT methods for management (#7) has been a fast-growing field for patents from both offices, with the highest-ranked growth of all technology categories at CIPO between 2000 and 2010 (21.5 per cent) and from 2010-2014 (50.6 per cent). IT methods for management also ranked second in patents at the USPTO from 2000 to 2010, experiencing an annual growth rate of 20.2 per cent in that period, though that technological category of patents slipped to eighth place in the 2010-2014 period, with average annual growth of only 11.4 per cent.

However, the most patented technological categories by Canadians at each office are not identical. Whereas the number of CIPO patents granted to Canadians has grown considerably for inventions in measurement (#10), civil engineering (#35) and engines, pumps and turbines (#27), the number of USPTO patents in these technological categories has not increased at the same pace between 2010 and 2014. Conversely, the USPTO granted a large number of patents to inventions in telecommunication (#3) and audio-visual technology (#2) that were not also matched by CIPO.

---

[43]Institut de la statistique du Québec, Definition: Brevet en biotechnologies et en technologies de l'information et des communications. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/cdmi.html.
[44] Annual total CIPO and USPTO patent grants do not equal the total annual grants in Appendix Tables 1 and 3.

Table 4: Number of CIPO Patent Grants to Canadian Inventors and Growth Rates by Technology, 2000-2014

Technology	Number of CIPO Patents Granted			Per Cent Change in CIPO Patent Grants, 2000-2014
	2000	2010	2014	
7 - IT methods for management	1	7	36	3500.0
4 - Digital communication	23	159	425	1747.8
27 - Engines, pumps, turbines	12	52	103	758.3
6 - Computer technology	45	89	228	406.7
13 - Medical technology	30	65	124	313.3
31 - Mechanical elements	22	77	86	290.9
35 - Civil engineering	97	269	332	242.3
18 - Food chemistry	7	22	22	214.3
19 - Basic materials chemistry	28	52	88	214.3
10 - Measurement	56	81	157	180.4
17 - Macromolecular chemistry, polymers	9	25	23	155.6
24 - Environmental technology	19	46	48	152.6
21 - Surface technology, coating	14	20	35	150.0
32 - Transport	57	107	137	140.4
16 - Pharmaceuticals	29	60	66	127.6
15 - Biotechnology	19	40	43	126.3
23 - Chemical engineering	38	52	85	123.7
2 - Audio-visual technology	26	24	56	115.4
1 - Electrical machinery, apparatus, energy	67	90	137	104.5
14 - Organic fine chemistry	17	33	34	100.0
30 - Thermal processes and apparatus	27	42	53	96.3
25 - Handling	47	57	92	95.7
29 - Other special machines	64	115	121	89.1
11 - Analysis of biological materials	7	18	12	71.4
12 - Control	22	19	33	50.0
33 - Furniture, games	63	53	91	44.4
8 - Semiconductors	7	5	10	42.9
26 - Machine tools	50	58	69	38.0
20 - Materials, metallurgy	29	53	40	37.9
3 - Telecommunications	70	79	95	35.7
34 - Other consumer goods	35	38	46	31.4
28 - Textile and paper machines	13	10	17	30.8
9 - Optics	23	31	26	13.0
5 - Basic communication processes	13	11	14	7.7
22 - Micro-structural and nano-technology	-	1	3	n.a.
Unknown	3	-	-	n.a.
Total Patents Granted to Canadian Inventors	**1089**	**1960**	**2987**	**174.3**

Source: World Intellectual Property Organization statistics database. Indicator: 5 - Patent grants by technology http://www.wipo.int/ipstats/en.

Table 5: Number of USPTO Patent Grants to Canadian Inventors and Growth Rates by Technology, 2000-2014

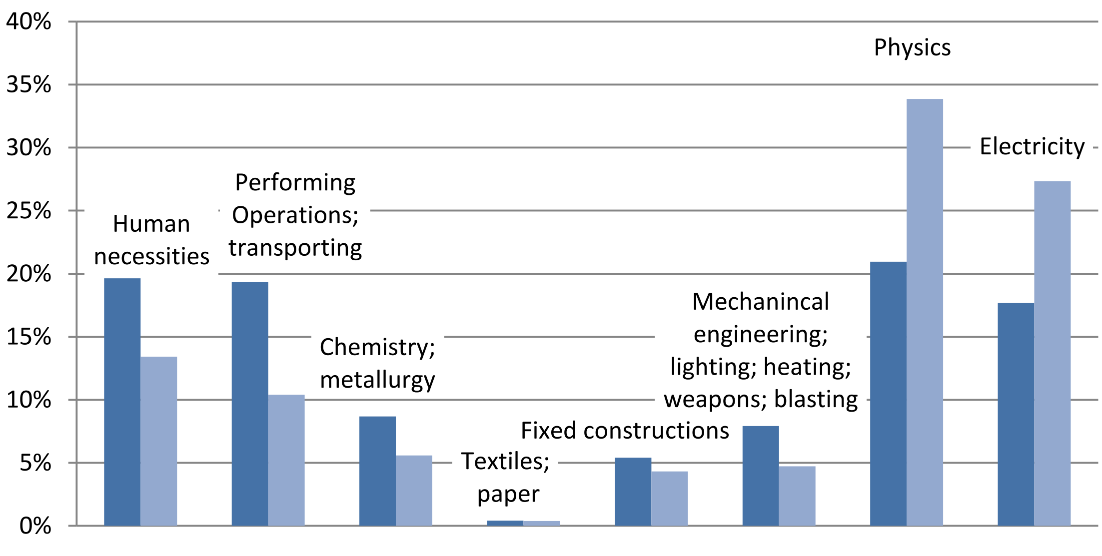
Technology	Number of USPTO Patents Granted			Per Cent Change in USPTO Patent Grants, 2000-2014
	2000	2010	2014	
6 - Computer technology	134	862	1384	932.8
7 - IT methods for management	10	63	97	870.0
22 - Micro-structural and nano-technology	1	1	6	500.0
4 - Digital communication	166	354	816	391.6
8 - Semiconductors	21	60	79	276.2
2 - Audio-visual technology	88	182	312	254.5
19 - Basic materials chemistry	37	67	100	170.3
17 - Macromolecular chemistry, polymers	16	48	41	156.3
10 - Measurement	112	208	251	124.1
12 - Control	57	95	127	122.8
18 - Food chemistry	25	41	55	120.0
1 - Electrical machinery, apparatus, energy	130	224	268	106.2
5 - Basic communication processes	59	114	120	103.4
3 - Telecommunications	247	352	496	100.8
13 - Medical technology	112	142	219	95.5
14 - Organic fine chemistry	56	97	109	94.6
31 - Mechanical elements	79	89	148	87.3
21 - Surface technology, coating	41	50	74	80.5
16 - Pharmaceuticals	114	147	175	53.5
9 - Optics	78	145	117	50.0
23 - Chemical engineering	89	75	119	33.7
27 - Engines, pumps, turbines	90	108	117	30.0
35 - Civil engineering	217	240	275	26.7
25 - Handling	110	104	138	25.5
32 - Transport	173	150	207	19.7
33 - Furniture, games	165	156	192	16.4
28 - Textile and paper machines	38	46	42	10.5
26 - Machine tools	116	90	125	7.8
29 - Other special machines	184	183	198	7.6
20 - Materials, metallurgy	48	48	46	-4.2
15 - Biotechnology	139	118	132	-5.0
34 - Other consumer goods	95	73	86	-9.5
24 - Environmental technology	71	64	54	-23.9
11 - Analysis of biological materials	38	37	26	-31.6
30 - Thermal processes and apparatus	54	40	35	-35.2
Unknown	2		4	100.0
Total Patents Granted to Canadian Inventors	**3212**	**4873**	**6790**	**111.4**

Source: World Intellectual Property Organization statistics database. Indicator: 5 - Patent grants by technology http://www.wipo.int/ipstats/en.

Appendix Table 9 decomposes the total number of patents issued by the USPTO to Canadian inventors by the invention's International Patent Classification.[45] Trends in the contribution of each IPC Class from 2003-2014 are presented in Chart 13. There are several hundred different sub-group IPC classifications, and more added in each annual update, but in Chart 13 and Appendix Table 9 for simplification they have been presented in the eight higher-level aggregated groupings. There is no clear concordance between the IPC classifications and WIPO technological classifications that appeared in Tables 4 and 5. The classification 'human necessities' encompasses categories such as agriculture, foodstuffs and personal domestic articles while 'performing operations and transporting' includes categories such as cleaning, casting, as well as power driven tools.

Since 2003 the physics category has accounted for the largest share of patents granted to Canada's inventors by the USPTO, with a peak of 33.8 per cent of the total patents in 2014. The relatively large number of patents under this classification fits with Moser's (2005) study of 19th century inventions which found that countries with stronger patent laws tend to innovate in more technical industries. The second highest number of patents is found under the electricity classification with a share of 27.3 per cent of total USPTO patents issued to Canadian invented products in 2014. The relatively high share of patents under these two classifications may be regarded as an indication of a greater degree of innovation in these categories, although, as Brydon *et al.* (2014:4) note, the "raw number" of patents across different industrial sectors reflects both the industrial structure of the economy as well as those parts of it that tend to show the most patenting activity.

Chart 13: Share of Patents Issued at the USPTO to Canadian Inventions, by International Patent Classification Classes, 2003 and 2014



Source: Appendix Table 9, Panel B.

[45]A patent application can be assigned multiple IPC symbols, as it may relate to multiple technical features. Further information is available from the WIPO at the following URL: http://www.wipo.int/ipstats/en/help.

In addition to having the largest shares of USPTO patents issued to Canadian inventors, the physics and electricity classes also exhibited the only increase in shares between 2003 and 2014. During this time, the share of patents in the physics class increased by 12.9 percentage points (from 21.0 per cent) while the electricity class experienced an increase of 9.7 percentage points (from 17.7 per cent) (Panel B, Appendix Table 9). This reflects the relatively large growth rates experienced by both classes, with patents under the physics classification increasing at an annual rate of 11.6 per cent and patents under the electricity class increasing at annual rate of 11.1 per cent. The higher growth rate of electricity related patents may be a result of increased pressure on energy resources that have led to increased innovation related to technologies such as solar energy, fuel cells, and wind energy (WIPO, 2008).

The increased share of patents going to inventions classified in the physics and electricity classes was at the cost of all other classes losing share (with the exception of the textiles and paper class, which in 2014 returned to its 2003 total share of 0.4 per cent), although other classes did experience a positive annual growth rate in USPTO patents between 2003 and 2014. The performing operations and transporting class saw the biggest share decline, of 8.9 percentage points; that category of patents grew at an annual rate of only 0.94 per cent. The human necessities class also saw a significant drop in the total share of patents, of 6.2 percentage points, from 19.6 per cent of the 2003 total to 13.4 per cent in 2014.

The USPTO provides data on the North American Industrial Classification System (NAICS) manufacturing codes associated with patent grants.[46] Table 6 presents these data for the patents granted to Canadians by the USPTO between 2000 and 2012 (the most recent year for which data on patents by NAICS are available). Panel A includes data on patents by three-digit NAICS codes (for example chemicals, NAICS code 325) while Panel B presents data on patents associated with the disaggregated four-digit NAICS codes (for example, pharmaceuticals and medicines, NAICS code 3254).[47]

Most of the manufacturing NAICS codes where Canadian inventors were granted the highest number of USPTO patents between 2000 and 2012 were related to ICT sectors, in terms of both number of patents issued and growth rates. The number of patents classified under computer and electronic products (NAICS code 334) was 3,153 in 2012 and grew by 235 per cent between 2000 and 2012. The increase in computer and electronic products (NAICS code 334) accounted for 41 per cent of the total increase in USPTO patent grants to Canadian residents. Of all three-digit NAICS manufacturing codes included in the dataset, computer and electronic products was the only to grow at a rate higher than average across included industries of 69 per cent. The number of patents classified under electrical equipment, appliances, and components (NAICS code 335) and miscellaneous manufacturing (NAICS code 339) experienced significant growth as well, growing at rates of 39 and 38 per cent, respectively.

---

[46]Detailed descriptions of each NAICS code can be found at the following URL: http://siccode.com/en/naicscode/list/directory/code/31-33/alias/manufacturing.

[47] The NAICS patent concordance provided by the USPTO associates each patent with its final use in the economy, meaning patents are associated with a manufacturing NAICS code regardless of whether they are owned by a manufacturing firm or a service sector firm (USPTO, 2012:6).

Table 6: Number of USPTO Patent Grants to Canadian Inventors and Growth Rates by Manufacturing North American Industrial Classification System Code, 2000-2012

Panel A: USPTO Patents to Canadian Inventor(s) by Three-Digit NAICS Code

North American Industrial Classification System (NAICS) Code	Number of USPTO Patents Granted		Per Cent Change in USPTO Patent Grants, 2000-2012	Per Cent Contribution to Total Change in USPTO Patent Grants by NAICS, 2000-2012
	2000	2012		
Computer and Electronic Products (334)	942	3,153	234.7	40.66
Wood Products (321)	18	25	38.9	0.42
Electrical Equipment, Appliances, and Components (335)	186	258	38.7	6.01
Miscellaneous Manufacturing (339)	289	398	37.7	7.55
Transportation Equipment (336)	161	195	21.1	4.97
Chemicals (325)	483	548	13.5	11.75
Primary Metal (331)	24	26	8.3	0.57
Machinery (333)	684	672	-1.8	15.44
Plastics and Rubber Products (326)	134	118	-11.9	2.66
Fabricated Metal Products (332)	311	263	-15.4	6.60
Nonmetallic Mineral Products (327)	66	52	-21.2	1.20
Textiles, Apparel and Leather (313-316)	43	32	-25.6	0.84
Food (311)	13	8	-38.5	0.27
Beverage and Tobacco Products (312)	5	3	-40.0	0.08
Furniture and Related Products (337)	30	13	-56.7	0.57
Paper, Printing and support activities (322 and 323)	31	11	-64.5	0.43
Total (all listed NAICS categories)	**3,419**	**5,775**	**68.9**	**100**

Panel B: USPTO Patents to Canadian Inventor(s) by Four-Digit NAICS Code

North American Industrial Classification System (NAICS) Code	Number of USPTO Patents Granted		Per Cent Change in USPTO Patent Grants, 2000-2012	Per Cent Contribution to Total Change in USPTO Patent Grants by NAICS, 2000-2012
	2000	2012		
Computer and Peripheral Equipment (3341)	192	1,132	489.6	18.65
Communications Equipment (3342)	287	1,103	284.3	20.85
Other Computer and Electronic Products (3343 and 3346)	42	131	211.9	2.31
Aerospace Product and Parts (3364)	19	47	147.4	1.43
Semiconductors and Other Electronic Components (3344)	159	321	101.9	10.08
Navigational, Measuring, Electromedical, and Control Instruments (3345)	263	466	77.2	15.82
Medical Equipment and Supplies (3391)	73	102	39.7	3.30
Basic Chemicals (3251)	118	162	37.3	5.38
Other Miscellaneous (339 (except 3391))	216	296	37.0	5.75
Other Chemical Product and Preparation (3253, 3255, 3256, and 3259)	142	173	21.8	2.55
Other Transportation Equipment (3365, 3366, and 3369)	50	56	12.0	4.63
Motor Vehicles, Trailers and Parts (3361-3363)	91	93	2.2	8.11
Pharmaceutical and Medicines (3254)	195	195	0.0	1.14
Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments (3252)	28	19	-32.1	18.65
Total (all listed NAICS categories)	**1,875**	**4,296**	**129.1**	**100**

Source: USPTO (https://www.uspto.gov/web/offices/ac/ido/oeip/taf/naics/stc_naics_fgall/cax_stc_naics_fg.htm)

The disaggregated four-digit NAICS manufacturing codes shown in Panel B are subsets of the three-digit NAICS codes shown in Panel A and therefore experience the same trends. In particular, the number of USPTO patents classified under the four-digit NAICS manufacturing codes associated with computer and electronic products (NAICS code 334) experienced the highest growth of the observed industrial sectors. The number of computer and peripheral equipment (NAICS code 3341) patents experienced the highest growth from 2000 to 2012, growing 490 per cent to 1,132 patents in 2012. Communications equipment (NAICS code 3342) received 1,103 patents in 2012, the second most patents of the disaggregated four-digit NAICS codes and grew by 284 per cent from the number issued in 2000. Four of the five sub-classifications in Panel B with the most growth in number of patents granted were classified under computer and electronic products. From these data it is clear that ICT inventions by Canadians received the most USPTO patents between 2000 and 2012, with inventions related to computers and communications equipment in particular leading the way.

In all three data sources examined, the technological and industrial classifications with the most patents are typically associated with information and communications technology (ICT): for example computer and electronics products (NAICS code 334, Table 6), physics and electricity (technologies by IPC code, Chart 13), and digital communications, computer technology, telecommunication, and audio-visual technology (technologies by WIPO classification, Tables 4 and 5). It is therefore worth looking closer at ICT patents. National level data on USPTO ICT patents to Canadians is presented in Table 7. These ICT inventions include electronic devices, computers, telecommunication devices and other ICT devices.

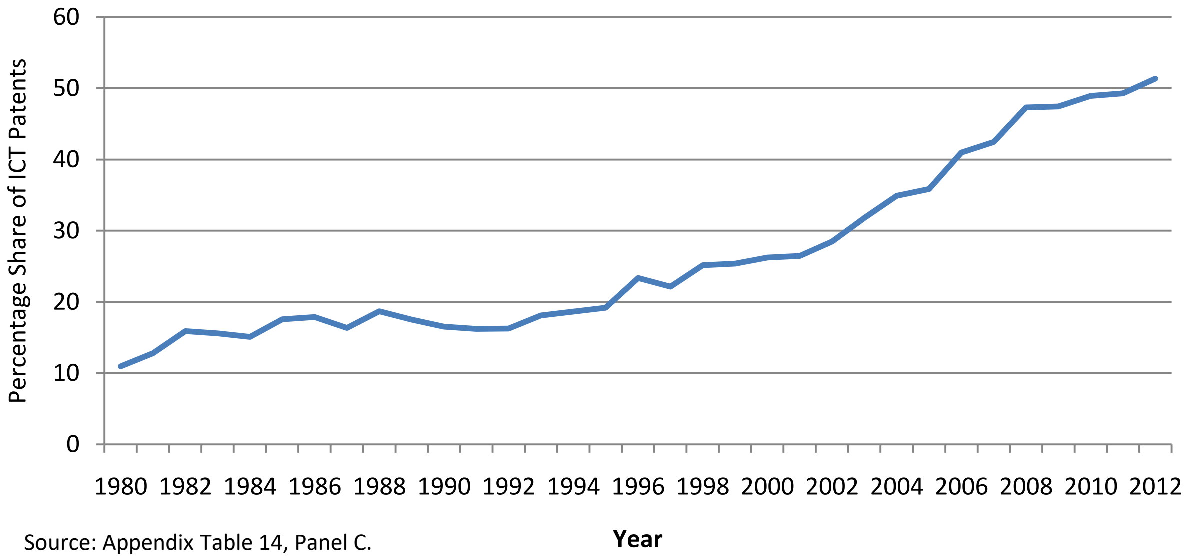
From 1980 to 2012, the number of USPTO ICT patents issued to Canadian inventors increased almost 28-fold from 125 patents in 1980 to 3,498 patents in 2012. Between 2000 and 2012, Canada experienced impressive average annual growth in the number of ICT patents issued by the USPTO (11 per cent) when compared to annual growth in the total number of USPTO patents issued to Canadian inventors (5 per cent, from Appendix Table 12). The application of IT may have substantially increased the productivity of further ICT research and

Table 7: Number of USPTO ICT Patented Inventions and its Share of Total USPTO Patents to Canadian Inventors, 1980, 1990, 2000, 2012

	Number of ICT Patents Granted to Canadian Inventors	Share of Total USPTO Patents to Canadian Inventors
1980	125	11.0
1990	324	16.5
2000	991	26.2
2012	3,498	51.4
% or Point Change, 2000-2012	253.0	25.2
Annual Growth Rate 2000-2012	11.1	5.8

Source: Appendix Table 14.

Chart 14: ICT Patents as a Percentage of Total Patents Granted to Canadian Inventors by the USPTO, 1980-2012



Source: Appendix Table 14, Panel C.

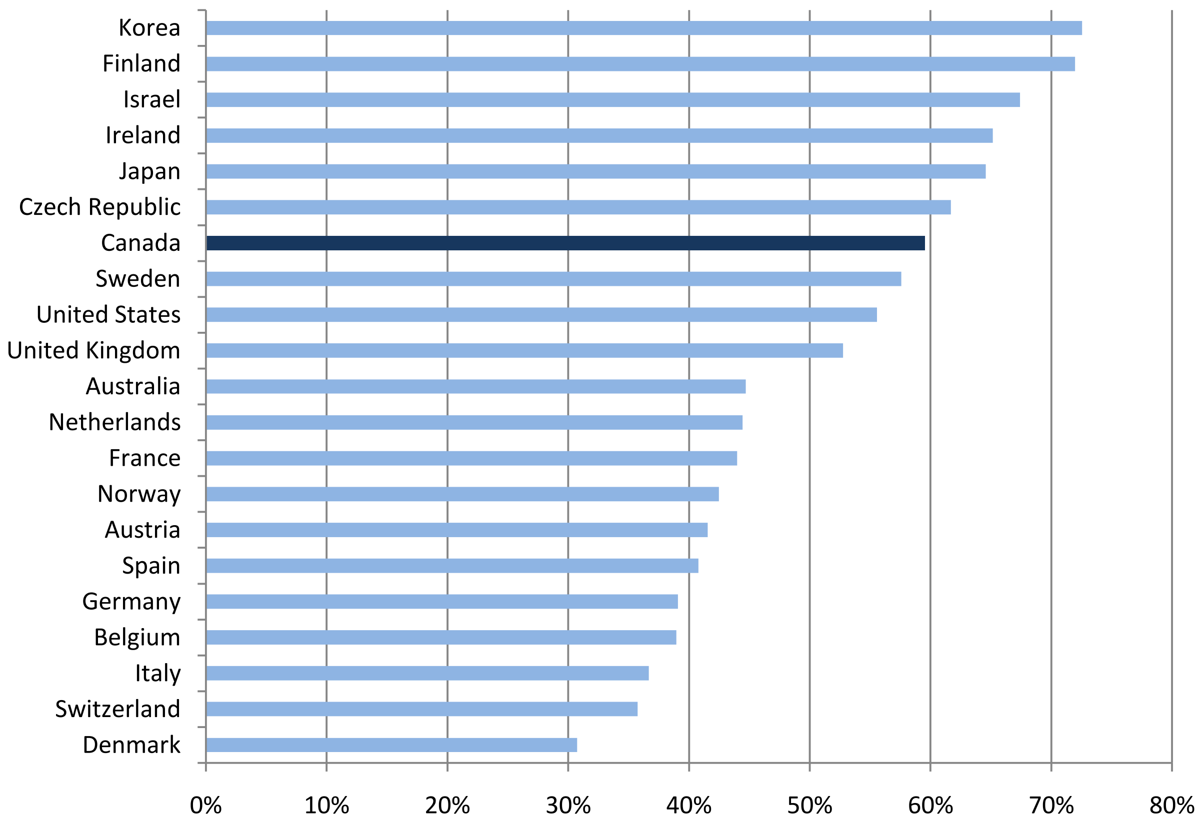
development, leading to compounding effects on ICT innovation (Rafiquzzaman and Whewell, 1998).

Chart 14 provides the share of ICT patents at the USPTO of total USPTO patents issued to Canadians. In 2012, ICT patents accounted for just over half of all USPTO patents issued at 51.4 per cent. Between 2000 and 2012, the share of USPTO patented ICT inventions out of total USPTO patented inventions almost doubled, increasing from 26.2 per cent in 2000 to 51.4 per cent in 2012. The large share of ICT patents in USPTO patents is reflective of Canada's above average number of ICT patent filings in the world (WIPO, 2008).

The high share of patents classified as ICT inventions could be explained by ICT firms' higher reliance on patenting over alternative methods of intellectual property protection. The USPTO (2012) found that ICT-related NAICS codes have a very high propensity to patent compared to other manufacturing NAICS codes, as measured by the ratio of patent grants to employment levels for each NAICS code.

The same method is applied to data on USPTO patents granted to Canadians and presented in Appendix Table 20. This research similarly finds that for USPTO patents granted to Canadians, all ICT-related NAICS classifications have an above-average propensity to patent. Between 2007 and 2012 the aggregated classification computer and electronic products (NAICS code 334) had an average patents-to-jobs ratio of 28.9 patents for every thousand jobs in that sector, compared to the mean of 3.5 patents per thousand jobs. The further disaggregated classification computer and peripheral equipment (NAICS code 3341) had an even higher average patents-to-jobs ratio over the same period, of 104.6 patents per thousand jobs in that sub-sector. One explanation for these findings is that some technological sectors rely more on patents to protect innovations than others, for example because some technologies are more difficult to

Chart 15: Per Cent Share of Total National USPTO Patent Grants Classified as ICT Inventions, Select OECD Countries, 2014



Source: Appendix Table 11.

protect through trade secrecy (Pavitt, 1988). However, an alternative explanation is that over this period these sectors were simply more innovative per employee than other sectors measured.

In either case, Canada performs well in international comparisons of ICT innovation as indicated by patent grants by technology. Chart 15 presents the per cent share of the total number of USPTO patents granted to residents of each OECD country in 2014 that were classified as ICT inventions.[48] In 2014 Canada ranked 7th, with 59.5 per cent of the patents granted to its inventors by the USPTO classified as ICT inventions.[49] This represented a doubling from ICT inventions' share of total USPTO patents granted to Canadian residents in 2000 (Appendix Table 11). Canada's high ranking among its peers for the importance of ICT inventions to total patent

[48]The analysis in Chart 15 does not include 13 of the 34 OECD countries that were granted fewer than 100 ICT patents by the USPTO in 2014.

[49]The OECD identifies ICT-patents as those classified under the following codes of the International Patent Classification (IPC): Telecommunications (G01S, G08C, G09C, H01P, H01Q, H01S3/025,043,063,067, 085, 0933, 0941,103,133,18,19,25, H01S5, H03B, H03C, H03D, H03H, H03M, H04B, H04J, H04K, H04L, H04M, H04Q); Consumer electronics (G11B, H03F, H03G, H03J, H04H, H04N, H04R, H04S; Computers, office machinery B07C, B41J, B41K, G02F, G03G, G05F, G06, G07, G09G, G10L, G11C, H03K, H03L); and Other ICT (G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, G01N, G01P, G01R, G01V, G01W, G02B6, G05B, G08G, G09B, H01B11, H01J(11/,13/,15/,17/,19/,21/,23/, 25/,27/,29/,31/,33/,40/,41/,43/,45/), H01L).

volumes provides further evidence that ICT innovation makes up a substantial component of the innovative activity in Canada.

III. Patents Trends at the Provincial Level

This section focuses on patent trends at the provincial level as an indicator of innovative activity within Canada. Trends in the number of patents granted by CIPO, the USPTO and the triadic patent family to Canadian inventors based on their province of residence are analyzed in order to locate where in Canada innovative activity is occurring.

Ontario, Canada's most populous province, leads all provinces in the number of USPTO and triadic patents granted to its resident inventors, even with patent counts normalized to provincial populations. However, Alberta ranks first in the number of CIPO patents granted to its inventors when patent counts are normalized to population size. Inventors from British Columbia and Québec are also granted relatively high volumes of patents by all three intellectual property offices.

A. Patents Granted by the Canadian Intellectual Property Office

Table 8 shows the number (both absolute and per 100,000 residents) and distribution of patents among the provinces of patents granted by CIPO for 2012 (the first year for which provincial patent data are publicly available from CIPO), 2013, and 2014 (the most recent year for which data are available).[50] Ontario and Alberta had the highest and second highest shares of patents granted by CIPO in 2014, at 50.8 per cent and 17.8 per cent respectively. Québec, which was only surpassed by Alberta in 2014, follows closely behind with 17.4 per cent of CIPO patents granted to Canadians. Ontario also experienced the largest growth in the number of CIPO granted patents, building off its already-largest number of patents to increase by nearly 40 per cent from 1,090 patents in 2012 to 1,520 patents in 2014. Most provinces experienced substantial growth in patenting, in line with the national-level data on CIPO patents. However Québec saw only a marginal increase in the number of patents granted to its residents between 2012 and 2014, and Nova Scotia and Prince Edward Island experienced decreases, although the latter was only from 3 patents in 2012 to 1 patent in 2014.

It is clear from examining the number of CIPO patents issued to Canadian residents that Ontario is the patenting centre of Canada.[51] In 2014, just over half (50.8 per cent) of all patents issued to Canadian residents went to residents of Ontario, up from 45 per cent in 2012. This is

[50]According to CIPO 2013-2014 and 2014-2015 Annual Reports, no inventors from the three territories were granted patents by CIPO in those years.

[51] These trends are in line with earlier observations by Brydon *et al*. (2014), who constructed two indices: the Provincial Innovation Index and the Sectoral Innovation Index to emphasize where Canadian inventors live and the sectors exhibiting the most innovation as measured through the number of patent applications. Using these indices, they find that inventors from Alberta and Ontario outperform all other provinces with respect to patent applications per capita. Our findings are also consistent with the observation in Brydon *et al.* (2014) that the Atlantic Provinces are dramatically below the national average of patent applications per capita.

Table 8: Number and Percentage Distribution of Patents Granted by CIPO to Residents of Canada by Province, 2012, 2013, and 2014

	Number of Patents			Per cent Change 2012-2014	% Distribution of Patents			Number of Patents (per 100,000 residents)		
Province	2012	2013	2014		2012	2013	2014	2012	2013	2014
N.L.	4	7	5	25.0	0.17	0.26	0.17	0.76	1.33	0.95
P.E.I.	3	2	1	-66.7	0.13	0.08	0.03	2.07	1.38	0.68
N.S	24	24	20	-16.7	1.01	0.91	0.67	2.54	2.55	2.12
N.B	19	26	19	0.0	0.80	0.98	0.64	2.51	3.44	2.52
Que.	508	543	521	2.6	21.27	20.49	17.41	6.28	6.66	6.34
Ont.	1,090	1,208	1520	39.4	45.64	45.58	50.80	8.13	8.91	11.11
Man.	67	78	80	19.4	2.81	2.94	2.67	5.36	6.16	6.25
Sask.	57	63	75	31.6	2.39	2.38	2.51	5.24	5.70	6.68
Alta.	446	535	531	19.1	18.68	20.19	17.75	11.47	13.35	12.89
B.C	170	164	220	29.4	7.12	6.19	7.35	3.74	3.58	4.74
CAN	**2,388**	**2,650**	**2,992**	**25.3**	**100.00**	**100.00**	**100.00**	**6.87**	**7.54**	**8.42**

Source: Canadian Intellectual Property Office, Annual Reports 2012-2013. 2013-2014, and 2014-2015. http://www.cipo.ic.gc.ca/eic/site/cipoInternet-Internetopic.nsf/eng/h_wr00025.html and CANSIM Table 051-0001.

due to Ontario's large population, as innovation often thrives in a larger peer group (Brydon *et al.*, 2014). However, it is also worth examining the number of patents granted to residents of each population when weighted by population (also in Table 8). In all three years from 2012-2014 Alberta led the country by this measure, with 12.9 patents per 100,000 residents in 2014, slightly over 1.5 times the national average. In 2014, Ontario was also above-average and, at 11.1 patents per 100,000 residents, had shrunk Alberta's lead among provinces. In 2014, all other provinces, however, were below the Canada-wide average of 8.42 patents per 100,000 residents.

