Centre for International
Governance Innovation

CIGI Papers No. 274 — April 2023

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How Canadian Universities Impact Freedom to Operate

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About the Authors

James W. Hinton is a senior fellow at CIGI, where he contributes expertise on intellectual property (IP) and innovation. He is an IP lawyer, patent agent and trademark agent with his firm Own Innovation. He has worked closely with the Council of Canadian Innovators on Canada's innovation initiatives and national IP strategy. James is co-founder of the Innovation Asset Collective and a proud supporter of Canadian technology companies. He is also an assistant professor at Western University, where he teaches on the commercialization of innovation.

Mardi Witzel is an associate with NuEnergy.ai and is focused on environmental, social and corporate governance and artificial intelligence governance, and the special challenges facing high-growth firms. She serves on the board of PolyML, a private firm specializing in machine learning and advanced analytics, and has 20 years of experience in not-for-profit board governance, stakeholder engagement and strategic planning.

Joanna Wajda is a former research associate, global economy, at CIGI. She holds a B.A. from the Honours Arts and Business (Economics) Program at the University of Waterloo and an M.A. in economics from the University of Toronto.

Acronyms and Abbreviations

AUTM	Association of University Technology Managers
BERD	business enterprise research and development
CIPO	Canadian Intellectual Property Office
EPO	European Patent Office
FTO	freedom to operate
GERD	gross domestic expenditure on research and development
HERD	higher education research and development
IP	intellectual property
OECD	Organisation for Economic Co-operation and Development
R&D	research and development
ROI	return on investment
SMEs	small and medium-sized enterprises
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization

Executive Summary

The Canadian university sector is celebrated as an engine of innovation with the U15, a collective of some of Canada's most research-intensive universities, accounting for 79 percent of all competitively allocated research funding in Canada and 83 percent of all contracted private sector research in Canada.

Since a significant amount of Canadian research and development (R&D) takes place through universities, it underscores the importance of the university sector and the need to assess the returns it generates on that investment, recognizing those returns are material to Canada's long-term competitiveness.

The central purpose of this paper is to examine publicly funded university research in Canada in terms of outcomes, namely, intellectual property (IP) as indicated by patent data, the resultant ownership of the IP generated and the implications for impact on freedom to operate (FTO), a measure of Canadian firms' ability to commercialize their technology given the IP landscape of their competitors.

While patents are used in this paper to understand commercialization activity and movement of economic value, this paper is not about patents — patents are only one form of IP in the "cloud" of IP rights. Since the other forms of IP (confidential information, know-how, software, copyrighted works, data, licence agreements and so forth) are not publicly disclosed and do not have ownership tracked, patents are used here as an identifier for the entire cloud of IP rights.

Against a backdrop of low levels of business investment in R&D, this paper finds a university sector that is significantly weaker at commercialization than its American counterparts — a system that, without intention, promotes a strong tendency for Canadian-generated IP (including patents) to land in the hands of foreign firms.

Public funds are being allocated to research projects without accountability for clearly defined outcomes that benefit Canadians and the Canadian economy, including enhanced FTO and a focus on commercialization by Canadian firms. Based on the extent to which Canadian U15 research generates IP that lands in the hands of foreign firms and reduces Canadian firms' FTO, a majority of the U15 universities receive a failing grade on *Canadian innovation.* Inadvertently, but in very real terms nonetheless, U15 research that is funded by the federal government is generating more economic benefit for foreign companies and countries than it is for Canada.

Ultimately, Canada's strong track record at invention does not equate to Canadian innovation. Invention is about creating something new while innovating is about putting it to use; one involves making a leap and the other involves reaping the rewards. Far too often, Canada has not been receiving the rewards of its own invention.

Historically, Canadians benefited from foreign investment in the traditional economy of goods and services through the multiplier effect. However, Canada is now amid the rise of a new economy, increasingly based on intangible assets such as software, data assets and IP, where the multiplier effect no longer holds. The digital economy manifests zero-sum benefits; even those foreign firms that come to Canada and employ its workers, leave the country in a net negative position if they take the IP generated here, as Canadians do not get to participate in the economic returns of ownership.

It is the hope of the authors that this analysis will illuminate some paths for Canada to better capitalize on its investment.

Introduction

Commentary and analysis from Canada's Economic Strategy Tables (Innovation, Science and Economic Development Canada 2019) emphasize the urgency of addressing Canada's competitiveness. Among many factors, the rate of technology adoption is identified as a weak spot in comparison with other leading global economies, underscored by Canadian performance on key investment indicators.

Recognizing the role of R&D investment as a critical driver of growth, the *Building a Nation of Innovators* report (ibid.) echoes this discussion, outlining Canadian levels and trends in investment across the various sectors that make up gross domestic expenditure on research and development (GERD).

Canadian GERD investment is noted to have declined as a percentage of GDP from 2.03 percent (2001) to 1.53 percent (2017), largely attributable to business enterprise research and development (BERD), which has fallen from 1.25 percent (2001) to 0.82 percent (2016) of GDP, and higher education research and development (HERD), which has been flat at around 0.66 percent of GDP for 15 years while other countries have accelerated investments (ibid.).

The weak levels of Canadian BERD are well documented and reflected in a key objective of the Economic Strategy Tables: to raise Canada's Organisation for Economic Co-operation and Development (OECD) ranking on BERD from 0.9 percent to 2.0 percent of GDP (Innovation, Science and Economic Development Canada 2018). The reasons for Canada's anemic BERD levels are often raised, usually with a reference to the nation's lack of large companies that tend toward greater R&D investment.

This paper focuses on HERD investment in Canada and specifically the case of public funding of R&D through the U15 university network,[1] including an examination of the productivity of that investment and the IP outcomes, and a discussion around the potential relationship between those outcomes and BERD investment levels in Canada. Specifically, the authors suggest that the success of Canadian universities at commercializing R&D and the extent to which the associated IP remains in Canadian hands, have an impact on the ecosystem as a whole, including the attraction of new investment.

As a result of beginning to recognize the value of innovation, Canada is expanding its public support of R&D. This focus has elevated the need to evaluate how that support ultimately benefits the Canadian public. Central to this evaluation is understanding the ownership of IP generally and not only patents, because the companies and organizations that own IP, capture a disproportionate share of profits in global value chains (Schwartz 2019). Multiple levels of government have recognized the IP protection imperative. In 2018, the federal government launched Canada's Intellectual Property Strategy, which is designed to enable better understanding and protection of and access to IP. In 2022, the Ontario government launched IP Ontario to help clients access IP strategy advice, legal expertise and educational resources. The shift to an explicit and proactive policy stance on Canadian IP at universities is found in language from the 2021 mandate letter of the federal minister of innovation, science and economic development to "Establish a new fund to help colleges and universities commercialize leading research, including identifying and securing patent rights for research done within their institutions and connecting researchers with people and businesses to help put these innovations into action and grow our economy."[2]

This paper facilitates this endeavour by tracking two IP ownership factors critical to a meaningful discussion of the issues: the performance of the investment in terms of outcomes and the degree to which these outcomes benefit Canadians. This discussion centres on the flow of publicly funded research dollars to Canadian universities, the resulting generation of IP, the projected value of this IP and the ownership destination of the IP stemming from this R&D.

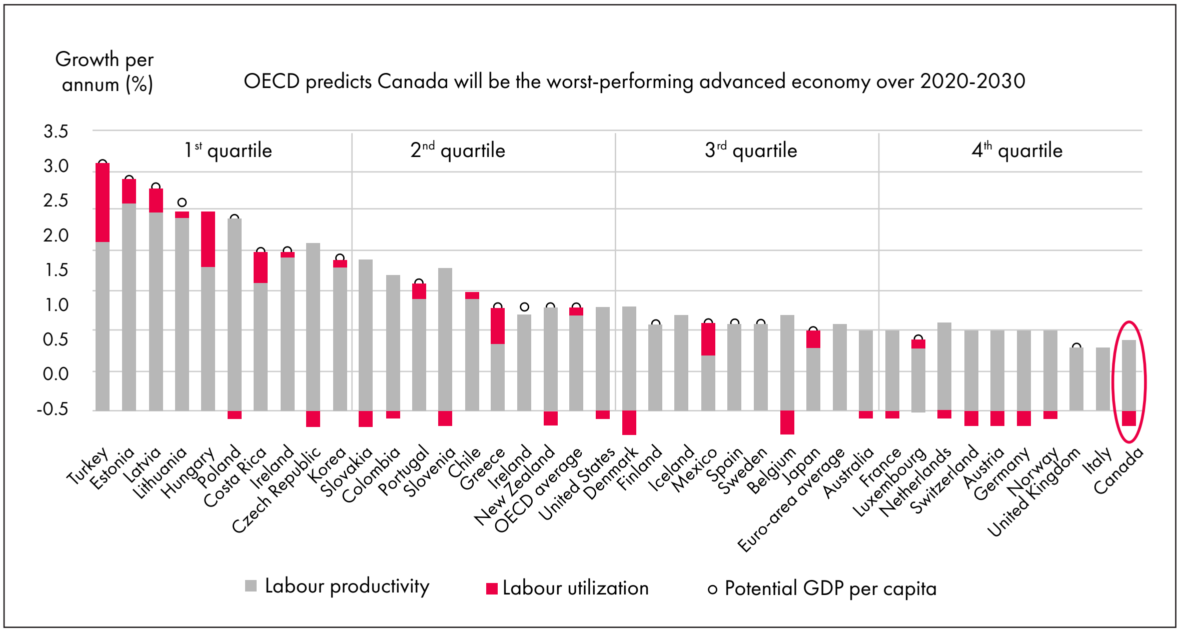
The need to evaluate the effectiveness of Canada's public funding of university-led R&D is not a novel concept. There is clear merit owing to the significant level of investment in absolute terms, the proportion of public investment in the university sector as compared to other countries, the opportunity cost of those dollars for public benefit, and questions around the effectiveness of this funding as a lever for national innovation, commercialization and productivity growth.

