Transfer and Licensing of University Research and Technology in Canadian Agriculture

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Abstract Reports from the past decade have indicated that Canada is a highly innovative country, but suffers from a bottleneck in technology transfer and commercialization. In fact, many of the reports give Canada a failing grade when it comes to the commercialization of innovation technologies. With substantial investments into public sector research, such a problem would reduce the public good from government funding of innovative research. This chapter assesses Canadian university technology transfer activities from 1998 to 2008, with a particular focus on the transfer of agricultural technologies.

Introduction

Innovation, and the ability to innovate, is a fundamental driver of the knowledge economy. Industrial economies and the Organisation for Economic Co-operation and Development (OECD) in particular have focused on innovative capacity. To measure a nation's innovative capacity, the OECD uses metrics such as gross expenditures on research and development (R&D) as a percentage of gross domestic product, R&D personnel per thousand employed, number of peer-reviewed publications per researcher, and number of patents. In comparing Canada in these four categories within the G8 group of countries, Holguin-Pando et al. (2014) identify that Canada ranks fifth, fourth, third, and third, respectively. By comparison, the Global Innovation Index ranks Canada in 15th position (GII 2016). In this position, Canada leads industrial countries such as Japan and France yet trails countries like the UK, Germany, Sweden, and the USA.

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While numerous options exist that measure a nation's innovative capacity, assessing the value and economic potential of public sector innovation is perhaps one of the most daunting challenges facing innovation researchers. This is especially the case when trying to assess innovations that have immediate commercial value. Universities routinely advance theories and philosophies for which they are well known. The development of innovation processes, products, and technologies is of key importance, but a lesser known component of universities.

University innovations with commercial potential historically came from the colleges of agriculture, medicine (human, veterinary, and pharmaceutical), and engineering. Agricultural innovations lay in the domain of improvements to plant and animal genetics. Most of the medical innovations have been related to diagnostic tools and occasionally, depending on the institution, new drugs and disease treatment processes. Innovations disseminating from colleges of engineering have been both process and product oriented. A shift occurred in the commercial value of innovation in the late 1970s and early 1980s following the exponential growth in the information technology industry. At this point, departments of computer and computational sciences within universities started to produce software that had commercial appeal to industry. Genomic innovations also facilitated a shift in university innovation, but this shift was different. The genomics shift was a shift away from tangential products to that of knowledge-based innovative processes.

Given the shift that was beginning to occur in public sector innovative research, many universities in Canada followed the American lead and began to establish technology transfer offices (TTOs) within a decade of the 1980 Bayh-Dole Act. There are a variety of terminologies regarding these offices, including technology transfer offices, offices of technology transfer, and industrial liaison offices. For the purposes of this chapter, the term TTO will refer to all potential acronyms referring to the same function. The majority of these offices were established with a "diamonds in the sky" attitude, and the thinking was that these offices would be substantial revenue streams for universities. With the exception of a handful of universities, the revenue streams are but a mere trickle of what was hoped.

Background on University Technology Transfer

Technology transfer has long been an important issue, with the early focus on transfers from the industrial to the developing world, especially during the Green Revolution. Like many streams of literature, there has been a divergence over time as the research and commercialization focus expanded. One stream of literature that has developed focuses on the relationship between innovation and the transfer of the resulting technologies.

While there is abundant literature on the interactions between innovators and commercializers, the literature examined relates to the transfer between public institutions and commercial interests. One of the first to examine the topic was Eisenberg (1996) who identifies a trend that developed in the USA whereby universities have quickly moved to patent innovations resulting from federally funded research. Drawing on qualitative panel data and interviews from American research intensive universities and TTOs, Owen-Smith and Powell (2001, 2003) identify that faculty decisions to submit a patent application are strongly correlated with the perception of accruing benefits and that the stronger the public-private network, the stronger the pool of university patents. However, the authors note that there is a delicate balance to be maintained between technology transfer and academia being co-opted by industry. Finally, Siegel et al. (2004) through similar survey of American research intensive universities identify several barriers to effective and efficient technology transfer.

Several frameworks exist that conceptualize the innovation systems that are used, or have been used, to enable the transfer of public sector innovations. One such framework is that offered by Etzkowitz and Leydesdorff (2000). The authors provide a Triple Helix analysis model of innovation that examines the dynamics occurring between the public sector innovators in academia and government and industrial technology commercializers. Most discussions regarding the Triple Helix model of innovation analysis refer to the third version of this model, or Triple Helix III. The initial model, Triple Helix I, was highly institutionalized, and the relationship between academia, government, and industry was largely controlled or directed by the state. Triple Helix II relationships can be described as distinct innovation agendas with lines of communication between the three stakeholders operating with high levels of mistrust and suspicion.