B. Patents Granted by the United States Patent Office

Patents granted by the USPTO to Canadian residents serve as a good indicator of innovative activity in Canada because the high degree of economic integration between Canada and the United States allows Canadian inventors access to a larger market. Unlike data for CIPO patents granted to Canadian residents by province, provincial data on patent grants by the USPTO are available from 1980, but only to 2012. Table 9 presents the breakdown by province of USPTO patents granted to Canadian inventors, in absolute terms, the distribution to each province, the number of patents granted per 100,000 residents, and the number of grants per 100,000 residents relative to the Canadian average.[52] Data are included in Table 9 for 1980, 1990, 2000, and 2012, the most recent year for which data are available from the ISQ.[53]

[52]The ISQ reports that, combined, inventors resident to the Northwest Territories and Yukon were granted on average only 1.2 USPTO patents per year between 1980 and 2012 (data on USPTO patent grants to inventors in Nunavut is not available from ISQ) (Institute de la statistique du Québec data. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/inventions_qc_prov.htm).
[53] Data on the USPTO and Triadic patents received by each province in 1981-1989 and 1991-1999 are included in Appendix Tables 12 and 13

Table 9: Number of USPTO Patents Issued to Residents of Canada by Province, 1980, 1990, 2000, 2012

Panel A: Number of USPTO Patents to Inventor(s)

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	CAN
1980	3	–	5	10	272	642	17	26	74	123	**1,140**
1990	8	4	22	15	388	1,055	51	43	155	255	**1,961**
2000	16	2	41	40	749	2,090	96	77	394	455	**3,779**
2012	26	9	64	51	1,216	4,082	114	89	604	856	**6,812**
% Change, 2000-2012	62.5	350.0	56.1	27.5	62.4	95.3	18.8	15.6	53.3	88.1	**80.3**
Annual Growth Rate, 2000-2012	4.13	13.4	3.78	2.05	4.12	5.74	1.44	1.21	3.62	5.41	**5.03**

Panel B: Percentage Distribution

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	0.26	-	0.44	0.88	23.9	56.3	1.49	2.28	6.49	10.8
1990	0.41	0.20	1.12	0.76	19.8	53.8	2.60	2.19	7.90	13.0
2000	0.42	0.05	1.08	1.06	19.8	55.3	2.54	2.04	10.43	12.0
2012	0.38	0.13	0.94	0.75	17.9	59.9	1.67	1.31	8.87	12.6
Percentage point change, 2000-2012	-0.04	0.08	-0.14	-0.31	-1.97	4.61	-0.87	-0.73	-1.56	0.53

Panel C: Number of Patents per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	CAN
1980	0.52	-	0.59	1.42	4.18	7.34	1.64	2.69	3.38	4.48	**4.65**
1990	1.39	3.07	2.42	2.03	5.55	10.25	4.61	4.27	6.08	7.75	**7.08**
2000	3.03	1.47	4.39	5.33	10.18	17.89	8.37	7.64	13.11	11.26	**12.32**
2012	4.93	6.20	6.77	6.74	15.04	30.44	9.12	8.19	15.53	18.84	**19.60**

Panel D: Relative Patents per 100,000 Residents, Provinces vs. Canada (Canada = 1.00)

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	0.11	-	0.13	0.30	0.90	1.58	0.35	0.58	0.73	0.96
1990	0.20	0.43	0.34	0.29	0.78	1.45	0.65	0.60	0.86	1.09
2000	0.25	0.12	0.36	0.43	0.83	1.45	0.68	0.62	1.06	0.91
2012	0.25	0.32	0.35	0.34	0.77	1.55	0.47	0.42	0.79	0.96

Source: Appendix Table 12.

Table 9, Panel A shows the number of USPTO patents granted to Canadian inventors by province while Panel B presents the percentage distribution by province of the total number of USPTO patents granted to Canadian residents. Inventors from Ontario accounted for the highest share of USPTO patents to Canadian inventors in 2012, just under 60 per cent of the total number of patents granted to Canadian residents. This share exceeds Ontario's 39 per cent share of Canada's population in 2012. That same year, inventors from Québec accounted for the second highest number of USPTO patents issued to Canadian residents with a share of 17.9 per cent, although this represented a decline from Quebec residents' 1980 share of 23.9 per cent of the total USPTO patents granted to Canadian residents. British Columbia and Alberta came in third and fourth place with USPTO patent shares of 12.6 per cent and 8.9 per cent, respectively. While the share of patents increased by about 4 percentage points for Ontario and about half a percentage point in B.C., it fell by 2 percentage points in Québec and 1.6 percentage points in Alberta between 2000 and 2012. P.E.I had the highest annual growth rate in the number of patents between 2000 and 2012 at 13.4 per cent. However, this can be attributed to a relatively small increase (when compared to the other provinces) in an already low number of patents. Ontario had the second highest growth rate in the number of patents between 2000 and 2012 at 5.7 per cent per year while B.C had the third highest growth rate at 5.4 per cent during this same time.

Panel C shows the number of USPTO patents granted to inventors from each province, weighted per 100,000 residents. Between 1980 and 2012, inventors from Ontario were consistently granted the highest number of patents of any province. In 2012, Ontario had 30.4 patents per 100,000 residents, 60 per cent more than the next province, British Columbia, had with 18.8 patents per 100,000 residents. Inventors from Alberta were granted the third most patents, 15.5 per 100,000 residents, and were only surpassed by inventors resident to British Columbia in 2006. In 2012, Albertan inventors were granted only slightly more patents than Québec residents, who were granted 15.0 in 2012. Panel D, shows what these provincial patent volumes look like relative to the Canadian average. Ontario is the only province to exceed the national average in USPTO patents per 100,00 residents, with 1.55 times the nation-wide number of total USPTO patents granted to Canadian inventors per 100,000 residents.

C. Patents Granted to Canadian Residents by Province by the Triadic Patent Family Offices

Data on the volume of triadic patents granted to each province are sourced from the ISQ and therefore only available up until 2008. However, given that triadic patents are the costliest to obtain, since the inventor or patent holder must apply separately for patents from each of the three triadic patent family offices, triadic patents remain a useful measure for indicating which provinces' inventors produce and own the right to commercialize the highest quality and most internationalized innovations.

Table 10: Number of Triadic Patents Issued to Residents of Canada by Province, 1980, 1990, 2000, 2008

Panel A: Number of Triadic Patents to Inventor(s)

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	CAN
1980	–	–	–	–	11	18	–	2	1	3	31
1990	–	–	7	1	75	266	4	3	17	38	400
2000	–	–	10	6	196	513	12	8	74	101	858
2008	–	1	11	4	191	457	12	8	61	125	821
% Change, 2000-2008	n.a.	n.a.	10	-33.3	-2.55	-10.9	0	0	-17.6	23.8	-4.31
Annual Growth Rate, 2000-2008	n.a.	n.a.	1.20	-4.94	-0.32	-1.43	0	0	-2.39	2.70	-0.55

Panel B: Percentage Distribution

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	-	-	-	-	35.48	58.06	-	6.45	3.23	9.68
1990	-	-	1.75	0.25	18.75	66.50	1.00	0.75	4.25	9.50
2000	-	-	1.17	0.70	22.84	59.79	1.40	0.93	8.62	11.77
2008	-	0.12	1.34	0.49	23.26	55.66	1.46	0.97	7.43	15.23
Percentage Point Change, 2000-2008	n.a.	n.a.	0.17	-0.21	0.42	-4.13	0.06	0.04	-1.19	3.45

Panel C: Number of Patents per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	CAN
1980	-	-	-	-	0.17	0.21	-	0.21	0.05	0.11	0.13
1990	-	-	0.77	0.14	1.07	2.58	0.36	0.30	0.67	1.15	1.44
2000	-	-	1.07	0.80	2.66	4.39	1.05	0.79	2.46	2.50	2.80
2008	0.20	0.73	1.28	0.67	2.60	3.96	1.68	0.90	1.94	3.31	2.72

Panel D: Relative Patents per 100,000 Residents, Provinces vs. Canada (Canada = 1.00)

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	-	-	-	-	1.34	1.63	-	1.63	0.36	0.86
1990	-	-	0.53	0.09	0.74	1.79	0.25	0.21	0.46	0.80
2000	-	-	0.38	0.29	0.95	1.57	0.37	0.28	0.88	0.89
2008	-	0.29	0.48	0.22	1.00	1.44	0.41	0.32	0.69	1.16

Source: Appendix Table 13.

Table 10, Panel A shows the number of triadic patents received by inventors in each province in 1980, 1990, 2000 and 2008.[54] Inventors in Ontario received the highest number of triadic patents in 2008 with 457 patents, followed by Québec with 191 patents and British Columbia with 125 patents. Although all three provinces received much higher number of patents than the other seven provinces—the next largest is Alberta, whose inventors received 61 patents—only British Columbia experienced an increase, of 23.8 per cent in their volume of triadic patents to inventors between 2000 and 2008. The number of triadic patents Québec inventors received decreased by 2.6 per cent from 2000 to 2008 and in Ontario the volume of patents declined by 10.9 per cent. Only Alberta saw a larger decline, of 17.6 per cent.[55]

Panel B includes data on the distribution of triadic patent grants by province. Similar to the distribution of USPTO patents, inventors in Ontario receive over half of the triadic patents granted to Canadian residents, while Québec has seen its share slip from 35.5 per cent in 1980 to 23 per cent in 2008. British Columbia significantly increased its share of triadic patents from 11.7 per cent in 2000 to 15.2 per cent in 2008, and was the only province to see its share grow significantly in that period.

Panel C presents the number of triadic patents granted to inventors in each province, weighted by provincial population. In 2008 Ontario residents were issued the most triadic patents with 4 patents granted to per 100,000 residents. British Columbia was next, with 3.3 patents per 100,000 residents, and Québec followed with 2.6 patents per 100,000 residents. After peaking in 2000 with 2.5 patents per 100,000 residents, Albert declined to fourth place, 1.9 patents per 100,000 residents, in 2008.

D. Comparing Provincial Patent Trends Across Intellectual Property Offices

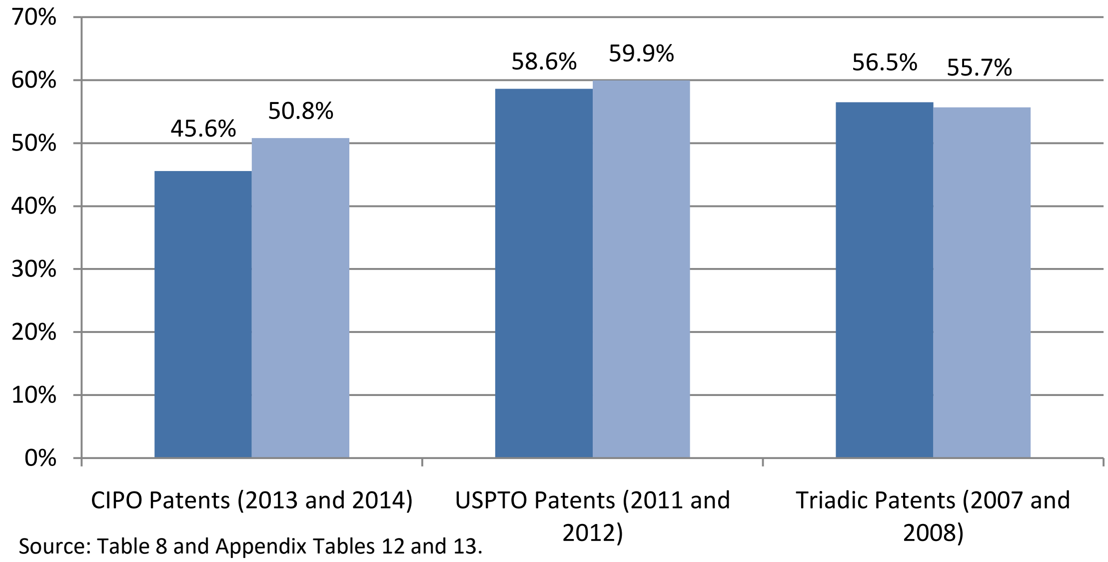
There are noteworthy differences in the number of patents granted by each intellectual property office to each Canadian province in the most recently available year, both in absolute terms and when patent grant volumes are normalized to provincial population sizes. In population-normalized terms, Alberta receives the largest number of CIPO patents, receiving 12.9 patents per 100,000 residents in 2014, while Ontario received the second most (11.1 patents per 100,000 residents), Saskatchewan the third most (6.68 patents per 100,000 residents) Québec the fourth most (6.34 patents per 100,000 residents) and British Columbia ranking sixth, with only 4.7 patents per 100,000 residents in 2014. However, Ontario receives far more USPTO patents per 100,000 residents than Alberta (30.4 and 15.5 patents per 100,000 residents, respectively), as does British Columbia (18.8 patents per 100,000 residents), in contrast to the

---

[54]The ISQ also releases data on the total number of triadic patents granted to residents of Nunavut, the Northwest Territories, and Yukon. Combined, inventors resident in the three territories were granted on average six triadic patents per year between 1980 and 2008 (Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/triad_canada.htm). However, very high annual patent counts in some years (for example, 20 patents granted in 2008 and 16 patents granted in 2002) merit strong scrutiny, especially considering the smaller number of USPTO patents granted to residents of the territories in those years.

[55] Although New Brunswick experienced an even larger decline of 33.3 per cent in the number of triadic patents its inventors received between 2000 and 2008, the small volume of patents (from 6 in 2000 to 4 in 2008) renders this change insignificant.

Chart 16: Ontario's Share of Total Canadian Patents, Two Most Recent Years Available



Source: Table 8 and Appendix Tables 12 and 13.

latter province's relatively weaker performance compared to Alberta in patents granted by CIPO. In population-normalized patent counts Alberta also performed worse in triadic patents than in CIPO patents. In 2008, Ontario ranked first in triadic patents (with 4.0 patents per 100,000 residents), while Québec and British Columbia each received more triadic patents per 100,000 residents than Alberta.

One explanation for these differences could be that the patent-driving industries in each province have differing levels of exposure and integration with foreign markets. Alberta, by receiving a comparatively higher number of CIPO patents among provinces than USPTO or triadic patents, may have patent-driving industries primarily focused on serving the domestic market (such as technology developed specifically for the Alberta oil and gas industry), compared to more export oriented patent-driving industries in Ontario, British Columbia, and Québec.

Ontario, with 38.6 per cent of Canada's population in 2012, in fact punches above its weight in terms of the number of patents granted to its residents as it receives at least half of all patents granted to Canadians from each intellectual property office. Chart 16 presents data on Ontario's share of the total volume of CIPO, USPTO, and triadic patents granted to Canadian inventors in the most recent year available for each patent type.

E. Trends in Patenting of ICT Inventions by Province

Data on the number of patent grants to each province across all technologies are not publicly available. However, the Institut de la statistique Québec provides data on the number of ICT inventions patented by inventors from each province between 1980 and 2012.[56] As shown in

[56] The ISQ identifies ICT-patents using the same methodology as the OECD, described in footnote 49 above.

Section II.E, ICT is the technological area with the most innovative activity in Canada, as measured by trends in patenting. Depending on the measure used to assign geographic origin to patents, between 51 to 57 per cent of the patents granted to Canadian residents in 2012 by the USPTO were classified as ICT patents, and this share rose to 59.4 per cent in 2014.[57] According to the ISQ, ICT inventions include electronic devices, computers, telecommunication devices and other ICT devices.

Table 11 includes information on the number of ICT inventions patented at the USPTO by Canadian inventors from each province.[58] In addition to the number of ICT inventions patented by inventors from each province, Table 11 also includes the percentage distribution of ICT patents among the provinces, the share ICT patents make up of each province's total number of patent grants from the USPTO, and the number of ICT patents granted per 100,000 residents for each province.

Ontario inventors received the greatest number of ICT patents from the USPTO, with 2,477 patents issued in 2012 (the highest in the 32 years covered), equal to 18.5 patents per 100,000 Ontario residents. Even in population-normalized terms Ontario received nearly twice as many ICT patents as the next highest, British Columbia (9.5 patents per 100,000 residents, or 430 in total) and over three times as many patents as Québec (5.7 patents per 100,000 residents, or 462 in total). Canadian inventors were granted 3,498 ICT patents by the USPTO in 2012. Inventors from Ontario had the highest share of ICT patents in 2012 at 70.8 per cent while Québec and British Columbia inventors followed with 13.2 per cent and 12.3 per cent of the total ICT patents in 2012, respectively. Ontario's 70.8 per cent share of ICT patents out of the total number of USPTO patented Canadian ICT inventions exceeds the province's 59.9 per cent share of the total USPTO patents granted to Canadian inventors across all technologies.

Between 2000 and 2012, the number of ICT patents granted to inventors from British Columbia quadrupled (an increase of 302 per cent), with growth in ICT patents to Ontario close behind (an increase of 291 per cent). The number of ICT patents granted to inventors from Alberta and Québec more than doubled, with these provinces experiencing growth of 141 per cent and 120 per cent, respectively. The highest growth in ICT patent grants was for inventors in New Brunswick (500 per cent) and Newfoundland (400 per cent), however in absolute terms these provinces experienced only small increases, of 15 and 16 patents each, respectively.

[57]The ISQ, which assigns origin to national patents based on the country of residence of the first-named inventor, reports that in 2012 51.4 per cent of USPTO patents granted to Canadian residents were ICT patents (Appendix Table 12, Panel C). The OECD, which uses fractional counting to establish national patent counts, reports that ICT patents made up 57.2 per cent of the total patents granted to Canadian residents in 2012 and 59.4 per cent of the total patents granted in 2014 (Appendix Table 11). Both the ISQ and OECD use the International Patent Classification system to determine whether patents were classified as ICT patents.

[58] Complete information on the number of ICT inventions patented at the USPTO by Canadian inventors from each province is included in Appendix Table 12.

Table 11: Number of ICT Patents Issued by USPTO by Inventor(s) Place of Residence, 1980, 1990, 2000, 2012

Panel A: Number

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	CAN
1980	–	–	–	–	28	88	–	2	4	10	**125**
1990	4	–	5	–	61	200	7	5	28	26	**324**
2000	4	1	9	3	210	633	10	13	71	107	**991**
2012	20	2	21	18	462	2,477	29	14	171	430	**3,498**
% Change 2000-12	400.0	100.0	133.3	500.0	120.0	291.3	190.0	7.7	140.9	301.9	**253.0**
Annual Growth Rate 2000-12	14.35	5.95	7.32	16.10	6.79	12.04	9.28	0.62	7.6	12.29	**11.08**

Panel B: Percentage Distribution

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	-	-	-	-	22.40	70.40	-	1.60	3.20	8.00
1990	1.23	n.a.	1.54	n.a.	18.83	61.73	2.16	1.54	8.64	8.02
2000	0.40	0.10	0.91	0.30	21.19	63.87	1.01	1.31	7.16	10.80
2012	0.57	0.06	0.60	0.51	13.21	70.81	0.83	0.40	4.89	12.29
Percentage point change, 2000-2012	0.17	-0.04	-0.31	0.21	-7.98	6.94	0.18	-0.91	-2.27	1.49

Panel C: Share of ICT Patents at the USPTO of Total USPTO Patents Granted to Canadian Inventors

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	CAN
1980	n.a.	n.a.	n.a.	n.a.	10.3	13.7	n.a.	7.7	5.4	8.1	**11.0**
1990	50.0	n.a.	22.7	n.a.	15.7	19.0	13.7	11.6	18.1	10.2	**16.5**
2000	25.0	50.0	22.0	7.5	28.0	30.3	10.4	16.9	18.0	23.5	**26.2**
2012	76.9	22.2	32.8	35.3	38.0	60.7	25.4	15.7	28.3	50.2	**51.4**

Panel D: ICT Patents per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	-	-	-	-	0.43	1.01	-	0.21	0.18	0.36
1990	0.69	-	0.55	-	0.87	1.94	0.63	0.50	1.10	0.79
2000	0.76	0.73	0.96	0.40	2.85	5.42	0.87	1.29	2.36	2.65
2012	3.80	1.38	2.22	2.38	5.71	18.47	2.32	1.29	4.40	9.47

Source: Appendix Table 14.

IV. Patent Trends at the Census Metropolitan Area (CMA) Level

There is an extensive literature on the role of cities as concentrated centres of innovative activity.[59] Cities are considered 'hubs' of innovation because their large size and dense concentration allows a greater degree of specialization and facilitates the "cross-fertilization" of ideas from diverse sectors (Wolfe, 2009: 27). They are also often the site of innovation loci such as universities, corporate research and development labs, and start-up incubators. Given Canada's high urbanization rate of 82 per cent in 2015, it is worth examining the levels of innovative activity occurring in Canadian cities (as measured by Census Metropolitan Area, CMA) as indicated by trends in patenting.[60] CMA level data are available from the ISQ for the USPTO and triadic patent family offices; however, patent data by CMA are not available from CIPO.

Canada's largest CMA, Toronto, by far led all CMAs in the absolute number of USPTO and triadic patents granted in 2012 and 2008, respectively (the most recent years for which data are available for each). However, Kitchener-Waterloo, Ontario led Canada's CMAs in both recent growth in UPSTO and triadic patents as well as in the number of patents granted per 100,000 residents.

A. Patents Granted to Canadians by the United States Patent Office by CMA

Data on the number of USPTO patents granted to inventors by Census Metropolitan Area of residence are included in Appendix Table 15. In 2012, Canada's largest city, Toronto, led the country in USPTO patents granted to inventors with 1,785 patents—equal to 26.2 per cent of the total number of USPTO patents granted to Canadian residents. That year, the Ottawa-Gatineau region was next with 951 patents, followed by the Kitchener-Waterloo region with 917 patents.

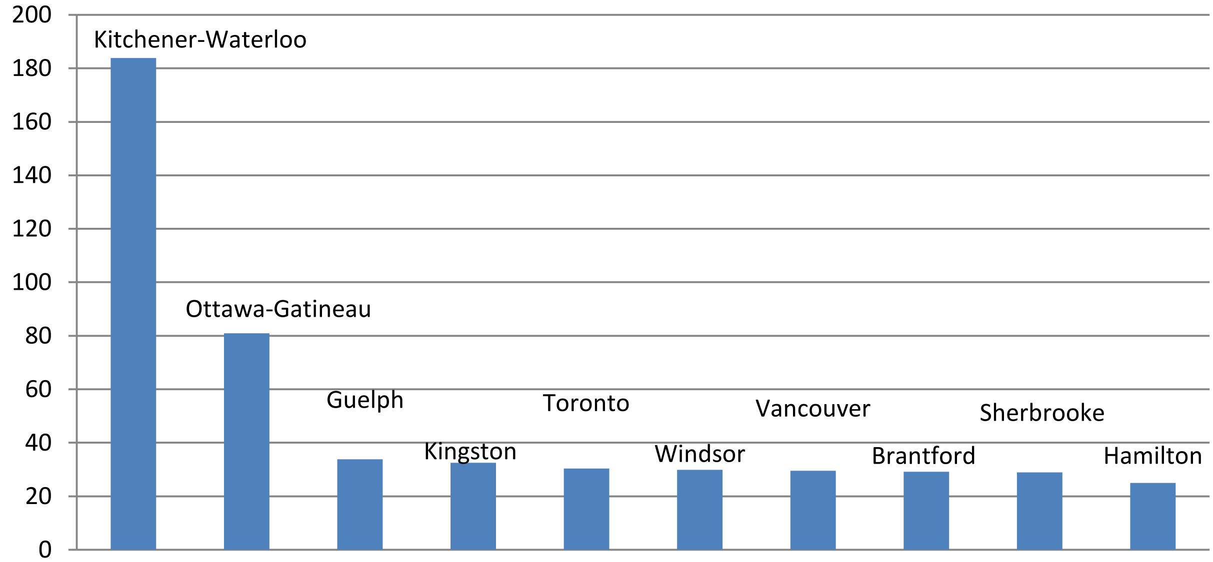
Chart 17 presents data on the 10 CMAs with the highest number of USPTO patent grants per 100,000 residents. Toronto ranks fifth among CMAs, with its inventors receiving 30.4 USPTO patents per 100,000 residents, but is dwarfed by Kitchener-Waterloo, which received 183.8 patents per 100,000 residents. The combined Ontario-Québec CMA of Ottawa-Gatineau ranked second, receiving 81 patents per 100,000 residents. Eight of the ten CMAs whose residents were granted the most patents in population-normalized terms are located in Ontario, with Vancouver and Sherbrooke, Québec the only exceptions.

Chart 18 presents the 10 Canadian CMAs with the greatest per cent change in USPTO patent grants between 2000 and 2012. Kitchener-Waterloo experienced the largest growth in patent volume between 2000 and 2012, 616 per cent. Among other large CMAs this compares with growth of 125 per cent for Ottawa-Gatineau, 110 per cent for Vancouver, 95 per cent for Québec, and an increase of 75 per cent for Toronto.

---

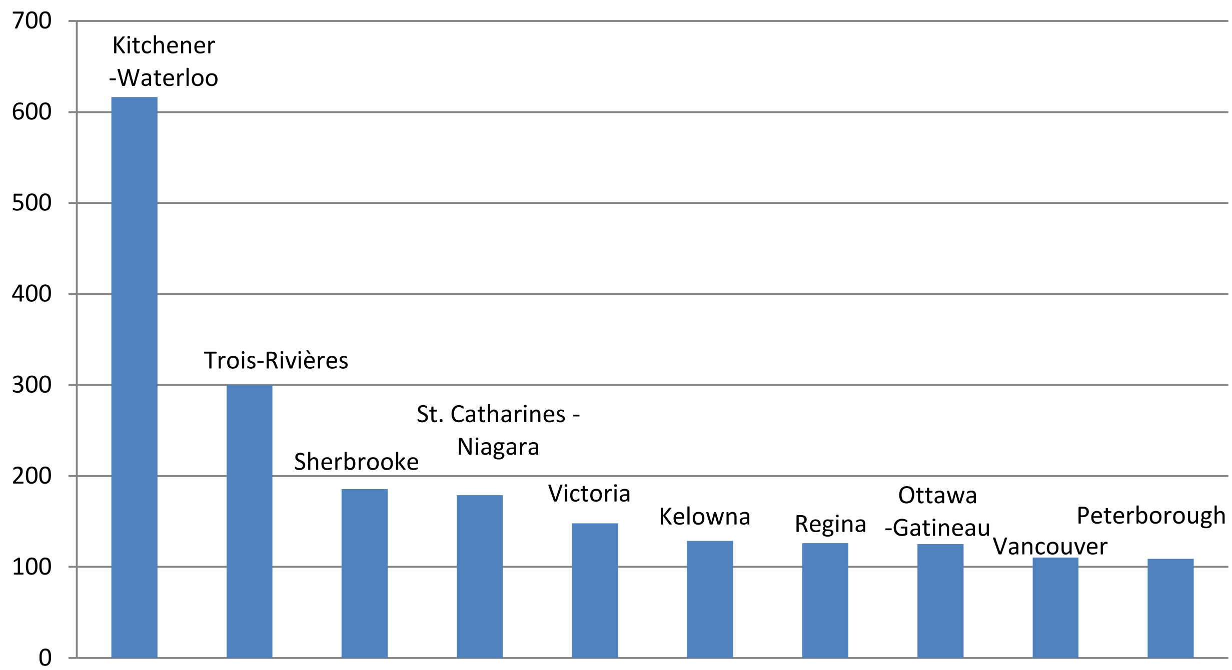
[59] For example, see Athey *et al*. (2008: 156-169), or Marceau (2008: 136-145).
[60] Data on Canada's urbanization rate are from the World Bank's Open Data database, available at the following URL: http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?year_high_desc=true.

Chart 17: 10 CMAs Granted the Most USPTO Patents per 100,000 Residents, 2012



Source: Appendix Table 15.

Chart 18: 10 CMAs with Largest Per Cent Change in USPTO Patent Grants, 2000-2012



Source: Appendix Table 15.

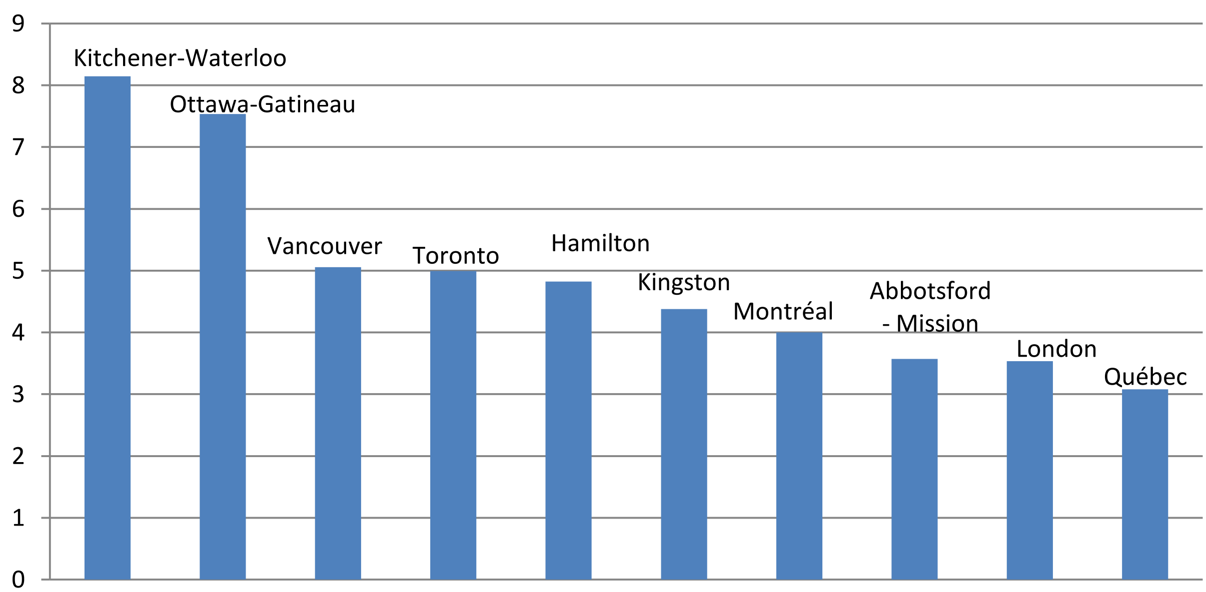
Kitchener-Waterloo also experienced the most substantial growth between 2008 and 2012, although the size of its increase is smaller than in the longer period from 2000 to 2012. The growth in the number of USPTO patents granted to inventors in Montreal, on the other hand, improved markedly post-recession, with growth of 100 per cent from 2008 to 2012, compared to a 14.3 per cent decline from 2000 to 2012 overall.

B. Patents Granted to Canadians by the Triadic Patent Family Offices by CMA

Appendix Table 16 includes data on the number of triadic patents granted to Canadians inventors by CMA from 1980 to 2008, the most recent year for which data are available from the ISQ. Chart 19 presents data on the 10 CMAs granted the highest number of triadic patents per 100,000 residents in 2008. As with the data on USPTO patents, Kitchener-Waterloo and Ottawa-Gatineau led Canada's largest CMAs in the number of triadic patents granted to their inventors, receiving 8.2 and 7.5 per 100,000 residents, respectively, in 2008. Inventors in Vancouver and Toronto received 5.1 and 5.0 triadic patents per 100,000 residents, respectively, in 2008.

Only 13 of the 33 CMAs covered in this report experienced growth in the number of triadic patents granted to their inventors between 2000 and 2008. This fits with the overall 4.3 per cent decrease in triadic patents granted to Canadian inventors from 2000 to 2008. However, some CMAs experienced periods of substantial growth in the number of triadic patents granted to their inventors. Among CMAs that were granted at least 10 triadic patents in 2008, Kitchener-Waterloo again led the pack with 50 per cent growth, while Québec and Vancouver followed

Chart 19: 10 CMAs Granted the Most Triadic Patents per 100,000 Residents, 2008



Source: Appendix Table 16.

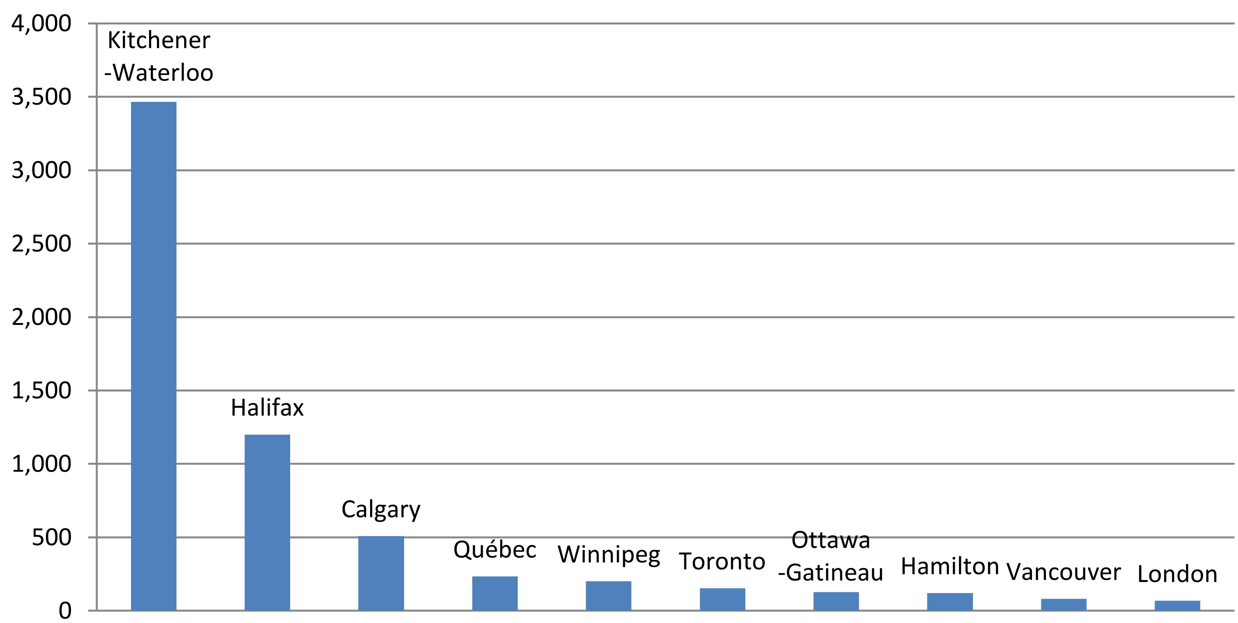
behind with 35.3 per cent and 34.1 per cent growth, respectively. Calgary, on the other hand, experienced a 35.1 per cent decline in the number of triadic patents granted to its inventors. Montreal experienced growth of 4.9 per cent while the number of triadic patents granted to inventors in Toronto declined by 4.2 per cent from 2000 to 2008.