What would it take to declare the Canadian government's legacy of funding university research programs a success? Any evaluation of success depends on understanding program performance through established metrics benchmarked against peer nations. The metrics should include a measure of how university research supports the commercialization of technology by Canadian firms and should carry the assurance that Canadians and the Canadian economy are the principal beneficiaries.

1 The U15 is a group of Canadian research universities: the University of Alberta, the University of British Columbia (UBC), the University of Calgary, Dalhousie University, Université Laval, the University of Manitoba, McGill University, McMaster University, Université de Montréal, the University of Ottawa, Queen's University, the University of Saskatchewan, the University of Toronto (U of T), the University of Waterloo and Western University. Where possible, these universities will be referred to by their abbreviations going forward (for example, UBC, Calgary, Western).

2 See https://pm.gc.ca/en/mandate-letters/2021/12/16/minister-innovation-science-and-industry-mandate-letter.

Figure 1: Projected Real GDP per Capita Growth among OECD Countries (2020–2030)



Source: Williams (2021).

Canada's productivity woes highlight how important it is to understand and optimize how public resources are applied to R&D. In 2021, the OECD predicted that Canada will be the worst-performing economy over the next decade (see Figure 1) — and for three decades after that (Guillemette and Turner 2021).

Canada's real GDP per capita grew 0.8 percent annually from 2007 to 2020 (ibid.), ranking in the third quartile among advanced countries. Looking forward, Canada's projected poor performance is predicted by weak labour productivity and labour utilization. This projects a lower growth in real GDP per capita, while other less well-off economies will have higher growth in real GDP per capita and suggests a need for policy renewal to support a more productive economy.

Public funding has a mission-critical role to play in addressing these issues, even acknowledging that commercialization of a new discovery is not the only objective of university research. To be effective, however, this funding must be underpinned by R&D mandates with specific and measurable objectives promoting Canadian competitiveness, economic performance and productivity growth. Identifying the levers for boosting labour productivity growth and real wage growth through higher business investment per worker, initiatives to enable technology uptake and innovation, and policy enabling Canadian companies to scale, will be paramount. Smarter R&D funding has been highlighted as one of several critical factors influencing productivity growth along with competition and skills (Malinovskaya and Sheiner 2016).

Taking a narrower lens, the goal of this paper is to provide insight into how Canada can leverage its public R&D funding in ways that encourage better protection and commercialization of Canadian-generated IP to realize the maximum return on public investment for Canadians.

Background

Canadian R&D Funding

The university sector in Canada represents a significant proportion of the R&D activity in Canada. One of the challenges in analyzing R&D investment outcomes is the fact that different sources publish different R&D investment numbers based on variance in who and what is included in the pool. The U15 is a group of Canadian research universities that includes some of the most research-intensive universities in the country. According to its website, the U15 conducts $8.5 billion[3] worth of research annually, which represents 79 percent of all competitively allocated research funding in Canada and 83 percent of all contracted private sector research in Canada.[4] AUTM (formerly the Association of University Technology Managers) recorded $6.98 billion in research expenditure through its Canadian members for 2020 (AUTM 2020a). Statistics Canada reported that R&D expenditures in the higher education sector in Canada increased 4.6 percent from 2018 to 2019 to $15.8 billion in 2019–2020, noting this was the tenth consecutive annual gain (Statistics Canada 2020a).

A significant percentage of the R&D funding for Canadian universities comes from the public sector. Statistics Canada reports that for 2019–2020, the biggest R&D funders in the HERD sector were the HERD sector itself ($7.8 billion), federal government ($3.8 billion), provincial governments ($1.3 billion), business ($1.3 billion), not-for-profit sector ($1.6 billion) and foreign funders ($0.14 billion) (AUTM 2020a). Ultimately, much of the HERD sector funding derives from grant programs such as the Social Sciences and Humanities Research Council and Natural Sciences and Engineering Research Council, suggesting that between the federal and provincial governments, about 90 percent of R&D in the higher education sector in Canada flows from public funding sources. These numbers are supported by AUTM for 2020, where 40.7 percent of Canadian member funding is reported to come from the federal government and 47.8 percent from "non-classified sources," reportedly most of which is provincial funding (ibid.).

Both AUTM and Statistics Canada report the larger role of Canadian universities as compared to other advanced countries in national R&D spending. According to Statistics Canada, from 2010 to 2019, Canada led the Group of Seven countries in higher education R&D intensity, the percentage of higher education R&D expenditures to GDP, with scores ranging between 0.65 and 0.70. In 2019, Canada scored 0.68 while the second- and third-ranked countries were Germany and France at 0.56 and 0.44, respectively (Statistics Canada 2022a). For 2020, AUTM reports a HERD intensity number of 0.68 for Canada as compared to 0.37 for the United States. Canada also ranked sixth among all OECD countries in HERD intensity (AUTM 2020a). The same is not true for Canadian R&D spending as a whole, considering Canada's GERD numbers. Canada's GERD intensity at 1.71 percent is well behind that of other advanced economies such as the United States (2.79 percent) or the OECD average (2.4 percent) (Gera 2015).

The implication is that Canada has a disproportionate number of its R&D eggs in the higher education sector basket as compared to other countries. Arguably, this is partially the result of anemic BERD levels, but it is also attributable to high comparative HERD numbers. Public funds are being poured into the university sector in the name of innovation, but what are Canadians getting for it?

Canadian IP Ownership and FTO

Previous studies have highlighted Canada's general problem with IP capture and commercialization, pointing to the more than 50 percent foreign ownership of Canadian-generated patents (Canadian Intellectual Property Office [CIPO] 2017). When this foreign capture occurs with Canada's IP originating in the university sector, there should be public concern; the incidence, intensity and conditions of foreign ownership should be the result of transparent and purposeful strategy. It should be acknowledged that R&D at research institutions is not solely commercially motivated. Research can be led by a researcher whose primary focus is an inherent interest in the technology, notwithstanding a commercial application. The fundamental nature of this research, absent of a known commercial problem, is potentially a noble and important endeavour. If not protected, it can either be overcome or co-opted by other research (for example, by patenting the valuable commercial applications). The cost of this approach, however, should be both acknowledged and balanced against the public economic interest.

Unfortunately, foreign ownership of publicly funded Canadian-generated IP is too often the result of ad hoc negotiations with little accountability to Canada as the funder and Canadian competitiveness as the deserving beneficiary. Worse, the foreign ownership of this IP constricts Canadian FTO by preventing Canadians from practising in the space of the foreign-owned IP. This is particularly true

3 All dollar figures in Canadian dollars unless otherwise noted.

4 See https://u15.ca/about-us/.

when large foreign firms use their dominant IP and data position to restrict innovation.

FTO is a business's ability to commercialize its technology while navigating the IP and intangible asset positions of its competitors — a business cannot commercialize what it does not own. In specific cases, an FTO review of a patent assesses whether the making, using or selling of a product or service infringes any one or more claims of a patent. Companies having FTO own valuable IP and data assets and can therefore commercialize their technology globally and at scale. Without a competitive IP position, a company will have reduced FTO and can be legally limited, financially penalized, and/or entirely restricted in business operations by a competitor who does hold IP that can be leveraged and asserted.

There are two principal ways that research projects find a home within universities in Canada. In the first instance, an industry partner will arrive with a problem, asking for help in solving it. In this situation, there is limited opportunity for commercial propagation inside Canada if the industry partner is not principally located in Canada. The university benefits because it is able to show it is the recipient of research funding, and researchers do benefit from the knowledge and expertise of foreign multinationals, but Canadian industry is left out in the cold as the commercial rights to the IP will be exclusively held by the foreign industry partner. Canadian research talent is essentially functioning as a hired gun to enrich foreign investors or taxpayers. In the second instance, a researcher at a Canadian university will come up with a solution to something. In this scenario, the challenge is usually a lack of local commercial receptors for the project (local Canadian industry partners to anchor the IP in Canada). The dearth of large, sophisticated Canadian companies with whom university researchers can partner is something to acknowledge and address in establishing healthy Canadian policy.

The terrain of prospective Canadian industry partners with whom inventors may partner is comprised of a very few big firms, some small and medium-sized enterprises (SMEs) and many start-ups. This has implications because while the start-ups represent the great hope of innovation and future productivity growth, they usually cannot be patient enough to wait on the time- and resource-intensive process of discovery through the university sector. The twin challenge of this situation is how best to stoke the fires of commercial innovation in the university sector and start-up economy while commercially benefiting Canadians. This paper begins to answer some of these questions, but more work will need to be done.

Methodology

The methodology of this study includes an approach to assessing both the productivity of R&D investment and the benefit of that investment to Canadians and to the Canadian economy:

- Evaluating the performance of R&D expenditures through the university sector in Canada involves three related subtopics:
  - the utility of using patents as a metric of investment outcome;
  - the mechanics of identifying a university-derived patent; and
  - the method for determination of the commercial value of patents.
- Evaluating the benefit of R&D outcomes to Canadians and the Canadian economy involves measuring the proportion of Canadian-generated patents where the IP is in domestic versus foreign control.

Measuring the Performance of Publicly Funded R&D

Patents as a Metric

Research outputs include numerous legal IP mechanisms, including non-registerable practical knowledge that is not easily transferred ("know-how"), trade secrets, confidential information and registerable types of IP such as patents, designs and copyrights. As universities are generally required to publish the results of their research for peer review and credibility reasons, relying exclusively on trade secrets or confidential information is not a viable long-term option. If patents are not used, and the details of the technology are published, then the technology becomes part of the public domain and those that are better positioned and resourced will often be able to commercialize more quickly. Accordingly, patents are critical to maintain some level of proprietary advantage necessitated by commercial realities. An industry partner may not adopt the technology unless they have some level of exclusivity that a patent provides. Otherwise, once they have commercial validation, competitors or new entrants will copy without recourse.