The Triple Helix III model most realistically represents the existing relationships in industrialized economies. In this model, academia, government, and industry are represented by distinct spheres, but all three spheres overlap each other. The center of this model, where all three spheres overlap, is characterized by trilateral networks and hybrid organizations (Etzkowitz and Leydesdorff 2000). Etzkowitz and Leydesdorff argue that the common objective of this model is "…to realize an innovative environment consisting of university spin-off firms, tri-lateral initiatives for knowledge-based economic development, and strategic alliances among firms (large and small, operating in different areas, and with different levels of technology), government laboratories, and academic research groups" (p. 112).

A second framework is the Contingent Effectiveness Model put forth by Bozeman (2000). Bozeman suggests that the various parties involved in technology transfer have diverse agendas and goals and that these are achieved with varying degrees of effectiveness. The Contingent Effectiveness Model examines numerous factors involved in technology transfer from public institutions, including transfer agents, transfer objects, transfer media, transfer recipients, and the demand environment. The transfer agent is the holder wishing to transfer a technology, such as a university. The transfer object is the particular innovative process or product to be transferred. The transfer medium is the avenue chosen to commercialize the technology, such as a spin-off company or an exclusive license agreement. The transfer recipient is the party (usually a private firm, but not necessarily) that is interested in gaining access to or purchasing the innovative technology. The demand environment includes market and nonmarket factors that will impact the transfer process, such as the price for the technology or the relationship to existing technologies. Bozeman argues that this model shows "that the impacts of technology transfer can be understood in terms of who is doing the transfer, how they are doing it, what is being transferred, and to whom" (p. 637).

A framework that focuses specifically on the transfer of university technologies is found in Bercovitz and Feldmann (2006). These authors argue that there are a variety of motivations and incentives within universities to transfer technology that are affected by economic, social, and political influences. In examining the black box of university technology transfer, the focus is on "factors that enhance or inhibit the creation and transfer of academic science" (p. 176). The University-Industry Relationship Schema provides for an analysis of the dynamics that exist between the four crucial elements of university technology transfer: the individual researcher, the transfer mechanism, the firm characteristics, and the university environment. The dynamics that exist between the four principles of the schema are defined as exogenous shift parameters, behavioral attributes, strategic responses, and policy/legal environments. Bercovitz and Feldmann argue that this framework highlights the "legal, economic, and policy environments that comprise the system of innovation, determine the rate and type of university knowledge production, and thereby influence the rate of technology change" (p. 186).

These frameworks provide some insight into the intricacies and challenges of transferring technologies created in the public sector, especially universities. The Etzkowitz and Leydesdorff framework provides a unique perspective on the interactions between public sector researchers and commercial firms regarding innovations. Bozeman's focus on the factors affecting technology transfer complements Bercovitz and Feldmann's focus on the environmental aspects of technology transfer. Drawing on the strengths of these frameworks provides the opportunity to focus specifically on the ability of technology transfer offices to successfully commercialize genomic innovations.

Much of the literature up to 2005–2006 offers framework assessments for TTOs, while the literature following was considerably more focused on results and impacts of TTO operations. In a comparison of research outcomes in Canada, the UK, and the USA, Heher (2006) observes that Canada had a patent filing rate of 17 per $100 million of adjusted total research expenditure (ATRE) in 2002. This is compared with 21 in the USA and 35 in the UK. In terms of efficiency, the UK leads as this patent filing rate is achieved with US$3.1 billion, while Canada had US$2.5 billion and the USA was more than tenfold above this with US$31.7 billion. The UK also leads in the number of start-up companies created with an average of 5.1 per US$100 million ATRE, whereas Canada has 2.0 and the USA 1.1. License income as a percentage of ATRE is 3% in the USA, 1.3% in Canada, and 1.1% in the UK. Probably the most interesting observation by Heher is that in 2002, the cost of TTO staffing as a percentage of license income was 11% in the USA, 51% in Canada, and 133% in the UK.