C. Trends in Patenting of ICT Inventions by CMA

Similarly to the provincial-level data, there are no available data on patent grants by CMA across all technology areas. However, the Institut de la statistique Québec provides data on ICT patents granted by the USPTO by the Census Metropolitan Area (CMA) of the inventor(s), which are included in Appendix Table 17. Data on Canada's 10 CMAs with the highest growth in the number of ICT patents granted by the USPTO to their resident inventors are presented in Chart 20.

From this data it is clear that Ontario's dominance in ICT patenting is mainly based on the high number of ICT patents granted in 2012 to inventors from three cities: Kitchener-Waterloo (820 patents), Toronto (363 patents), and Ottawa-Gatineau (311 patents). ICT patents made up 89.4, 20.3, and 29.8 per cent of the total number of USPTO patents granted to residents of each CMA, respectively. Other than Calgary, which received 79 ICT patents in 2012 (an increase of 508 per cent from 2000) these three cities in Ontario experienced the fastest growth rates in Canada among CMAs that generated more than 20 patents in 2012. The number of patents granted to inventors in Halifax exploded from 2000-2012, increasing by 1200 per cent; however, this represented an absolute increase of only 12 patents.

Chart 20: 10 CMAs with Largest Per Cent Change in USPTO ICT Patent Grants, 2000-2012



Source: Appendix Table 17.

V. Explaining Divergent Trends in R&D Expenditures and Patenting

An additional measure of innovation is research and development (R&D) expenditures, a crucial input to innovation. As mentioned above, this report tracks levels of innovative activity by examining trends in patenting because patents serve as a well-established output indicator of innovation. Trends in R&D expenditures, an input measure of innovative activity, can serve as a valuable complement to patents when measuring trends in innovative activity.

However, a paradox emerges when comparing the trends of these input and output measures of innovation. Between 2000 and 2014 real business enterprise expenditure on research and development (BERD) decreased by 6 per cent and real total expenditures on R&D increased marginally, by only 14 per cent (in 2007 prices). However, in the same period, the number of patents granted to Canadians by CIPO and USPTO increased significantly (by 167 per cent and 102 per cent, respectively), despite the decreased input to innovation, R&D spending.

The paradox is tempered somewhat when utilizing patent applications as a measure of innovation because the number of patent applications filed at CIPO increased by only 0.3 per cent between 2000 and 2014, however patent applications at the USPTO still increased by 90 per cent over this period. The number of triadic patents granted to Canadians also fell, by 6 per cent, between 2000 and 2011, in line with the decline in BERD, so it is possible that the decrease in inputs to innovation mainly impacted the output of high-quality inventions, which typically receive triadic patents.

This report proposes six explanations for this paradox, although several are found to lack evidence. First, the observed divergence may be due to lags in the causal relationship between R&D spending and patenting over time, such that not enough time has passed for the decrease in R&D spending to result in fewer patents. The divergence may also be caused by changes to the patent administration system, such as revisions to the patent regulatory regimes or the ability of patent offices to process patent applications. Alternatively, it is possible that the divergence is caused by the average quality of patent applications increasing. A higher number of strategic patent filings may have led to the increases in patent volumes. Finally, increases in the efficiency of R&D spending because of improved technologies, or shifts in R&D spending from sectors with low patent-to-R&D ratios to higher patent-to-R&D ratios could have allowed patent volumes to increase with less R&D spending inputted. Differing trends in the number of patent grants and patent applications shed some light on these explanations.

This analysis concludes that an increased efficiency of R&D spending and a higher number of strategic patent filings are the most likely explanations behind this divergence, although further research is needed to confirm exactly what has caused the growing gap between R&D expenditures and patent grants.

A. Trends in Research and Development Expenditures in Canada

There are in fact several types of R&D, reflecting the various sectors performing innovative research. BERD measures the amount firms spend on research and development and so is most relevant for tracking private sector innovation. In addition, GovERD measures expenditure on research and development by both federal and provincial governments; HERD measures research and development expenditure by the higher education sector; and GERD sums up these three components, along with substantially smaller categories of R&D expenditure by the private non-profit sector and provincial research organizations.

Table 12 presents data on the value of each type of real R&D expenditures in 2007 constant prices and the total share of GDP spent on GERD which measures total gross R&D expenditure. Despite a 14.0 per cent increase in GERD, from 24.7 billion dollars in 2000 to 28.2 billion dollars in 2014, GERD accounted for only 1.61 per cent of Canada's nominal GDP in

Table 12: Real R&D Expenditure, Millions of Dollars, and GERD Per Cent Share of GDP, 2000-2014 (2007 Constant Prices)

	Gross Expenditure on R&D (GERD)	Business Enterprise Expenditure on R&D (BERD)	Higher Education Expenditure on R&D (HERD)	Government Expenditure on R&D (GovERD)	Gross Expenditure on R&D (GERD) Per Cent Share of Nominal GDP
2000	24,706	14,898	6,963	2,697	1.86
2001	27,343	16,863	7,592	2,785	2.03
2002	27,493	15,824	8,709	2,857	1.98
2003	27,902	15,925	9,202	2,641	1.97
2004	29,190	16,569	9,910	2,570	2.0
2005	29,716	16,583	10,093	2,857	1.98
2006	30,009	17,001	9,933	2,896	1.95
2007	30,038	16,756	10,187	2,867	1.91
2008	29,597	16,019	10,517	2,851	1.86
2009	29,625	15,770	10,637	3,062	1.92
2010	29,267	15,137	10,775	3,191	1.84
2011	29,503	15,657	10,966	2,733	1.80
2012	29,869	15,251	11,829	2,618	1.79
2013	28,804	14,443	11,455	2,734	1.69
2014	28,164	14,050	11,381	2,562	1.61
Per Cent Change 2000-2014	14.0	-5.7	63.4	-5.0	-0.25
Per Cent Change 2010-2014	-3.8	-7.2	5.6	-19.7	-0.21

Source: Appendix Table 18.

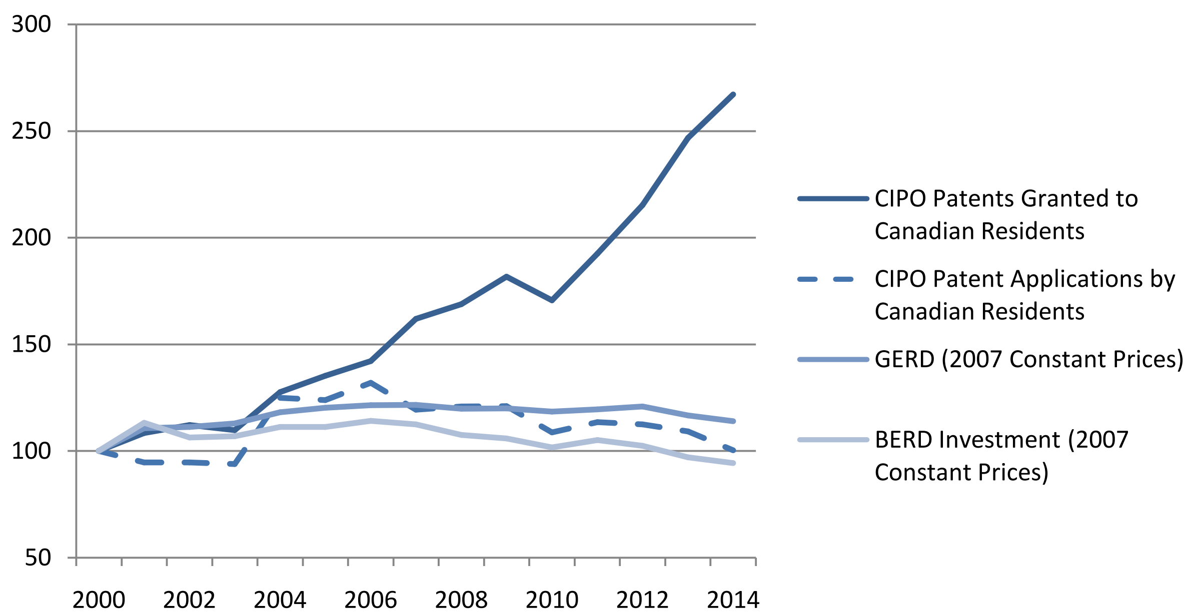
2014, down 1.86 per cent in 2000. BERD, which measures only firms' expenditures on R&D, decreased by 5.7 per cent over the same period, from 14.9 billion dollars in 2000 to 14.0 billion dollars in 2014. GovERD similarly fell by 5.0 per cent from 2.7 billion dollars in 2000 to 2.6 billion dollars in 2014. The increase in GERD over this period was only possible because of a 63.4 per cent increased in HERD between 2000 and 2014.

Data on the composition and per cent share of GDP for total R&D, from 1980 to 2014, is included in Appendix Table 18, Panel E. The overall composition of R&D funding has changed significantly in the past 15 years: the contribution from HERD has increased by 12 percentage points while the contributions from BERD and GovERD have fallen by 10 and 2 percentage points, respectively. Although Jaffe (1989) finds some evidence that academic research has positive spillover effects on corporate patenting, it is unlikely that academic researchers patent their research outcomes to the same degree as inventors employed by firms attempting to profit from the inventions.

Recent trends in total R&D and BERD, as well as the volume of patent applications and grants from CIPO and USPTO to Canadian residents, are shown in Charts 21 and 22, respectively. Appendix Table 18 includes further data on R&D expenditure by type of performer from 1980 to 2014.

Chart 21 illustrates how, in recent years, the number of patents granted to Canadian residents by CIPO has increased substantially, by 167 per cent, far outpacing the change in R&D expenditure. When measured in constant 2007 dollars, GERD increased by only 14 per cent from 2000 to 2014. Despite a 63.4 per cent increase in real HERD from 2000 to 2014, GERD did not

Chart 21: Real R&D Investment and the Number of CIPO Patent Applications and Grants to Canadian Residents, 2000-2014 (2007 Constant Prices, 2000=100)



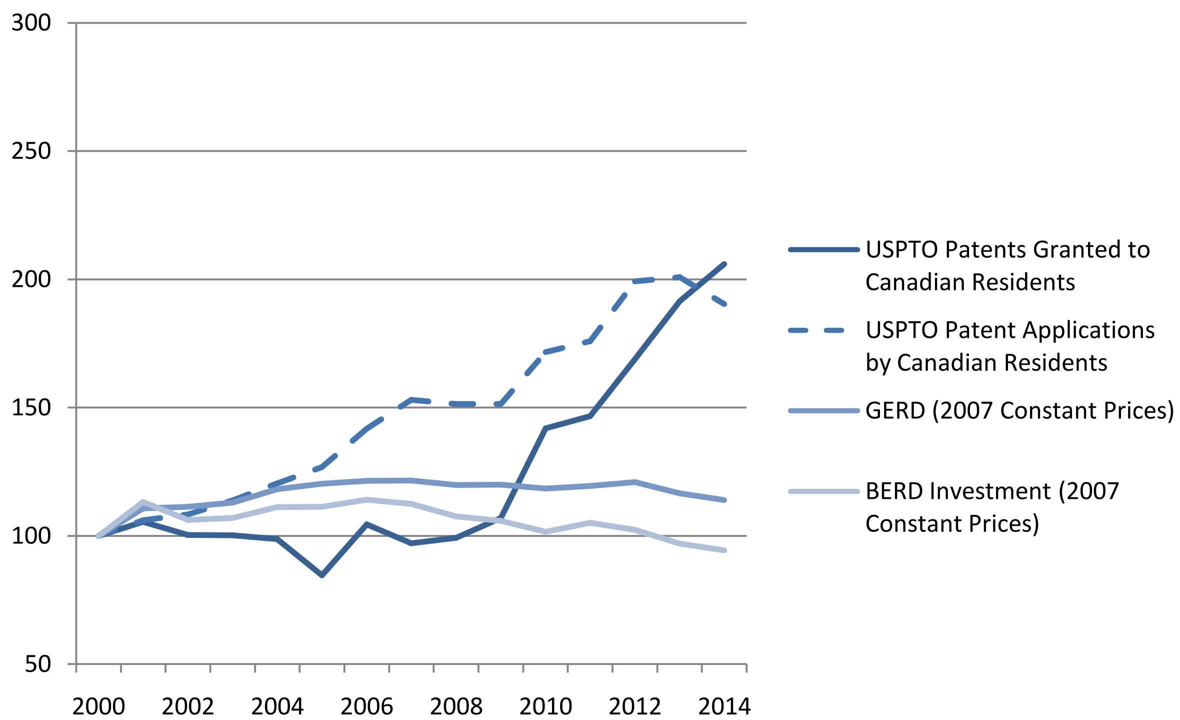
Source: Appendix Tables 1 and 18.

substantially increase in this period—at least compared to the 167 per cent increase in patent grants over the same period—due to the 5.7 per cent decrease in BERD, which contributed an average of 55 per cent of GERD, compared to an average annual contribution of only 35 per cent from HERD. However, between 2000 and 2014 the number of patent applications filed at CIPO remained stagnant in line with the trends in R&D expenditures, suggesting that the patent applications measure of research output may be more tied to R&D spending than patent grants.

Chart 22 presents these same trends in Canadian R&D expenditure as in Chart 21, but instead compared to the number of USPTO patent applications and grants to Canadian inventors between 2000 and 2014, indexed to their year 2000 levels. USPTO patent grants doubled from 2000 to 2014, increasing by 106 per cent, even as BERD decreased by 6 per cent and GERD increased by only 14 per cent. Unlike for CIPO, however, patent applications by Canadian inventors to the USPTO also increased over this period, by 90 per cent.

Finally, Chart 23 compares trends in Canadian R&D expenditures to the number of triadic patents granted to Canadian inventors between 2000 and 2011, the most recent year for which data are available.[61] Unlike the upward trends in the number of patents granted to Canadian inventors by CIPO and USPTO between 2000 and 2011, the number of triadic patents granted to Canadian inventors decreased, by 6 per cent, from 2000 to 2011. This decline could be

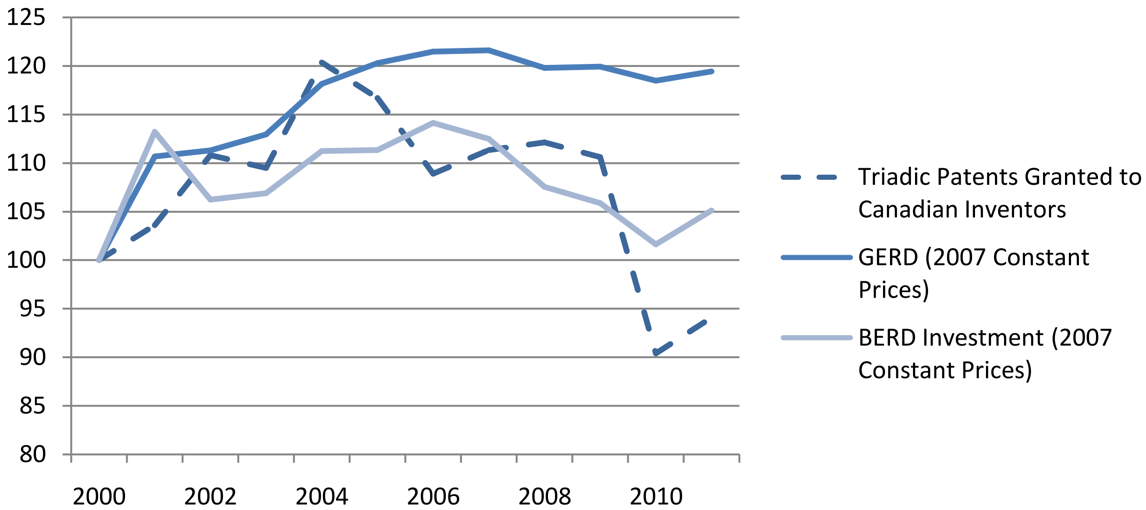
Chart 22: Real R&D Investment and the Number of USPTO Patent Applications and Grants to Canadian Residents, 2000-2014 (2007 Constant Prices, 2000=100)



Source: Appendix Tables 3 and 18.

[61]The OECD, the source of data on patents granted to Canadians by the triadic patent family offices, does not have any publicly available data on triadic patent applications.

Chart 23: Real R&D Investment and the Number of Triadic Patents Granted to Canadian Inventors, 2000-2011 (2007 Constant Prices, 2000=100)



Source: Appendix Tables 5 and 18.

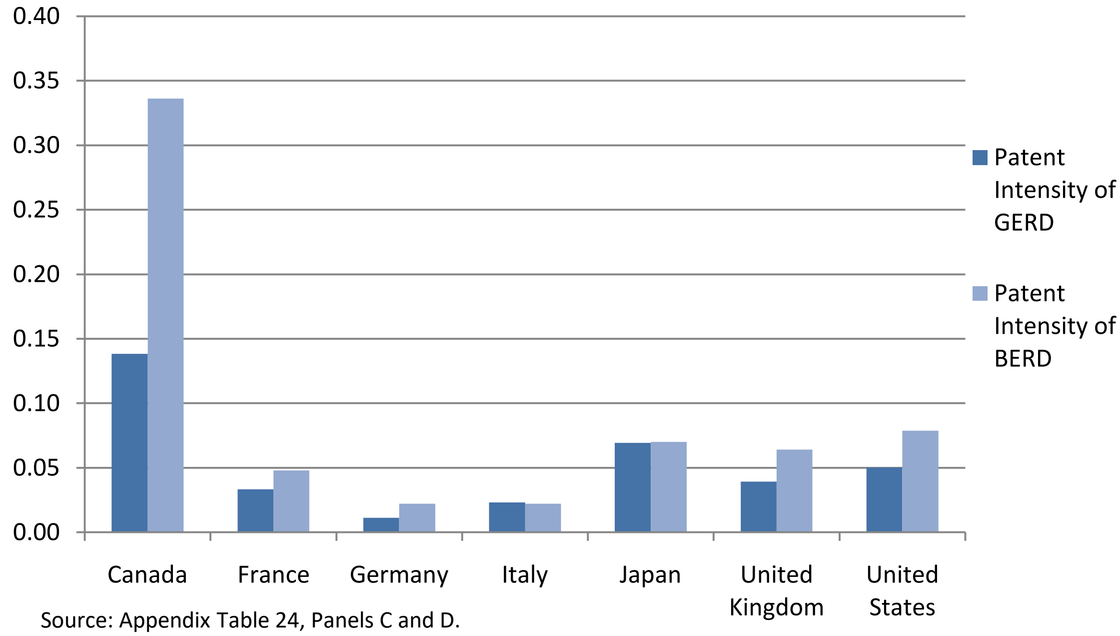
explained by the decrease in BERD over this same period, but is puzzling given the increase in CIPO and USPTO patent grants to Canadians despite the decrease in BERD. Seemingly, the change in triadic patents was the most closely correlated with the reduction in BERD, perhaps because triadic patents are the most costly applications to file and typically represent the most high-value inventions.

B. International Comparison of Trends in Research and Development Expenditures and Patenting

Given the divergence in Canada between R&D expenditures and the number of patents granted since 2000, it is worth examining these trends in other countries. Appendix Table 24 includes data on GERD and BERD across the G7 between 1981 and 2001, as well as the USPTO patent intensity of GERD and BERD (number of USPTO patents granted per million dollars of R&D spending) for the same period. Chart 24 presents the change in the USPTO patent intensity of GERD and BERD for each G7 country.

Canada has experienced the largest percentage point change among the G7 in both USPTO patent intensity of GERD and USPTO patent intensity of BERD. Between 2001 and 2014, the USPTO patent intensity of GERD in Canada increased by 0.14 patents per million dollars (from 0.15 to 0.29), double the next-largest increase, in Japan, from 0.27 to 0.34 patents per million dollars. The gap between Canada and other G7 countries is even wider when calculating the number of USPTO patent grants per million dollars of BERD. Between 2001 and 2014 the USPTO patent intensity of BERD increased by 0.34 patents per million dollars (from 0.25 to 0.59) for Canadians, compared to the next-largest increases of 0.08 patents per million dollars in the United States (between 2001 and 2013, the most recent year for which data are available) and 0.07 patents per million dollars in Japan. While all G7 countries saw a growing

Chart 24: Change in Patent Intensity of GERD and BERD, G7 Countries, 2001-2014



Source: Appendix Table 24, Panels C and D.

Note: Data for 2014 are unavailable for the United States, so the change reported for the U.S. is for the 2001-2013 period.

divergence between trends in patenting and R&D expenditures between 2001 and 2014, this divergence was most pronounced in Canada.

The patenting intensity of GERD and BERD is affected by changes in both the number of USPTO patents granted and in R&D expenditures. As seen above in Chart 8 and detailed in Appendix Table 4, between 2000 and 2014 Canada experienced the highest growth in USPTO patent grants among the G7, and was the only G7 country to see a doubling of the number of patents granted to its inventors. Canada stood out among the G7 even more when comparing R&D expenditures (in constant 2010 dollars). Canada saw the smallest increase in GERD among the G7 with only a 14.0 per cent increase between 2000 and 2014, compared to the next-smallest increase of 25.4 per cent in the United Kingdom, and a 39.1 per cent increase in Germany, the largest change among the G7. Furthermore, Canada experienced a decrease in real BERD, of 5.7 per cent, between 2001 and 2014, while BERD in all other G7 countries grew in the range of 23.5 and 40.5 per cent in that period.

C. Divergence in Research and Development Expenditures and Patenting Trends

Prodan (2005) established a strong positive correlation between R&D expenditure and patent applications (most of which are subsequently included in counts of patent grants), and found the link between patenting activity and BERD especially strong in developed countries. It is therefore puzzling that the number of patents granted by CIPO and the USPTO, as well as the volume of applications at the USPTO, has increased while R&D expenditures have declined, or, at best, increased only marginally. Most significantly, BERD in Canada decreased by nearly 6 per cent between 2000 and 2014, while the number of CIPO patents granted to Canadians nearly doubled over this same time period. Moreover, the compositional shift within R&D expenditure since 2000, from business and enterprise sector R&D to higher education sector R&D, would in theory lead to even fewer patent grants.

Some research claims that Canada has a clear innovation problem, as seen across various indicators.[62] Considering this literature, perhaps the puzzle of divergent patenting trends and R&D expenditures is best approached as an exploration of how the number of patents, an output measure of innovation, was able to increase despite stagnant or decreased R&D expenditures, an input to innovation. We see six potential explanations behind this apparent puzzle of divergent patenting trends and R&D expenditures:

- **The lag effect:** There may be a measurement challenge in that the number of patent grants in a given year does not reflect R&D spending in that year, but in previous years, and therefore the decrease in BERD has not yet reduced the number of CIPO and USPTO patent grants, but will lead to a smaller number of grants in the future.

- **Changes in the patent administration system and opportunity costs of patenting:** Rather than a changing level of innovative activity in Canada, the increased number of patent grants may be caused by administrative changes, such as an improved capacity in patent offices for examination, and by changes in the direct costs and benefits of patenting, such as a reduced burden around filing applications. The volume of patent grants could also have increased due to changes to alternative methods of intellectual property protection that made these methods less attractive and decreased the opportunity costs of patenting.

- **Increased quality of patent applications:** The number of patents grants may have increased despite reduced BERD because of an increase in the quality of patent applications, as suggested by the higher patent granting rate at CIPO recently. However, other measures of patent quality show that the quality of Canadian patents may have actually slightly decreased recently.

- **Increased strategic filing of patents:** Traditionally, firms are thought to file for patents in order to secure a monopoly over the profits from their R&D-funded innovations. Research has also focused on firms' strategic use of patents to restrict competitors' technological development in areas of competition, generate licensing revenues, or other goals unrelated to innovation occurring in that firm. These strategic patent filings may have allowed for greater number of patent applications (and grants) with less R&D expenditure.

[62]For example, see Council of Canadian Academies (2013) for a discussion of Canada's difficulties in translating research success to business innovation.

- **More efficient R&D spending:** The number of patent grants may have increased despite a decrease in BERD because firms have become more efficient in their R&D spending, perhaps due to the beginnings of a new innovation 'supercycle'.

- **Sectoral shifts in R&D spending:** Total patents may have increased because although BERD has decreased economy-wide, the remaining BERD has been allocated from sectors with low patent-to-R&D ratios to sectors with higher patent-to-R&D ratios.

Each explanation will be reviewed and evaluated in turn, followed by an analysis of which hypotheses best explain the divergence between trends in R&D expenditures and patenting.

i. The Lag Effect

One reason for the increase in patenting despite the decrease in R&D expenditures is that the number of patents granted in a given year does not necessarily reflect the level of business sector R&D in that year, but instead the level of investment by firms in previous years. Consider an increase in R&D expenditures. If a substantial portion of R&D spending occurs in early stages of a years-long research process, then an increase in R&D expenditures would only lead to an increase in output measures of research (such as patent grants) a few years later, after that innovative research has actually had time to produce outputs. The same logic applies to decreases in R&D expenditures: the output measure, patents, would only be affected by the decrease in R&D spending a few years later because in earlier years the research would not be expected to have resulted in patent grants in any case. This effect is in addition to the pendency time, a lag between the date of a patent application and the year the patent is actually granted for that invention.

For example, the number of patents granted by CIPO in 2014 (2,984) does not represent the product of R&D investment in 2014, but of investment that occurred in previous years. BERD was at a low point of $14 billion (in 2007 constant dollars) in 2014 but had actually increased at a rate of 2.7 per cent annually between 1998 and 2008 (Appendix Table 16, Panel B). Higher levels of R&D investment during this earlier period likely helped the number of patents granted to Canadians increase to the level seen in 2014 as the innovative processes leading to the patents granted in this year would have started well before 2014.

However, there is not a clear lag relationship in the historical data. For example, despite the value of BERD in 2000 being at its third-lowest point between 2000 and 2014 (at $14.9 billion in 2007 constant prices), the number of CIPO patents granted in the years following 2000 increased. In addition, it is unlikely that the lag between R&D spending and patent grants would persist when these indicators are measured over a lengthy time period, such as between 2000 and 2014. There is therefore likely more behind this puzzle than the lag effect.

ii. Changes in the Patent Administration System and Opportunity Costs of Patenting

Another potential explanation for the divergence in patenting and R&D expenditures is that the number of patent grants may have increased for reasons unrelated to changing levels of innovation and instead because of changes to the patent administrative and regulatory systems or in the alternatives to patenting. Reductions in the intrinsic costs of patenting through changes in the patent granting process and the legal environment may have increased incentives to patent. For example, CIPO began a program in 2008 with the USPTO, the Patent Prosecution Highway (PPH), which fast-tracked applications that had already been processed at certain intellectual property offices, including the USPTO, JPO, and others. Potts (2011) suggests that PPH programs may speed up processing times through work-sharing across patent offices, though at the cost of lowering the quality of patent reviews. Strengthened patent rules to conform to the 1994 *Agreement on Trade-Related Aspects of Intellectual Property Rights* may also have increased the incentive to patent.

The volume of patents granted by the USPTO may have increased recently, regardless of the decline in R&D expenditures, due to changes to alternative methods of intellectual property protection that decreased the opportunity costs around patenting. For example, greater reliance on computers for research may have increased the susceptibility of research to theft through hacking, and thus made it more difficult to keep trade secrets secure. Such a change would then increase the relative attractiveness of filing a patent to protect an invention.

Alternatively, the number of patent grants may have increased recently due to intellectual property offices becoming more efficient at examining patents. If these offices recently increased their capacity, for example through increasing the number of patent applications reviewed by each examiner or hiring more examiners, then subsequent increases in patent grants may primarily reflect a shorter lag time for processing patent applications due to the increased examination capacity.[63] Indeed, both CIPO (2016:16) and the USPTO (2011:10 and 2016:61-63) in their annual performance reports highlight initiatives to decrease pendency times and reduce backlogs of patent applications by increasing recruitment patent examiners.

Given these initiatives to reduce the regulatory burden and increase the benefits of patenting, it is likely that changed direct costs and benefits played a role in the increase in patent grants at CIPO and USPTO. However two recent efforts to reduce the regulatory burden around patenting—the 2014 amendments of the Canadian *Patent Act* and the 2011 *America Invents Act*—occurred far after the recent boom in patent grants at CIPO and USPTO. It is also unclear if the increases to intellectual property offices' capacity to examine patent applications that result in greater volumes of patent grants would persist over the long-term, such as between 2000 and 2014. Moreover, examination capacity increases cannot explain the increase in the number of patent applications at the USPTO. Finally, decreased opportunity costs of patenting may play a part in the increased volume of patent grants despite decreased R&D expenditures, but it is not clear that alternatives to patenting, such as trade secrets and open source inventions, have recently become much less attractive to inventors.

iii. Increased Quality of Patent Applications

The number of patents grants may have increased despite reduced BERD because of an increase in the quality of the average patent application. While the number of CIPO patent grants to Canadian residents increased by 167 per cent from 2000 to 2014, the volume of patent applications from CIPO decreased by 10.5 per cent over the same period. This resulted in spike

[63] See footnote 11 for a detailed theoretical explanation of this phenomenon.

of 22.3 percentage points in the CIPO granting rate (an increase from 43.2 per cent to 65.6 per cent) between 2000 and 2014.

These increases in the CIPO granting rate for Canadian residents suggest that the quality of patent applications has increased substantially as the quantity filed at the CIPO has decreased. However, the granting rate at the USPTO for Canadian inventors declined, by 4.6 per cent, between 2000 and 2014. As well, the number of triadic patent grants, which are typically seen as representing high quality inventions, decreased between 2000 and 2011.

Trends in other indicators of patent quality and value also complicate the apparent increase in quality suggested by the higher CIPO granting rate.OECD (2015) surveys several measures of patent quality and value that appear in the literature and estimates the performance of each indicator for patents from the European Patent Office (EPO). Between 1999 and 2009, the performance on these patent quality measures was mixed for the average EPO patent granted to Canadian residents.[64] On most measures, the average quality of Canadian patents improved only slightly, including for patent scope (technological breadth), number of backward citations, the number of protective claims per patent and on the originality index (based on the range of technologies in the backwards citations of a patent). The number of protective claims (normalized with backward citations) of the average Canadian EPO patent declined slightly, while the number of average citations to non-patent literature experienced a more significant decline. For patents granted to Canadian residents by the EPO only the technological radicalness index (based on the number of IPC technology classes, other than the class of the patent, cited) experienced significant improvement between 1999 and 2009.

Taken together, the stable or negative performance of other patent quality indicators make it unlikely that the CIPO granting rate increased due to higher average patent quality. As noted in Section II.A.iii, granting rates may change over time as a result of several factors other than patent quality, such as changes in the stringency with which patents are being evaluated, the patent pendency time, the rate of withdrawal of applications, the quantity and quality of examiners, and changes in the demand for patents relative to other forms of intellectual property protection. Higher patent quality is therefore likely not an explanation for the divergence in patenting trends and R&D expenditures.

iv. Increased Strategic Filing of Patents

Research that focuses on firms' motives to patent may shed light on the observed trends in patenting. The traditional motive to patent (described in detail in Section I) is that firms file for a patent in order to secure themselves a monopoly of the profits from their innovation. Strategic patenting, though lacking an agreed-upon definition, is considered instead as firms using patent ownership rights for a variety of defensive and offensive purposes (Blind et al., 2007).

[64] Other measures were estimated for 1994 and 2004 in OECD (2015). Of these measures, Canadian EPO patents experienced on average a small decline in patent family size, forward citations, and across all three composite indices of patent quality; larger decreases in grant lag and in the generality index; and a small improvement in the breakthrough innovations index.