While this study focuses on patents as a core piece of the IP that provides exclusivity to the university-generated research, they represent the entire cloud of surrounding IP rights. In this sense, patents have been used as an indicator, while in reality, the entire cloud of IP rights may include trade secrets, design and/or copyrighted works such as software. In addition, for the reasons outlined above, other forms of IP may be less likely to track in any quantity and be relevant to the discussion of commercialization in a university setting. Patents therefore represent a singularly useful and appropriate measure.

As with any indicator, limitations exist to using patents to measure IP capture, such as the variation in patentable innovation across industries and variation in the relative quality of patents, particularly across jurisdictions. The limitations of using patents as an indicator of innovation have been discussed (Greenspon and Rodigues 2017). Even in the case of patentable subject matter, professors may also work directly with industry partners to provide direction on where the research is headed and the practical knowledge to use the patented technology effectively, something that is not transferable with a patent or licence. Furthermore, it is not until many years after a patent application is filed that its true commercial contribution to the state of the art may be known. Patents are just the tip of the innovation iceberg — aggregating university-generated patents and their values indicates trends rather than absolute value transfer. Comparing patent-based numbers from Canadian research institutions to other benchmarks while recognizing these limitations nevertheless provides important insight into the success and, importantly, the direction of public R&D investment.

Identifying a University-Derived Patent

University patent ownership policies vary from inventor owned, to institution owned, or some mix of the two. These are default positions of the policy, and they can be varied based on agreement, such as with industry sponsorships. Under inventor-owned policies, the inventor (researcher) will be able to decide who will own the product of their research. In some cases, the university's technology transfer office or industry liaison office will help the researcher to find an industry partner for the technology, in exchange for a fee (for example, a portion of royalties). In either case, the university may or may not be assigned any rights, so it may not appear on any recorded title. This results in an opaque understanding of the designation of the research outputs because the owners are the researchers/individuals, and then the research partner, and the university where the research was generated may not be identified.

This paper uniquely includes university-derived patents based on the inventor and their association with the university rather than solely looking at a university assignee. This allows for the capture of a more comprehensive set of patents originating at universities.

Determining the Commercial Value of Patents

While there are many valuation methods, this analysis utilizes patent valuation assessments from the PatSnap database. The PatSnap database provides coverage of more than 90 countries worldwide, offering full text data from organizations such as the European Patent Office (EPO) and the World Intellectual Property Organization (WIPO), and countries such as China, Germany, Japan and the United States. PatSnap covers more than 160 million patents and employs an indicator approach to patent valuation, which consists of qualitative consideration of a patent's value based on distinctions in the features of a patent. There are several considerations used in this approach, including the number of inventors, number of citations, patents per employee, age of patent, patent status (granted or pending), litigation, patent family size and International Patent Classification.

Determination of Foreign versus Domestic Control of Canadian-Funded R&D

Identifying the ownership and commercial rights associated with a patent that has been generated through R&D at a Canadian university is relatively straightforward when the university shows up on the title of the patent. In the event the patent is inventor owned, it is less straightforward. For the purposes of this analysis, patents were identified by looking through faculty webpages and public sector salary disclosures, pursuing an inventor search in patent databases and ensuring connection to the proper name. This process involved identifying the class of potential university inventors, including through faculty webpages and employee lists. This list of potential university inventors was searched in global patent databases as inventors, to create a total list of patents and patent applications having those inventors. The data was manually cleaned and verified to ensure that individuals at universities had connections to the resulting patents. The final list of patents and applications was analyzed based on assignee (the owner of the patent) and their primary business location.

Scope

This study covers Canadian patent applications filed between 2006 and 2015 with the Canadian, European and US patent offices that list present-day professors of the U15.[5]

5 Professors are identified from public directories and salary disclosures.

Results

As shown in Table 1, a total of 2,381 granted patent assets, spread across more than 1,000 professors, were identified. When adjusted for similar patent publications and filings at multiple offices, this number comes to 1,851 patent families.[6] What follows is a discussion of how these patents break down by different factors such as filing office or university.

Figure 2 shows how each member of the U15 performs based on different metrics relative to patent families. The figure illustrates the proportion of granted patents and patent applications originating from each university. U of T, Waterloo, McGill and UBC had proportionally more activity than the other universities.

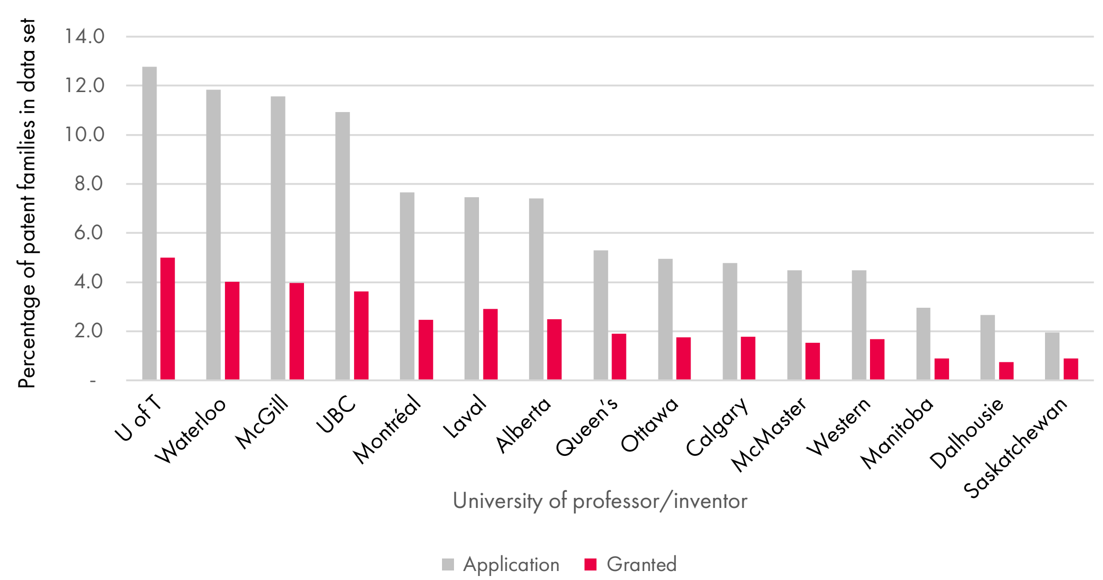
6 The difference in granted patents versus families was predominately due to the similar patent publications rather than multiple office fillings. Percentages are based on simple patent families: each simple patent family is counted once and assigned to one of the listed ownership types. For example, a Canadian industry-owned patent family may have more than one Canadian company (based on the ultimate parent company) as a current assignee but would be counted only once. Patents with more than one type of current assignee are also counted once in the "mixed" category. For a definition of patent families and other terms, see definitions in the appendix.

Table 1: Relative Performance of Publicly Funded R&D Expenditures across Canadian Universities (2006–2015)

	Total Count	Yearly Average U15	Yearly Average per Institution
Patent applications	7,619	762	51
Granted patents	2,381	238	16
Patent application families	5,266	527	35
Granted patent families	1,851	185	12
Professors on applications	1,874		
Professors on granted patents	1,074		

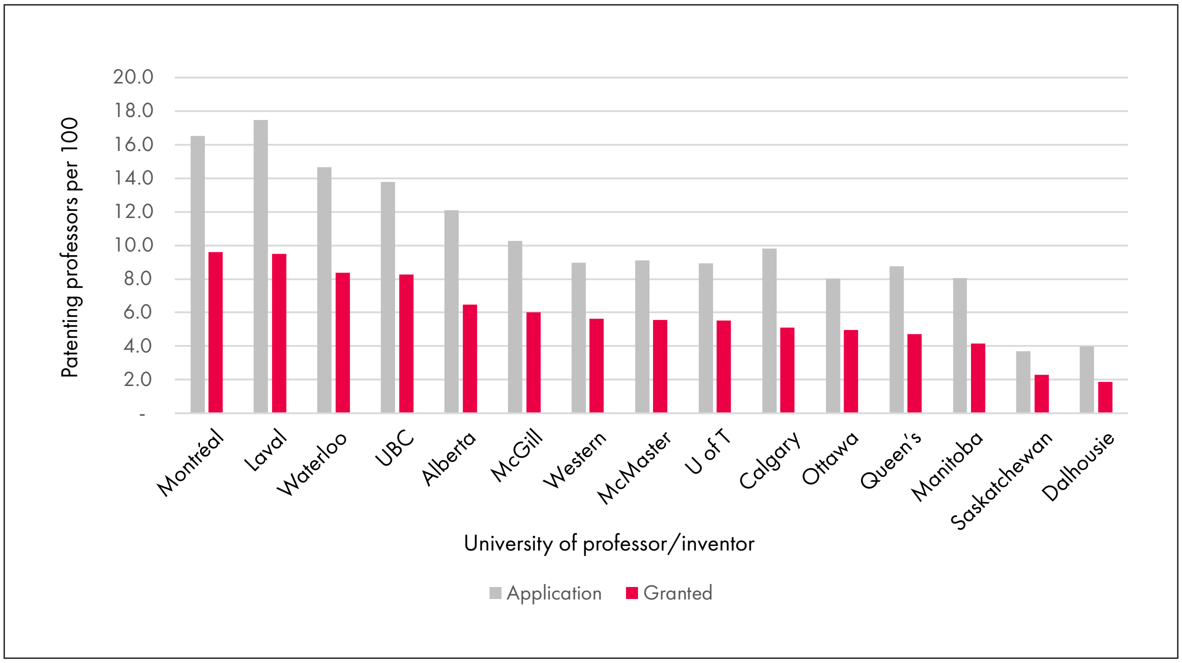
Source: Authors' research compiled from global patent office data via PatSnap patent database, including the United States Patent and Trademark Office (USPTO), CIPO and the EPO.
Note: See appendix for full methodology.