Niosi (2006) examines the success of university spin-off firms, identifying that the majority of technologies commercialized in this manner are either in the fields of biotechnology or information technology. Nearly 1200 firms had been established as university spin-offs at the time of this study, but only 65 were listed as publicly traded. Of these 65 firms, Niosi found that 38 of the 65 firms were biotechnology-driven enterprises. In the first few years of the last decade, there were considerable levels of stagnancy in the spin-off firms as barely 40% exhibited signs of growth, in terms of either increased sales or employment, with the most stagnant firms found in biotechnology. Unfortunately, Niosi does not delve into the concerns about a success rate of just over 5% for spin-off companies.

Using data from the Association of University Technology Managers (AUTM) to assess why university TTOs struggle to produce income revenue streams, Swamidass and Vulasa (2008) report that the income from licensing university inventions as a percentage of total research expenditures was 1.7% in 1995 and 2.9% in 2004. To examine this in greater detail, the authors undertook a random survey of 99 American research universities. Three-quarters of the respondents identified the shortage of staff for nonlegal and legal processing as the biggest impediment to greater success rates. Trune and Goslin (1998) argue that TTOs act as significant economic drivers and commercialization success crucially depends on the size and experience of the TTO (Caldera and Debande 2010). Indeed, there would appear to be a contrast between the lack of staff response in the Swamidass and Vulasa survey with the results of Herer, where it is shown that higher TTO staffing does not translate into higher licensing revenues. Regrettably, Swamidass and Vulasa do not examine the correlation between TTO staffing levels in licensing income, thus leaving this question open to some debate. However, Heisey and Adelman (2009) found that increasing the size of a TTO staff increased its ability to patent research and generate licensing revenue. Specifically, the authors relate licensing revenues to the characteristics of TTOs and university research expenditures, suggesting that early initiation of technology transfer programs and staff size increase expected licensing revenues.

In a study on the impacts of the Bayh-Dole Act 30 years after its ascent into law, Grimaldi et al. (2011) conclude that the Act has not resulted in a decrease in basic research and in fact may have actually encouraged the movement toward university spin-off firms. Link et al. (2011) examined the relationship between the Bayh-Dole Act and the US system of national laboratories and determine that while the Bayh-Dole Act was not directly responsible for any noticeable effects in patenting activity, it did have an effect on changes in financial incentives required for technology transfer.

Recent studies indicate that TTOs are earning licensing revenue, albeit at a rate that is lower than hoped for. Part of the challenge to increase this might be found in the staffing levels of TTOs, but this should be cautioned somewhat by the relation between increased staffing and the increased cost of operating TTOs. It should not be taken as a panacea that simply increasing TTO staffing will directly increase licensing revenues and result in greater numbers of university TTOs becoming profitable.

Technology Transfer in Canada

The transfer of university innovation to the private sector grew rapidly beginning in the late 1980s, when universities began to establish offices devoted specifically to transferring intellectual property (IP). By the mid-1990s, most major universities in Canada had established a TTO. Once established, it became possible to gather statistics on TTO operations, raising the question of whether returns to scale existed from public funding of academic research. Ultimately, governments wanted to know if it was possible to establish a correlation between the amount of funding (inputs) and the resulting patents or commercialization agreements (outputs). Whether the TTOs wanted this to develop or not, eventually specific offices were compared to national averages regarding commercialization success.

In October 1998, the Canadian government established the Expert Panel on the Commercialization of University Research. The Panel was established by the Prime Minister's Advisory Council on Science and Technology with the mandate of suggesting a strategy to "… maximize the economic and social returns to Canada from public investments in university research" (Government of Canada 1999; p. v). While the report identifies universities as a crucial part of Canada's innovation capacity, it recommended standardizing operating procedures for TTOs. While the report does not go so far as to suggest that all TTOs should have identical structures and frameworks, thereby recognizing the uniqueness of regional innovation, it does suggest that TTOs should be required to develop and adopt consistent policies. While identifying that developing regulations for TTOs is not practical, the report stresses that technologies should be preferably transferred to Canadian firms or Canadian operations of multinational firms rather than to foreign operations. The report called for greater TTO funding, specifically where the "federal government should invest new and additional resources to strengthen the commercialization capacity of universities in an amount equal to 5 percent of its investment in university research" (p. 28).

The report clearly identifies that universities should not expect the revenues generated from TTOs to provide any relief to the stress that many university operating budgets face. The report observes that in the USA, research universities that have revenue streams from commercialized research indicate that such revenues account for less than one percent of the university budget. The Panel noted that it would not be fiscally feasible for Canadian universities to expect returns at a level greater than this.