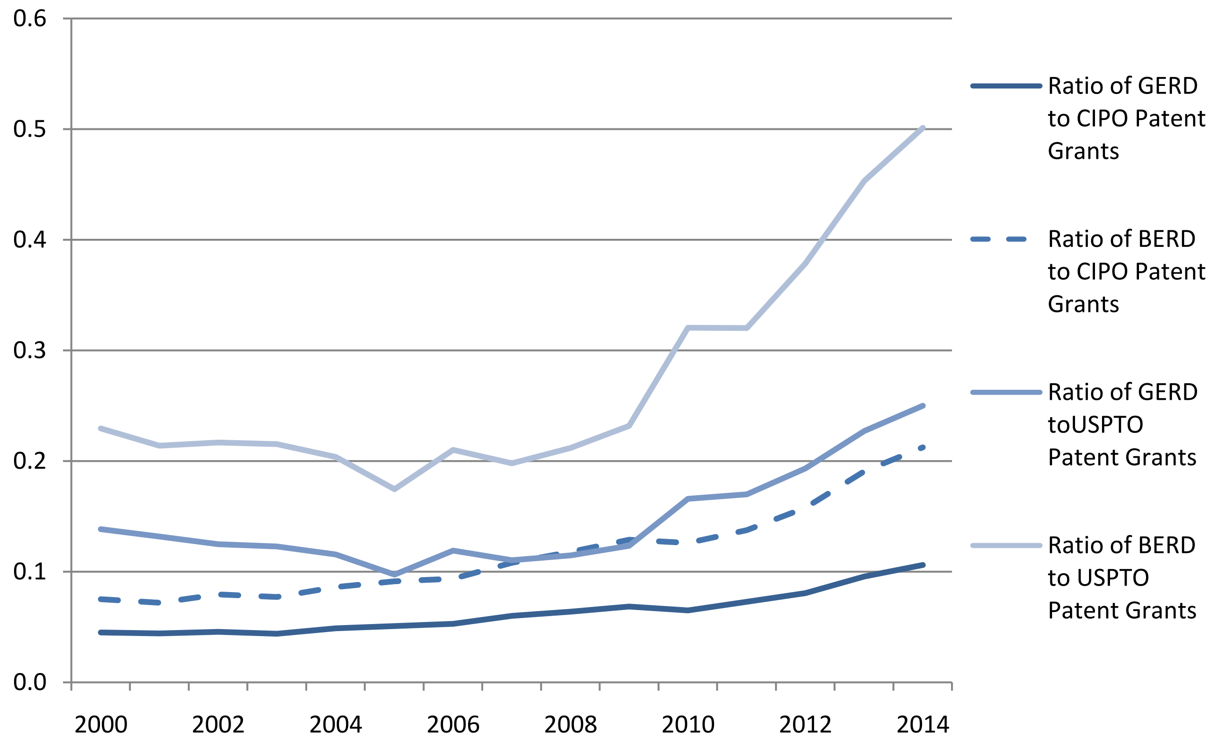
One defensive strategic motivation is a firm successfully protecting an invention through trade secrets but then deciding to patent that invention only to prevent other firms from patenting the invention and suing the innovative firm. Firms may also patent defensively in order to use that patent ownership as leverage in negotiations with another firm. Hall and Ziedonis (2001) found this to be one of the most important motives for patenting in the ICT sector. Firms can also create these 'patent thickets' for offensive means, such as in order to prevent competitors from filing patents for similar (though not identical) products that could be considered as substitutes by consumers (Blind *et al.*, 2007). Another offensive motivation to patent is seen with so-called 'submarine patents' whose rights are put up for sale by the innovating firm and purchased by other firms (often called 'patent trolls') that wait until another firm has developed a similar product, and then 'emerge' to launch a patent infringement lawsuit with the goal of forcing the other firm into a costly (but profitable for the patent troll) settlement (Pogue, 2015). Other non-traditional motives to patent include to earn licensing income, avoid litigation by others, motivate and reward R&D employees, measure performance, attract investors, and bolster the firm's reputation (Somaya, 2012).

The global increase in patent applications has been traced in part to an increase in strategic patenting by firms (van Zeebroeck and van Pottelsberghe de la Potterie, 2008). It is therefore a possibility that strategic patenting may be responsible for part of the increase in patent grants at the CIPO and in patent applications and grants by Canadians at the USPTO. Blind *et al*. (2007) found that strategic patents are typically measured as lower quality patents (in terms of citations), so it is possible that the decreases in the average quality of Canadian patents on many measures surveyed in OECD (2015) (discussed in detail above) may be linked to an increase in the number of strategic patent filings. An increase in strategic patenting also fits with the divergence between certain patenting trends and R&D expenditures, since the research and development process would be less intensive for strategic patent-protected inventions that the firm has no intention of actually producing themselves.

v. More Efficient R&D Spending

It is also possible that R&D funding has grown more efficient recently, so that a given dollar of R&D spending leads to more innovation in terms of patenting than in the past. One mechanism could be changes in the management of R&D involving a shift to more applied research that is associated with increased patenting, as suggested by Kortum and Lerner (1999). In addition, increases in technological efficiency could have occurred that allow for more innovative research at a lower cost and lead to a greater number of patents with less investment spending involved. For example, the widespread adoption of modern information and communications technologies has likely made researchers far more productive by facilitating collaboration, improving researchers' analytical capabilities, and increasing access to knowledge and data. Kortum and Lerner (1999) found the increase in patenting at the USPTO between 1985 and 1995 was primarily caused by improvements in the automation and management of the research process, likely associated with the application of information technologies to research processes.

Chart 25: Ratio of CIPO and USPTO Patent Grants to Canadian Residents to R&D Expenditures, Millions of Dollars, 2000-2014 (2007 Constant Prices)



Source: Appendix Tables 1, 3 and 18.

Chart 25 presents the ratio calculated from the number of CIPO and USPTO patents granted to Canadian residents per million dollars of GERD and BERD between 2000 and 2014. The number of patents granted per million dollars of R&D has increased across all four measures, with the ratio of USPTO patent grants to BERD in particular increasing from 0.23 in 2000 to 0.50 in 2014. This provides some evidence for an increase in the efficiency of research processes over this time in terms of higher patent output per input of R&D expenditures.

Rising patents may also represent the beginnings of a new innovation supercycle.[65] A supercycle begins when major technological breakthroughs stimulate a period of innovation. The breakthrough may generate a surge of invention and patenting by reducing costs and feasibility constraints. This could explain the diverging paths of R&D expenditure and patenting if, for example, achieving the technological breakthrough had required high levels of spending but then facilitated an abundance of low cost follow-up innovations. However, supercycles are typically proposed based on long-term historical data and it is difficult to confirm the existence of a supercycle as it occurs. Moreover, the impact of a supercycle on spending is ambiguous because the technological revolution may incentivize a further inflow of spending to take advantage of the new technologies.

[65]Such supercycles are also known as 'long cycles,' 'long waves,' or 'Kondratiev waves,' named after Nikolai Kondratiev and popularized by Joseph Schumpeter. See Freeman (1982) for a background discussion.

In addition, if some components of R&D expenditure (for example, R&D staff versus R&D capital expenditures) result in more patents than other components, it may be that spending in R&D leading to patents rose, increasing patents in recent years, but that this has been obscured by a large reduction in the components of R&D spending unrelated to patenting.

Altogether, it seems possible that recent technological changes, particularly around information and communications technology, have increased the productivity of research processes and rendered R&D spending more efficient in terms of producing patents.[66] It remains unconfirmed whether a new innovation supercycle has begun, although the scope of technological change suggests it is possible. Further research is needed on shifts within the components of R&D expenditures to clarify changes in the efficiency of R&D spending.

vi. Sectoral Shifts in R&D Spending

The final potential explanation behind the divergence of patenting trends and R&D spending is that if returns on R&D investment are considered in terms of patent grants, R&D spending may have shifted from sectors with low patent-to-R&D ratios to sectors with higher patent-to-R&D ratios. As established in Section II.E, there has been an increase in patent filings in information and communication technologies (ICT) in recent years. Data on the number of patents granted per job in each manufacturing industry, presented in Appendix Table 10, show that ICT innovation relies on patenting more than other manufacturing industry sectors. It is possible that R&D spending has increased in fields where it results in a relatively large number of patents, while R&D spending has fallen in areas where relatively few patents are generated per dollar spent.

However, as detailed in Appendix Table 19 Panel A, data on BERD by industry between 1994 and 2014 shows that during the decline of aggregate BERD, less R&D spending has occurred in ICT industries that have a higher reliance on patenting to protect intellectual property, based on Appendix Table 10. Between 2000 and 2014, BERD in the information and communication technologies industry classification decreased by 17.5 per cent and declined by 24 per cent in the manufacturing industry classification, which includes several ICT industries.

Moreover, it is possible to calculate the patenting-return on BERD for manufacturing industry sub-classifications using data from Table 8 on the number of USPTO patent grants to Canadian inventors by manufacturing North American Industrial Classification System (NAICS) code and data on BERD by NAICS code. These results are presented in Appendix Table 20 as six-year averages of the number of patent grants per million dollars of BERD.

[66] Some evidence against the view that research productivity is rising is presented in Bloom *et al.* (2017). Based on an analysis of trends in the development of a variety of technologies, they show that the amount of research effort required to maintain a given rate of technological advance has been rising in recent decades. For example, the number of researchers required to maintain Moore's Law (i.e. the doubling of the density of computer chips every two years) has increased by a factor of 75 since the early 1970s.

From 2007 to 2012, the sector with the highest patent-to-R&D ratios was computer and peripheral equipment (NAICS code 3341) with 9.68 patents per million dollars of BERD. The industry with the second highest patent-to-BERD ratio was other computer and electronic products (a combination of NAICS codes 3343 and 3346) with 2.89 patents per million dollars of BERD. Electrical equipment, appliances, and components (NAICS code 335) was the aggregated three-digit NAICS code sector with the highest patent-to- BERD ratio, with 1.36 patents per million dollars of BERD However, BERD in these three ICT-related industries declined substantially between 2000 and 2014, as shown in Appendix Table 19, Panel B. The decreases in BERD in these industries with the highest patent-to-BERD ratios suggest that the divergence between R&D and patent grants has not been caused by R&D shifts from sectors with low patent-to-R&D ratios to sectors with higher patent-to-R&D ratios.

vii. Summary of Explanations for the Divergence between Research and Development Expenditures and Patent Grants

Six potential reasons have been presented to explain the recent divergence between the growing volume of patent grants to Canadians by CIPO and the USPTO and the decline in R&D expenditures, especially BERD, over the same period. Some explanations prove more compelling than others, but further research is needed to confirm exactly what lies behind the recent divergence in R&D spending and patent grants.

It is possible that patent grants will decline in a few years due to current downward trends in R&D spending. However, there is no clear relationship between R&D expenditures and patent grants historically when adjusting for a lag and, moreover, it is unlikely a lag effect would persist when data are examined in terms of per cent change over a 14 year period. The data presented in Appendix Tables 19 and 20 indicate that BERD spending has not increased in ICT-related sectors that have demonstrated high patenting-to-R&D ratios in the past. Although the increased patent granting rate at CIPO in recent years suggests an increase in the quality of patent applications, opposite trends in other measures of patent quality and challenges in using granting rate calculations as a measure of patent quality suggest that patent quality may have in fact slightly decreased in Canada in recent years.

On the other hand, it seems possible that recent changes in the direct costs and benefits of patenting, in particular the implementation of the Patent Prosecution Highway (PPH), have increased the incentive for inventors to file patents and made it easier for Canadian inventors to patent inventions at the USPTO which have already been patented at CIPO. These changes could explain part of the rise in patenting grants, although some of these changes occurred too recently to have such an impact. Recent increases in patent grants at CIPO and the USPTO could also be caused in part by these offices' improved capacities to examine patent applications that resulted in shorter pendency times and a jump in patents. However, examination capacity increases cannot explain the increase in the number of patent applications at the USPTO. An increased propensity for Canadian inventors to file strategic patents could have led to an increase in CIPO patent grants and USPTO patent applications and grants, especially if inventions that are granted strategically-filed patents do not require the same level of research and development investment from firms. Finally, although parts of the explanation regarding increased efficiency are difficult to prove (such as the rise of a new innovation supercycle) it is possible that the advancement of

ICT and other technologies in the past two decades has increased the productivity of research processes and thus R&D spending.

Together, these two latter potential explanations—an increase in strategic filing of patent applications, and greater efficiency of research processes—provide a basis for understanding the divergence between R&D expenditures and the number of patents granted to Canadian inventors. Changes to the patenting administrative and regulatory systems and the increase in patent examination capacity at CIPO and the USPTO could have also been a factor in the patenting trends, although the evidence on this point is mixed. While further research is necessary to confirm the causes of the divergence in patenting trends and R&D expenditures, these potential explanatory factors shed light contribute to a better understanding of this divergence.

VI. Agenda for Future Research

This report has explored trends in the number of patents granted to Canadians by CIPO, USPTO, and triadic family patent offices, and produced several observations about the state of innovative activity in Canada. However, further research may enhance our understanding of observed patterns:

- The factors that have led to recent increases in the patent granting rates at CIPO and USPTO should be further researched. In particular, a more comprehensive survey is needed of recent changes to Canadian and American patenting legal regimes, changes in patent offices' capacities to examine patent applications, and the effects on the stringency of patenting screening standards and the direct costs and benefits of patenting.

- While the granting rate for residents and non-residents at CIPO are generally positively correlated, the rate for non-residents has nearly always exceeded the granting rate for residents. From 1984-2014 the granting rate at CIPO was on average 5 percentage points higher for non-residents than for residents. The resident vs. non-resident patent granting rate gap could be cause for concern for Canadian innovators and policymakers and thus merits further research.

- As noted in section I.D, the number of patents granted to Canadian inventors exceeds the number granted to Canadian assignees—the actual owners of the patenting rights—and this gap is growing. The percentage of Canadian-invented patents with rights held by foreign residents increased by 21 percentage points between 2000 and 2012 for USPTO patents, and increased by 17 percentage points between 2000 and 2008 for triadic patents. Although increasing the level of innovative activity that takes place in Canada is a crucial policy goal, it is also important for Canadian firms to commercialize these inventions. This inventor-assignee patent gap merits further research and attention because it suggests that Canada may be unable to profit from increases in innovative activity.

- It would be useful to better understand changes in the components of R&D expenditures to understand whether, and how, R&D spending has become more efficient in terms of patenting. Breaking down R&D spending into components of spending on (for example) labour, research equipment, licensing, and other categories would allow analysis of how changing spending in each category within R&D expenditures has impacted the number of patents granted to Canadian inventors.

- The vast majority of patents granted at CIPO (87 per cent in 2014) were to residents of foreign countries. How many of these foreign resident patents at CIPO have already been patented at other intellectual property offices, and in what jurisdictions? And specifically, how many of the patent applications at CIPO (by both Canadian and foreign residents) were also filed at the USPTO?

- What explains the decrease, in nominal terms, in BERD, HERD, and GovERD since 2011, in addition to the decrease in all three types of R&D in real terms?

- Is the order that inventors are listed on patent applications—which for many organizations is crucial to assigning geographic origin to the patent—random? For example if the listing is typically alphabetical, there is no reason to believe that certain countries' inventors are more likely to have surnames that begin with letters later in the alphabet and would therefore be biased against. However, there are differences in patent counts by organizations that assign origin to patents based on the residency of the first listed inventor and organizations that use fractional counting that would not occur if the order of inventors was truly random. For example, differences in the annual volume of triadic patents granted to Canadians as reported by the ISQ (821 patents in 2008, origin by first-listed inventor) and the OECD (686.5 patents in 2008, origin by fractional counting) suggests that Canadian inventors have an above-average tendency to be named first on patents.

- It would be useful to analyze a cohort of patent applications at CIPO and track the progress of each patent over time to better understand pendency times, granting rates, rates of withdrawal and other phenomena that could be affected by spurious factors when observed at the aggregate scale.

- The annual patent volumes used in this report count the number of patent applications filed or the number of patents granted by a particular intellectual property office. One inventor could be associated with a single patent or multiple patents. In order to better understand changes in the level of innovative activity over time, it would be useful to compile data on the number of unique inventors in Canada who have filed patent applications or have been granted patents by CIPO, USPTO, and other intellectual property offices.

- Data on the number of triadic patents associated with Canadian inventors are more difficult to obtain than data for CIPO and USPTO patents. In particular, there was no data on the number of applications filed for triadic patents and no data past 2011 for annual triadic patents grants to Canadians. More and better triadic patent data would allow better understanding of how downward trends in the annual volume of triadic patent grants between 2000 and 2011 should be considered alongside high growth in the number of CIPO and USPTO patents granted over the same period.

- Applications for patents can be filed by individuals, firms, universities, and other researchers and inventors. How many of the patent applications and grants by residents of Canada are to members of each group, and what incentives and barriers does each group face in the patenting process?

- A more extensive literature review on patent location decisions (for example, why inventors choose to file for a patent at CIPO versus the USPTO) could better contextualize the trends in Canadian patenting activities described in this report.

- The discussion of trends in various measures of patent quality would be more relevant if it included data on the quality of CIPO and USPTO patents granted to Canadians. Data on various patent quality measures for USPTO patents may be available from the OECD.

- While the ISQ provides breakdowns by province and by CMA of the number of ICT patents granted to Canadian residents, similar data are not available for other technologies. Data at the provincial and CMA level for the number of patents granted by technology should be compiled in order to give a better basis for understanding what innovative activity is occurring where in Canada.

VII. Conclusions

The overall increase in patents granted to Canadians by CIPO and USPTO from 2000 to 2014 suggests an increase in innovative activity by Canadians. Much of this innovation is concentrated technologically in the ICT sector of the economy, and geographically in Ontario, especially in the Kitchener-Waterloo, Toronto, and Ottawa-Gatineau regions.

However, several other trends should be taken to temper this optimism about recent trends in Canadian innovative activity. The decline in triadic patent grants between 2000 and 2011 suggests fewer high-quality inventions are being produced in Canada. Decreased expenditure on R&D, in particular BERD, seems to have reduced the number of patent applications to CIPO and triadic patent grants, although trends in CIPO patent grants and both patent grants and applications at the USPTO have largely diverged from BERD between 2000 and 2014. While much of this divergence between patenting trends and R&D expenditures seems to be consistent with increased innovative activity that has coincided with more efficient research, part of the divergence is could also be due to a higher number of strategic patent filings and changes in the patent administrative and regulatory systems that do not reflect increased innovation.

From these trends, it can be concluded that although Canadian innovation appears to have increased between 2000 and 2014, the increase has not been as significant as first appears in the data on patent grant. Important questions remain about what innovative activity has occurred in Canada and how to ensure patents can serve as a better indicator of innovation.

References

American Intellectual Propoerty Law Association (n.d.) "Summary of the America Invents Act," available at http://www.aipla.org/advocacy/congress/aia/Pages/summary.aspx.

Arrow, Kenneth (1962) “Economic Welfare and the Allocation of Resources for Invention,” *The Rate and Direction of Inventive Activity: Economic and Social Factors*, National Bureau of Economic Research, pp. 609-626.

Athey, Glenn, Max Nathan, Chris Webber, and Sami Mahroum (2008) "Innovation and the City," *Innovation* Vol. 10, No. 2-3. pp.156-169.

Blind, Knut, Katrin Cremers, and Elisabeth Mueller (2007) “The Influence of Strategic Patenting on Companies' Patent Portfolios,” Leibniz Information Centre for Economics (ZEW) Discussion Papers, No. 07-013.

Brydon, Robbie, Nicholas Chesterly, Benjamin Dachis, and Aaron Jacobs (2014) "Measuring Innovation in Canada: The Tale Told by Patent Applications," C.D. Howe Institute, E-Brief.

Dernis, Helen and Mosahid Khan (2004) “Triadic Patent Families Methodology” OECD Science, Technology and Industry Working Papers 2004-02, OECD Publishing.

Canadian Intellectual Property Office (2013) "Examination Practice Respecting Computer-Implemented Inventions - PN 2013-03," available at www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/wr03627.html.

Canadian Intellectual Property Office (2016) “Canadian Intellectual Property Office: Annual Report 2014–2015,” Canadian Intellectual Property Office.

Cornell University, INSEAD, and WIPO (2016): *The Global Innovation Index 2016: Winning with Global Innovation* (Ithaca, Fontainebleau, and Geneva).

Council of Canadian Academies (2013) “Paradox Lost: Explaining Canada’s Research Strength and Innovation Weakness,”(Ottawa, Ont: Advisory Group, Council of Canadian Academies).

Eckert, Andrew and Corinne Langinier (2014) "A Survey of the Economics of Patent Systems and Procedures," *Journal of Economic Surveys*, Vol. 28, No. 5, pp. 996-1015.

Freeman, Christopher (1982) “Innovation and Long Cycles of Economic Development,” paper presented at the International Seminar on Innovation and Development of the Industrial Sector, University of Campinas, August, http://www.enterrasolutions.com/media/docs/2013/02/JoseCassiolato_2.pdf.

Gault, Fred (2003) *Understanding Innovation in Canadian Industry* (Kingston, Ont: McGill-Queen’s University Press).

Hall, Bronwyn and Rosemarie Ziedonis (2001) “The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979–1995,” *RAND Journal of Economics*, Vol. 32, No. 1, Spring, pp. 101–128.

Hall, Bronwyn, Grid Thoma and Salvatore Torrisi (2007) "The Market Value of Patents and R&D: Evidence from European Firms," National Bureau of Economic Research, Working paper No. 13426.

Hall, Bronwyn and Dietmar Harhoff (2011) "Recent Research on the Economics of Patents," National Bureau of Economic Research, Working Paper No. 17773.

Hall, Bronwyn, Christian Helmers, Mark Rogers and Vania Sena (2012) “The Choice Between Formal and Informal Intellectual Property: A Literature Review,” National Bureau of Economic Research, Working Paper No. 17983.

Institut de la statistique du Québec (2015) "Définitions," available at http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/cdmi.html.

Jaffe, Adam B. (1989) “Real Effects of Academic Research,” *The American Economic Review*, Vol. 79, No. 5, pp. 957-970.

Kortum, Samuel and Josh Lerner (1999) “What is Behind the Recent Surge in Patenting?” *Research Policy*, Vol. 28, pp. 1-22.

Lemley, Mark A. and Bhaven Sampat (2008) “Is the Patent Office a Rubber Stamp?” *Emory Law Journal*, Vol. 58, pp. 101-128.

Lo, Shih-tse and Dhanoos Sutthiphisal (2009) "Does it Matter who has the Right to Patent: First to Invent of First-to-File? Lessons From Canada," National Bureau of Economic Research, Working Paper No. 14926.

Marceau, Jane (2008) "Introduction: Innovation in the City and Innovative Cities." *Innovation*, Vol. 10, No. 2-3, pp. 136-145.

Moser, Petra (2005) "How do Patent laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs" *American Economic Review*, Vol. 95, No.4, pp. 1214-1236.

Murray, Alexander (2016) "Partial versus Total Factor Productivity Measures: An Assessment of their Strengths and Weaknesses," *International Productivity Monitor*, Number 31, Fall, pp. 113-126.

Nagaoka, Sadao, Kazuyuki Motohashi, and Akira Goto (2010) “Patent Statistics as an Innovation Indicator” *Handbook of the Economics of Innovation* Vol. 2, pp. 1083-1127

Nelson, Richard D. and Roberto Mazzoleni (1997) "Economic Theories About the Costs and Benefits of Patents." *Journal of Economic Issues*, Vol. 32, No. 4, pp. 1031-1052.

OECD (2006) "Glossary of Patent Terminology" Organization for Economic Co-operation and Development Economic Analysis and Statistics Division Directorate for Science, Technology and Industry, (Paris: Organization for Economic Co-operation and Development).

OECD (2009) *OECD Patent Statistics Manual* (Paris: Organization for Economic Co-operation and Development).

OECD (2015) "Chapter 2: Measuring the Technological and Economic Value of Patents" in *Enquiries into Intellectual Property's Economic Impact* (Paris: Organization for Economic Co-operation and Development).

Pavitt, Keith (1988) "Uses and Abuses of Patent Statistics," in *Handbook of Quantitative Studies of Science and Technology*, A. F. J. van Raan, ed. (Amsterdam: Elsevier Science Publishers).

Park, Walter G. (2008) "International Patent Protection:1960-2005," *Research Policy*, Vol. 37, No. 4, pp. 761-766.

Potts, Christopher A. (2011) "The Patent Prosecution Highway: A Global Superhighway to Changing Validity Standards," *Available at SSRN 1959587*.

Pogue, Melissa (2015) "Under the Bridge: Patent Trolls and the Toll on Innovation," Martin Prosperity Institute, Infrastructure Series, May 12.

Prodan, Igor (2005) "Influence of Research and Development Expenditures on Number of Patent Applications: Selected Case Studies in OECD Countries and Central Europe, 1981-2001," *Applied Econometrics and International Development,* Vol. 5, No. 4, pp. 5-22.

Quillen, Cecil D. and Ogden H. Webster (2006) "Continuing Patent Applications and Performance of the U.S. Patent and Trademark Office-Updated," *Federal Bar Journal*, Vol. 15, No.4, pp. 653-677.

Quinn, G. (2011). "The Cost of Obtaining a Patent in the US", IPWatchdog.com, April 4.

Rafiquzzaman, Mohammed and Lori Whewell (1998) "Recent Jumps in Patenting Activities: Comparative Innovative Performance of major Industrial Countries, Patterns and Explanations," Industry Canada Research Publications Program, Working Paper No. 27.

Schmoch, Ulrich (2008) "Concept of a Technology Classification for Country Comparisons," Report to the World Intellectual Property Organisation (WIPO), http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf.

Somaya, Deepak (2012) "Patent Strategy and Management: An Integrative Review and Research Agenda," *Journal of Management,* Vol. 38, No. 4, July, pp. 1084-1114.

Sung, Hui-Yun, Chun-Chieh Wang, Dar-Zen Chen, and Mu-Hsuan Huang (2014) “A Comparative Study of Patent Counts by the Inventor Country and the Assignee Country,” *Scientometrics* (2014) Vol. 100, No. 2 pp. 577-593.

Taylor, Mark Zachary. (2016) *The Politics of Innovation: Why Some Countries are Better than Others at Science & Technology* (New York: Oxford University Press).

United States Patent and Trademark Office (2011) “Status of USPTO Initiatives to Improve Patent Timeliness and Quality,” United States Patent and Trademark Office, Final Report No. OIG-11-032-I, September 29, https://www.oig.doc.gov/oigpublications/oig-11-032-i.pdf.

United States Patent and Trademark Office (2012) “Intellectual Property and the U.S. Economy: Industries in Focus” Prepared with U.S. Department of Commerce Economics and Statistics Administration. March. https://www.uspto.gov/sites/default/files/news/publications/IP_Report_March_2012.pdf.

United States Patent and Trademark Office (2015) "Patent Counts by Country, State, and Year - Utility Patents (December 2015)," available at https://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utl.htm.

United States Patent and Trademark Office (2016) “Performance and Accountability Report: Fiscal Year 2016,” United States Patent and Trademark Office, https://www.uspto.gov/sites/default/files/documents/USPTOFY16PAR.pdf.

van Zeebroeck, Nicolas and Bruno van Pottelsberghe de la Potterie(2008) “Filing strategies and Patent Value," *Economics of Innovation and New Technology*, Vol. 20, No.6, pp. 539-561.

World Intellectual Property Organization (2008) "World Patent Report: a Statistical Review," World Intellectual Property Organization.

World Intellectual Property Organization (n.d.) "Frequently Asked Questions on Patents: SMEs," available at http://www.wipo.int/sme/en/faq/patent_faqs.html.

Wolfe, David A. (2009) "21st Century Cities in Canada: the Geography of Innovation," *Conference Board of Canada*.

Appendix

List of Appendix Tables

Appendix Table 1: Number of CIPO Patent Applications, Patent Grants, and Granting Rates (with 4 year lag) for Canadian Resident Inventors, 1980-2014

	CIPO Patents Granted to Canadian Residents	CIPO Patent Applications by Canadian Residents	Granting Rate, With 4 year Lag	Share of Total CIPO Patents Granted to Canadian Residents
1980	1,450	1,648	-	6.33%
1981	1,526	2,164	-	6.31%
1982	1,386	2,000	-	6.17%
1983	1,359	2,017	-	6.47%
1984	1,427	2,026	86.59%	6.95%
1985	1,355	2,092	62.62%	7.25%
1986	1,377	2,161	68.85%	7.85%
1987	1,082	2,527	53.64%	7.39%
1988	1,184	2,772	58.44%	7.04%
1989	1,069	3,031	51.10%	6.56%
1990	1,109	2,549	51.32%	7.82%
1991	1,109	2,182	43.89%	7.17%
1992	1,305	2,807	47.08%	7.12%
1993	1,056	3,623	34.84%	7.24%
1994	852	2,480	33.42%	7.32%
1995	743	2,431	34.05%	8.13%
1996	709	2,583	25.26%	9.92%
1997	648	3,344	17.89%	8.90%
1998	949	3,809	38.27%	9.91%
1999	1,347	4,061	55.41%	9.78%
2000	1,117	4,187	43.24%	9.21%
2001	1,210	3,963	36.18%	10.07%
2002	1,253	3,959	32.90%	14.06%
2003	1,226	3,929	30.19%	10.61%
2004	1,425	5,231	34.03%	10.90%
2005	1,511	5,183	38.13%	9.74%
2006	1,588	5,522	40.11%	10.61%
2007	1,809	4,998	46.04%	9.75%
2008	1,886	5,061	36.05%	10.08%
2009	2,029	5,067	39.15%	10.41%
2010	1,906	4,550	34.52%	9.97%
2011	2,150	4,754	43.02%	10.36%
2012	2,404	4,709	47.50%	11.02%
2013	2,756	4,567	54.39%	11.56%
2014	2,984	4,198	65.58%	12.56%
% or Point Change, 2000-2014	167.1%	0.26%	22.34	3.35
Annual growth rate, 2000-2014	7.27%	0.02%	n.a.	n.a.

Source: World Intellectual Property Organization , IP Statistics Data Centre (data are filtered by total patent grants and resident and non-resident count by filling office). http://www.wipo.int/ipstats/en

Appendix Table 2: Number of CIPO Patent Applications, Patent Grants, and Granting Rates (with 4 year lag) for Non-Resident Inventors, 1980-2014

	CIPO Patents Granted to Non-Residents	CIPO Patent Applications by Non-Residents	Granting Rate, With 4 year Lag	Share Granted to Non-Residents of Total CIPO Patents Granted
1980	21,444	22,699	-	93.67%
1981	22,639	23,267	-	93.69%
1982	21,061	23,883	-	93.83%
1983	19,640	23,690	-	93.53%
1984	19,118	24,709	84.22%	93.05%
1985	17,342	25,482	74.53%	92.75%
1986	16,173	25,596	67.72%	92.15%
1987	13,567	26,598	57.27%	92.61%
1988	15,629	28,869	63.25%	92.96%
1989	15,230	32,060	59.77%	93.44%
1990	13,078	24,375	51.09%	92.18%
1991	14,364	21,097	54.00%	92.83%
1992	17,027	22,950	58.98%	92.88%
1993	13,524	23,307	42.18%	92.76%
1994	10,789	24,683	44.26%	92.68%
1995	8,396	24,161	39.80%	91.87%
1996	6,436	24,987	28.04%	90.08%
1997	6,635	25,238	28.47%	91.10%
1998	8,623	30,163	34.93%	90.09%
1999	12,431	33,189	51.45%	90.22%
2000	11,008	35,435	44.05%	90.79%
2001	10,809	35,753	42.83%	89.93%
2002	7,657	35,782	25.39%	85.94%
2003	10,325	33,299	31.11%	89.39%
2004	11,652	32,970	32.88%	89.10%
2005	14,005	34,705	39.17%	90.26%
2006	13,384	36,516	37.40%	89.39%
2007	16,741	35,133	50.27%	90.25%
2008	16,817	37,028	51.01%	89.92%
2009	17,468	32,410	50.33%	89.59%
2010	17,214	30,899	47.14%	90.03%
2011	18,612	30,357	52.98%	89.64%
2012	19,415	30,533	52.43%	88.98%
2013	21,077	30,174	65.03%	88.44%
2014	20,765	31,283	67.20%	87.44%
% or Point Change, 2000-2014	88.6%	-11.7%	23.15	-3.35
Annual growth rate, 2000-2014	4.64%	-0.89%	n.a	n.a

Source: World Intellectual Property Organization , IP Statistics Data Centre (data are filtered by total patent grants and resident and non-resident count by filling office). http://www.wipo.int/ipstats/en

Appendix Table 3: Number of USPTO Patent Applications, Patent Grants, Share of Total USPTO Patent Grants, and Granting Rates (with 3 year lag) for Canadian Inventors, 1980-2014

	USPTO Patents Granted to Canadians	USPTO Patent Applications by Canadians	Granting Rate, With 3 year Lag (%)	Canadian Inventors' Share of Total USPTO Patent Grants
1980	1083	1969	-	1.75
1981	1138	2202	-	1.73
1982	993	2138	-	1.72
1983	1002	1995	50.9	1.76
1984	1202	2273	54.6	1.79
1985	1342	2270	62.8	1.87
1986	1314	2438	65.9	1.85
1987	1594	2791	70.1	1.92
1988	1489	3046	65.6	1.91
1989	1960	3425	80.4	2.05
1990	1859	3511	66.6	2.06
1991	2037	3641	66.9	2.11
1992	1964	3761	57.3	2.02
1993	1944	3910	55.4	1.98
1994	2008	4255	55.1	1.97
1995	2104	4745	55.9	2.07
1996	2232	4443	57.1	2.04
1997	2379	4694	55.9	2.12
1998	2973	5689	62.7	2.02
1999	3226	6149	72.6	2.10
2000	3419	6809	72.8	2.17
2001	3606	7221	63.4	2.17
2002	3431	7375	55.8	2.05
2003	3427	7750	50.3	2.03
2004	3374	8202	46.7	2.05
2005	2894	8638	39.2	2.01
2006	3572	9652	46.1	2.06
2007	3318	10421	40.5	2.11
2008	3393	10307	39.3	2.15
2009	3655	10309	37.9	2.18
2010	4852	11685	46.6	2.21
2011	5014	11975	48.6	2.23
2012	5775	13560	56.0	2.28
2013	6547	13675	56.0	2.36
2014	7042	12963	58.8	2.34
% or Point Change, 2000-2014	105.97%	90.38%	-4.58	0.17
Annual growth rate, 2000-2014	5.30%	4.71%	n.a.	n.a.