Figure 2: Distribution of Patent Families in Data Set



Source: Ibid.

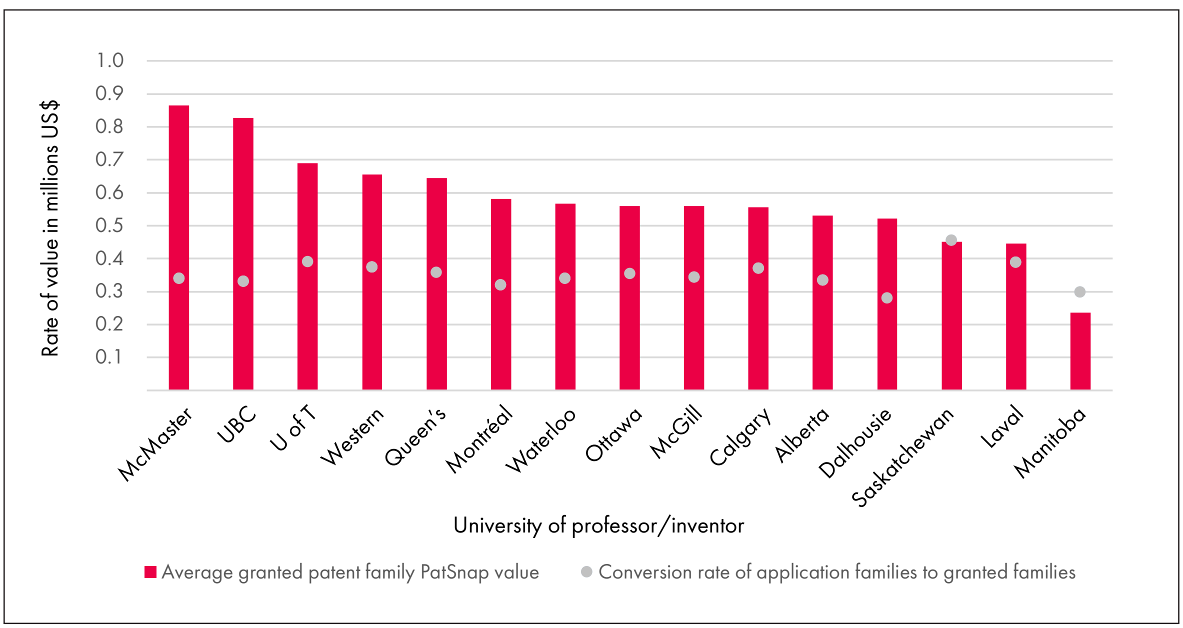
Figure 3: Patenting Professors Relative to Faculty Size



Source: Ibid.

Note: Total full-time teaching staff from CANSIM, including assistant, associate and full professors only (2016–2017).

Figure 4: Conversion Rates and Average Granted Family Value



Source: Ibid.

Figure 3 adjusts the patent activity for relevant faculty size. On an adjusted-for-size basis, for example, Université Laval and Université de Montréal have the highest number of researchers, both making applications and securing patent grants relative to their peers.

Figure 4 shows the conversion from application to grant rates by university as well as the average granted value according to the PatSnap valuation method. The conversion rate from applications to patents granted is fairly consistent across the U15 and is not a significant influence on patent value. UBC and McMaster University are shown to generate the highest average granted patent value for each patent family.

Results indicate that there were, on average, 238 patent grants for each year. This represents 16 patents per university per year on average. Based on the U15's self-report of $8.5 billion in annual research spending, this suggests research funding that averages more than $35 million per granted patent.

For perspective but not direct comparison, a common industry benchmark performance indicator for R&D spending is 0.3 to 0.6 applications for every $1 million spent on R&D (Sullivan 2019). Applying this industry benchmark to the U15's research expenditure amounts to 2,550 to 5,100 new patent applications per year — the amount observed over the entire 10-year period in Canada.

Foreign versus Domestic Control of Canadian-Funded R&D

Who ends up deriving the most commercial benefit from the R&D that does generate patents is one of the most important factors in making the determination of a successful public investment. While this cannot be measured directly, this study endeavours to provide insight by determining the destination of the patents identified as well as presenting these results weighted by monetary value.

Figures 5 and 6 are an aggregation of the data presented in Figures 2 to 4. Figure 5 shows the percentage of identified patent assets that are:

→ unassigned;

→ assigned to an individual;

→ assigned to a mix of assignees;

→ assigned to a research institute;

→ assigned to Canadian industry; and

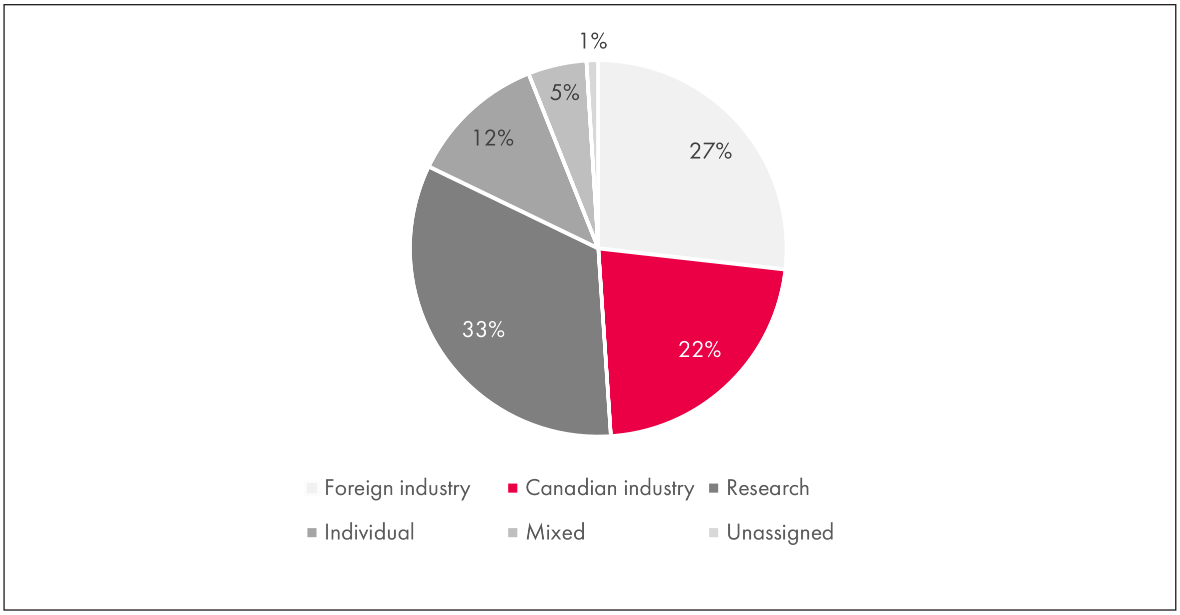
→ assigned to foreign industry.

For assignment to individuals and research institutions, there may be no industry activity or the beneficial ownership of commercial rights, which may be assigned under licence, is not publicly available. According to Figure 5, about half of the identified patents granted end up being owned by industry.

In order to understand what patents are actually being used by industry, Figure 6 shows that of all the patents that are assigned to industry, 55 percent are foreign owned while 45 percent are owned by Canadian industry.

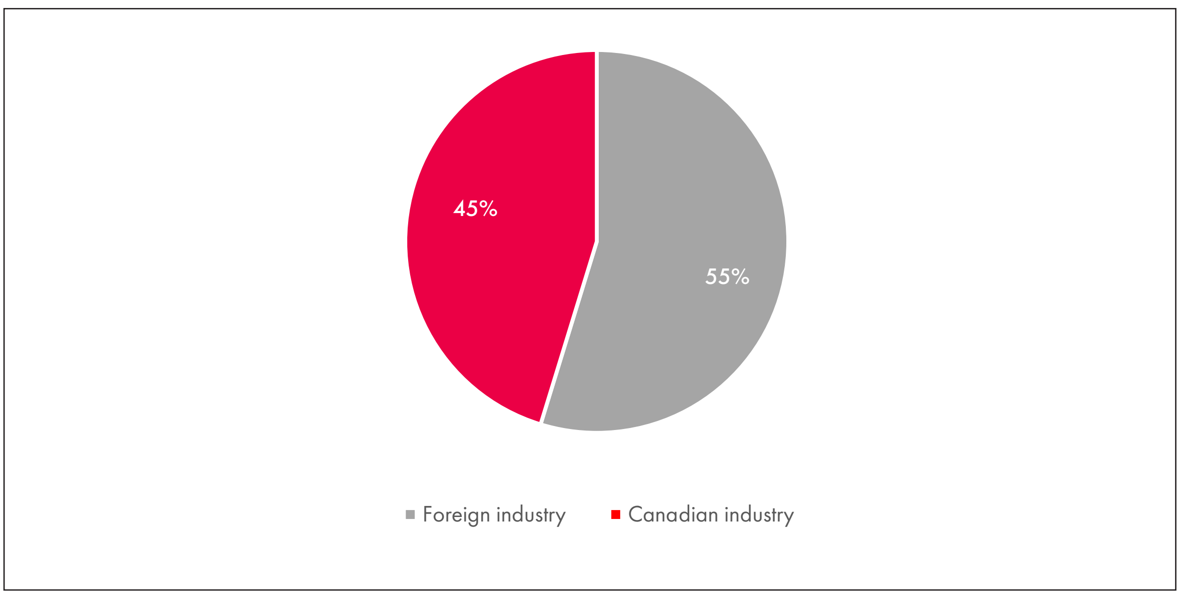
It may be expected that individually owned or research institution-owned IP that is licensed (but not assigned) to a commercial entity would follow the same or similar foreign-Canadian ownership breakdown as with the outright assignment. However, universities do not publicize who licensees are, and the destination of the flow of value through exclusive or non-exclusive licences with industry partners is not publicly available.