The Council of Canadian Academies (2006) released a report on science and technology in Canada, identifying Canada as a world leader in many research areas and increasing research strength in emerging fields. However, Canada does not measure well when it comes to converting strength in basic R&D to commercial activity. The report states that the lack of commercialization success from public sector innovative research is "… a long-standing deficiency in Canada's innovation system…" (p. 25). The findings of this report were reiterated 1 year later when Industry Canada (Government of Canada 2007) released Canada's science and technology strategy. The S&T strategy report acknowledges that Canada is internationally recognized as having a strong research base, but there is considerable room for improvement in the commercialization of innovative research. This perspective held by the federal government has not dissipated and in fact is a constant theme in S&T reports, as the 2012 version observes that "Canada continues to face chronic challenge in knowledge transfer… related to licensing activities and spinoff companies…Canada continues to show disappointing results" (Government of Canada 2012, p. 2).

Is this truly the case? Are Canadian universities really struggling to commercialize technologies through spin-off companies or by licensing IP to private firms? An examination of the data presented below offers a contrasting view. The next section examines Canadian university IP transfer.

Trends in Canadian University Technology Transfer[1]

This section draws upon data from six different surveys on intellectual property at institutions of higher learning, undertaken by Statistics Canada between 1998 and 2008. These surveys were initiated, in part, to respond to the government reports outlined in the previous section as well as to gather data on an important, but not quantified, aspect of the innovation cycle. Unfortunately, this survey series was discontinued after the release of the 2008 data, and further information that is directly comparable to the following is not available.

Statistics Canada (2010) identifies that there are nearly 6,000 issued patents held by universities and research hospitals in Canada. In 1998, a total of 1,250 public institution patents existed, increasing to 3,000 in 2003 and 5,900 by 2008 (Table 1).

If the use of active licenses for existing patents is used as a metric for assessing the transfer of knowledge, then an increase in knowledge transfer is not taking place. The results shown in Fig. 1 reveal that from this perspective, the transfer of knowledge is actually in decline and even the increase in 2008 licensing activity

Table 1 Trends in patents and licensing

Year	Total patents	Total active licenses	Percentage(%)
1998	1,252	788	63
2001	2,133	1,424	67
2003	3,047	1,756	58
2004	3,827	2,022	53
2006	4,784	2,038	43
2008	5,908	3,343	57

Source: Statistics Canada (1999, 2003, 2005, 2006, 2008, 2010)

[1] Statistics Canada began a survey series on intellectual property of the higher education sector in 1998. The next study should have been released in late 2012 or early 2013. However, the survey series was discontinued.

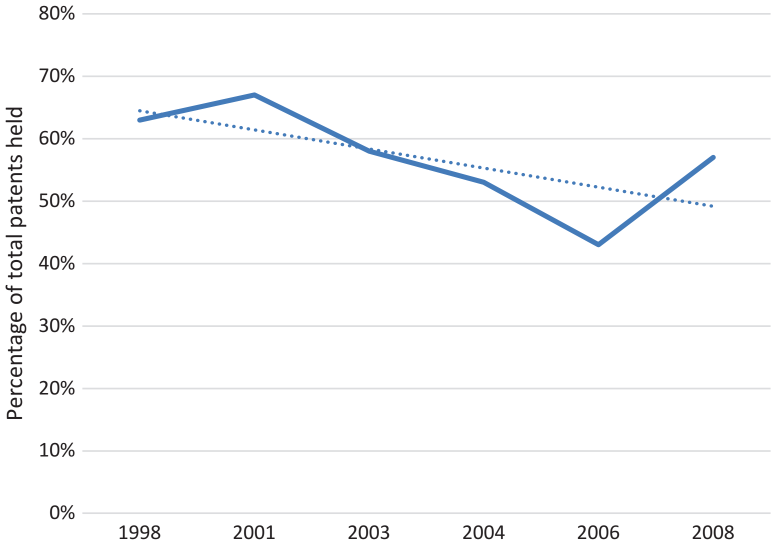

Fig. 1 Trend in patent licensing (% age of total patents held)

does not reverse the decade long downward trend. However, to counter this, at no one point in time has less than 50% of university IP not been licensed to private companies, indicating that at a minimum at least half of the knowledge being generated by universities is being transferred to private firms.