Source: Unites States Patent and Trademark Office, Patent Counts By Country, State, and Year - Utility Patents; Number of Utility Patent Applications Filed in the United States, By Country of Origin, Calendar Years 1965 to Present; and Number of Patents Granted as Distributed by Year of Patent Grant, Breakout by Country of Origin https://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm

Appendix Table 4: Patents Granted by the USPTO by Inventor(s)'s Country of Residence and Date of Grant, G7 Countries, 1980-2014

Country	Canada	France	Germany	Italy	Japan	United Kingdom	United States
1980	1,083	2,087	5,782	806	7,124	2,405	37,350
1981	1,138	2,181	6,304	883	8,389	2,470	39,218
1982	993	1,975	5,469	753	8,149	2,137	33,889
1983	1,002	1,895	5,478	625	8,793	1,928	32,866
1984	1,202	2,163	6,323	794	11,110	2,268	38,373
1985	1,342	2,400	6,718	919	12,746	2,493	39,556
1986	1,314	2,369	6,856	995	13,209	2,403	38,126
1987	1,594	2,874	7,884	1,183	16,557	2,769	43,519
1988	1,489	2,661	7,352	1,076	16,158	2,582	40,497
1989	1,960	3,140	8,352	1,297	20,169	3,095	50,184
1990	1,859	2,866	7,614	1,259	19,525	2,791	47,391
1991	2,037	3,030	7,680	1,209	21,025	2,802	51,177
1992	1,964	3,029	7,309	1,271	21,925	2,425	52,253
1993	1,944	2,909	6,893	1,285	22,293	2,300	53,231
1994	2,008	2,779	6,731	1,215	22,384	2,231	56,066
1995	2,104	2,821	6,600	1,078	21,764	2,479	55,739
1996	2,232	2,788	6,818	1,200	23,053	2,450	61,104
1997	2,379	2,958	7,008	1,239	23,179	2,672	61,708
1998	2,973	3,674	9,095	1,584	30,840	3,460	80,289
1999	3,226	3,820	9,337	1,492	31,104	3,565	83,906
2000	3,419	3,819	10,235	1,714	31,295	3,659	85,068
2001	3,606	4,041	11,260	1,709	33,222	3,955	87,600
2002	3,431	4,035	11,280	1,751	34,858	3,829	86,971
2003	3,427	3,868	11,444	1,722	35,515	3,618	87,893
2004	3,374	3,380	10,779	1,584	35,346	3,441	84,270
2005	2,894	2,866	9,011	1,296	30,340	3,141	74,637
2006	3,572	3,431	10,005	1,480	36,807	3,579	89,823
2007	3,318	3,130	9,051	1,302	33,354	3,291	79,526
2008	3,393	3,163	8,914	1,357	33,682	3,085	77,502
2009	3,655	3,140	9,000	1,346	35,501	3,173	82,382
2010	4,852	4,450	12,363	1,798	44,813	4,298	107,791
2011	5,014	4,532	11,919	1,885	46,139	4,292	108,622
2012	5,775	5,386	13,835	2,120	50,677	5,211	121,026
2013	6,547	6,083	15,498	2,499	51,919	5,806	133,593
2014	7,042	6,691	16,550	2,628	53,848	6,488	144,621
% Change or point change, 2000-2014	106.0	75.2	61.7	53.3	72.1	77.3	70.0
Annual Growth Rate, 2000-2014	5.30	4.09	3.49	3.10	3.95	4.18	3.86

Source: United States Patent and Trademark Office, Number of Patents Granted as Distributed by Year of Patent Grant, Breakout by Country of Origin. https://www.uspto.gov/web/offices/ac/ido/oeip/taf/h_at.htm#PartA1_1a

Appendix Table 5: Triadic Patents issued to Canadian Inventor(s), 1985-2011

	Triadic Patents Granted to Canadian Inventors (Fractional Count, OECD)	Triadic Patents Granted to Canadian Inventors (Count by First Inventor, ISQ)
1985	205.7	196
1986	221.1	222
1987	291.3	292
1988	254.1	303
1989	320.1	421
1990	290.8	400
1991	298.8	431
1992	288.0	404
1993	305.9	448
1994	372.5	421
1995	391.2	457
1996	432.7	509
1997	547.3	588
1998	566.2	794
1999	565.8	809
2000	612.3	858
2001	634.3	906
2002	678.4	916
2003	670.3	811
2004	736.9	834
2005	714.5	665
2006	666.8	896
2007	681.6	894
2008	686.5	821
2009	677.1	n.a.
2010	553.5	n.a.
2011	576.1	n.a.
% Change 2000-2014	-5.92	n.a.
Annual growth rate, 2000-2014	-0.55	n.a.

Source: OECD Patent Statistics. http://stats.oecd.org/Index.aspx?DatasetCode=PATS_IPC# and Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/triad_canada.htm

Appendix Table 6: Average Annual Growth Rates of CIPO and USPTO Patent Grants by Technology, 1980-2014

	Patents Granted by CIPO				Patents Granted by USPTO			
Technology	1980-1990	1990-2000	2000-2010	2010-2014	1980-1990	1990-2000	2000-2010	2010-2014
1 - Electrical machinery, apparatus, energy	-5.10	0.46	3.00	11.08	7.18	3.30	5.59	4.59
2 - Audio-visual technology	1.55	2.16	-0.80	23.59	7.76	8.76	7.54	14.42
3 - Telecommunications	-0.84	7.49	1.22	4.72	8.11	17.80	3.61	8.95
4 - Digital communication	7.18	11.14	21.33	27.86	25.89	32.44	7.87	23.22
5 - Basic communication processes	-2.84	0.80	-1.66	6.21	5.76	15.47	6.81	1.29
6 - Computer technology	3.31	9.60	7.06	26.51	14.87	23.68	20.46	12.57
7 - IT methods for management	n.a.	n.a.	21.48	50.59	n.a.	n.a.	20.21	11.39
8 - Semiconductors	7.18	-3.50	-3.31	18.92	15.79	4.91	11.07	7.12
9 - Optics	2.36	-0.42	3.03	-4.30	4.62	8.98	6.40	-5.22
10 - Measurement	-3.50	-1.17	3.76	17.99	9.02	0.94	6.39	4.81
11 - Analysis of biological materials	-10.40	13.35	9.90	-9.64	7.18	16.86	-0.27	-8.44
12 - Control	-1.73	0.47	-1.46	14.80	2.26	11.04	5.24	7.53
13 - Medical technology	-1.99	1.06	8.04	17.52	7.70	5.92	2.40	11.44
14 - Organic fine chemistry	-6.86	-4.87	6.86	0.75	3.05	7.57	5.65	2.96
15 - Biotechnology	3.42	10.50	7.73	1.82	27.66	19.71	-1.62	2.84
16 - Pharmaceuticals	-0.74	8.35	7.54	2.41	13.35	23.33	2.57	4.46
17 - Macromolecular chemistry, polymers	0.45	-8.96	10.76	-2.06	6.05	-5.10	11.61	-3.86
18 - Food chemistry	-8.76	-1.33	12.13	0.00	1.34	4.56	5.07	7.62
19 - Basic materials chemistry	-7.26	-3.50	6.39	14.06	0.72	2.47	6.12	10.53
20 - Materials, metallurgy	-13.92	2.35	6.22	-6.79	1.88	0.21	0.00	-1.06
21 - Surface technology, coating	-7.63	-3.01	3.63	15.02	4.30	2.51	2.00	10.30
22 - Micro-structural and nano-technology	n.a.	n.a.	n.a.	31.61	n.a.	n.a.	0.00	56.51
23 - Chemical engineering	-6.70	-1.00	3.19	13.07	3.61	4.56	-1.70	12.23
24 - Environmental technology	-3.97	0.54	9.24	1.07	6.44	9.75	-1.03	-4.16
25 - Handling	-3.33	-1.91	1.95	12.71	4.73	0.96	-0.56	7.33
26 - Machine tools	-1.55	-1.64	1.50	4.44	5.50	3.53	-2.51	8.56
27 - Engines, pumps, turbines	-7.06	-7.08	15.79	18.63	3.75	8.72	1.84	2.02
28 - Textile and paper machines	-9.67	-2.65	-2.59	14.19	1.50	2.74	1.93	-2.25
29 - Other special machines	1.54	-4.92	6.04	1.28	8.29	1.86	-0.05	1.99
30 - Thermal processes and apparatus	-1.20	-3.61	4.52	5.99	2.26	4.43	-2.96	-3.28
31 - Mechanical elements	0.00	-6.26	13.35	2.80	7.53	2.45	1.20	13.56
32 - Transport	-3.68	-1.46	6.50	6.37	6.57	5.43	-1.42	8.39
33 - Furniture, games	3.08	-3.29	-1.71	14.47	5.89	3.50	-0.56	5.33
34 - Other consumer goods	-1.41	-2.70	0.83	4.89	3.27	3.25	-2.60	4.18
35 - Civil engineering	-3.76	-2.11	10.74	5.40	4.73	3.49	1.01	3.46
Unknown	-22.92	-2.84	-100	n.a.	n.a.	n.a.	-100	n.a.
Average Annual Growth Rate, All Patents	**-3.48**	**-0.92**	**6.05**	**11.11**	**5.77**	**6.56**	**4.26**	**8.65**

Source: World Intellectual Property Organization statistics database. Indicator :5 - Patent grants by technology http://www.wipo.int/ipstats/en

Appendix Table 7: Contribution to Increase in Total CIPO and USPTO Patent Grants by Technology 1980-2014

	Patents Granted by CIPO				Patents Granted by USPTO			
Technology	1980-1990	1990-2000	2000-2010	2010-2014	1980-1990	1990-2000	2000-2010	2010-2014
1 - Electrical machinery, apparatus, energy	-8.66	-2.86	2.64	4.58	-6.44	2.38	5.66	2.30
2 - Audio-visual technology	0.59	-4.76	-0.23	3.12	-2.74	3.31	5.66	6.78
3 - Telecommunications	-0.59	-34.3	1.03	1.56	-3.56	13.17	6.32	7.51
4 - Digital communication	0.79	-14.3	15.61	25.9	-1.23	10.32	11.32	24.1
5 - Basic communication processes	-0.79	-0.95	-0.23	0.29	-0.82	2.98	3.31	0.31
6 - Computer technology	0.98	-25.7	5.05	13.53	-1.64	7.81	43.83	27.23
7 - IT methods for management	0.00	-0.95	0.69	2.82	0.00	0.66	3.19	1.77
8 - Semiconductors	0.98	2.86	-0.23	0.49	-1.37	0.53	2.35	0.99
9 - Optics	0.98	0.95	0.92	-0.49	-1.64	2.98	4.03	-1.46
10 - Measurement	-5.31	6.67	2.87	7.40	-8.08	0.66	5.78	2.24
11 - Analysis of biological materials	-0.79	-4.76	1.26	-0.58	-0.55	1.99	-0.06	-0.57
12 - Control	-0.79	-0.95	-0.34	1.36	-0.55	2.45	2.29	1.67
13 - Medical technology	-1.18	-2.86	4.02	5.74	-4.52	3.24	1.81	4.02
14 - Organic fine chemistry	-5.71	10.48	1.84	0.10	-0.96	1.92	2.47	0.63
15 - Biotechnology	0.39	-11.4	2.41	0.29	-2.88	7.68	-1.26	0.73
16 - Pharmaceuticals	-0.20	-15.2	3.56	0.58	-1.37	6.62	1.99	1.46
17 - Macromolecular chemistry, polymers	0.20	13.33	1.84	-0.19	-1.64	-0.73	1.93	-0.37
18 - Food chemistry	-2.36	0.95	1.72	0.00	-0.27	0.60	0.96	0.73
19 - Basic materials chemistry	-8.86	11.43	2.76	3.51	-0.27	0.53	1.81	1.72
20 - Materials, metallurgy	-15.8	-5.71	2.76	-1.27	-1.10	0.07	0.00	-0.10
21 - Surface technology, coating	-4.53	4.76	0.69	1.46	-1.51	0.60	0.54	1.25
22 - Micro-structural and nano-technology	0.00	0.00	0.11	0.19	0.00	0.07	0.00	0.26
23 - Chemical engineering	-8.27	3.81	1.61	3.21	-2.33	2.12	-0.84	2.30
24 - Environmental technology	-1.77	-0.95	3.10	0.19	-1.78	2.85	-0.42	-0.52
25 - Handling	-4.53	9.52	1.15	3.41	-5.07	0.66	-0.36	1.77
26 - Machine tools	-1.97	8.57	0.92	1.07	-4.66	2.25	-1.57	1.83
27 - Engines, pumps, turbines	-5.31	12.38	4.59	4.97	-1.64	3.38	1.08	0.47
28 - Textile and paper machines	-5.91	3.81	-0.34	0.68	-0.55	0.60	0.48	-0.21
29 - Other special machines	2.95	40.00	5.86	0.58	-11.5	2.05	-0.06	0.78
30 - Thermal processes and apparatus	-0.98	11.43	1.72	1.07	-0.96	1.26	-0.84	-0.26
31 - Mechanical elements	0.00	19.05	6.31	0.88	-4.38	1.13	0.60	3.08
32 - Transport	-5.91	8.57	5.74	2.92	-6.58	4.70	-1.38	2.97
33 - Furniture, games	4.53	23.81	-1.15	3.70	-6.99	3.18	-0.54	1.88
34 - Other consumer goods	-1.38	10.48	0.34	0.78	-2.60	1.72	-1.32	0.68
35 - Civil engineering	-11.0	21.90	19.75	6.13	-7.81	4.17	1.38	1.83
Unknown	-9.84	0.95	-0.34	0.00	0.00	0.13	-0.12	0.21
Total Absolute Change in Patents Granted	**-508**	**-105**	**871**	**1027**	**730**	**1511**	**1661**	**1917**

Source: World Intellectual Property Organization statistics database. Indicator: 5 - Patent grants by technology http://www.wipo.int/ipstats/en

Appendix Table 8: Change in Number of CIPO and USPTO Patent Grants by Technology 1980-2014

Technology	Patents Granted by CIPO 1980-1990	1990-2000	2000-2010	2010-2014	Patents Granted by USPTO 1980-1990	1990-2000	2000-2010	2010-2014
1 - Electrical machinery, apparatus, energy	-44	3	23	47	47	36	94	44
2 - Audio-visual technology	3	5	-2	32	20	50	94	130
3 - Telecommunications	-3	36	9	16	26	199	105	144
4 - Digital communication	4	15	136	266	9	156	188	462
5 - Basic communication processes	-4	1	-2	3	6	45	55	6
6 - Computer technology	5	27	44	139	12	118	728	522
7 - IT methods for management	0	1	6	29	0	10	53	34
8 - Semiconductors	5	-3	-2	5	10	8	39	19
9 - Optics	5	-1	8	-5	12	45	67	-28
10 - Measurement	-27	-7	25	76	59	10	96	43
11 - Analysis of biological materials	-4	5	11	-6	4	30	-1	-11
12 - Control	-4	1	-3	14	4	37	38	32
13 - Medical technology	-6	3	35	59	33	49	30	77
14 - Organic fine chemistry	-29	-11	16	1	7	29	41	12
15 - Biotechnology	2	12	21	3	21	116	-21	14
16 - Pharmaceuticals	-1	16	31	6	10	100	33	28
17 - Macromolecular chemistry, polymers	1	-14	16	-2	12	-11	32	-7
18 - Food chemistry	-12	-1	15	0	2	9	16	14
19 - Basic materials chemistry	-45	-12	24	36	2	8	30	33
20 - Materials, metallurgy	-80	6	24	-13	8	1	0	-2
21 - Surface technology, coating	-23	-5	6	15	11	9	9	24
22 - Micro-structural and nano-technology	0	0	1	2	0	1	0	5
23 - Chemical engineering	-42	-4	14	33	17	32	-14	44
24 - Environmental technology	-9	1	27	2	13	43	-7	-10
25 - Handling	-23	-10	10	35	37	10	-6	34
26 - Machine tools	-10	-9	8	11	34	34	-26	35
27 - Engines, pumps, turbines	-27	-13	40	51	12	51	18	9
28 - Textile and paper machines	-30	-4	-3	7	4	9	8	-4
29 - Other special machines	15	-42	51	6	84	31	-1	15
30 - Thermal processes and apparatus	-5	-12	15	11	7	19	-14	-5
31 - Mechanical elements	0	-20	55	9	32	17	10	59
32 - Transport	-30	-9	50	30	48	71	-23	57
33 - Furniture, games	23	-25	-10	38	51	48	-9	36
34 - Other consumer goods	-7	-11	3	8	19	26	-22	13
35 - Civil engineering	-56	-23	172	63	57	63	23	35
Unknown	-50	-1	-3	0	0	2	-2	4
Total Absolute Change in Patents Granted	**-508**	**-105**	**871**	**1027**	**730**	**1511**	**1661**	**1917**

Source: World Intellectual Property Organization statistics database. Indicator: 5 - Patent grants by technology http://www.wipo.int/ipstats/en

Appendix Table 9: Number and Percentage Distribution of Patents Issued at the USPTO to Canadian Inventions, by International Patent Classification, 2003-2014

Panel A: Number

IPC	A	B	C	D	E	F	G	H	
	Human Necessities	Performing Operations; Transporting	Chemistry; Metallurgy	Textiles Paper	Fixed Construction	Mechanical Engineering Lighting; Weapons; Blasting	Physics	Electricity	Total*
2003	671	661	296	14	185	270	716	604	3,417
2004	533	626	294	15	203	246	758	694	3,369
2005	451	537	201	14	179	249	644	611	2,886
2006	506	630	262	20	160	278	888	818	3,562
2007	439	529	267	11	162	255	873	776	3,312
2008	459	507	258	23	137	190	964	854	3,392
2009	465	479	292	14	174	223	1,129	877	3,653
2010	670	580	363	14	246	267	1,583	1,126	4,849
2011	701	605	371	29	250	240	1,609	1,205	5,010
2012	691	685	387	26	268	325	1,844	1,548	5,774
2013	918	706	353	18	281	325	2,122	1,822	6,545
2014	945	733	393	27	303	333	2384	1,925	7,043
% Change 2003-2014	40.83	10.89	32.77	92.86	63.78	23.33	232.96	218.71	106.12
Annual Growth rate 2003-2014	3.16	0.94	2.61	6.15	4.59	1.92	11.56	11.11	6.80

Panel B: Percentage Distribution

2003	19.6	19.3	8.7	0.4	5.4	7.9	21.0	17.7	100.0
2004	15.8	18.6	8.7	0.4	6.0	7.3	22.5	20.6	100.0
2005	15.6	18.6	7.0	0.5	6.2	8.6	22.3	21.2	100.0
2006	14.2	17.7	7.4	0.6	4.5	7.8	24.9	23.0	100.0
2007	13.3	16.0	8.1	0.3	4.9	7.7	26.4	23.4	100.0
2008	13.5	14.9	7.6	0.7	4.0	5.6	28.4	25.2	100.0
2009	12.7	13.1	8.0	0.4	4.8	6.1	30.9	24.0	100.0
2010	13.8	12.0	7.5	0.3	5.1	5.5	32.6	23.2	100.0
2011	14.0	12.1	7.4	0.6	5.0	4.8	32.1	24.1	100.0
2012	12.0	11.9	6.7	0.5	4.6	5.6	31.9	26.8	100.0
2013	14.0	10.8	5.4	0.3	4.3	5.0	32.4	27.8	100.0
2014	13.4	10.4	5.6	0.4	4.3	4.7	33.8	27.3	100.0
Percentage point change, 2003-2014	-6.2	-8.9	-3.1	0.0	-1.1	-3.2	12.9	9.7	0

Note: A patent is considered issued to a Canadian inventor only if his/her name appears first on the patent application. Source: fiveIPoffices: Historical numbers of grants by IPC codes. http://www.fiveipoffices.org/statistics/statisticaldata.html
* These totals (sourced from fiveIPoffices) slightly differ from the numbers of patents issued at the USPTO to Canadian inventions listed earlier in this report due to differences in accounting measures by the two sources they are taken from.

Appendix Table 10: USPTO Patenting Intensity of Employment by Manufacturing North American Industrial Classification System (NAICS) Code, 2001-2012

Panel A: USPTO Patents to Canadian Inventor(s) by Three-Digit NAICS Code

	2001-2006 Average			2007-2012 Average		
North American Industrial Classification System (NAICS) Code	Patents (Average Annual)	Employment (Annual Average, 1,000 Jobs)	Patent Intensity (Patents/ 1,000 Jobs)	Patents (Averag e Annual)	Employment (Annual Average, 1,000 Jobs)	Patent Intensity (Patents/ 1,000 Jobs)
Computer and Electronic Products (334)	1156.83	91.4	12.7	2165.17	75.0	28.9
Electrical Equipment, Appliances, and Components (335)	217.83	44.5	4.9	235.33	38.7	6.1
Chemicals (325)	421.17	92.5	4.6	460.33	83.9	5.5
Miscellaneous Manufacturing (339)	268.5	57.7	4.7	305.67	56.0	5.5
Machinery (333)	576.83	138.4	4.2	558	130.1	4.3
Fabricated Metal Products (332)	268	179.7	1.5	207.83	158.1	1.3
Transportation Equipment (336)	189.83	231.6	0.8	182.83	185.2	1.0
Plastics and Rubber Products (326)	107.17	125.9	0.9	85.67	99.9	0.9
Nonmetallic Mineral Products (327)	50	52.1	1.0	35.17	50.6	0.7
Textiles, Apparel and Leather (313-316)	34.17	111.4	0.3	25.83	53.3	0.5
Primary Metal (331)	23.33	84.3	0.3	18.83	65.2	0.3
Furniture and Related Products (337)	23	95.6	0.2	16.33	72.7	0.2
Wood Products (321)	16.5	134.4	0.1	15.33	98.3	0.2
Paper, Printing and support activities (322 and 323)	16.83	170.5	0.1	12.17	130.6	0.1
Beverage and Tobacco Products (312)	3.17	32.9	0.1	2.17	30.2	0.1
Food (311)	11.17	233.4	0.0	8.67	224.6	0.0

Panel B: USPTO Patents to Canadian Inventor(s) by Four-Digit NAICS Code

	2001-2006 Average			2007-2012 Average		
North American Industrial Classification System (NAICS) Code	Patents (Average Annual)	Employment (Annual Average, 1,000 Jobs)	Patent Intensity (Patents/ 1,000 Jobs)	Patents (Averag e Annual)	Employment (Annual Average, 1,000 Jobs)	Patent Intensity (Patents/ 1,000 Jobs)
Computer and Peripheral Equipment (3341)	252.17	10.4	24.2	737	7.0	104.6
Communications Equipment (3342)	341.83	26.5	12.9	697.5	24.2	28.8
Semiconductors and Other Electronic Components (3344)	192.67	25.5	7.6	273.7	16.1	17.0
Other Computer and Electronic Products (3343 and 3346)	38.83	5.2	7.5	73.17	4.4	16.8
Navigational, Measuring, Electromedical, and Control Instruments (3345)	331.17	23.8	13.9	384.2	23.3	16.5
Basic Chemicals (3251)	103.5	14.0	7.4	135.7	11.8	11.5
Pharmaceutical and Medicines (3254)	170.5	27.1	6.3	177	27.8	6.4
Other Miscellaneous (339 (except 3391))	193.33	40.7	4.8	236.7	37.6	6.3
Medical Equipment and Supplies (3391)	75	17.0	4.4	69	18.4	3.7
Other Transportation Equipment (3365, 3366, and 3369)	56	22.7	2.5	53.8	17.7	3.0
Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments (3252)	27.83	11.0	2.5	19	8.9	2.1
Motor Vehicles, Trailers and Parts (3361-3363)	102.5	165.2	0.6	95.8	122.6	0.8
Aerospace Product and Parts (3364)	31.5	43.6	0.7	33.5	44.9	0.7

Source: USPTO (https://www.uspto.gov/web/offices/ac/ido/oeip/taf/naics/stc_naics_fgall/cax_stc_naics_fg.htm) and CANSIM Table 281-002

Appendix Table 11: Per Cent Share of Total National USPTO Patent Grants Classified as ICT Inventions, Select OECD Countries, 2000-2014

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	% Point Change 2000-2014
Australia	24.16	32.27	34.82	38.45	43.78	49.09	61.16	67.01	69.75	65.36	63.25	63.86	50.01	44.94	44.71	20.56
Austria	21.92	20.52	22.26	28.55	28.45	30.48	36.11	38.68	42.14	41.39	43.13	42.00	41.02	39.00	41.55	19.64
Belgium	21.51	23.67	21.02	29.29	33.78	33.33	38.74	39.57	43.11	39.46	38.54	38.55	39.96	37.02	38.95	17.43
Canada	29.88	29.53	31.95	34.25	38.21	38.62	45.39	46.74	51.29	51.63	53.14	54.56	57.23	58.51	59.52	29.64
Czech Republic	13.62	22.57	40.43	25.04	32.45	39.14	42.55	28.53	39.04	37.34	36.03	49.04	58.17	45.82	61.68	48.06
Denmark	16.81	16.05	21.72	23.97	31.48	31.06	42.67	38.31	35.54	35.66	33.05	32.16	33.00	31.81	30.75	13.94
Finland	47.91	45.98	49.35	55.24	58.43	59.22	67.93	73.56	72.77	74.28	70.43	72.24	69.38	70.53	71.98	24.07
France	28.41	27.89	29.68	32.70	36.96	40.35	44.86	43.39	46.03	45.76	44.69	43.76	44.32	45.61	43.98	15.57
Germany	23.37	23.73	25.85	28.48	30.51	34.28	39.23	41.61	42.52	41.70	40.85	39.49	39.16	38.43	39.09	15.72
Ireland	33.93	45.55	46.19	50.31	53.96	48.72	62.11	66.40	68.38	62.53	62.55	57.92	61.11	65.16	65.16	31.23
Israel	49.82	51.06	50.83	52.95	59.43	61.86	65.07	64.48	67.86	66.33	66.18	66.07	68.78	67.83	67.41	17.60
Italy	21.49	27.29	24.33	26.14	25.23	27.05	33.07	33.34	35.65	34.96	32.04	34.25	34.57	35.50	36.68	15.19
Japan	56.31	56.17	57.28	59.31	62.19	63.71	67.72	67.49	67.73	67.47	64.84	65.04	64.98	64.75	64.59	8.28
Korea	73.87	72.51	70.80	71.00	72.49	73.66	77.63	78.47	79.20	78.89	77.09	76.19	75.58	73.79	72.55	-1.32
Netherlands	37.58	38.13	41.35	45.20	48.48	47.01	58.27	49.84	53.26	51.93	48.75	48.82	45.30	44.46	44.43	6.85
Norway	20.52	21.34	25.99	30.13	36.86	37.90	42.78	49.82	50.39	42.31	42.69	43.11	43.51	41.43	42.47	21.96
Spain	24.34	26.73	22.42	26.48	24.92	30.74	31.09	34.34	40.52	37.68	29.53	35.47	41.18	40.33	40.78	16.43
Sweden	37.75	35.81	38.24	37.65	36.79	40.33	46.53	43.42	42.70	46.50	48.49	49.59	53.73	54.17	57.58	19.83
Switzerland	19.53	19.56	23.76	26.39	30.73	33.63	35.21	38.47	37.84	39.04	37.51	35.23	33.63	33.55	35.75	16.22
United Kingdom	33.77	36.24	38.69	40.17	45.45	47.03	51.25	51.78	53.55	55.87	51.54	51.38	51.25	51.95	52.76	18.99
United States	39.36	41.03	42.72	44.52	47.68	49.67	53.92	54.02	56.12	56.01	54.41	54.29	54.52	54.19	55.58	16.22

Note: 13 of the 34 OECD countries that were granted fewer than 100 ICT patents by the USPTO in 2014 are not included.
Source: Calculations from OECD Patent Statistics. http://stats.oecd.org/Index.aspx?DatasetCode=PATS_IPC#

Appendix Table 12: USPTO Patents Granted to Canadians by Inventor(s)'s Place of Residence, Canada and the Provinces, 1980-2012

Panel A: Number

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	3	–	5	10	272	642	17	26	74	123	1,140
1981	3	–	11	9	318	613	26	32	85	131	1,201
1982	2	–	6	9	247	558	26	27	97	111	1,050
1983	3	3	11	11	254	549	28	26	97	110	1,059
1984	5	–	13	7	272	678	30	27	96	141	1,232
1985	4	1	12	11	313	813	26	28	105	115	1,390
1986	3	–	12	6	266	791	46	31	111	129	1,359
1987	5	–	14	6	350	946	42	39	116	169	1,644
1988	5	2	14	8	312	875	50	47	120	167	1,557
1989	4	1	23	17	400	1,139	74	55	155	225	2,052
1990	8	4	22	15	388	1,055	51	43	155	255	1,961
1991	7	3	21	13	411	1,152	53	66	231	272	2,162
1992	4	8	34	18	418	1,085	65	55	185	280	2,093
1993	11	1	20	15	421	1,143	61	53	186	238	2,101
1994	3	–	19	24	417	1,157	56	49	203	289	2,163
1995	8	4	16	25	441	1,199	60	48	243	273	2,239
1996	10	3	19	20	450	1,358	57	51	218	312	2,416
1997	9	4	26	39	503	1,410	53	54	274	341	2,612
1998	5	2	35	33	599	1,737	74	80	343	464	3,253
1999	7	6	32	37	654	1,916	102	94	375	462	3,536
2000	16	2	41	40	749	2,090	96	77	394	455	**3,779**
2001	11	3	20	73	764	2,151	91	86	462	498	**3,982**
2002	9	3	26	49	818	2,169	85	81	374	444	**3,895**
2003	11	6	34	40	817	2,138	78	68	381	493	**3,911**
2004	8	5	24	24	805	2,130	79	74	382	508	**3,855**
2005	6	4	32	21	714	1,765	42	67	359	427	**3,307**
2006	5	4	43	27	832	2,311	74	71	412	525	**4,107**
2007	6	1	41	35	726	2,169	76	51	393	534	**3,827**
2008	6	2	43	33	791	2,239	90	67	335	493	**3,966**
2009	13	7	39	28	794	2,545	79	84	404	517	**4,300**
2010	15	4	47	54	1,040	3,385	107	106	529	751	**5,709**
2011	18	3	53	45	1,087	3,475	100	96	569	783	**5,926**
2012	26	9	64	51	1,216	4,082	114	89	604	856	**6,812**
% change, 2000-2012	62.50	350.0	56.10	27.50	62.35	95.31	18.75	15.58	53.3	88.13	**80.26**
Annual Growth Rate, 2000-2012	4.13	13.35	3.78	2.05	4.12	5.74	1.44	1.21	3.62	5.41	**5.03**

Panel B: Percentage Distribution

1980	0.26	-	0.44	0.88	23.86	56.32	1.49	2.28	6.49	10.79
1985	0.29	0.07	0.86	0.79	22.52	58.49	1.87	2.01	7.55	8.27
1990	0.41	0.20	1.12	0.76	19.79	53.80	2.60	2.19	7.90	13.00
1995	0.36	0.18	0.71	1.12	19.70	53.55	2.68	2.14	10.85	12.19
2000	0.42	0.05	1.08	1.06	19.82	55.31	2.54	2.04	10.43	12.04
2005	0.18	0.12	0.97	0.64	21.59	53.37	1.27	2.03	10.86	12.91
2010	0.26	0.07	0.82	0.95	18.22	59.29	1.87	1.86	9.27	13.15
2011	0.30	0.05	0.89	0.76	18.34	58.64	1.69	1.62	9.60	13.21
2012	0.38	0.13	0.94	0.75	17.85	59.92	1.67	1.31	8.87	12.57
Percentage point change, 2000-2012	-0.04	0.08	-0.14	-0.31	-1.97	4.61	-0.87	-0.73	-1.56	0.53

Panel C: Number of Patents per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	0.52	-	0.59	1.42	4.18	7.34	1.64	2.69	3.38	4.48	4.65
1985	0.69	0.78	1.35	1.52	4.70	8.75	2.40	2.73	4.37	3.87	5.38
1990	1.39	3.07	2.42	2.03	5.55	10.25	4.61	4.27	6.08	7.75	7.08
1995	1.41	2.98	1.72	3.33	6.11	10.95	5.31	4.73	8.89	7.23	7.64
2000	3.03	1.47	4.39	5.33	10.18	17.89	8.37	7.64	13.11	11.26	12.32
2005	1.17	2.90	3.41	2.81	9.42	14.09	3.56	6.74	10.81	10.18	10.26
2010	2.87	2.82	4.99	7.17	13.12	25.77	8.76	10.08	14.17	16.82	16.79
2011	3.43	2.08	5.61	5.96	13.57	26.20	8.11	9.00	15.01	17.40	17.26
2012	4.93	6.20	6.77	6.74	15.04	30.44	9.12	8.19	15.53	18.84	19.60

Panel D: Relative Patents Per 100,000 Residents, Provinces vs. Canada

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	0.11	-	0.13	0.30	0.90	1.58	0.35	0.58	0.73	0.96
1985	0.13	0.15	0.25	0.28	0.87	1.63	0.45	0.51	0.81	0.72
1990	0.20	0.43	0.34	0.29	0.78	1.45	0.65	0.60	0.86	1.09
1995	0.18	0.39	0.23	0.44	0.80	1.43	0.70	0.62	1.16	0.95
2000	0.25	0.12	0.36	0.43	0.83	1.45	0.68	0.62	1.06	0.91
2005	0.11	0.28	0.33	0.27	0.92	1.37	0.35	0.66	1.05	0.99
2010	0.17	0.17	0.30	0.43	0.78	1.54	0.52	0.60	0.84	1.00
2011	0.20	0.12	0.33	0.35	0.79	1.52	0.47	0.52	0.87	1.01
2012	0.25	0.32	0.35	0.34	0.77	1.55	0.47	0.42	0.79	0.96

Note: The sum of the provinces will be greater than the total for Canada due to collaborations between provinces. For example, adding the patents granted to an inventor from each province in the year 2000 yields a total of 3,960 patents, whereas only 3,779 patents were issued to Canada. This means that 181 inventors collaborated with inventors from other provinces. Source: Institute de la statistique du Québec data. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/inventions_qc_prov.htm. Calculations for panels C and D are based on data from ISQ and CANSIM Table 051-0001.