Figure 5: Ownership Type of Granted Patent Families by Count



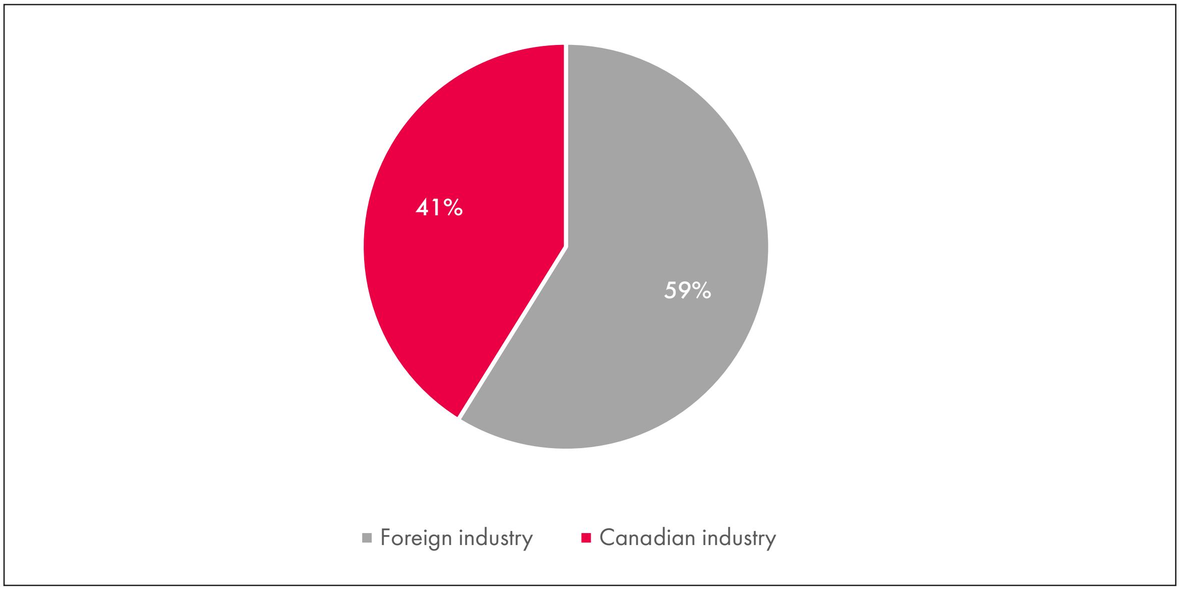
Source: Ibid.

Figure 6: Industry Ownership Type of Granted Patent Families



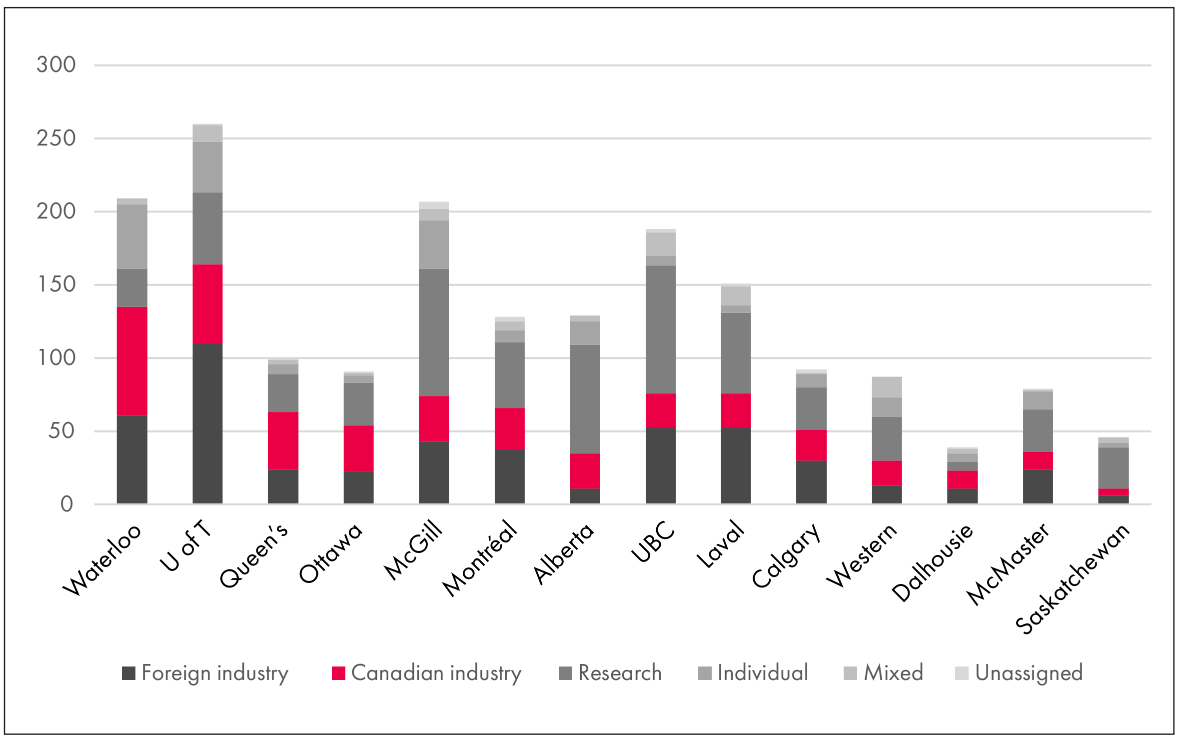
Source: Ibid.

Figure 7: Industry Ownership Type of Granted Patent Families by Value



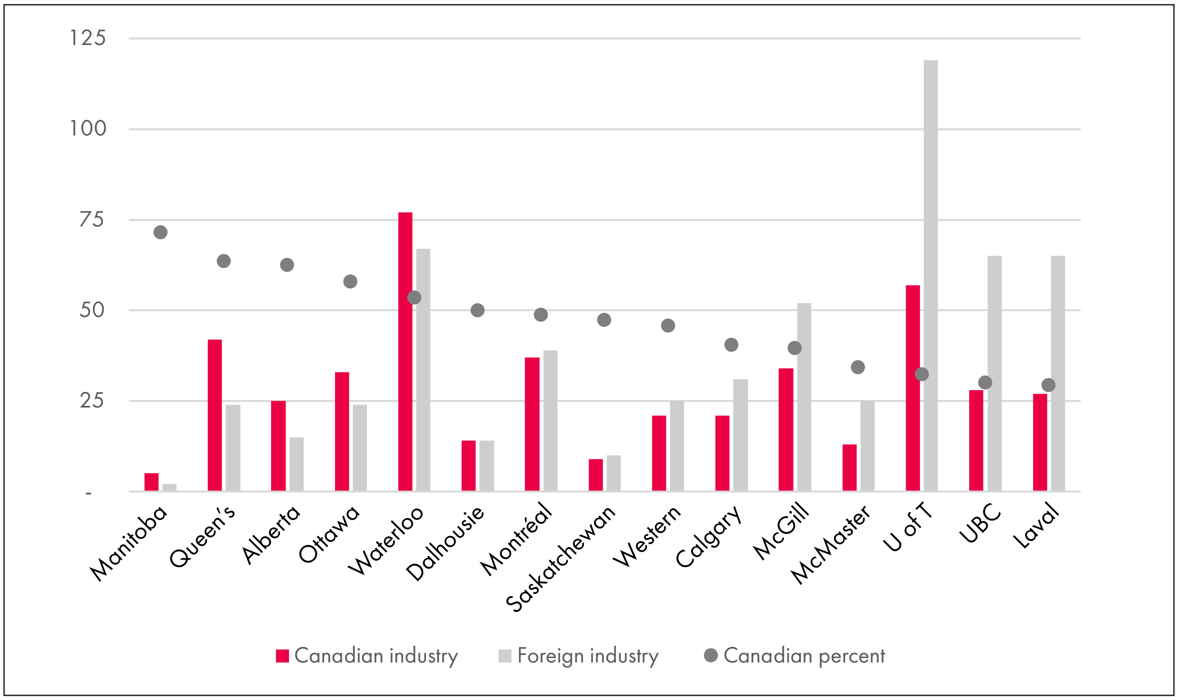
Source: Ibid.

Figure 8: Ownership Type of Granted Patent Families by University



Source: Ibid.

Figure 9: Industry Ownership Type by University



Source: Ibid.

Note: The descending line of grey bullets captures the percent of Canadian IP ownership of each of the U15 universities and provides the basis for the scoring below.

Figure 7 shows that when weighted by the value of patents (using the PatSnap valuation tool), the percent of value being owned by foreign firms rises to 59 percent, showing that foreign industry may also be deriving greater benefit than its Canadian counterparts. This indicates that the foreign-assigned patents have at least as much value as the Canadian-assigned patents.

This situation is very similar to what occurs on the open market for total Canadian-generated patents: 58 percent of Canadian-invented patents that are filed in the United States are assigned to foreign companies (CIPO 2017). Therefore, universities do no better at retaining IP in the Canadian economy than the general public and industry.

Figure 8 shows the breakdown of the totals shown in Figure 5 at each of the universities. For nine of the 15 universities, foreign industry owners of patent families outnumber Canadian industry owners.

Report Card: Canadian University Class Rankings

This report card is an illustration of the extent to which Canadian universities drive innovation for Canadian economic benefit through commercialization by Canadians. FTO is employed as the critical outcome measure, capturing the performance of universities as participants in the cause of promoting innovation by and for Canadians.

In considering the impact of U15-generated IP on Canadian firms' FTO, this paper has examined two factors: IP ownership and number of patents granted.