The commercialization of IP has resulted in a total of 1,242 spin-off companies over the 1998–2008 period. The number of spin-off companies rose rapidly starting in the early 1990s, peaking with 359 spin-off firms established between 1995 and 1999. The number of spin-off firms then declined substantially over the period of a few years, with only 142 spin-offs between 2005 and 2008. This is a 4-year comparison, but the trend is downward as only 19 spin-offs were identified in 2008. At the peak, over 70 firms a year were being spin-off, but this has fallen to an average of 35 a year in the 2005 to 2008 period, half of what it was a decade earlier.

The series of surveys found that in 2008 the revenue received (Table 2) by the 121 organizations from commercialized IP was $53.2M.[2] This figure represents a gross return of 2.7% on the $2 billion invested in research. These TTOs identified total operating expenses for managing and transferring IP of $51.1 million (Table 3), making the net return on the investment a negligible 0.1%. Royalty revenue peaked in 2001 and has been trending downward ever since.

Expenses were up dramatically over revenues (Table 3). This has to be of considerable concern to universities, as in 2008 IP management costs were nearly equal to IP revenues. It is worthwhile to note that TTOs began tracking the cost of protecting their IP starting in 2003. Litigation costs ranged from $0.4 to $1.4M which raises

[2] All figures are in Canadian dollars.

Table 2 Income from commercialized IP ($millions)

Revenue forms	1998	2001	2003	2004	2006	2008
Royalties	$15.6	$44.4	$40.M	$38.6	$41.2	$35.4
Reimbursements	$0.7	$4.9	$4.4	$5.0	$5.4	$5.9
Others	na	$3.2	$10.3	$7.6	$13.1	$11.9
Total	$16.3	$52.5	$55.5	$51.2	$59.7	$53.2

Source: Statistics Canada (1999, 2003, 2005, 2006, 2008, 2010)

Table 3 Expenses on IP management ($millions)

Expenses	1998	2001	2003	2004	2006	2008
Salaries and benefits	$7.5	$11.9	$16.9	$20.0	$23.9	$28.1
Patent and legal	$5.1	$9.5	$10.4	$10.6	$12.4	$15.3
Litigation	na	na	$1.4	$0.4	$0.6	$0.4
Others	na	$7.1	$7.7	$5.9	$5.6	$7.4
Total	$12.6	$25.7	$36.4	$36.9	$42.5	$51.1

Source: Statistics Canada (1999, 2003, 2005, 2006, 2008, 2010)

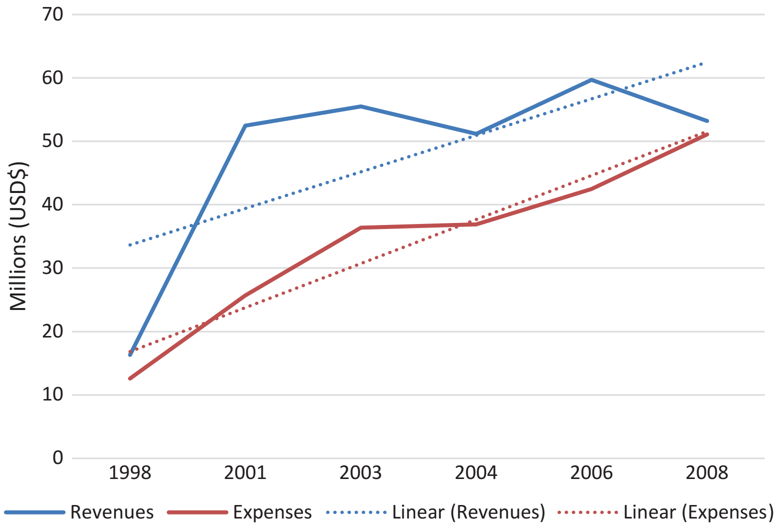

Fig. 2 Trend in revenues and expenses ($millions)

questions of how financially underfunded universities are able to devote financial resources to protection of IP.

Revenues have been in the $50 million range for all of the first decade of the century, while expenses have risen considerably. Figure 2 shows that revenues are trending flatter than expenditures. With TTO revenues and expenses on the verge of intersecting, this should be of concern to university administrators.