Appendix Table 13: Number and Percentage Distribution of Triadic Family Patents by Inventor(s)'s Place of Residence, Canada and the Provinces, 1980-2008

Panel A: Number

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	CAN
1980	–	–	–	–	11	18	–	2	1	3	31
1981	–	–	–	1	18	39	–	–	4	5	66
1982	–	–	–	1	22	55	3	–	5	3	86
1983	–	–	1	2	22	71	2	1	3	5	101
1984	2	–	1	1	37	102	1	–	6	12	162
1985	1	–	–	2	39	138	1	1	12	8	196
1986	–	–	2	1	49	143	2	2	13	21	222
1987	1	–	2	–	54	197	1	1	17	24	292
1988	2	1	3	–	54	202	1	8	17	27	303
1989	–	–	2	3	89	272	6	9	20	33	421
1990	–	–	7	1	75	266	4	3	17	38	400
1991	1	–	–	1	71	273	5	3	40	52	431
1992	–	6	3	–	75	260	6	3	28	44	404
1993	1	–	2	2	77	278	7	7	30	46	448
1994	–	–	4	4	92	246	6	3	28	45	421
1995	1	–	2	–	93	277	5	2	35	54	457
1996	2	–	4	–	100	303	5	4	46	63	509
1997	1	1	8	5	122	334	10	3	51	78	588
1999	3	1	13	9	146	467	19	9	81	115	809
2000	–	–	10	6	196	513	12	8	74	101	858
2001	1	1	4	6	211	513	12	3	101	100	906
2002	–	–	6	6	209	536	10	6	73	113	916
2003	1	–	5	6	194	431	16	6	77	107	811
2004	–	–	6	1	195	470	14	12	63	120	834
2005	–	–	11	2	141	353	11	8	63	110	665
2006	1	1	6	5	209	509	10	8	73	121	896
2007	1	1	12	5	200	505	20	9	68	142	894
2008	–	1	11	4	191	457	12	8	61	125	821
% Change 2000-2008	N/A	N/A	10.00	-33.33	-2.55	-10.92	0.00	0.00	-17.57	23.76	-4.31
Growth Rate 2000-2008	N/A	N/A	1.20	-4.94	-0.32	-1.43	0.00	0.00	-2.39	2.70	-0.55

Panel B: Percentage Distribution

1980	N/A	N/A	N/A	N/A	35.48	58.06	N/A	6.45	3.23	9.68	100.0
1985	0.51	–	–	1.02	19.90	70.41	0.51	0.51	6.12	4.08	0.51
1990	N/A	N/A	1.75	0.25	18.75	66.50	1.00	0.75	4.25	9.50	100.0
1995	0.22	N/A	0.44	N/A	20.35	60.61	1.09	0.44	7.66	11.82	100.0
2000	N/A	N/A	1.17	0.70	22.84	59.79	1.40	0.93	8.62	11.77	100.0
2001	0.11	0.11	0.44	0.66	23.29	56.62	1.32	0.33	11.15	11.04	100.0
2005	N/A	N/A	1.65	0.30	21.20	53.08	1.65	1.20	9.47	16.54	100.0
2006	0.11	0.11	0.67	0.56	23.33	56.81	1.12	0.89	8.15	13.50	100.0
2007	0.11	0.11	1.34	0.56	22.37	56.49	2.24	1.01	7.61	15.88	100.0
2008	N/A	0.12	1.34	0.49	23.26	55.66	1.46	0.97	7.43	15.23	100.00
Percentage point change, 2000-2008	N/A	N/A	0.17	-0.21	0.42	-4.13	0.06	0.04	-1.19	3.45	0

Panel C: Number of Patents per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	-	-	-	-	0.17	0.21	-	0.21	0.05	0.11	0.13
1985	0.17	-	-	0.28	0.59	1.48	0.09	0.10	0.50	0.27	0.76
1990	-	-	0.77	0.14	1.07	2.58	0.36	0.30	0.67	1.15	1.44
1995	0.18	-	0.22	-	1.29	2.53	0.44	0.20	1.28	1.43	1.56
2000	-	-	1.07	0.80	2.66	4.39	1.05	0.79	2.46	2.50	2.80
2001	-	-	1.07	0.80	2.66	4.39	1.05	0.79	2.46	2.50	2.80
2002	0.19	0.73	0.43	0.80	2.85	4.31	1.04	0.30	3.30	2.45	2.92
2003	-	-	0.64	0.80	2.81	4.43	0.86	0.60	2.33	2.76	2.92
2004	0.19	-	0.53	0.80	2.59	3.52	1.38	0.60	2.42	2.59	2.56
2005	-	-	0.64	0.13	2.59	3.79	1.19	1.20	1.95	2.89	2.61
2006	-	-	1.17	0.27	1.86	2.82	0.93	0.81	1.90	2.62	2.06
2007	0.20	0.73	0.64	0.67	2.74	4.02	0.84	0.81	2.13	2.85	2.75
2008	0.20	0.73	1.28	0.67	2.60	3.96	1.68	0.90	1.94	3.31	2.72

Panel D: Relative Patents Per 100,000 Residents, Provinces vs. Canada

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	-	-	-	-	1.34	1.63	-	1.63	0.36	0.86
1985	0.23	-	-	0.36	0.77	1.96	0.12	0.13	0.66	0.35
1990	-	-	0.53	0.09	0.74	1.79	0.25	0.21	0.46	0.80
1995	0.11	-	0.14	-	0.83	1.62	0.28	0.13	0.82	0.92
2000	-	-	0.38	0.29	0.95	1.57	0.37	0.28	0.88	0.89
2001	0.07	0.25	0.15	0.27	0.98	1.48	0.36	0.10	1.13	0.84
2002	-	-	0.22	0.27	0.96	1.52	0.30	0.21	0.80	0.94
2003	0.08	-	0.21	0.31	1.01	1.37	0.54	0.23	0.94	1.01
2004	-	-	0.24	0.05	0.99	1.45	0.46	0.46	0.74	1.11
2005	-	-	0.57	0.13	0.90	1.37	0.45	0.39	0.92	1.27
2006	0.07	0.26	0.23	0.24	1.00	1.46	0.31	0.29	0.78	1.04
2007	0.07	0.27	0.47	0.25	0.96	1.46	0.62	0.33	0.71	1.22
2008	-	0.29	0.48	0.22	1.00	1.44	0.41	0.32	0.69	1.16

Note: The sum of the provinces will be greater than the total for Canada due to collaborations between provinces. For example, the sum of the number of patents in each province for 2001 yields 946 patents while the only 916 patents were issued. This means that 30 inventors from different provinces collaborated when creating an invention.
Source: Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/triad_canada.htm and CANSIM Table 051-0001.

Appendix Table 14: Number and Percentage Distribution of ICT Patents at the USPTO by Inventor(s)'s Place of Residence, Canada and the Provinces, 1980-2012

Panel A: Number

	N.L.	P.E.I	N.S	N.B	Que.	Ont.	Man.	Sask.	Alta.	B.C.	**CAN**
1980	–	–	–	–	28	88	–	2	4	10	**125**
1981	1	–	3	1	48	83	2	3	9	8	154
1982	–	–	1	–	30	101	5	3	18	16	167
1983	–	1	–	1	26	97	4	5	18	17	165
1984	–	–	2	1	34	111	5	2	15	22	186
1985	–	–	4	2	39	166	9	5	11	15	244
1986	–	–	5	2	37	162	4	5	20	19	243
1987	–	–	1	1	43	190	2	6	19	21	269
1988	–	–	5	2	54	184	4	6	19	29	291
1989	1	–	10	5	57	236	6	10	22	23	360
1990	4	–	5	–	61	200	7	5	28	26	324
1991	2	–	4	1	50	231	6	11	32	35	351
1992	–	–	6	2	51	220	5	6	35	28	340
1993	1	1	4	2	56	249	5	9	37	32	380
1994	–	–	2	2	75	252	3	9	32	45	403
1995	4	–	1	6	67	263	8	9	47	48	430
1996	3	–	4	1	85	361	10	6	40	75	565
1997	5	1	6	7	97	359	6	7	43	65	579
1998	–	1	3	3	136	500	11	8	63	124	818
1999	–	1	5	5	190	538	16	12	53	120	898
2000	4	1	9	3	210	633	10	13	71	107	991
2001	3	1	5	7	174	715	11	9	77	110	1,054
2002	2	1	2	4	213	760	10	8	59	101	**1,110**
2003	4	3	6	11	212	817	17	10	89	145	**1,244**
2004	2	1	8	5	255	879	10	10	88	168	**1,346**
2005	2	–	7	2	234	741	5	11	77	156	**1,186**
2006	1	–	17	12	279	1,123	16	10	95	212	**1,683**
2007	1	–	9	14	266	1,069	15	5	113	221	**1,625**
2008	5	–	13	10	301	1,276	24	8	80	221	**1,876**
2009	5	–	12	8	279	1,458	14	9	113	244	**2,040**
2010	11	1	16	16	379	1,996	22	16	145	338	**2,794**
2011	12	1	21	12	411	2,046	16	19	155	374	**2,921**
2012	20	2	21	18	462	2,477	29	14	171	430	**3,498**
% Change 2000-12	400.0	100.0	133.3	500.0	120.0	291.3	190.0	7.7	140.9	301.9	**253.0**
Annual Growth Rate 2000-12	14.35	5.95	7.32	16.10	6.79	12.04	9.28	0.62	7.6	12.29	**11.08**

Panel B: Percentage Distribution

1980	-	-	-	-	22.40	70.40	-	1.60	3.20	8.00	**100.0**
1985		–	1.64	0.82	15.98	68.03	3.69	2.05	4.51	6.15	**100.0**
1990	1.23	n.a.	1.54	n.a.	18.83	61.73	2.16	1.54	8.64	8.02	**100.0**
1995	0.93	n.a.	0.23	1.40	15.58	61.16	1.86	2.09	10.93	11.16	**100.0**
2000	0.40	0.10	0.91	0.30	21.19	63.87	1.01	1.31	7.16	10.80	**100.0**
2005	0.17	n.a.	0.59	0.17	19.73	62.48	0.42	0.93	6.49	13.15	**100.0**
2010	0.39	0.04	0.57	0.57	13.56	71.44	0.79	0.57	5.19	12.10	**100.0**
2011	0.41	0.03	0.72	0.41	14.07	70.04	0.55	0.65	5.31	12.80	**100.0**
2012	0.57	0.06	0.60	0.51	13.21	70.81	0.83	0.40	4.89	12.29	**100.0**
Percentage point change, 2000-2012	0.17	-0.04	-0.31	0.21	-7.98	6.94	0.18	-0.91	-2.27	1.49	**n.a.**

Panel C: Share of ICT Patents at the USPTO of Total Patents at the USPTO Granted to Canadian Inventors, 1980-2012

	N.L.	P.E.I	N.S	M.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	n.a.	n.a.	n.a.	n.a.	10.29	13.71	n.a.	7.69	5.41	8.13	**10.96**
1985	–	–	33.33	18.18	12.46	20.42	34.62	17.86	10.48	13.04	**17.55**
1990	50.00	n.a.	22.73	n.a.	15.72	18.96	13.73	11.63	18.06	10.20	**16.52**
1995	50.00	n.a.	6.25	24.00	15.19	21.93	13.33	18.75	19.34	17.58	**19.21**
2000	25.00	50.00	21.95	7.50	28.04	30.29	10.42	16.88	18.02	23.52	**26.22**
2005	33.33	n.a.	21.88	9.52	32.77	41.98	11.90	16.42	21.45	36.53	**35.86**
2010	73.33	25.00	34.04	29.63	36.44	58.97	20.56	15.09	27.41	45.01	**48.94**
2011	66.67	33.33	39.62	26.67	37.81	58.88	16.00	19.79	27.24	47.77	**49.29**
2012	76.92	22.22	32.81	35.29	37.99	60.68	25.44	15.73	28.31	50.23	**51.35**

Panel D: ICT Patents by Inventor Per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	-	-	-	-	0.43	1.01	-	0.21	0.18	0.36	**0.51**
1985	-	-	0.45	0.28	0.59	1.79	0.83	0.49	0.46	0.50	**0.94**
1990	0.69	-	0.55	-	0.87	1.94	0.63	0.50	1.10	0.79	**1.17**
1995	0.70	-	0.11	0.80	0.93	2.40	0.71	0.89	1.72	1.27	**1.47**
2000	0.76	0.73	0.96	0.40	2.85	5.42	0.87	1.29	2.36	2.65	**3.23**
2001	0.57	0.73	0.54	0.93	2.35	6.01	0.96	0.90	2.52	2.70	**3.40**
2002	0.38	0.73	0.21	0.53	2.86	6.28	0.86	0.80	1.89	2.46	**3.54**
2003	0.77	2.19	0.64	1.47	2.83	6.67	1.46	1.00	2.80	3.52	**3.93**
2004	0.39	0.73	0.85	0.67	3.38	7.09	0.85	1.00	2.72	4.04	**4.21**
2005	0.39	-	0.75	0.27	3.09	5.91	0.42	1.11	2.32	3.72	**3.68**
2006	0.20	-	1.81	1.61	3.66	8.87	1.35	1.01	2.78	5.00	**5.17**
2007	0.20	-	0.96	1.88	3.46	8.37	1.26	0.50	3.22	5.15	**4.94**
2008	0.98	-	1.39	1.34	3.88	9.90	2.00	0.79	2.22	5.08	**5.64**
2009	0.97	-	1.28	1.07	3.56	11.22	1.16	0.87	3.07	5.53	**6.07**
2010	2.11	0.71	1.70	2.12	4.78	15.20	1.80	1.52	3.88	7.57	**8.22**
2011	2.29	0.69	2.22	1.59	5.13	15.43	1.30	1.78	4.09	8.31	**8.51**
2012	3.80	1.38	2.22	2.38	5.71	18.47	2.32	1.29	4.40	9.47	**10.07**

Panel E: Relative Per 100,000 Residents ICT Patents by Inventor at the USPTO, Provinces vs. Canadian Total

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	-	-	-	-	0.84	1.97	-	0.41	0.36	0.71
1985	-	-	0.48	0.29	0.62	1.89	0.88	0.52	0.48	0.53
1990	0.59	-	0.47	-	0.75	1.66	0.54	0.42	0.94	0.67
1995	0.48	-	0.07	0.54	0.63	1.64	0.48	0.60	1.17	0.87
2000	0.23	0.23	0.30	0.12	0.88	1.68	0.27	0.40	0.73	0.82
2005	0.11	-	0.20	0.07	0.84	1.61	0.12	0.30	0.63	1.01
2006	0.04	-	0.35	0.31	0.71	1.72	0.26	0.20	0.54	0.97
2007	0.04	-	0.19	0.38	0.70	1.69	0.26	0.10	0.65	1.04
2008	0.17	-	0.25	0.24	0.69	1.76	0.36	0.14	0.39	0.90
2009	0.16	-	0.21	0.18	0.59	1.85	0.19	0.14	0.51	0.91
2010	0.26	0.09	0.21	0.26	0.58	1.85	0.22	0.19	0.47	0.92
2011	0.27	0.08	0.26	0.19	0.60	1.81	0.15	0.21	0.48	0.98
2012	0.38	0.14	0.22	0.24	0.57	1.84	0.23	0.13	0.44	0.94

Note: ICT includes electronic devices, computers, telecommunication devices and other ICT devices.

Note: The sum of the provinces will be greater than the total for Canada due to collaborations between provinces. For example, the sum of ICT patents of the provinces in 2000 yields 1,061 patents while the total for Canada in 2000 is 991 patents. This means that 71 inventors from different provinces collaborated when creating an invention.

Source: Institut de la statistique du Québec, http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/inventions_tic_prov.htm and CANSIM Table 051-0001.

Appendix Table 15: Number of USPTO Patents Granted to Canadian Inventors, 1980-2012, by Census Metropolitan Area

Panel A: Number of USPTO Patents to Inventors(s)

	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change 2000-2012
St. John's, N.L	2	6	11	8	6	6	4	5	5	5	6	10	12	17	20	81.82
Halifax, N.S.	5	17	26	12	17	18	13	24	26	26	34	26	36	40	48	84.62
Moncton, N.B.	1	2	10	7	4	7	2	2	7	9	6	4	9	4	11	10.00
Saint John, N.B.	–	–	14	42	22	10	6	2	4	8	6	6	13	11	12	-14.29
Montréal, Que	203	254	502	515	569	532	498	465	532	490	533	535	684	740	856	70.52
Ottawa-Gatineau, Que	5	10	39	58	49	48	70	49	62	68	75	68	77	88	92	135.90
Québec, Que	14	28	57	51	65	67	55	83	90	74	78	78	107	91	111	94.74
Saguenay, Que	4	16	8	14	6	12	6	8	7	7	8	7	5	7	13	62.50
Sherbrooke, Que	3	8	21	23	31	50	39	38	41	29	46	37	56	54	60	185.71
Trois-Rivières, Que	–	1	3	2	6	11	9	8	6	4	5	6	5	6	12	300.00
Barrie, Ont	3	9	19	15	14	22	21	20	15	19	13	22	23	36	22	15.79
Brantford, Ont	4	9	20	18	29	26	22	7	21	25	21	16	33	30	41	105.00
Greater Sudbury, Ont	8	10	9	18	10	11	6	9	3	3	5	6	4	6	8	-11.11
Guelph, Ont	9	24	47	40	42	33	30	33	29	49	27	49	42	70	50	6.38
Hamilton, Ont	42	66	131	140	133	152	122	100	116	107	126	144	174	157	188	43.51
Kingston, Ont	36	37	52	49	72	55	44	30	30	38	24	39	43	39	54	3.85
Kitchener-Waterloo, Ont	20	62	128	155	123	123	104	132	200	245	260	384	532	682	917	616.41
London, Ont	21	33	63	67	79	77	77	64	83	56	63	84	78	102	98	55.56
Oshawa, Ont	10	18	20	16	14	16	18	18	13	6	17	21	39	29	37	85.00
Ottawa-Gatineau, Ont	91	150	422	483	505	538	591	446	630	549	608	634	841	837	951	125.36
Peterborough, Ont	7	9	11	15	8	17	18	23	23	14	16	18	36	35	23	109.09
St. Catharines - Niagara, Ont	17	23	19	33	30	41	30	24	35	37	31	41	50	55	53	178.95
Thunder Bay, Ont	1	–	6	5	4	6	2	1	3	2	3	5	7	7	7	16.67
Toronto, Ont	273	511	1,019	959	937	894	863	736	1,018	996	1,073	1,143	1,555	1,527	1,785	75.17
Windsor, Ont	18	22	50	70	76	72	89	72	91	84	39	76	87	87	99	98.00
Winnipeg, Man	14	39	62	66	65	54	59	37	61	64	74	63	86	81	93	50.00
Regina, Sask	9	8	4	10	15	12	14	11	6	4	3	8	22	7	9	125.00
Saskatoon, Sask	3	13	44	44	39	31	31	41	43	33	44	49	68	58	65	47.73
Calgary, Alta	25	59	204	237	170	182	190	169	198	205	169	225	276	321	325	59.31
Edmonton, Alta	41	58	138	179	149	147	133	141	167	154	126	136	196	196	210	52.17
Abbotsford - Mission, B.C	–	7	13	8	12	9	10	13	12	15	12	11	17	21	23	76.92
Kelowna, B,C.	2	3	7	17	8	8	26	18	26	25	22	13	16	12	16	128.57

Vancouver, B.C.	83	174	338	381	334	387	397	325	412	424	387	434	610	654	711	110.36
Victoria, B.C.	8	22	25	27	31	46	33	38	34	47	47	36	66	64	62	148.00
Canada	**1,140**	**1,961**	**3,779**	**3,982**	**3,895**	**3,911**	**3,855**	**3,307**	**4,107**	**3,827**	**3,966**	**4,300**	**5,709**	**5,926**	**6,812**	**80.26**

Panel B: Number of USPTO Patents to Inventors(s) per 100,000 residents

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change 2000-2012
St. John's, N.L	6.24	4.53	3.37	3.34	2.20	2.74	2.72	2.69	3.16	5.16	6.05	8.39	9.71	55.58
Halifax, N.S.	7.30	3.25	4.54	4.76	3.42	6.29	6.76	6.73	8.72	6.60	9.04	9.94	11.80	61.56
Moncton, N.B.	8.29	5.73	3.23	5.58	1.57	1.56	5.40	6.86	4.52	2.96	6.54	2.85	7.71	-7.11
Saint John, N.B.	10.96	33.31	17.48	7.95	4.77	1.59	3.20	6.37	4.75	4.71	10.15	8.55	9.34	-14.81
Montréal, Que	14.43	14.58	15.94	14.78	13.72	12.72	14.44	13.19	14.21	14.09	17.80	19.04	21.74	50.68
Québec, Que	8.25	7.24	9.17	9.40	7.66	11.50	12.36	10.04	10.45	10.31	13.96	11.71	14.14	71.31
Saguenay, Que	4.99	8.62	3.73	7.51	3.78	5.07	4.45	4.45	5.07	4.43	3.15	4.39	8.13	62.86
Sherbrooke, Que	13.66	12.49	16.68	26.62	20.56	19.83	21.21	14.87	23.38	18.58	27.77	26.38	28.92	111.72
Trois-Rivières, Que	2.12	1.40	4.19	7.67	6.24	5.52	4.12	2.72	3.36	3.99	3.29	3.92	7.77	266.79
Barrie, Ont	12.49	9.66	8.66	13.10	12.08	11.14	8.13	10.21	6.92	11.62	12.05	18.67	11.26	-9.85
Brantford, Ont	15.69	14.01	22.37	19.83	16.59	5.21	15.51	18.34	15.33	11.62	23.83	21.52	29.20	86.09
Greater Sudbury, Ont	5.71	11.15	6.20	6.80	3.70	5.52	1.83	1.82	3.02	3.62	2.42	3.63	4.83	-15.28
Guelph, Ont	36.83	30.96	32.01	24.78	22.17	23.97	20.81	34.99	19.09	34.36	29.13	48.06	33.78	-8.29
Hamilton, Ont	19.49	20.32	19.08	21.59	17.18	13.98	16.12	14.82	17.37	19.75	23.64	21.14	25.04	28.48
Kingston, Ont	34.29	32.07	46.47	35.13	27.93	19.00	18.97	23.95	15.02	24.17	26.39	23.71	32.54	-5.11
Kitchener-Waterloo, Ont	30.20	35.92	27.96	27.53	22.82	28.48	42.50	51.66	54.31	79.57	109.20	138.35	183.82	508.6
London, Ont	14.92	14.79	17.22	16.64	16.47	13.57	17.44	11.70	13.09	17.39	16.05	20.84	19.82	32.85
Oshawa, Ont	6.69	5.18	4.44	4.96	5.45	5.33	3.78	1.72	4.82	5.88	10.77	7.90	9.90	47.95
Ottawa-Gatineau, Ont/Que	42.40	48.72	49.19	51.40	57.48	42.66	59.04	51.93	56.57	57.14	73.41	72.82	80.95	90.93
Peterborough, Ont	8.52	13.01	6.85	14.42	15.14	19.16	19.07	11.61	13.23	14.88	29.54	28.64	18.74	119.87
St. Catharines - Niagara, Ont	4.86	8.42	7.60	10.32	7.49	5.96	8.66	9.19	7.72	10.22	12.44	13.66	13.12	169.83
Thunder Bay, Ont	4.77	3.95	3.15	4.71	1.57	0.78	2.36	1.59	2.39	4.00	5.60	5.60	5.59	17.39
Toronto, Ont	21.35	19.64	18.73	17.58	16.70	14.02	19.08	18.38	19.49	20.44	27.37	26.47	30.42	42.49
Windsor, Ont	16.29	21.81	23.27	21.80	26.71	21.48	27.08	25.19	11.80	23.15	26.51	26.50	29.92	83.72
Winnipeg, Man	9.09	9.48	9.29	7.67	8.31	5.19	8.52	8.90	10.23	8.64	11.68	10.86	12.24	34.76
Regina, Sask	2.01	5.08	7.62	6.06	7.03	5.52	3.00	1.98	1.46	3.82	10.31	3.22	4.00	99.37
Saskatoon, Sask	19.05	19.04	16.75	13.22	13.09	17.21	17.88	13.51	17.62	19.11	25.86	21.46	23.10	21.30
Calgary, Alta	21.52	24.24	16.87	17.68	18.04	15.53	17.61	17.77	14.25	18.45	22.26	25.39	24.86	15.50
Edmonton, Alta	14.65	18.60	15.13	14.69	13.08	13.53	15.55	13.94	11.14	11.70	16.57	16.25	16.91	15.41
Abbotsford - Mission, B.C	8.55	5.20	7.72	5.73	6.26	8.03	7.30	9.05	7.14	6.45	9.84	12.05	13.02	52.24
Kelowna, B,C.	4.62	11.03	5.13	5.05	16.14	11.00	15.56	14.62	12.57	7.29	8.82	6.54	8.62	86.67
Vancouver, B.C.	16.40	18.37	15.92	18.29	18.61	15.05	18.82	19.12	17.17	18.86	26.02	27.56	29.52	80.01
Victoria, B.C.	7.88	8.29	9.44	13.90	9.90	11.28	10.01	13.76	13.66	10.34	18.79	18.18	17.46	121.44

Official 2000 population estimates unavailable for some CMAs, thus were estimated by ‘back-casting’ from the 2001 population and annual growth rate from 2001-2012 Source: Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/inventions_rmr.htm and CANSIM Tables 051-0056 & 051-0014

Appendix Table 16: Number of Triadic Patents Granted to Canadian Inventors, 1980-2012 by Census Metropolitan Area

Panel A: Number of Triadic Patents to Inventors(s)

	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change 2000-2008
St. John's, N.L	–	–	–	1	–	1	–	–	1	–	–	n.a.
Halifax, N.S.	–	6	7	2	4	3	6	9	4	7	8	14.29
Moncton, N.B.	–	–	2	1	1	3	–	1	2	2	–	n.a.
Saint John, N.B.	–	–	–	–	2	–	–	–	2	2	–	n.a.
Montréal, Que	10	51	143	169	170	149	150	111	168	157	150	4.90
Québec, Que	–	3	17	8	14	15	3	11	15	17	23	35.29
Saguenay, Que	–	10	3	1	2	–	1	–	2	1	–	n.a.
Sherbrooke, Que	–	–	4	3	5	7	9	8	8	9	5	25.00
Trois-Rivières, Que	–	–	–	–	2	1	–	2	1	1	3	n.a.
Barrie, Ont	–	–	1	1	1	1	–	1	2	–	–	n.a.
Brantford, Ont	–	1	6	2	6	6	2	1	–	3	3	-50.00
Greater Sudbury, Ont	–	1	3	6	2	3	–	–	–	–	1	-66.67
Guelph, Ont	2	4	19	14	10	7	6	7	9	12	2	-89.47
Hamilton, Ont	–	13	32	42	35	24	32	22	32	41	35	9.38
Kingston, Ont	3	23	24	20	45	28	25	12	14	19	7	-70.83
Kitchener-Waterloo, Ont	3	13	26	42	23	20	26	31	40	59	39	50.00
London, Ont	–	5	22	14	27	24	21	18	22	11	17	-22.73
Oshawa, Ont	–	3	5	2	1	2	2	2	–	–	2	-60.00
Ottawa-Gatineau, Ont/Que	–	26	85	90	97	88	111	70	103	105	91	7.06
Peterborough, Ont	–	1	1	4	3	6	5	4	9	6	3	200.00
St. Catharines - Niagara, Ont	–	5	5	5	5	2	3	3	6	8	9	80.00
Thunder Bay, Ont	–	–	1	1	–	–	–	–	–	–	–	n.a.
Toronto, Ont	4	134	287	274	255	209	214	173	274	282	275	-4.18
Windsor, Ont	1	4	8	23	9	14	22	15	19	16	7	-12.50
Winnipeg, Man	–	3	11	11	8	14	12	10	10	16	9	-18.18
Regina, Sask	1	1	1	–	–	–	1	1	–	–	1	0.00
Saskatoon, Sask	–	2	4	1	6	4	9	7	5	9	6	50.00
Calgary, Alta	1	5	37	52	38	41	33	27	33	39	24	-35.14
Edmonton, Alta	–	10	34	42	30	39	26	31	39	31	34	0.00
Abbotsford - Mission, B.C	–	–	2	1	1	1	–	–	3	4	6	200.00
Kelowna, B,C.	–	–	1	3	1	2	5	3	6	8	5	400.00
Vancouver, B.C.	2	30	85	87	95	94	102	95	101	121	114	34.12
Victoria, B.C.	–	3	5	2	8	4	7	6	7	13	5	0.00
Canada	**31**	**400**	**858**	**906**	**916**	**811**	**834**	**665**	**896**	**894**	**821**	**-4.31**