IP ownership: The ratings in this scorecard reflect the percentage of IP generated that remains in the hands of Canadian owners. Overall university scores have been constructed based on impact to FTO through a determination of the percentage of IP generated by a university where the commercial rights are retained under Canadian control: A (80 percent and above); B (70–79 percent), C (60–69 percent), D (50–59 percent) and F (under 50 percent). Figure 9 breaks down Figure 7 by university. The scores are based on the percentage of industry-assigned IP (as indicated by patent and ownership) data that is assigned to Canadian industry. A passing grade means that, on balance, more IP is supporting Canadian firms than foreign firms, where publicly funded IP from the institution (at least in part) increases Canadian innovators' FTO. A failing grade means the institution limits Canadian innovators' FTO because more IP is supporting foreign firms than Canadian firms.

Number of patents granted: The performance of the universities in securing granted patents is also discussed in the context of impact on Canadian firms' FTO. Universities with more granted patent families are understood to have a greater impact on Canadian innovation, but that impact may be either net positive or negative, depending on the percentage of IP that is Canadian owned.

Class average: 47 percent

Honours (Grade A): These universities excel by providing significant FTO for Canadian innovators through a high percentage of Canadian-owned IP.

- No universities scored this grade.

Pass (Grade B, C, D): These universities provide some or little FTO for Canadian innovators through a moderate percentage of Canadian-owned IP.

1. University of Manitoba: B (71%)
2. Queen's University: C (64%)
3. University of Alberta: C (63%)
4. University of Ottawa: C (58%)
5. University of Waterloo: D (53%)
6. Dalhousie University: D (50%)

Fail (Grade F): These universities provide a net negative impact on Canadian innovators' FTO because they generate more IP that is or becomes foreign owned.

7. Université de Montréal: F (49%)
8. University of Saskatchewan: F (47%)
9. Western University: F (46%)
10. University of Calgary: F (40%)
11. McGill University: F (40%)
12. McMaster University: F (34%)
13. University of Toronto: F (32%)
14. University of British Columbia: F (30%)
15. Université Laval: F (29%)

Comments

Given the negative rights nature of IP, as exemplified by patents, FTO can be viewed as zero-sum. Every cloud of IP, including the patents that are visible, that is held by a foreign company, works to prevent any existing or potential future Canadian company from commercializing that technology. On this basis, each university is given a grade reflecting the percentage of IP it generates that remains Canadian owned. In assessing the extent of a university's impact on Canadian firms' FTO, the scale of the university's activity in securing patents also needs to be considered.

A more fulsome assessment of institutional impact on Canadian firms' FTO needs to consider both IP ownership and number of patents generated. This is because the volume of patents generated influences the effect of IP ownership to be more or less impactful. The Canadian universities of the U15 can be grouped into four categories according to whether they generate more or less than 50 percent Canadian-owned IP and whether they generate a volume of patents that is greater than or less than the median:

- **Greatest positive impact:** These institutions generate a higher percentage of Canadian-owned IP, and their number of patents granted is above the median. These schools are making a strong (relative to the pool) net positive contribution to Canadian firms' FTO.
- **Moderate positive impact:** These institutions generate a higher percentage of Canadian-owned IP, but the number of patents granted is below the median. These schools are making a weak (relative to the pool) net positive contribution to FTO.
- **Moderate negative impact:** These institutions generate more IP that lands in the hands of foreign owners, and their number of patents granted is below the median. These schools are making a weak (relative to the pool) net positive contribution to FTO.
- **Greatest negative impact:** These institutions generate a lower percentage of Canadian-owned IP, and their number of patents granted is above the median. These schools are making a strong (relative to the pool) net negative contribution to Canadian firms' FTO.

It is greater negative impact universities (receiving an F grade) that pose the greatest threat to Canadian FTO, as they are relatively more efficient at generating IP for foreign owners.

The two-by-two matrix in Figure 10 groups members of the U15 according to two dimensions: the percentage of their patent families (having at least one granted patent) that is Canadian owned and the absolute volume of patent families.

Interpretation

A major contribution of this study is to examine the foreign versus domestic control of Canadian-funded R&D. In contrast to other report cards that evaluate university R&D performance based on the level of funding and find it to be "middling" (for example, The Conference Board of Canada [2021] gives Canada a C and ranks it thirteenth out of 26 countries), this research is focused on outcomes: patents, IP ownership, and the implications for Canadian firms' FTO and, by extension, their ability to innovate at scale.

While not homogenous, the U15 as individual units provided the same understanding as the whole; objectively, since Canadian universities generate more patents for foreign companies, Canadian universities reduce the FTO for Canadian innovators because the universities are net generating more patents for foreign companies that can leverage this position to reduce the ability of a Canadian company to commercialize (for example, by blocking or preventing company creation in this area). While not all patents are equal in value, the value of foreign-owned patents was shown to be of greater value than the Canadian-owned patents (see Figure 7), so the reduction of FTO is comparable on a net basis.

While international companies may provide students with experience and global presence, Canadian universities may also be seen as low-cost research labs for hire by international companies. This is particularly dismaying because it is the public purse that represents the overwhelming source of university R&D funding.

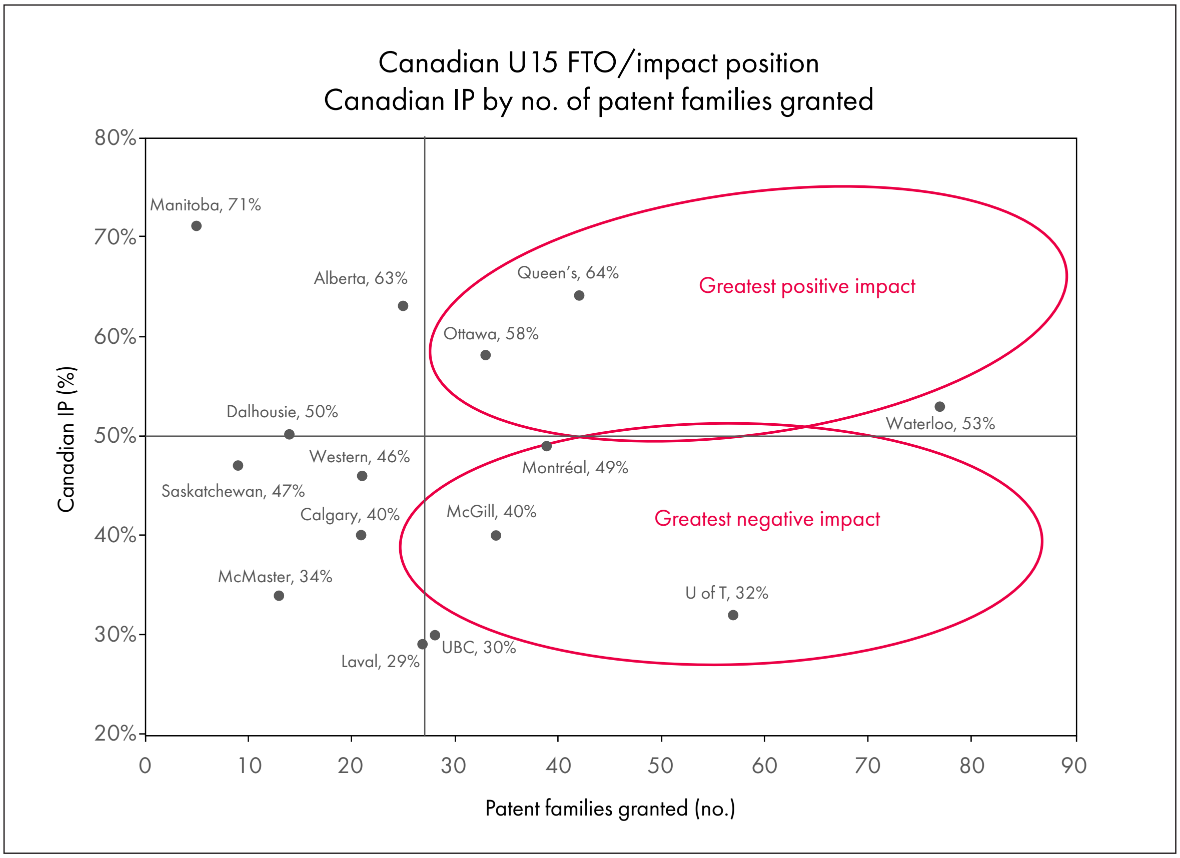
The reduction of FTO for Canadian firms happens, to some extent, because research that originates through the university sector, but is commercially driven in whole or in part, will often attract or even be initiated by a foreign industry partner. In these partnerships, industry funding often complements existing funding provided by various other sources from the university (such as government grants, philanthropic contributions and student fees). With the possibility of direct commercial opportunities if successful, the industry-led research is likely to have greater initial monetary value. Typically, however, industry often receives all of the IP for particular projects despite contributing only a portion of the total resources to the project. More broadly speaking, only 11.5 percent of universities' total research funding comes from industry (with the remaining 88.5 percent coming from federal and provincial sources), which raises questions of whose interests are prioritized (AUTM 2020a). Of course, students and researchers will gain experience and training; however, the fruits of the underlying funding flow to these foreign companies.

The real source of pain for Canada is a function of the university sector's mediocre economic performance outcomes, combined with the relatively scant amount of R&D that takes places directly through industry. By comparison, other countries have massive industry-driven R&D expenditures that yield patent applications, granted patents and ultimately valuable IP that can be commercialized. A 2020 study on IP revealed that Canada is not even in the top 20 countries globally among resident patent applications when scaled for GDP (WIPO 2020). To put this industry-academic chasm in perspective, the United States was reported to have spent 13.6 percent of its R&D at universities with approximately US$612 billion spent on R&D in 2019,[7] and AUTM data indicates US$83.1 billion went through US academic and not-for-profit research institutions (AUTM 2020b). The same balance is not present in Canada where 26.1 percent of R&D spending happens at universities, with total Canadian R&D expenditures reported to be $26.6 billion in 2019,[8] and AUTM (2020a) reported that $6.98 billion of R&D spending went through the university sector. Almost twice as much of Canada's R&D investment happens at publicly funded Canadian universities and research institutes, as compared

7 See https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm.

8 Ibid.

Figure 10: FTO Total Impact Score by University



Source: Ibid.

to the United States, which highlights the importance of ensuring that Canadian universities are working for Canadian economic advantage.