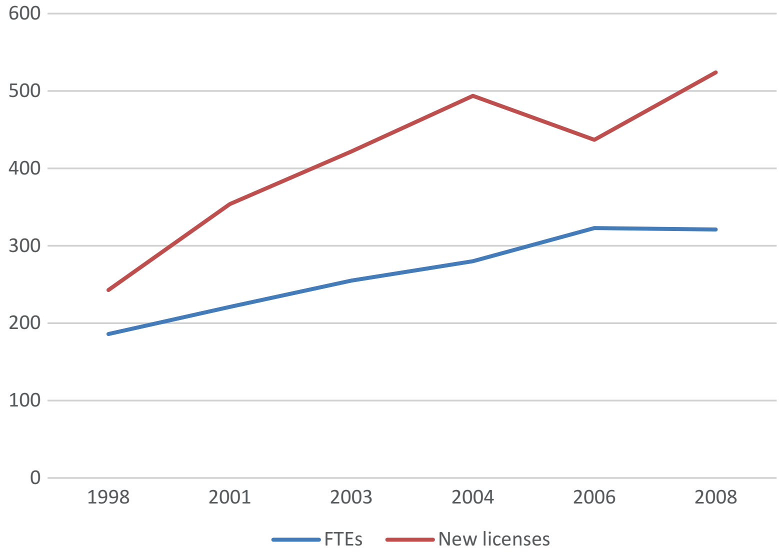

Fig. 3 Relationship between staff and activity

Some of the above cited literature has shown that there is an identifiable correlation in the USA between increased TTO staff and the level of patent activity. Figure 3 examines similar data for Canada. As the number of full-time equivalents (FTEs) increased between 1998 and 2008, so too has the number of new licenses. The early reports revealed that many universities had more than one office for technology transfer and that over time, these activities were consolidated into one office. With the exception of 2006, licensing activity has steadily increased, doubling between 1998 and 2008.

However, it is pertinent to note that even though there was a rise in licensing activity, the rise in TTO operating expenses increased at a faster rate than royalty revenues. To some extent, this places Canadian TTOs in between the proverbial rock and a hard place. For a TTO to be more successful, it has to increase the number of active licenses; however, staff increases are required to accomplish this, which raised operating expenses more than it does royalty revenues. This data suggests that most TTOs are not self-sustaining and require subsidies from university operating budgets.

The federal government has a preference for licensing IP to Canadian firms. Table 4 provides a breakdown of new licenses between 1998 and 2008, including exclusive and non-exclusive as well as domestic and foreign. Exclusive foreign licenses were relatively constant at approximately 11%, while exclusive Canadian licenses varied from 22 to 39%. Non-exclusive foreign licenses dominated the licensing activity, ranging 12–36%, while non-exclusive Canadian licenses ranged from 8 to 20%.

Table 4 Distribution of licenses (percentages)

Year	Non-exclusive Canadian	Exclusive Canadian	Non-exclusive Foreign	Exclusive foreign	Multi-jurisdiction or unknown	Total
1998	32 (13%)	58 (24%)	30 (12%)	24 (10%)	99 (41%)	243
2001	29 (9%)	104 (32%)	82 (26%)	37 (12%)	68 (21%)	320
2003	40 (9%)	108 (26%)	137 (32%)	42 (10%)	95 (22%)	422
2004	41 (8%)	103 (21%)	178 (36%)	55 (11%)	117 (24%)	494
2006	58 (13%)	169 (39%)	156 (36%)	50 (11%)	4 (1%)	437
2008	109 (20%)	120 (22%)	129 (24%)	57 (11%)	123 (23%)	538

Source: Statistics Canada (1999, 2003, 2005, 2006, 2008, 2010)

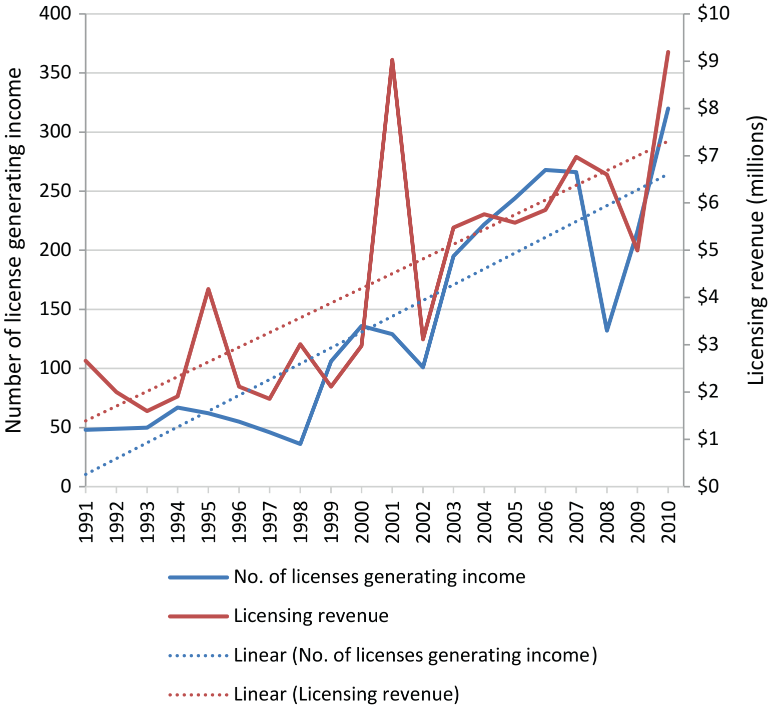

Fig. 4 Licensing revenue and number of licenses, 1991–2010 (Source: AUTM STATT 1991–2010)