Panel B: Number of Triadic Patents to Inventors(s) per 100,000 residents

	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Change 2000-2012
St. John's, N.L	-	0.57	-	0.56	-	-	0.54	-	-	n.a.
Halifax, N.S.	1.97	0.54	1.07	0.79	1.58	2.36	1.04	1.81	2.05	4.31
Moncton, N.B.	1.66	0.82	0.81	2.39	-	0.78	1.54	1.53	-	n.a.
Saint John, N.B.	-	-	1.59	-	-	-	1.60	1.59	-	n.a.
Montréal, Que	4.11	4.78	4.76	4.14	4.13	3.04	4.56	4.23	4.00	-2.69
Québec, Que	2.46	1.14	1.98	2.11	0.42	1.52	2.06	2.31	3.08	25.16
Saguenay, Que	1.87	0.62	1.24	-	0.63	-	1.27	0.64	-	n.a.
Sherbrooke, Que	2.60	1.63	2.69	3.73	4.74	4.18	4.14	4.61	2.54	-2.30
Trois-Rivières, Que	-	-	1.40	0.70	-	1.38	0.69	0.68	2.02	n.a.
Barrie, Ont	0.66	0.64	0.62	0.60	-	0.56	1.08	-	-	n.a.
Brantford, Ont	4.71	1.56	4.63	4.58	1.51	0.74	-	2.20	2.19	-53.47
Greater Sudbury, Ont	1.90	3.72	1.24	1.86	-	-	-	-	0.60	-68.23
Guelph, Ont	14.89	10.84	7.62	5.26	4.43	5.09	6.46	8.57	1.41	-90.50
Hamilton, Ont	4.76	6.10	5.02	3.41	4.51	3.08	4.45	5.68	4.83	1.35
Kingston, Ont	15.83	13.09	29.05	17.89	15.87	7.60	8.85	11.97	4.38	-72.33
Kitchener-Waterloo, Ont	6.13	9.73	5.23	4.48	5.71	6.69	8.50	12.44	8.15	32.78
London, Ont	5.21	3.09	5.89	5.19	4.49	3.82	4.62	2.30	3.53	-32.20
Oshawa, Ont	1.67	0.65	0.32	0.62	0.61	0.59	-	-	0.57	-66.09
Ottawa-Gatineau, Ont/Que	7.82	8.11	8.61	7.72	9.65	6.03	8.79	8.84	7.54	-3.58
Peterborough, Ont	0.77	3.47	2.57	5.09	4.20	3.33	7.46	4.98	2.48	220.25
St. Catharines - Niagara, Ont	1.28	1.28	1.27	0.50	0.75	0.74	1.49	1.99	2.24	75.23
Thunder Bay, Ont	0.79	0.79	-	-	-	-	-	-	-	n.a.
Toronto, Ont	6.01	5.61	5.10	4.11	4.14	3.30	5.14	5.20	5.00	-16.91
Windsor, Ont	2.61	7.17	2.76	4.24	6.60	4.48	5.65	4.80	2.12	-18.72
Winnipeg, Man	1.61	1.58	1.14	1.99	1.69	1.40	1.40	2.23	1.24	-22.80
Regina, Sask	0.50	-	-	-	0.50	0.50	-	-	0.49	-2.88
Saskatoon, Sask	1.73	0.43	2.58	1.71	3.80	2.94	2.08	3.69	2.40	38.76
Calgary, Alta	3.90	5.32	3.77	3.98	3.13	2.48	2.93	3.38	2.02	-48.15
Edmonton, Alta	3.61	4.36	3.05	3.90	2.56	2.98	3.63	2.81	3.01	-16.74
Abbotsford - Mission, B.C	1.32	0.65	0.64	0.64	-	-	1.83	2.41	3.57	171.46
Kelowna, B,C.	0.66	1.95	0.64	1.26	3.10	1.83	3.59	4.68	2.86	333.06
Vancouver, B.C.	4.12	4.19	4.53	4.44	4.78	4.40	4.61	5.46	5.06	22.60
Victoria, B.C.	1.58	0.61	2.44	1.21	2.10	1.78	2.06	3.81	1.45	-7.84

Official 2000 population estimates unavailable for some CMAs, thus were estimated by ‘back-casting’ from the 2001 population and annual growth rate from 2001-2012 Source: Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/inventions_rmr.htm and CANSIM Tables 051-0056 & 051-0014

Appendix Table 17: Number of ICT Inventions Patented at the USPTO, 1980-2012 by Census Metropolitan Area (CMA)

Panel A: Number of USPTO ICT Patents to Inventors(s)

	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change 2000-2012
St. John's, N.L	–	4	3	1	–	4	2	–	–	1	2	4	8	6	3	0.00
Halifax, N.S.	–	3	1	4	3	6	4	7	6	3	7	4	8	10	13	1,200.00
Moncton, N.B.	–	–	–	–	1	3	–	1	1	1	–	–	1	–	2	n.a.
Saint John, N.B.	–	–	–	1	–	–	–	–	–	1	–	1	–	–	3	n.a.
Montréal, Que	–	82	457	512	472	479	558	422	393	351	359	320	276	155	150	-67.18
Québec, Que	–	4	6	6	11	18	19	24	21	18	15	15	24	27	20	233.33
Saguenay, Que	1	–	–	–	–	1	–	–	–	–	–	2	–	–	–	n.a.
Sherbrooke, Que	–	–	2	3	–	2	–	4	–	1	2	1	–	2	3	50.00
Trois-Rivières, Que	–	–	–	–	–	2	1	–	1	–	1	1	–	–	–	n.a.
Barrie, Ont	–	1	–	1	–	1	–	–	–	–	–	–	1	–	–	n.a.
Brantford, Ont	–	–	–	–	–	–	1	–	–	–	1	–	–	–	1	n.a.
Greater Sudbury, Ont	–	–	–	–	–	–	2	–	–	–	1	1	–	1	1	n.a.
Guelph, Ont	–	–	2	3	3	1	3	6	4	5	7	6	7	3	1	-50.00
Hamilton, Ont	–	5	10	9	4	11	9	10	21	15	18	6	15	12	22	120.00
Kingston, Ont	2	–	2	2	5	1	1	1	3	2	3	5	3	4	2	0.00
Kitchener-Waterloo, Ont	2	4	23	27	34	44	42	46	104	155	217	301	454	591	820	3,465.22
London, Ont	1	3	3	1	6	8	6	4	4	6	10	5	5	10	5	66.67
Oshawa, Ont	1	1	–	–	–	–	–	1	1	–	1	–	1	3	–	n.a.
Ottawa-Gatineau, Ont/Que	29	51	138	136	193	229	230	163	268	202	190	185	258	272	311	125.36
Peterborough, Ont	22	–	2	4	–	5	1	12	4	2	4	6	6	7	1	-50.00
St. Catharines - Niagara, Ont	1	1	–	4	7	4	2	2	4	1	–	–	–	8	4	n.a.
Thunder Bay, Ont	–	–	–	–	2	–	–	–	–	–	–	1	–	–	–	n.a.
Toronto, Ont	–	50	134	150	139	120	130	132	191	179	191	195	264	363	339	152.99
Windsor, Ont	28	2	7	2	1	2	3	1	7	–	–	3	6	4	2	-71.43
Winnipeg, Man	1	6	4	6	2	8	6	2	6	7	10	7	10	9	12	200.00
Regina, Sask	–	1	–	2	3	1	1	2	1	1	–	1	4	–	1	n.a.
Saskatoon, Sask	–	–	6	6	4	4	3	2	1	1	1	1	4	10	7	16.67
Calgary, Alta	1	8	13	34	19	39	32	33	35	34	34	42	43	51	79	507.69
Edmonton, Alta	2	8	20	13	16	27	21	17	21	25	14	9	23	23	16	-20.00
Abbotsford - Mission, B.C	–	–	–	1	1	1	1	2	1	1	–	1	–	1	1	n.a.
Kelowna, B,C.	–	–	1	–	–	1	4	2	2	1	2	–	2	2	1	0.00
Vancouver, B.C.	1	17	58	57	62	77	83	80	90	79	58	85	108	112	105	81.03
Victoria, B.C.	5	2	–	4	5	7	16	9	13	13	24	8	16	20	8	n.a.

Panel B: Number of USPTO Patents to Inventors(s) per 100,000 Residents

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	% Change 2000-2012
St. John's, N.L	1.70	0.57	-	2.23	1.10	-	-	0.54	1.05	2.06	4.03	2.96	1.46	-14.43
Halifax, N.S.	0.28	1.08	0.80	1.59	1.05	1.83	1.56	0.78	1.79	1.02	2.01	2.48	3.20	1,037.66
Moncton, N.B.	-	-	0.81	2.39	-	0.78	0.77	0.76	-	-	0.73	-	1.40	n.a.
Saint John, N.B.	-	0.79	-	-	-	-	-	0.80	-	0.78	-	-	2.33	n.a.
Montréal, Que	13.13	14.49	13.22	13.30	15.38	11.55	10.67	9.45	9.57	8.43	7.18	3.99	3.81	-71.00
Québec, Que	0.87	0.85	1.55	2.53	2.65	3.32	2.88	2.44	2.01	1.98	3.13	3.48	2.55	193.23
Saguenay, Que	-	-	-	0.63	-	-	-	-	-	1.27	-	-	-	n.a.
Sherbrooke, Que	1.30	1.63	-	1.06	-	2.09	-	0.51	1.02	0.50	-	0.98	1.45	11.15
Trois-Rivières, Que	-	-	-	1.39	0.69	-	0.69	-	0.67	0.67	-	-	-	n.a.
Barrie, Ont	-	0.64	-	0.60	-	-	-	-	-	-	0.52	-	-	n.a.
Brantford, Ont	-	-	-	-	0.75	-	-	-	0.73	-	-	-	0.71	n.a.
Greater Sudbury, Ont	-	-	-	-	1.23	-	-	-	0.60	0.60	-	0.61	0.60	n.a.
Guelph, Ont	1.57	2.32	2.29	0.75	2.22	4.36	2.87	3.57	4.95	4.21	4.85	2.06	0.68	-56.90
Hamilton, Ont	1.49	1.31	0.57	1.56	1.27	1.40	2.92	2.08	2.48	0.82	2.04	1.62	2.93	96.96
Kingston, Ont	1.32	1.31	3.23	0.64	0.63	0.63	1.90	1.26	1.88	3.10	1.84	2.43	1.21	-8.63
Kitchener-Waterloo, Ont	5.43	6.26	7.73	9.85	9.22	9.92	22.10	32.69	45.33	62.37	93.19	119.89	164.38	2,928.93
London, Ont	0.71	0.22	1.31	1.73	1.28	0.85	0.84	1.25	2.08	1.04	1.03	2.04	1.01	42.34
Oshawa, Ont	-	-	-	-	-	0.30	0.29	-	0.28	-	0.28	0.82	-	n.a.
Ottawa-Gatineau, Ont/Que	12.69	12.25	17.14	20.09	20.00	14.05	22.86	17.00	15.74	15.06	20.63	21.41	24.14	90.18
Peterborough, Ont	1.55	3.47	-	4.24	0.84	10.00	3.32	1.66	3.31	4.96	4.92	5.73	0.81	-47.42
St. Catharines - Niagara, Ont	-	1.02	1.77	1.01	0.50	0.50	0.99	0.25	-	-	-	1.99	0.99	n.a.
Thunder Bay, Ont	-	-	1.58	-	-	-	-	-	-	0.80	-	-	-	n.a.
Toronto, Ont	2.81	3.07	2.78	2.36	2.52	2.52	3.58	3.30	3.47	3.49	4.65	6.29	5.78	105.78
Windsor, Ont	2.28	0.62	0.31	0.61	0.90	0.30	2.08	-	-	0.91	1.83	1.22	0.60	-73.49
Winnipeg, Man	0.59	0.86	0.29	1.14	0.84	0.28	0.84	0.97	1.38	0.96	1.36	1.21	1.58	169.53
Regina, Sask	-	1.02	1.52	0.50	0.50	1.00	0.50	0.49	-	0.48	1.87	-	0.44	n.a.
Saskatoon, Sask	2.60	2.60	1.72	1.71	1.27	0.84	0.42	0.41	0.40	0.39	1.52	3.70	2.49	-4.21
Calgary, Alta	1.37	3.48	1.89	3.79	3.04	3.03	3.11	2.95	2.87	3.44	3.47	4.03	6.04	340.56
Edmonton, Alta	2.12	1.35	1.63	2.70	2.06	1.63	1.96	2.26	1.24	0.77	1.94	1.91	1.29	-39.33
Abbotsford - Mission, B.C	-	0.65	0.64	0.64	0.63	1.24	0.61	0.60	-	0.59	-	0.57	0.57	n.a.
Kelowna, B,C.	0.66	-	-	0.63	2.48	1.22	1.20	0.58	1.14	-	1.10	1.09	0.54	n.a.
Vancouver, B.C.	2.81	2.75	2.95	3.64	3.89	3.71	4.11	3.56	2.57	3.69	4.61	4.72	4.36	54.92
Victoria, B.C.	-	1.23	1.52	2.12	4.80	2.67	3.83	3.81	6.98	2.30	4.56	5.68	2.25	n.a.

Official 2000 population estimates unavailable for some CMAs, thus were estimated by ‘back-casting’ from the 2001 population and annual growth rate from 2001-2012 Source: Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/inventions_rmr.htm and CANSIM Tables 051-0056 & 051-0014

Appendix Table 18: Research and Development Expenditure, Millions of Dollars, 1980-2014

Panel A: Gross Expenditures on Research and Development (GERD)

	Current Prices	2007 Constant Prices	Deflator	Nominal GDP	Nominal Total R&D Per Cent Share of Nominal GDP
1980	3,575	N/A	N/A	N/A	N/A
1981	4,415	9,317	47.4	367,121	1.20%
1982	5,198	10,116	51.4	386,773	1.34%
1983	5,517	10,181	54.2	419,691	1.31%
1984	6,273	11,207	56.0	460,243	1.36%
1985	6,985	12,109	57.7	498,075	1.40%
1986	7,546	12,690	59.5	524,450	1.44%
1987	7,950	12,783	62.2	571,926	1.39%
1988	9,045	13,919	65.0	624,401	1.45%
1989	9,517	14,019	67.9	669,026	1.42%
1990	10,260	14,636	70.1	692,997	1.48%
1991	10,767	14,923	72.2	699,253	1.54%
1992	11,338	15,516	73.1	716,019	1.58%
1993	12,184	16,424	74.2	744,608	1.64%
1994	13,341	17,781	75.0	789,507	1.69%
1995	13,754	17,924	76.7	828,973	1.66%
1996	13,817	17,730	77.9	857,023	1.61%
1997	14,635	18,557	78.9	903,902	1.62%
1998	16,088	20,489	78.5	937,295	1.72%
1999	17,637	22,080	79.9	1,004,456	1.76%
2000	20,555	24,706	83.2	1,102,380	1.86%
2001	23,132	27,343	84.6	1,140,505	2.03%
2002	23,534	27,493	85.6	1,189,452	1.98%
2003	24,693	27,902	88.5	1,250,315	1.97%
2004	26,680	29,190	91.4	1,331,178	2.00%
2005	28,022	29,716	94.3	1,417,028	1.98%
2006	29,079	30,009	96.9	1,492,207	1.95%
2007	30,038	30,038	100.0	1,573,532	1.91%
2008	30,751	29,597	103.9	1,652,923	1.86%
2009	30,129	29,625	101.7	1,567,365	1.92%
2010	30,555	29,267	104.4	1,662,130	1.84%
2011	31,834	29,503	107.9	1,769,921	1.80%
2012	32,707	29,869	109.5	1,822,808	1.79%
2013	31,972	28,804	111.0	1,892,193	1.69%
2014	31,825	28,164	113.0	1,973,043	1.61%
% or % Point Change 2000-2014	54.8%	14.0%	29.8	79.0%	-0.25
% or % Point Change 2010-2014	4.2%	-3.8%	-54.8	18.7%	-0.23

Panel B: Business Enterprise Sector Research and Development Expenditure (BERD)

	Current Prices	2007 Constant Prices	Deflator	Nominal GDP	Nominal BERD Per Cent Share of Nominal GDP
1980	1,571	N/A	N/A	N/A	N/A
1981	2,124	4,482	47.4	367,121	0.58%
1982	2,489	4,844	51.4	386,773	0.64%
1983	2,602	4,802	54.2	419,691	0.62%
1984	3,022	5,399	56.0	460,243	0.66%
1985	3,635	6,302	57.7	498,075	0.73%
1986	4,022	6,764	59.5	524,450	0.77%
1987	4,341	6,980	62.2	571,926	0.76%
1988	4,623	7,114	65.0	624,401	0.74%
1989	4,779	7,040	67.9	669,026	0.71%
1990	5,169	7,374	70.1	692,997	0.75%
1991	5,355	7,422	72.2	699,253	0.77%
1992	5,742	7,858	73.1	716,019	0.80%
1993	6,424	8,660	74.2	744,608	0.86%
1994	7,567	10,086	75.0	789,507	0.96%
1995	7,991	10,414	76.7	828,973	0.96%
1996	7,997	10,262	77.9	857,023	0.93%
1997	8,739	11,081	78.9	903,902	0.97%
1998	9,682	12,331	78.5	937,295	1.03%
1999	10,399	13,018	79.9	1,004,456	1.04%
2000	12,395	14,898	83.2	1,102,380	1.12%
2001	14,266	16,863	84.6	1,140,505	1.25%
2002	13,545	15,824	85.6	1,189,452	1.14%
2003	14,094	15,925	88.5	1,250,315	1.13%
2004	15,144	16,569	91.4	1,331,178	1.14%
2005	15,638	16,583	94.3	1,417,028	1.10%
2006	16,474	17,001	96.9	1,492,207	1.10%
2007	16,756	16,756	100.0	1,573,532	1.06%
2008	16,644	16,019	103.9	1,652,923	1.01%
2009	16,038	15,770	101.7	1,567,365	1.02%
2010	15,803	15,137	104.4	1,662,130	0.95%
2011	16,894	15,657	107.9	1,769,921	0.95%
2012	16,700	15,251	109.5	1,822,808	0.92%
2013	16,032	14,443	111.0	1,892,193	0.85%
2014	15,877	14,050	113.0	1,973,043	0.80%
% or % Point Change 2000-2014	28.1%	-5.7%	29.8	79.0%	-0.32
% or % Point Change 2010-2014	0.5%	-7.2%	-54.8	18.7%	-0.15

Panel C: Higher Education Sector Research and Development Expenditure (HERD)

	Current Prices	2007 Constant Prices	Deflator	Nominal GDP	Nominal HERD Per Cent Share of Nominal GDP
1980	1,055	N/A	N/A	N/A	N/A
1981	1,177	2,484	47.4	367,121	0.32%
1982	1,373	2,672	51.4	386,773	0.35%
1983	1,452	2,680	54.2	419,691	0.35%
1984	1,604	2,866	56.0	460,243	0.35%
1985	1,722	2,985	57.7	498,075	0.35%
1986	1,839	3,093	59.5	524,450	0.35%
1987	1,934	3,110	62.2	571,926	0.34%
1988	2,669	4,107	65.0	624,401	0.43%
1989	2,844	4,189	67.9	669,026	0.43%
1990	3,033	4,327	70.1	692,997	0.44%
1991	3,289	4,559	72.2	699,253	0.47%
1992	3,519	4,816	73.1	716,019	0.49%
1993	3,660	4,934	74.2	744,608	0.49%
1994	3,675	4,898	75.0	789,507	0.47%
1995	3,691	4,810	76.7	828,973	0.45%
1996	3,697	4,744	77.9	857,023	0.43%
1997	3,879	4,919	78.9	903,902	0.43%
1998	4,370	5,566	78.5	937,295	0.47%
1999	5,082	6,362	79.9	1,004,456	0.51%
2000	5,793	6,963	83.2	1,102,380	0.53%
2001	6,423	7,592	84.6	1,140,505	0.56%
2002	7,455	8,709	85.6	1,189,452	0.63%
2003	8,144	9,202	88.5	1,250,315	0.65%
2004	9,058	9,910	91.4	1,331,178	0.68%
2005	9,518	10,093	94.3	1,417,028	0.67%
2006	9,625	9,933	96.9	1,492,207	0.65%
2007	10,187	10,187	100.0	1,573,532	0.65%
2008	10,927	10,517	103.9	1,652,923	0.66%
2009	10,818	10,637	101.7	1,567,365	0.69%
2010	11,249	10,775	104.4	1,662,130	0.68%
2011	11,832	10,966	107.9	1,769,921	0.67%
2012	12,953	11,829	109.5	1,822,808	0.71%
2013	12,715	11,455	111.0	1,892,193	0.67%
2014	12,860	11,381	113.0	1,973,043	0.65%
% or % Point Change 2000-2014	122.0%	63.4%	29.8	79.0%	0.13
% or % Point Change 2010-2014	14.3%	5.6%	-54.8	18.7%	-0.02

Panel D: Federal and Provincial Government Research and Development Expenditure (GovERD)

	Current Prices	2007 Constant Prices	Deflator	Nominal GDP	Nominal GovERD Per Cent Share of Nominal GDP
1980	876	N/A	N/A	N/A	N/A
1981	1,025	2,163	47.4	367,121	0.28%
1982	1,241	2,415	51.4	386,773	0.32%
1983	1,360	2,510	54.2	419,691	0.32%
1984	1,528	2,730	56.0	460,243	0.33%
1985	1,490	2,583	57.7	498,075	0.30%
1986	1,556	2,617	59.5	524,450	0.30%
1987	1,534	2,467	62.2	571,926	0.27%
1988	1,591	2,448	65.0	624,401	0.25%
1989	1,721	2,535	67.9	669,026	0.26%
1990	1,860	2,653	70.1	692,997	0.27%
1991	1,923	2,665	72.2	699,253	0.28%
1992	1,924	2,633	73.1	716,019	0.27%
1993	1,949	2,627	74.2	744,608	0.26%
1994	1,950	2,599	75.0	789,507	0.25%
1995	1,913	2,493	76.7	828,973	0.23%
1996	1,955	2,509	77.9	857,023	0.23%
1997	1,876	2,379	78.9	903,902	0.21%
1998	1,898	2,417	78.5	937,295	0.20%
1999	2,032	2,544	79.9	1,004,456	0.20%
2000	2,244	2,697	83.2	1,102,380	0.20%
2001	2,356	2,785	84.6	1,140,505	0.21%
2002	2,446	2,857	85.6	1,189,452	0.21%
2003	2,337	2,641	88.5	1,250,315	0.19%
2004	2,349	2,570	91.4	1,331,178	0.18%
2005	2,694	2,857	94.3	1,417,028	0.19%
2006	2,806	2,896	96.9	1,492,207	0.19%
2007	2,867	2,867	100.0	1,573,532	0.18%
2008	2,963	2,851	103.9	1,652,923	0.18%
2009	3,114	3,062	101.7	1,567,365	0.20%
2010	3,332	3,191	104.4	1,662,130	0.20%
2011	2,949	2,733	107.9	1,769,921	0.17%
2012	2,867	2,618	109.5	1,822,808	0.16%
2013	3,035	2,734	111.0	1,892,193	0.16%
2014	2,895	2,562	113.0	1,973,043	0.15%
% or % Point Change 2000-2014	29.0%	-5.0%	29.8	79.0%	-0.06
% or % Point Change 2010-2014	-13.1%	-19.7%	-54.8	18.7%	-0.05

Panel E: Per Cent Contribution to Total R&D Expenditure of BERD, HERD, and GovERD, 1980-2014 (Current Prices)

	Business Enterprise Sector Research and Development Expenditure (BERD) (%)	Higher Education Sector Research and Development Expenditure (HERD) (%)	Federal and Provincial Government Research and Development Expenditure (GovERD) (%)
1980	43.9	29.5	24.5
1981	48.1	26.7	23.2
1982	47.9	26.4	23.9
1983	47.2	26.3	24.7
1984	48.2	25.6	24.4
1985	52.0	24.7	21.3
1986	53.3	24.4	20.6
1987	54.6	24.3	19.3
1988	51.1	29.5	17.6
1989	50.2	29.9	18.1
1990	50.4	29.6	18.1
1991	49.7	30.5	17.9
1992	50.6	31.0	17.0
1993	52.7	30.0	16.0
1994	56.7	27.5	14.6
1995	58.1	26.8	13.9
1996	57.9	26.8	14.1
1997	59.7	26.5	12.8
1998	60.2	27.2	11.8
1999	59.0	28.8	11.5
2000	60.3	28.2	10.9
2001	61.7	27.8	10.2
2002	57.6	31.7	10.4
2003	57.1	33.0	9.5
2004	56.8	34.0	8.8
2005	55.8	34.0	9.6
2006	56.7	33.1	9.6
2007	55.8	33.9	9.5
2008	54.1	35.5	9.6
2009	53.2	35.9	10.3
2010	51.7	36.8	10.9
2011	53.1	37.2	9.3
2012	51.1	39.6	8.8
2013	50.1	39.8	9.5
2014	49.9	40.4	9.1
Average Contribution, 2000-2014	55.0	34.7	9.7
Average Contribution, 2010-2014	51.2	38.8	9.5
% Change 2000-2014	-10.4	12.2	-1.8
% Change 2010-2014	-1.8	3.6	-1.8

Source: CANSIM 358-0001; CANSIM 384-0038

Appendix Table 19: Business Enterprise Research and Development (BERD) Intramural Expenditures by North American Industry Classification System (NAICS), Millions of Dollars, 1994-2014

Panel A: BERD by NAICS, All Industries

	Agriculture, forestry, fishing and hunting [11]	Mining, quarrying, and oil and gas extraction [21]	Utilities (221 and 562)	Construction [315, 316 and 339]	Manufacturing [31-33]	Services (41, 44-45, 48-49, 51, 52, 53, 54, 55, 561, 61 (excluding 611310), 62, 71, 72,and 81)	Information and communications technologies (33411, 33421, 33422, 33429, 33431, 33441, 33461, 4173, 5112, 517 to 518, 5415 and 8112)	**Total all industries**
1994	x	x	x	x	4529	2539	n.a.	**7567**
1995	58	x	x	x	4977	2523	n.a.	**7991**
1996	x	197	x	23	5118	2362	n.a.	**7997**
1997	61	189	x	x	5766	2501	n.a.	**8739**
1998	x	x	x	x	6483	2750	n.a.	**9682**
1999	x	134	x	x	7044	2920	3972	**10399**
2000	x	182	x	x	8474	3430	5588	**12395**
2001	92	218	x	x	9194	4539	6101	**14266**
2002	107	x	x	49	8198	4805	4859	**13545**
2003	94	300	x	x	8172	5349	5027	**14094**
2004	102	389	243	56	8281	6073	5107	**15144**
2005	111	480	270	72	8367	6339	5167	**15638**
2006	118	731	313	85	8850	6376	5267	**16474**
2007	179	781	288	97	8427	6984	5408	**16756**
2008	134	980	217	122	7724	7468	5200	**16644**
2009	127	929	187	135	7764	6896	4861	**16038**
2010	131	981	188	113	7334	7056	4664	**15803**
2011	145	1387	199	158	7372	7632	5190	**16894**
2012	97	1608	213	110	7165	7507	5070	**16700**
2013	81	1585	232	68	6753	7313	5006	**16032**
2014	85	1442	212	76	6785	7277	4940	**15877**
% Change, 2000-2014 (unless otherwise noted)	-7.6% (from 2001-2014)	692.3%	-12.8% (from 2004-2014)	55.1% (from 2002-2014)	-19.9%	112.2%	-11.6%	28.1%
Annual Growth Rate 2000-2014 (where available)	-0.6%	15.9%	-1.4%	3.1%	-1.6%	5.5%	-0.9%	1.8%

Panel B: BERD in Millions by Manufacturing Three-Digit NAICS Code

North American Industrial Classification System (NAICS) Code	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	2014	% Change, 2000-2014
Food manufacturing [311]	74	71	89	119	136	141	152	158	183	182	178	156	142	129	91.9
Beverage and tobacco product manufacturing [312]	x	22	27	43	x	19	19	25	16	19	16	13	x	x	n.a.
Wood product manufacturing [321]	42	x	56	66	80	135	126	112	219	103	87	88	88	77	78.6
Paper, Printing and support activities [322, 323]	n.a.	436	427	448	455	354	607	329	202	144	204	197	174	177	n.a.
Plastics and Rubber Products [326]	n.a.	101	107	145	150	165	194	232	180	176	154	174	172	134	n.a.
Non-metallic mineral product manufacturing [327]	x	29	46	49	44	73	76	78	66	83	76	78	63	60	n.a.
Primary Metal [331]	n.a.	216	n.a.	n.a.	272	n.a.	n.a.	351	338	265	n.a.	215	208	238	n.a.
Fabricated metal product manufacturing [332]	95	113	156	188	202	211	230	258	260	285	234	221	197	188	115.8
Machinery manufacturing [333]	405	441	456	473	498	561	576	543	565	658	554	652	597	556	39.8
Electrical equipment, appliance and component manufacturing [335]	210	313	213	175	152	173	177	261	163	163	159	147	146	162	-25.2
Furniture and related product manufacturing [337]	9	x	21	28	31	33	36	42	49	50	43	38	30	22	155.6

Panel C: BERD in Millions by Manufacturing Four-Digit NAICS Code

North American Industrial Classification System (NAICS) Code	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	2014	% Change, 2000-2014
Pharmaceutical and medicine manufacturing [3254]	764	889	1160	1058	1129	1065	1085	975	675	671	668	518	453	403	-43.6
Other chemicals manufacturing [3251-3253 and 3255-3259]	227	225	211	261	210	165	191	187	258	295	352	320	224	177	-20.7
Computer and peripheral equipment manufacturing [3341]	207	202	206	192	165	156	112	110	118	63	55	53	58	60	-70.0
Communications equipment manufacturing [3342]	x	3179	1994	1695	1502	1405	1480	1487	1468	1526	1078	1479	1489	1314	n.a.
Semiconductor and other electronic component manufacturing [3344]	826	872	811	743	811	849	847	849	453	511	528	521	485	455	-46.4
Navigational, measuring, medical and control instrument manufacturing [3345]	363	372	369	365	383	482	451	402	418	427	437	376	440	360	6.3
Other computer and electronic products manufacturing [3343 and 3346]	x	23	18	x	22	19	15	24	22	21	26	26	33	29	n.a.
Motor vehicle and parts manufacturing [3361, 3362 and 3363]	411	407	425	538	657	631	608	509	425	310	313	256	247	n.a.	-40.6
Aerospace products and parts manufacturing [3364]	883	949	860	891	x	860	x	925	1000	1107	1228	1315	1454	1573	72.9
All other transportation equipment manufacturing [3365, 3366 and 3369]	x	26	17	47	45	x	68	70	161	155	166	188	144	146	n.a.