Compared to other countries, Canada lacks the presence of a robust, vibrant, industry-led R&D program. Canada exhibits a relatively smaller R&D spend compared to other nations both when scaled for GDP (OECD 2020) and when adjusted for population.[9] And for several contributing reasons, many of Canada's eggs sit in the same basket when it comes to funding R&D, with the vast majority of R&D activity taking place inside its universities. For perspective regarding higher-learning institutions, the non-Canadian university with the highest number of granted patents is the University of California, with 489, followed by the Massachusetts Institute of Technology, with 278. In comparison, the top five industry assignees were granted patents at the USPTO in 2021, numbering in the thousands (International Patent Office 2018).

Accepting that low levels of Canadian business investment explain this difference to some extent, it is nonetheless true that Canada is both over reliant on Canadian universities for R&D and significantly underperforming in its ability to commercialize. According to AUTM, Canada underperforms on both new patent applications and licensing income. For 2021, US AUTM data recorded 2.14 new patent applications per US$10 million in research expenditure and a return on investment (ROI) of 3.5 percent (AUTM 2020b) while in Canada, the comparable numbers were 1.27 and 1.76 percent, respectively (AUTM 2020a).

Looking ahead, decisions relating to the funding of Canadian universities must recognize their historical limitations as agents of innovation, based on a demonstrated anemic capacity to realize commercial ROI (Arora 2019). Universities have a valuable role to play in the innovation

9 See https://ourworldindata.org/grapher/patent-applications-per-million.

economy: talent creation through training and education, and fundamental research that may ultimately be philanthropic.

Improvement to the policies and practices of Canadian universities is clearly needed, and recommendations made in the Ontario Expert Panel on Intellectual Property (2020) should be undertaken. In particular, universities should provide essential IP (business, engineering, legal) training to students and faculty through courses and hands-on training in IP clinics. If universities have on-campus incubators, IP education and services must be embedded. In addition, stoking the fires of Canadian innovation will ultimately demand funding approaches and tax policy that focus more resources into the hands of Canada's scaling companies rather than perpetuating over reliance on universities. Innovation funding to intermediaries such as incubators and accelerators must also be governed by proper IP retention strategies. Ultimately, the authors see a strong role for universities, both as engines of invention and innovation, guided and governed by policy that will facilitate a better record of commercialization through both universities and the private sector — for the benefit of Canadians.

Professors at publicly funded universities arrive with strong skill sets that may not have been funded publicly, but lucrative partnerships stemming from years of work at the institution should qualify for maximizing the social and economic benefit of the technology for Canadians. By leaving the process entirely open, strong international players have been able to disproportionately reap the rewards, patent on top of the existing IP and reduce or eliminate FTO for Canadian companies.

There is evidence that IP plays a role in attracting investment and driving growth. An OECD report discussed the economic impact of IP as knowledge-based capital and highlighted the role that different forms of IP have in attracting investment. IP rights are understood to support innovation by making it a more worthwhile investment and stimulating knowledge diffusion. The report points out that while there have been more empirical studies relating to the role of patents, copyright appears to be the type of IP that is attracting business investment at the highest growth rate (OECD 2015). Another study demonstrates a positive relationship between IP and business investment. Using the United States and European Union as examples, Patrick Otomo (2017) found that patents have an increasing effect on R&D at a decreasing rate, contrary to the expectation that patent influence would simply be negative.

Recommendations

The evidence suggests Canadian universities have not been an answer to solving Canada's innovation challenges. Based on FTO, Canadian universities have failed at innovation. This reality cannot be blamed on the universities alone and, in particular, not on the dedicated and talented researchers, whose proven track record for invention is acknowledged. It is more likely a reflection of gaps and deficiencies in Canadian leadership on innovation policy, with universities doing what they can under the framework and guidance of outdated policy. While the role and practice of universities is a part of the problem, a singular focus on fixing them is not the solution, nor will efforts at addressing university effectiveness in this regard be sufficient.

Universities are part of a larger set of issues, including the well-recognized paucity of large Canadian firms with which they might partner on research projects in the interest of generating and retaining IP in Canada. However, that does not mean Canada should not try to do a better job at innovation through its universities. In a 2022 address to the Public Policy Forum, Robert Asselin (2022) lamented Canada's almost non-existent capacity to undertake industrial research at scale and the weakness of the country's technology mechanisms. Characterizing the innovation ecosystem as one with a deepening divide between the innovation labour of universities and private firms, he made the argument for more coordination and integration, recognizing the value of the foundational R&D that universities excel at, and Canada's failure to translate that into better innovation outcomes and enhanced productivity.

This paper revealed that there are three destinations for IP generated by Canadian universities: research that is received by Canadian industry, increasing FTO; research that stays with the institution or professor and is not commercialized; and research that is transferred out of the country to foreign industry, thus reducing FTO.

The first group is a mark of success for Canadian economic development because the economic returns of the value of IP can be realized by the Canadian economy. Measures must be taken to increase this transfer, such as no-cost contributions of publicly funded university IP to Canadian companies, having Canadian universities work for Canadians and not against them (Silcoff 2018). Quite rightly, Canadians have already paid for the technology once through the university's public funding and should not have to bargain again to use this technology.

For the second group, IP that is developed but not readily received by industry, consideration should be given to pooling these patents in a patent collective for strategic access by Canadian companies. For example, the patent collective would provide a licence to these patents to Canadian companies that would increase the Canadian companies' FTO. The Canadian companies would not be required to license their own IP into the pool, thereby maintaining their proprietary advantage. In addition, certain patents may be nurtured to provide defensive counter-assertion value for a Canadian company. The practical challenges with setting up and executing a central public resource would need to be navigated.

For the third group, IP that is transferred out of the country to foreign firms, this should be limited by funding policies so that the universities receive a fair ROI. Alternatively, Canadian companies should be prioritized with FTO (for example, a non-assertion type licence) to the IP generated for foreign funders.10 These rights could be managed by an organization such as the patent collective or a centralized resource. Ultimately, there must be some incentive to retain innovation's economic value in Canada and a price to pay for losing the economic returns that public funders expect in exchange for receiving Canada's generous investment in research.

Specifically for universities, there is considerable potential for the federal government's role, particularly as direct federal funding currently accounts for 40.7 percent of research funding at universities (AUTM 2020a), so the funding could be tied to commercialization outcomes, including IP retention within Canadian firms. While there is a role for universities in this, they have less insight into commercial advantage and do not have the incentive to capture relevant market applications via patent protection. IP retention by the universities themselves or maximization of licensing revenue for the university is second-best to Canadian companies commercializing directly.

It is important to distinguish between the role of invention and the role of commercialization. Future Canadian economic prosperity depends on inventions being commercialized with the economic rents accruing to Canadians. Where universities choose to participate in the innovation economy, they must be responsible to the Canadian public when tax dollars have funded the effort. Essentially, they must operate as guardians of innovation assets such as IP and data as the factors of production, and in support of future domestic productivity growth.

Agreements from governments should include explicit terms for institutional controls over innovation funding to universities: the protection of R&D with a proper IP strategy for Canadian economic benefit, and if not feasible, the management of the IP strategy defaults to an organization (for example, patent collectives or central resources) that will properly manage the innovation assets. The following recommendations provide a starting point from which more comprehensive guidance can be built.

Transparency and Disclosure

Universities receiving public funding must track and report the flow of R&D efforts with annual and concrete disclosures, including the economic benefit provided to Canada, what IP (including open IP) is being generated, and who is economically benefiting and by how much, so that Canadians can understand how public funding is providing an ROI for Canadians. Without proper innovation metrics, proper policy orientation will be very hard to achieve.

Prioritize Canadian Companies

Universities must steward IP rights for the benefit of Canadians, and prioritize Canadians and Canadian firms by, in order of preference:

10 This could include both a patent non-assertion, as well as access to all IP, including know-how, trade secrets and anything required to competitively implement the technology.

- **First, supporters of Canadian innovation:** These entities preferably provide direct, no-cost transfer of R&D and IP to Canadian companies and support Canadian companies with growth and FTO.

- **Second, research labs for hire:** Require foreign companies to pay fair market value for research or provide downstream ROI for the research (for example, licencing revenues for use of IP when used at scale), whichever is greater. Alternatively, the IP developed may be provided freely to Canadian companies. This recommendation would also include preventing foreign companies from simply setting up a Canadian corporate entity to siphon IP for the ultimate benefit of foreign firms.

Resourcing

To execute on the above noted goals, policy makers must provide resources and proper incentive structures to universities, such as:

- a central IP resource, for example, as described in the Ontario Expert Panel on Intellectual Property recommendations; and

- integration into national and provincial IP strategy initiatives directed to support Canadian firms, including activities for IP education, IP funding for IP generation and strategy, and patent collectives.

Canadian Economy Net Benefits Test

While the above recommendations are considered in the context of university research, all Canadian innovation policy (for example, tax credits, economic development programs, foreign direct investment policies) should consider a net benefits test that measures the innovation benefit (increased or decreased FTO) to the Canadian economy and provide IP strategies and policies that can achieve economic success.

In addition to the recommendations above, HERD programs in Canada may benefit from a better understanding of how the best universities in other parts of the world have come to perform as they do. Future research could include an examination of the top US and global university R&D programs and their technology transfer offices, with a particular focus on those that have improved in the last decade on metrics related to the creation, development and commercialization of IP.

Conclusion

Canada's university R&D policy needs to be reoriented toward an innovator's perspective, with a greater focus on outcomes that drive productivity and improve Canadian firms' FTO. Swift action is required, even more so as the knowledge-based economy is giving way to the data-driven economy. The impacts will be magnified as foreign companies are ahead both as owners of valuable data assets and the IP to turn those assets into revenue.