On average, non-exclusive licensing leads exclusive licensing. With exclusive foreign licenses at approximately 11%, the concern about the benefits of Canadian innovative research accruing to foreign corporations is minimized.

Figure 4 illustrates that TTO licensing revenue increased significantly between 1994 and 2001, even though the number of licenses generating income declined, suggesting a significant increase in the subscription of high-value licenses by the private sector. In 1994, 67 licenses generated $2 million in revenues, with the average license value of $28,500. A similar analysis can be made in 2001, as the number of licenses generating income was 129, with license revenues of $9 million in 2001. The average value of a license in 2001 was almost $70,000.

While the Canadian government has identified the transfer of Canadian university IP and knowledge to the private sector as barrier to innovation in Canada, based on this review of the data, this perspective would appear to be misplaced. Certainly, Canadian university TTOs are not highly profitable, but they are transferring nearly two-thirds of patented IP via licenses to the private or, and the average value of these licenses has increased by almost 150%.

Transfer of Agricultural Technology

While some agricultural patent licenses and spin-off companies will be included in the above discussion, agricultural innovation, both plant and livestock based, does not factor heavily into this reporting. There is some information on new plant varieties that can be gleaned from the reports, relating to reporting requirements for plant varieties (Table 5) and ownership (Table 6).

The first thing that stands out from Table 5 is that over half of the institutes of higher education are not involved in the development of new plant varieties. Policies vary in regard to reporting, in that about 20% of institutions always require the

Table 5 Reporting requirements for new plant varieties (percentages)

Year	Always	Sometimes	Never	No policy	No such IP	Total
1998	16	15	47	22	-	81
2001	13	20	8	16	36	85
2003	12	13	7	12	55	121
2004	15	13	5	14	53	119
2006	24	11	7	19	40	101

Source: Statistics Canada (1999, 2003, 2005, 2006, 2008)

Table 6 Ownership of new plant varieties (percentages)

Year	Institution owns	Researcher owns	Shared	No policy	No such IP	Total
1998	12	52	14	22	-	81
2001	12	26	6	26	36	85
2003	7	20	7	8	55	121
2004	8	20	8	11	53	119
2006	6	26	12	28	28	101
2008	8	17	4	-	-	-
Avg.	9%	27%	9%	19%	43%	

Source: Statistics Canada (1999, 2003, 2005, 2006, 2008, 2010) reporting of new plant varieties, while 15% occasionally have policies of this nature and just under 10% never require the reporting of new plant varieties. Over the decade of reporting, the percentage of institutions requiring the reporting of new plant varieties varied from 25% to 35%.

Table 6 reports on the ownership structure of new plant varieties across the decade in which data was collected. Again, it is readily observable that many institutions are not engaged in agriculture research as 61% of reporting institutions either have no policy on new plant varieties or have no IP in this area. Interestingly, of those institutions reporting new plant varieties, the vast majority of the varieties are solely owned by the plant breeder that developed the variety, meaning that all of the royalties incurred through plant breeders' rights will go directly to the plant breeder. In just 9% of cases, the institution owns the plant variety and in an equal number ownership is shared between the institution and the plant breeder.

In terms of how institutions manage IP, plant varieties are not part of research activities at many institutions of higher learning (Fig. 5). In comparing research ownership of other forms of IP, the number of institutions reporting that they have no plant varieties at their institution is double that of those institutions holding trademarks of industrial designs. Institutional policy favoring the researcher is evident as researchers retain ownership more than any other form. While copyright residing with researchers is logical based on publication practices, it is somewhat surprising that researchers own such a high percentage of IP in terms of patents and industrial designs.