NB: ‘x’ signifies that the data are unavailable from Statistics Canada because they have been suppressed to meet the confidentiality requirements of the Statistics Act. ‘n.a.’ signifies the data are otherwise unavailable from Statistics Canada.
Source: CANSIM 358-0024

Appendix Table 20: USPTO Patenting Intensity of Business Enterprise Expenditure on Research and Development (BERD) by Manufacturing North American Industrial Classification System (NAICS) Code, 1994-2012 (Patent to R&D Ratio)

Panel A: Patenting Intensity of BERD by Manufacturing Three-Digit NAICS Code

	1994-2001 Average			2001-2006 Average			2007-2012 Average		
North American Industrial Classification System (NAICS) Code	Patents (Annual Average)	BERD (Annual Average, Millions Dollars)	Patenting Return (Patents/ BERD in Millions)	Patents (Annual Average)	BERD (Annual Average, Millions Dollars)	Patenting Return (Patents/ BERD in Millions)	Patents (Annual Average)	BERD (Annual Average, Millions Dollars)	Patenting Return (Patents/ BERD in Millions)
Electrical Equipment, Appliances, and Components, 335	149	210.00	0.71	217.83	200.50	1.09	235.33	173.17	1.36
Machinery, 333	536.43	405.00	1.32	576.83	500.83	1.15	558.00	594.83	0.94
Fabricated Metal Products, 332	257.29	95.00	2.71	268.00	183.33	1.46	207.83	242.50	0.86
Nonmetallic Mineral Products, 327	52.29	x	n.a.	50.00	52.83	0.95	35.17	74.00	0.48
Plastics and Rubber Products, 326	119.00	x	n.a.	107.17	143.67	0.75	85.67	181.33	0.47
Furniture and Related Products, 337	20.00	9.00	2.22	23.00	29.80	0.77	16.33	42.00	0.39
Wood Products, 321	18.71	42.00	0.45	16.50	92.60	0.18	15.33	116.17	0.13
Beverage and Tobacco Products, 312	4.29	x	n.a.	3.17	26.00	0.12	2.17	17.80	0.12
Primary Metal, 331	26.57	x	n.a.	23.33	244.00	0.10	18.83	275.40	0.07
Paper, Printing and support activities, 322, 323	25.29	x	n.a.	16.83	454.50	0.04	12.17	208.33	0.06
Food, 311	9.86	74.00	0.13	11.17	118.00	0.09	8.67	166.50	0.05

Panel B: Patenting Intensity of BERD by Manufacturing Four-Digit NAICS Code

	1994-2001 Average			2001-2006 Average			2007-2012 Average		
North American Industrial Classification System (NAICS) Code	Patents (Annual Average)	BERD (Annual Average, Millions Dollars)	Patenting Return (Patents/ BERD in Millions)	Patents (Annual Average)	BERD (Annual Average, Millions Dollars)	Patenting Return (Patents/ BERD in Millions)	Patents (Annual Average)	BERD (Annual Average, Millions Dollars)	Patenting Return (Patents/ BERD in Millions)
Computer and Peripheral Equipment, 3341	95.86	207.00	0.46	252.17	172.17	1.46	737.00	76.17	9.68
Other Computer and Electronic Products, 3343, 3346	24.57	x	n.a.	38.83	19.40	2.00	73.17	25.33	2.89
Other chemicals manufacturing [3251-3253 and 3255-3259]	231.57	227.00	1.02	250.67	210.50	1.19	283.33	272.67	1.04
Navigational, Measuring, Electromedical, and Control Instruments, 3345	212.57	363.00	0.59	331.17	403.67	0.82	384.17	416.67	0.92
Communications Equipment, 3342	175.86	x	n.a.	341.83	1875.83	0.18	697.50	1421.17	0.49
Semiconductors and Other Electronic Components, 3344	106.86	826.00	0.13	192.67	822.17	0.23	273.67	557.83	0.49
Other Transportation Equipment, 3365, 3366, 3369	37.29	x	n.a.	56.00	40.60	1.38	53.83	147.33	0.37
Motor Vehicles, Trailers and Parts, 3361-3363	67.86	411.00	0.17	102.50	544.33	0.19	95.83	343.33	0.28
Pharmaceutical and Medicines, 3254	134.86	764.00	0.18	170.50	1064.33	0.16	177.00	660.00	0.27
Aerospace Product and Parts, 3364	15.29	883.00	0.02	31.50	890.00	0.04	33.50	1171.50	0.03

Source: USPTO (https://www.uspto.gov/web/offices/ac/ido/oeip/taf/naics/stc_naics_fgall/cax_stc_naics_fg.htm) and CANSIM Table 358-0024

Appendix Table 21: Number and Percentage Distribution of Patents Granted at the USPTO to Assignees, Canada and the Provinces, 1980-2012

Panel A: Number

	N.L.	P.E.I	N.S	M.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	**CAN**
1980	2	–	5	6	254	522	14	22	58	98	**971**
1985	3	1	6	5	347	644	22	21	67	94	**1203**
1990	8	2	14	11	390	862	37	38	129	220	**1,712**
1995	6	3	8	17	460	919	51	45	208	221	**1,932**
2000	10	2	28	17	980	1,430	70	62	282	349	**3,212**
2005	2	1	26	16	878	1,151	33	44	272	325	**2,737**
2006	3	3	20	13	891	1,506	45	37	278	358	**3,155**
2007	4	–	18	17	755	1,344	58	34	248	329	**2,800**
2008	2	–	25	14	772	1,356	61	47	233	281	**2,779**
2009	7	4	14	17	777	1,433	50	57	260	265	**2,872**
2010	11	3	23	16	775	1,982	77	70	301	393	**3,640**
2011	8	3	22	21	655	2,242	75	68	354	394	**3,832**
2012	7	6	48	36	723	2,632	85	66	377	368	**4,335**
% Change 2000-12	-30.0%	200.0%	71.43%	111.76%	-26.22%	84.06%	21.43%	6.45%	33.69%	5.44%	**34.96%**
Growth Rate 2000-12	-2.93%	9.59%	4.59%	6.45%	-2.50%	5.22%	1.63%	0.52%	2.45%	0.44%	**2.53%**

Panel B: Percentage Distribution

1980	0.21	N/A	0.51	0.62	26.16	53.76	1.44	2.27	5.97	10.09	**100.0**
1985	0.25	0.08	0.50	0.42	28.84	53.53	1.83	1.75	5.57	7.81	**100.0**
1990	0.47	0.12	0.82	0.64	22.78	50.35	2.16	2.22	7.54	12.85	**100.0**
1995	0.31	0.16	0.41	0.88	23.81	47.57	2.64	2.33	10.77	11.44	**100.0**
2000	0.31	0.06	0.87	0.53	30.51	44.52	2.18	1.93	8.78	10.87	**100.0**
2005	0.07	0.04	0.95	0.58	32.08	42.05	1.21	1.61	9.94	11.87	**100.0**
2006	0.10	0.10	0.63	0.41	28.24	47.73	1.43	1.17	8.81	11.35	**100.0**
2007	0.14	N/A	0.64	0.61	26.96	48.00	2.07	1.21	8.86	11.75	**100.0**
2008	0.07	N/A	0.90	0.50	27.78	48.79	2.20	1.69	8.38	10.11	**100.0**
2009	0.24	0.14	0.49	0.59	27.05	49.90	1.74	1.98	9.05	9.23	**100.0**
2010	0.30	0.08	0.63	0.44	21.29	54.45	2.12	1.92	8.27	10.80	**100.0**
2011	0.21	0.08	0.57	0.55	17.09	58.51	1.96	1.77	9.24	10.28	**100.0**
2012	0.16	0.14	1.11	0.83	16.68	60.72	1.96	1.52	8.70	8.49	**100.0**
Percentage point change, 2000-2012	-0.15	0.08	0.24	0.30	-13.83	16.19	-0.22	-0.41	-0.08	-2.38	**0**

Panel C: Number of Patents per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	0.35	-	0.59	0.85	3.90	5.97	1.35	2.27	2.65	3.57	3.96
1985	0.52	0.78	0.68	0.69	5.21	6.93	2.03	2.05	2.79	3.16	4.66
1990	1.39	1.53	1.54	1.49	5.57	8.37	3.35	3.77	5.06	6.68	6.18
1995	1.06	2.23	0.86	2.26	6.37	8.39	4.52	4.44	7.61	5.85	6.59
2000	1.89	1.47	3.00	2.27	13.32	12.24	6.10	6.15	9.39	8.64	10.47
2001	1.34	1.46	1.93	3.07	14.10	12.38	5.73	8.40	10.63	9.32	11.02
2002	1.35	-	2.89	1.73	13.90	12.39	5.45	6.62	8.60	8.61	10.57
2003	1.74	1.46	2.88	2.80	14.03	11.70	4.81	4.72	9.30	9.24	10.49
2004	0.97	2.18	1.92	1.60	13.82	11.08	5.11	5.01	8.65	9.58	10.12
2005	0.39	0.72	2.77	2.14	11.58	9.19	2.80	4.43	8.19	7.75	8.49
2006	0.59	2.18	2.13	1.74	11.67	11.89	3.80	3.73	8.13	8.44	9.69
2007	0.79	-	1.92	2.28	9.81	10.53	4.88	3.39	7.06	7.67	8.51
2008	0.39	-	2.67	1.87	9.95	10.53	5.09	4.62	6.48	6.46	8.36
2009	1.35	2.86	1.49	2.27	9.91	11.03	4.14	5.51	7.07	6.01	8.54
2010	2.11	2.12	2.44	2.12	9.77	15.09	6.31	6.66	8.06	8.80	10.70
2011	1.52	2.08	2.33	2.78	8.18	16.90	6.08	6.38	9.34	8.76	11.16
2012	1.33	4.13	5.08	4.76	8.94	19.63	6.80	6.07	9.69	8.10	12.47

Panel D: Patents Per 100,000 Residents, Provinces vs. Canadian Total

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.
1980	0.09	-	0.15	0.21	0.99	1.51	0.34	0.57	0.67	0.90
1985	0.11	0.17	0.15	0.15	1.12	1.49	0.44	0.44	0.60	0.68
1990	0.22	0.25	0.25	0.24	0.90	1.35	0.54	0.61	0.82	1.08
1995	0.16	0.34	0.13	0.34	0.97	1.27	0.69	0.67	1.15	0.89
2000	0.18	0.14	0.29	0.22	1.27	1.17	0.58	0.59	0.90	0.83
2005	0.12	0.13	0.18	0.28	1.28	1.12	0.52	0.76	0.96	0.85
2006	0.13	-	0.27	0.16	1.31	1.17	0.52	0.63	0.81	0.81
2007	0.17	0.14	0.27	0.27	1.34	1.12	0.46	0.45	0.89	0.88
2008	0.10	0.22	0.19	0.16	1.37	1.10	0.51	0.50	0.85	0.95
2009	0.05	0.09	0.33	0.25	1.36	1.08	0.33	0.52	0.96	0.91
2010	0.06	0.22	0.22	0.18	1.21	1.23	0.39	0.38	0.84	0.87
2011	0.09	-	0.23	0.27	1.15	1.24	0.57	0.40	0.83	0.90
2012	0.05	-	0.32	0.22	1.19	1.26	0.61	0.55	0.78	0.77

Note: The sum of the provinces will be greater than the total for Canada due to collaborations between provinces. For example, the sum of the number of patents in each province for 2000 yields 3,230 patents while the only 3,212 patents were issued. This means that 18 assignees from different provinces collaborated when patenting an invention.
Source: Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/pi_qc_prov.htm and CANSIM Table 051-0001.

Appendix Table 22: Number and Percentage Distribution of Triadic Patents by Assignee, Canada and the Provinces, 1980-2008

Panel A: Number

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	CAN
1980	–	–	–	–	10	11	–	–	1	2	24
1990	–	–	3	1	86	173	3	3	8	30	305
1995	–	–	–	–	98	185	2	2	21	36	346
2000	–	–	4	1	222	319	5	4	46	80	674
2001	1	–	3	1	210	332	3	3	63	76	693
2002	–	–	5	–	197	346	5	5	40	85	680
2003	1	–	5	3	185	243	7	5	60	80	591
2004	–	–	4	–	141	293	8	6	45	100	597
2005	–	–	4	–	134	206	7	5	49	89	490
2006	–	1	–	–	157	294	4	3	48	90	598
2007	–	–	3	3	145	319	13	5	38	80	608
2008	–	–	4	–	127	264	5	4	36	66	504
% Change, 2000-2008	N/A	N/A	0.0%	N/A	-42.97%	-17.24%	0.0%	0.00	-27.74%	-17.50%	-25.22%
Annual Growth Rate 2000-2012	N/A	N/A	0.0%	N/A	-6.74%	-2.34%	0.0%	0.00	-3.02%	-2.38%	-3.57%

Panel B: Percentage Distribution

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	CAN
1980	N/A	N/A	N/A	N/A	41.67	45.83	N/A	N/A	4.17	8.33	100.0
1990	N/A	N/A	0.98	0.33	28.20	56.72	0.98	0.98	2.62	9.84	100.0
1995	N/A	N/A	N/A	N/A	28.32	53.47	0.58	0.58	6.07	10.40	100.0
2000	N/A	N/A	0.59	0.15	32.94	47.33	0.74	0.59	6.82	11.87	100.0
2001	0.14	N/A	0.43	0.14	30.30	47.91	0.43	0.43	9.09	10.97	100.0
2002	N/A	N/A	0.74	N/A	28.97	50.88	0.74	0.74	5.88	12.50	100.0
2003	0.17	N/A	0.85	0.51	31.30	41.12	1.18	0.85	10.15	13.54	100.0
2004	N/A	N/A	0.67	N/A	23.62	49.08	1.34	1.01	7.54	16.75	100.0
2005	N/A	N/A	0.82	N/A	27.35	42.04	1.43	1.02	10.00	18.16	100.0
2006	N/A	0.17	N/A	N/A	26.25	49.16	0.67	0.50	8.03	15.05	100.0
2007	N/A	N/A	0.49	0.49	23.85	52.47	2.14	0.82	6.25	13.16	100.0
2008	N/A	N/A	0.79	N/A	25.20	52.38	0.99	0.79	7.14	13.10	100.0
Percentage point change, 2000-2008	N/A	N/A	0.20	N/A	-7.74	5.05	0.25	0.20	0.32	1.23	0

Note: The sum of the provinces will not equal the total for Canada due to collaborations or unavailable data from provinces. For example, the sum of the number of patents in each province for 2001 yields 692 patents while the 693 patents were issued.
Source: Institut de la statistique du Québec. http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/triad_canada_titu.htm and CANSIM Table 051-0001.

Appendix Table 23: Number and Percentage Distribution of ICT Patents at the USPTO by Assignee(s)'s Place of Residence, Canada and the Provinces, 1980-2012

Panel A: Number

	N.L.	P.E.I	N.S	N.B	Que.	Ont.	Man.	Sask.	Alta.	B.C.	**CAN**
1980	–	–	–	–	36	61	–	2	2	7	**105**
1981	1	–	1	–	58	67	1	3	2	7	140
1982	–	–	–	–	49	73	2	2	9	9	142
1983	–	–	–	–	44	66	4	5	4	12	135
1984	–	–	–	–	67	62	5	2	3	18	156
1985	–	–	2	–	84	104	6	4	3	10	211
1986	–	–	2	1	65	120	2	4	5	9	210
1987	–	–	–	–	96	128	–	4	5	16	249
1988	–	–	3	1	75	134	3	1	9	15	241
1989	–	1	3	1	95	160	5	4	14	15	295
1990	4	–	3	–	91	120	6	2	18	20	265
1991	–	–	2	–	87	132	4	7	20	27	278
1992	–	–	1	1	89	123	4	4	24	19	263
1993	1	–	2	1	90	137	4	4	26	23	286
1994	–	–	1	1	106	133	3	7	25	31	301
1995	3	–	1	3	98	154	6	8	38	34	343
1996	2	–	4	–	130	189	6	6	22	50	410
1997	2	1	4	3	113	212	3	4	35	43	416
1998	–	1	3	2	235	278	7	4	41	76	645
1999	–	1	4	4	352	285	10	5	35	59	753
2000	3	1	3	–	468	331	4	7	39	63	**912**
2001	1	–	5	3	522	351	6	8	52	63	**1010**
2002	–	–	4	1	487	406	3	8	40	68	**1013**
2003	5	–	6	5	510	434	10	7	61	88	**1123**
2004	2	1	5	–	586	445	6	5	58	106	**1211**
2005	–	–	7	1	461	389	2	4	51	96	**1008**
2006	–	–	6	4	426	619	7	3	59	110	**1232**
2007	1	–	4	6	382	578	8	2	63	98	**1141**
2008	2	–	8	7	385	655	11	1	50	84	**1199**
2009	4	–	5	4	350	717	7	3	55	95	**1235**
2010	8	1	9	3	306	1030	10	11	68	129	**1571**
2011	6	2	12	3	196	1278	11	13	77	139	**1731**
2012	3	1	19	12	183	1523	14	10	97	117	**1973**
% Change 2000-12	0.0%	0.0%	533.3%	N/A	-60.9%	360.1%	250.0%	42.9%	148.7%	85.7%	**116.3%**
Annual Growth Rate 2000-12	0.0%	0.0%	16.6%	N/A	-7.5%	13. 6%	11.0%	3.02%	7.89%	5.29%	**6.64%**

Panel B: Percentage Distribution

1980	-	-	-	-	32.38	58.10	-	1.90	1.90	6.67	**100.0**
1985	-	–	0.95	-	39.81	49.29	2.84	1.90	1.42	4.74	**100.0**
1990	1.51	-	1.13	-	34.34	45.28	2.26	0.75	6.79	7.55	**100.0**
1995	0.87	-	0.29	0.87	28.57	44.90	1.75	2.33	11.08	9.91	**100.0**
2000	0.33	0.11	0.33	-	51.32	36.29	0.44	0.77	4.28	6.91	**100.0**
2005	-	-	0.69	0.10	45.73	38.59	0.20	0.40	5.06	9.52	**100.0**
2010	0.51	0.06	0.57	0.19	19.48	65.56	0.64	0.70	4.33	8.21	**100.0**
2011	0.35	0.12	0.69	0.17	11.32	73.83	0.64	0.75	4.45	8.03	**100.0**
2012	0.15	0.05	0.96	0.61	9.28	77.19	0.71	0.51	4.92	5.93	**100.0**
Percentage point change, 2000-2012	-0.18	-0.06	0.63	N/A	-42.04	40.9	0.27	-0.26	0.64	-0.98	**0**

Panel C: ICT Patents by Assignee at the USPTO Per per 100,000 Residents

	N.L.	P.E.I	N.S	N.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	-	-	-	-	0.52	0.70	–	0.21	0.09	0.25	**0.43**
1985	-	-	0.23	–	1.26	1.12	0.55	0.39	0.12	0.34	**0.82**
1990	0.69	–	0.33	–	1.30	1.17	0.54	0.20	0.71	0.61	**0.96**
1995	0.53	–	0.11	0.40	1.36	1.41	0.53	0.79	1.39	0.90	**1.17**
2000	0.57	0.73	0.32	-	6.36	2.83	0.35	0.69	1.30	1.56	2.97
2001	0.19	-	0.54	0.40	7.06	2.95	0.52	0.80	1.70	1.55	3.26
2002	-	-	0.43	0.13	6.54	3.36	0.26	0.80	1.28	1.66	3.23
2003	0.96	-	0.64	0.67	6.81	3.54	0.86	0.70	1.92	2.13	3.55
2004	0.39	0.73	0.53	-	7.78	3.59	0.51	0.50	1.79	2.55	3.79
2005	-	-	0.75	0.13	6.08	3.11	0.17	0.40	1.54	2.29	3.13
2006	-	-	0.64	0.54	5.58	4.89	0.59	0.30	1.72	2.59	3.78
2007	0.20	-	0.43	0.80	4.97	4.53	0.67	0.20	1.79	2.28	3.47
2008	0.39	-	0.85	0.94	4.96	5.08	0.92	0.10	1.39	1.93	3.61
2009	0.77	-	0.53	0.53	4.46	5.52	0.58	0.29	1.49	2.15	3.67
2010	1.53	0.71	0.96	0.40	3.86	7.84	0.82	1.05	1.82	2.89	4.62
2011	1.14	1.39	1.27	0.40	2.45	9.64	0.89	1.22	2.03	3.09	5.04
2012	0.57	0.69	2.01	1.59	2.26	11.36	1.12	0.92	2.49	2.58	5.68

Panel D: Share of ICT Patents at the USPTO of Total Patents at the USPTO Granted to Canadian Assignees, 1980-2012

	N.L.	P.E.I	N.S	M.B.	Que.	Ont.	Man.	Sask.	Alta	B.C.	**CAN**
1980	–	–	–	–	12.50	9.50	-	7.69	2.70	5.69	**9.21**
1985	–	–	16.67	–	26.84	12.79	23.08	14.29	2.86	8.70	**15.18**
1990	50.00	–	13.64	–	23.45	11.37	11.76	4.65	11.61	7.84	**13.51**
1995	37.50	–	6.25	12.00	22.22	12.84	10.00	16.67	15.64	12.45	**15.32**
2000	18.75	50.00	7.32	–	62.48	15.84	4.17	9.09	9.90	13.85	**24.13**
2005	–	–	21.88	4.76	64.57	22.04	4.76	5.97	14.21	22.48	**30.48**
2010	53.33	25.00	19.15	5.56	29.42	30.43	9.35	10.38	12.85	17.18	**27.52**
2011	33.33	66.67	22.64	6.67	18.03	36.78	11.00	13.54	13.53	17.75	**29.21**
2012	11.54	11.11	29.69	23.53	15.05	37.31	12.28	11.24	16.06	13.67	**28.96**

Note: ICT includes electronic devices, computers, telecommunication devices and other ICT devices.
Note: The sum of the provinces will be greater than the total for Canada due to collaborations between provinces. For example, the sum of ICT patents of the provinces in 2000 yields 1,061 patents while the total for Canada in 2000 is 991 patents. This means that 71 inventors from different provinces collaborated when creating an invention.
Source: Institut de la statistique du Québec, http://www.stat.gouv.qc.ca/statistiques/science-technologie-innovation/brevets/inventions_tic_prov.htm and CANSIM Table 051-0001.

Appendix Table 24: R&D Expenditures and Patent-to-R&D Ratio, G7, 1981-2014

Panel A: Gross Expenditure on Research and Development (GERD) in G7, in Millions US Dollars, 1981-2014 (2010 Constant Prices)

Country	Canada	France	Germany	Italy	Japan	United Kingdom	United States
1981	8172.0	24753.1	41011.5	11197.5	53526.6	25132.2	151767.4
1982	8844.6	26452.6	42042.0	11547.6	57519.2	n.a.	159434.2
1983	8874.3	27294.2	42838.0	12301.1	62691.0	24629.8	170833.7
1984	9644.5	28961.2	44057.6	13494.0	67736.1	n.a.	187739.4
1985	10384.8	30237.7	48333.3	15414.9	75526.5	26541.6	203747.8
1986	10893.6	30773.7	49952.3	15999.5	76734.1	27565.9	208979.6
1987	10963.9	32174.4	52809.5	17324.7	82194.7	28001.0	214099.2
1988	11307.5	33553.8	54504.8	18446.1	88509.5	28762.8	219163.6
1989	12129.1	35695.5	56294.4	19356.7	96259.5	29377.1	223574.1
1990	12646.4	38063.1	56906.0	20414.8	104188.2	29445.0	231004.9
1991	12879.5	38509.8	61358.8	19708.4	106924.5	27950.7	236765.8
1992	13359.6	39213.5	59572.6	19205.2	106307.3	27586.6	237867.4
1993	14169.0	39570.3	57111.6	18131.9	104319.8	28680.8	232776.2
1994	15294.4	39618.9	56303.6	17288.5	103340.2	29398.5	232680.5
1995	15421.4	39957.2	57424.8	16927.1	110313.7	29370.2	247364.1
1996	15223.6	40187.7	58068.8	17360.4	108982.2	28844.4	261029.4
1997	15945.2	39722.4	60294.9	18452.8	113228.0	28821.3	275991.5
1998	17563.5	40146.2	62434.1	19090.0	116162.7	29906.2	291287.7
1999	18902.7	41768.9	67172.5	18916.9	116602.2	32400.4	310429.6
2000	21128.5	43119.4	70876.0	20059.5	120209.9	33144.5	333146.1
2001	23397.5	44914.6	71894.4	21216.0	123562.6	33850.9	338685.1
2002	23516.5	46197.3	72793.9	22081.3	125578.5	34723.2	333151.4
2003	23874.3	45402.7	73509.3	21648.9	128853.0	34978.6	342930.8
2004	24977.5	46119.3	73285.2	21807.9	131446.9	34590.3	347142.2
2005	25420.0	45920.0	73856.2	21888.8	140617.7	35988.8	361066.0
2006	25682.2	47029.1	77648.3	23178.1	147337.3	37398.2	377206.8
2007	25691.8	47545.4	79863.3	24509.3	152878.3	39168.9	395493.3
2008	25321.3	48523.9	85703.6	24914.8	151532.2	39061.4	415342.3
2009	25352.7	50564.9	84915.7	24714.3	138626.7	38609.1	411368.6
2010	25048.2	50765.0	87966.1	25168.9	140607.4	38165.6	410093.0
2011	25241.0	52190.9	93939.6	25039.0	145528.2	38825.1	420072.1
2012	25548.3	53203.4	96885.8	25560.5	146329.8	37682.6	419528.8
2013	24633.4	53894.1	95644.8	25827.0	154514.9	39506.4	432583.2
2014	24087.2	54296.8	98621.3	25341.7	159219.7	41556.7	n.a.
% Change, 2001-2014 (unless noted)	14.0	25.9	39.1	26.3	32.5	25.4	29.8*
% Change, 2008-2014 (unless noted)	-4.9	11.9	15.1	1.7	5.1	6.4	4.2*

Source: OECD Research and Development Statistics. http://stats.oecd.org/Index.aspx?DataSetCode=GERD_FUNDS, Performer: Total Intramural

*Note: 2014 United States data unavailable, so percent change is calculated from 2001 to 2013 and from 2008 to 2013

Panel B: Business Enterprise Research and Development Expenditure (BERD) in G7, in Millions US Dollars,1981-2014 (2010 Constant Prices)

Country	Canada	France	Germany	Italy	Japan	United Kingdom	United States
1981	3931.4	14583.4	28286.3	6312.4	32477.3	15823.6	105194.7
1982	4235.1	15323.4	29549.9	6554.8	35584.6	n.a.	112291.2
1983	4186.9	15504.7	30189.0	7023.1	39811.7	15392.2	120341.1
1984	4697.9	16552.4	31161.0	7607.1	44076.3	n.a.	133331.7
1985	5470.0	17756.3	34916.2	8778.3	50462.1	17080.8	145670.1
1986	5874.7	18068.3	35994.5	9336.2	51085.4	19024.1	148953.0
1987	6052.8	18948.7	38200.8	9909.3	54265.9	19237.2	152393.7
1988	6167.3	19952.7	39448.2	10665.9	60124.6	19840.2	154968.4
1989	6089.4	21539.5	40717.3	11376.1	67080.0	20303.1	156976.7
1990	6371.3	22997.3	41015.2	11904.9	73826.7	20425.6	162812.9
1991	6403.9	23676.3	42549.4	10998.3	75646.7	18742.1	168235.2
1992	6765.8	24502.1	40926.4	10717.8	73070.3	18217.0	167472.0
1993	7470.6	24414.0	38345.9	9728.7	68893.5	18955.7	161727.9
1994	8674.3	24500.3	37500.3	9152.9	68256.8	18995.7	161042.5
1995	8959.8	24366.4	38060.5	9040.4	71937.7	19078.6	174466.6
1996	8811.7	24733.3	38381.6	9286.5	77441.4	18705.8	187889.3
1997	9520.7	24840.2	40671.0	9195.7	81575.1	18790.5	201644.6
1998	10569.9	24995.4	42417.3	9229.4	82704.7	19608.2	214488.6
1999	11144.2	26388.3	46866.1	9330.4	82453.8	21631.0	230204.0
2000	12740.2	26953.0	49846.6	10044.0	85302.5	21530.7	247172.6
2001	14429.1	28382.4	50230.0	10412.3	91033.4	22173.6	244150.1
2002	13533.8	29220.0	50403.8	10672.7	93483.0	22517.7	230759.1
2003	13626.9	28429.8	51257.1	10230.1	96610.0	22284.4	234248.7
2004	14179.1	29103.0	51147.8	10427.1	98836.9	21640.9	236585.7
2005	14186.3	28523.7	51214.0	11023.6	107499.0	22092.7	248861.2
2006	14550.5	29666.5	54357.3	11306.3	113678.6	23057.4	264407.1
2007	14335.3	29943.6	55899.9	12710.4	119077.7	24492.6	280012.7
2008	13705.2	30439.4	59349.6	13345.3	118894.9	24215.8	296465.7
2009	13495.5	31194.7	57314.7	13172.4	105026.5	23323.4	285842.0
2010	12954.9	32062.8	58961.7	13567.8	107584.6	23261.6	278977.0
2011	13395.2	33378.2	63493.9	13682.3	112002.7	24685.3	288142.9
2012	13044.8	34358.1	65876.3	13847.4	112122.2	23869.7	290780.5
2013	12352.1	34856.1	64258.9	14130.6	117571.2	25240.0	305311.2
2014	12016.7	35170.9	67208.3	14111.7	123804.1	26761.8	n.a.
% Change, 2001-2014 (unless noted)	-5.7	30.5	34.8	40.5	45.1	24.3	23.5*
% Change, 2008-2014 (unless noted)	-12.3	15.5	13.2	5.7	4.1	10.5	3.0*

Source: OECD Research and Development Statistics. http://stats.oecd.org/Index.aspx?DataSetCode=GERD_FUNDS, Performer: Business Enterprise Sector

*Note: 2014 United States data unavailable, so percent change is calculated from 2001 to 2013 and from 2008 to 2013

Panel C: USPTO Patenting Intensity of Gross Expenditure on Research and Development (GERD) in G7, 1981-2014

Country	Canada	France	Germany	Italy	Japan	United Kingdom	United States
1981	0.14	0.09	0.15	0.08	0.16	0.10	0.26
1982	0.11	0.07	0.13	0.07	0.14	n.a.	0.21
1983	0.11	0.07	0.13	0.05	0.14	0.08	0.19
1984	0.12	0.07	0.14	0.06	0.16	n.a.	0.20
1985	0.13	0.08	0.14	0.06	0.17	0.09	0.19
1986	0.12	0.08	0.14	0.06	0.17	0.09	0.18
1987	0.15	0.09	0.15	0.07	0.20	0.10	0.20
1988	0.13	0.08	0.13	0.06	0.18	0.09	0.18
1989	0.16	0.09	0.15	0.07	0.21	0.11	0.22
1990	0.15	0.08	0.13	0.06	0.19	0.09	0.21
1991	0.16	0.08	0.13	0.06	0.20	0.10	0.22
1992	0.15	0.08	0.12	0.07	0.21	0.09	0.22
1993	0.14	0.07	0.12	0.07	0.21	0.08	0.23
1994	0.13	0.07	0.12	0.07	0.22	0.08	0.24
1995	0.14	0.07	0.11	0.06	0.20	0.08	0.23
1996	0.15	0.07	0.12	0.07	0.21	0.08	0.23
1997	0.15	0.07	0.12	0.07	0.20	0.09	0.22
1998	0.17	0.09	0.15	0.08	0.27	0.12	0.28
1999	0.17	0.09	0.14	0.08	0.27	0.11	0.27
2000	0.16	0.09	0.14	0.09	0.26	0.11	0.26
2001	0.15	0.09	0.16	0.08	0.27	0.12	0.26
2002	0.15	0.09	0.15	0.08	0.28	0.11	0.26
2003	0.14	0.09	0.16	0.08	0.28	0.10	0.26
2004	0.14	0.07	0.15	0.07	0.27	0.10	0.24
2005	0.11	0.06	0.12	0.06	0.22	0.09	0.21
2006	0.14	0.07	0.13	0.06	0.25	0.10	0.24
2007	0.13	0.07	0.11	0.05	0.22	0.08	0.20
2008	0.13	0.07	0.10	0.05	0.22	0.08	0.19
2009	0.14	0.06	0.11	0.05	0.26	0.08	0.20
2010	0.19	0.09	0.14	0.07	0.32	0.11	0.26
2011	0.20	0.09	0.13	0.08	0.32	0.11	0.26
2012	0.23	0.10	0.14	0.08	0.35	0.14	0.29
2013	0.27	0.11	0.16	0.10	0.34	0.15	0.31
2014	0.29	0.12	0.17	0.10	0.34	0.16	n.a.
% Point Change, 2001-2014 (unless noted)	0.14	0.03	0.01	0.02	0.07	0.04	0.05*
% Point Change, 2008-2014 (unless noted)	0.16	0.06	0.06	0.05	0.12	0.08	0.12*

Source: Calculations from Appendix Table 4 and Appendix Table 24, Panel A

*Note: 2014 United States data unavailable, so percent point change is calculated from 2001 to 2013 and from 2008 to 2013

Panel D: USPTO Patenting Intensity of Business Enterprise Expenditure on Research and Development (BERD) in G7, 1981-2014

Country	Canada	France	Germany	Italy	Japan	United Kingdom	United States
1981	0.29	0.15	0.22	0.14	0.26	0.16	0.37
1982	0.23	0.13	0.19	0.11	0.23	n.a.	0.30
1983	0.24	0.12	0.18	0.09	0.22	0.13	0.27
1984	0.26	0.13	0.20	0.10	0.25	n.a.	0.29
1985	0.25	0.14	0.19	0.10	0.25	0.15	0.27
1986	0.22	0.13	0.19	0.11	0.26	0.13	0.26
1987	0.26	0.15	0.21	0.12	0.31	0.14	0.29
1988	0.24	0.13	0.19	0.10	0.27	0.13	0.26
1989	0.32	0.15	0.21	0.11	0.30	0.15	0.32
1990	0.29	0.12	0.19	0.11	0.26	0.14	0.29
1991	0.32	0.13	0.18	0.11	0.28	0.15	0.30
1992	0.29	0.12	0.18	0.12	0.30	0.13	0.31
1993	0.26	0.12	0.18	0.13	0.32	0.12	0.33
1994	0.23	0.11	0.18	0.13	0.33	0.12	0.35
1995	0.23	0.12	0.17	0.12	0.30	0.13	0.32
1996	0.25	0.11	0.18	0.13	0.30	0.13	0.33
1997	0.25	0.12	0.17	0.13	0.28	0.14	0.31
1998	0.28	0.15	0.21	0.17	0.37	0.18	0.37
1999	0.29	0.14	0.20	0.16	0.38	0.16	0.36
2000	0.27	0.14	0.21	0.17	0.37	0.17	0.34
2001	0.25	0.14	0.22	0.16	0.36	0.18	0.36
2002	0.25	0.14	0.22	0.16	0.37	0.17	0.38
2003	0.25	0.14	0.22	0.17	0.37	0.16	0.38
2004	0.24	0.12	0.21	0.15	0.36	0.16	0.36
2005	0.20	0.10	0.18	0.12	0.28	0.14	0.30
2006	0.25	0.12	0.18	0.13	0.32	0.16	0.34
2007	0.23	0.10	0.16	0.10	0.28	0.13	0.28
2008	0.25	0.10	0.15	0.10	0.28	0.13	0.26
2009	0.27	0.10	0.16	0.10	0.34	0.14	0.29
2010	0.37	0.14	0.21	0.13	0.42	0.18	0.39
2011	0.37	0.14	0.19	0.14	0.41	0.17	0.38
2012	0.44	0.16	0.21	0.15	0.45	0.22	0.42
2013	0.53	0.17	0.24	0.18	0.44	0.23	0.44
2014	0.59	0.19	0.25	0.19	0.43	0.24	n.a.
% Point Change, 2001-2014 (unless noted)	0.34	0.05	0.02	0.02	0.07	0.06	0.08*
% Point Change, 2008-2014 (unless noted)	0.34	0.09	0.10	0.08	0.15	0.12	0.18*

Source: Calculations from Appendix Table 4 and Appendix Table 24, Panel B

*Note: 2014 United States data unavailable, so percent point change is calculated from 2001 to 2013 and from 2008 to 2013