Recipients of public funding have a greater burden of responsibility when it comes to the technology they develop, which extends to providing non-assertion rights to Canadian industry for commercialization. This argument is not born out of a nationalistic ideology but out of recognition that the total effect of individually rational decisions contributes to a gap in the stock of Canadian IP, which disadvantages Canadian industry, the tax base and labour markets. This consideration for publicly funded research is not new: some form of it is already employed in other countries, for example, the restrictions on IP export in Israel (Marcus and Katz 2013).

The federal government can implement oversight and enforcement by linking IP directives to funding envelopes that encourage national participation in innovation; the roles of provincial governments and unions also need to be aligned.

With or without empirical evidence, it is not a major stretch to contemplate the deflating effect that selling off Canadian-generated IP has on local business investment. Canadians have ideas, invest in opportunities, register patents, generate IP and too frequently that IP is sold at an early stage to foreign firms that invest to commercialize and leverage it while Canadians go back to create another good idea for somebody else. This cycle is taking place through HERD projects that are mainly funded by public dollars, and by extension, taxpayer funds are enriching foreign entities. In no way are the authors suggesting a policy of intention here but instead a failure to establish appropriate objectives, guardrails and accountability for public funding of R&D through the higher education sector, and to govern accordingly.

In response to Canada's recognized poor performance in IP ownership and commercialization, Canada released its first national Intellectual Property Strategy in early 2018. Through IP education and tools for identifying and licensing IP, including a pilot patent collective, the strategy creates mechanisms for Canadian companies to commercialize technology globally. As policy makers rethink the national R&D strategy, the realities and capacity of various sectors within the Canadian economy and society will need to be recognized. Canada is not a country with many large national researcher-oriented companies; rather, it has universities, a few large companies and financial institutions, and an array of SMEs and start-ups. This puts a lot of pressure on the higher education sector as a high-potential avenue for R&D to benefit Canadians. Going forward, policy makers must consider how to harness the talent and expertise within universities in a way that more effectively channels opportunity to Canadian companies and Canadians.

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Appendix: Detailed Data Collection Methodology

Collection of Professor Names

In order to identify university-derived patents by the inventor, the names of professors at the U15 were compiled. For the Ontario universities, the names were collected from the Ontario public sector disclosure of salaries over $100,000 for 2016 (commonly known as the "Sunshine List"). The names of professors at the U15 outside of Ontario were collected from their online directories; for some universities, a school-wide directory was used, except if one was unavailable or incomplete, in which case it was targeted by department or faculty.

The professors of interest exclude retired professors and professors emeriti, adjuncts and lecturers. They are limited predominantly to those in science, technology, engineering and mathematics fields, which are most likely to cover patentable subject matter. While actual coverage varies depending on the academic focus of the university, this includes science, engineering, math, medicine, surgery, agricultural, environmental, pharmaceutical, computer science and information management faculties and departments.

As the U15 is composed of six Ontario universities, some of which are among the largest in terms of faculty size, using an already-compiled list saved considerable time compared to collecting the names from the source. Furthermore, as the professors within the scope of this study are likely to be among the higher-paying positions in universities, this deviation in methodology is not unreasonable.

Collection of Patents

Using the PatSnap database, a search was run for the professor names as inventors.[1] PatSnap is an IP intelligence platform that offers in-application analysis and metrics and the ability to export patent records that have been merged with additional information about the patent, including initial and current assignees and legal status, and standardized to allow for searching and comparison across many patent office databases worldwide. Such databases are often used by IP professionals for due diligence but also serve a secondary purpose for academic research. For this paper, the search and export functions were used to collect the data, with the remaining analysis performed in the statistical programming language R. In addition to the exported data, PatSnap's custom value metric is also collected; the measure is based on patent and technology indicators as well as market valuation.[2]

Patents were collected by searching for combinations of the professors' first and last names as inventors (middle names and initials were excluded at this stage), and addresses of inventors that contain CA, Canada, or the name or abbreviation of a province. The search was limited to granted patents and applications filed with the USPTO, CIPO and EPO. Professors listed in directories with only a first initial were discarded from the search (accounting for less than five percent of all names collected and as high as 15 percent for Saskatchewan).

Identifying Correct Inventor/ Professor Matches

The exported patent records were analyzed using the statistical programming language R. The inventors and assignees and their respective addresses were extracted into separate data sets. Patents with inventors whose middle names or initials conflicted with the professor's name were filtered out. False matches due to common names and the same abbreviation referring to Canada and California were also filtered out using the steps below.

The format and completeness of inventors' addresses vary. Addresses were disambiguated into state or province (for the United States and Canada only) and country codes by matching patterns based on unique country codes, postal and zip codes, and place names (such as cities, towns and counties) in California and the Canadian provinces. Where the location was still unclear, such as with city names in multiple jurisdictions

1 A subset of the University of Manitoba professors was not included in the original professor name scraping; the patent records for these professors had to be collected after the initial analysis using the EPO's Espacenet database (www.epo.org/searching-for-patents/technical/espacenet.html#tab-1). Status and assignment data were pulled from the INPADOC database information on Espacenet. The required variables were then reformatted to fit the PatSnap data.

2 The input variables for this valuation are technology class codes, litigation history, claims history, age of the patent, characteristics of the assignee, number of inventors and value of the market covered by the patent family (https://blog.patsnap.com/japanese-interface-custom-fields-patent-value).

and partial or missing addresses, a number of steps were taken to provide a best estimate of the state or province and country. These steps include selecting the highest-occurring location that was assigned to other inventors with the same name and a similar address across all patents, and co-inventors on the same patent. Where an obvious match was not made, the inventor location was flagged for manual review. The patents were further filtered to keep only those where the matching inventor's province was the same as that of the university (inventors matched to professors at universities in Montreal or Ottawa were acceptable if located in either Quebec or Ontario). Where the province was not identified, the patent was not removed if the matching inventor was in Canada.

The professor-inventor matches were manually reviewed and confirmed if the professor's name was matched to multiple permutations of inventor names (for example, different middle names or initials), or if the professor's name appeared multiple times in the data set and was composed of common first and last names. For first names, this includes John, David, Brian, Jean, Michael, Pierre and James. Surnames include Thomson, Brown, White, Smith and Anderson. They were excluded if technology codes and patent titles diverged from the professor's stated research and interests per their profiles on the university's website or their personal websites. This last step served to remove false matches that could significantly bias the general results. Top-ranking professors (those with five or more granted patent families) with industry partners were also reviewed, and any patent families with priority or application years preceding their tenure with the university, as indicated in university profiles and personal websites, were removed.

Identifying Assignees

The state or province and country of initial assignees were identified in the same way as those of inventors. At the time the data was exported, the address of the current assignees was not included. The current assignee's location could still be determined if it was also an initial assignee on that or any other patent in the data set, was the name of an inventor, or if it could be inferred from the name (for example, Héma-Québec).

Assignee names were then standardized by removing punctuation, abbreviating company suffixes (for example, "Corp." instead of "Corporation") and removing leading or trailing instances of "The." Variations on frequently occurring assignee names, such as the U15, were standardized to one variation using pattern matching (for example, any assignee name containing some spelling variation of "University" and "Manitoba" was corrected to be "University of Manitoba"). Misspelled assignee names were corrected to the highest-occurring version of the name out of the assignee names that were "close" to each other as determined by the Levenshtein edit distance (the number of edits needed to transform one character string into another). Once standardized, assignee names were classified as inventors, initial assignees and/or current assignees, allowing for a single list of all entities named on each patent.

Identifying Entity Type and Corporate Group of Assignees

Assignees were classified as individuals (mostly inventors) or as academic and government institutions (identified by keywords in the name, for example, "Institute," "Hospital," "Minister"), with the remainder classified as industry assignees. In order to identify the country of the parent company as the ultimate beneficiary of the patent, the industry assignee names were merged with Canadian mergers and acquisitions records from the Thomson Reuters Eikon platform and company hierarchies from LexisNexis Academic. As it was not possible to bulk download company hierarchies, they were only looked up for key multinational companies and industry assignees that appeared in the data set more than a handful of times. Remaining assignees were assigned their own name and location as that of the group. Where no address was identified, it was manually added based on a basic internet search. Results throughout the paper are reported based on the corporate group name and location, if applicable.

Converting from Assets to Families

Results are reported by patent family. Inventors and initial and current assignees are given equal weight for the patent family regardless of the number of patents on which they are named. The PatSnap value of a patent family is calculated as the maximum value of any patent in the family.

Definitions

Applicant: Individual or organization who files a patent application with a patent office.

Assignee: A party who receives patent rights transferred from the owner.

Assignor: An owner who transfers patent rights to another party.

Claims: The part of a patent that defines the legal boundaries of the invention.

FTO: The ability of a company to commercialize a technology while navigating the existing positions, including IP positions, of other actors. For example, if other actors own patents that prevent a company from entering a marketplace, the company's FTO has been limited by the IP positions of the other actors. In effect, FTO influences a company's competitiveness.

Granted patent: A patent application that has been found allowable by a patent office and grants the owner an exclusive right to prevent others from making, using or selling an invention defined by the claims of the patent.

Patent: A patent is a government grant that gives the owner the right to exclude others from making, using or selling the invention that is the subject matter of the claims of a granted patent. A patent usually has a 20-year term from the date of filing of the patent application.

Patent application: A document filed with a patent office that includes a written description of the invention and claims. The document is examined by the patent office to determine if it complies with the formal and legal requirements to be granted as a patent.

Patent family: A collection of patent applications covering the same or similar technical content. The applications in a family are related to each other through priority claims and may be filed in one or more jurisdictions. A "parent application" is the patent application that a member of a family cites priority to or originates from. Applications filed in other jurisdictions that are part of the same family, carry the same priority filing date as other members of the patent family.

Centre for International Governance Innovation

67 Erb Street West
Waterloo, ON, Canada N2L 6C2
www.cigionline.org

@cigionline

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