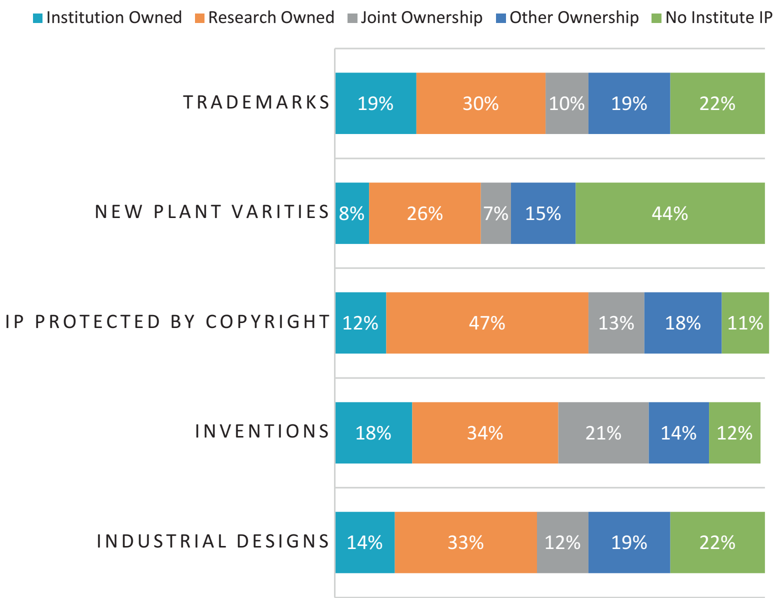

Fig. 5 IP ownership, 1998–2008 (Source: Statistics Canada (1999, 2003, 2005, 2006, 2008, 2010)

In some institutions, the reporting of plant varieties as IP was not required, as agricultural innovations were commonly managed directly by the agricultural colleges. For example, at the University of Saskatchewan, the Crop Development Centre (CDC), housed within the College of Agriculture and Bioresources, manages the commercial release of new plant varieties. As a result of this, for many years, the CDC results were not included in the University of Saskatchewan's IP reporting. The release of new plant varieties by the CDC is now included in the University of Saskatchewan's IP reporting.

Given the disconnect between the reporting of new plant varieties and university TTOs, it is likely that federal government data on agricultural IP is underreported. As a case in point, the CDC at the University of Saskatchewan began in 1971 with the mandate to improve existing crop varieties and develop new crop varieties. Between 1971 and 2016, over 400 new varieties were released. The commercial release of many of these varieties was not captured by surveys of IP and technology transfer, thus inflating the concern that universities are inefficient transfer agents of innovation, knowledge, and technology. Not only was the commercialization of new crop varieties not captured by federal surveys on IP, but in many instances, new plant varieties were not recognized as a form of IP by many universities. When new varieties of fruits, vegetables, and livestock are included in the transfer of IP from universities to the public, the picture looks much different than the one presented by current government reports on the state of public IP transfer in Canada.

Policy Implications

Based on the academic and government studies cited above, the fundamental question that needs to be posed is: Is university IP being transferred to the private sector? A simple response of yes has been shown to be the case based on the above data, but the simplicity of this response fails to delve into the fuller complexity of the issue. The Council of Canadian Academies (CCA) (2006) criticizes universities' abilities to convert basic R&D into commercial success. In fact, this report calls this a "deficiency in Canada's innovation system…." (p.25). But, is it?

Based on Table 1, from 1998 to 2008, the percentage of university IP licensed in any given year has ranged from 43% to 67%, averaging 57%. Given that there are no benchmarks against which to compare, due to the differing governing regimes in the USA and Europe, the fact that Canadian universities have, and are, transferring over 50% of their IP should be seen as a success, not a deficiency. While the trend line in Fig. 1 is downward sloping, Fig. 3 shows there is a positive correlation between the number of FTEs and implemented IP licenses. While the number of active IP licenses had been declining, the 2008 numbers show a sharp increase, from 43% to 57%. If TTOs are able to secure additional operating revenues to hire more staff, it would be expected that this percentage would get back into the range above

60%. If we accept that an IP transfer rate exceeding 60% is successful, then the CCA's referral to the ability of universities to convert basic R&D into commercial success is unsubstantiated and causes one to ponder if the use of the word "deficiency," then, is in reference to fiscal success. This, in turn, raises the crucial research policy question of whether basic public sector R&D has to be profit oriented.

It is quite possible that, given the recent trend toward increased public sector profitability, when the CCA refers to the "deficiency" in Canada's innovation system, they are referring to the fact that TTOs are not lucrative financial revenue generators. If this is what in fact is being referred to, it raises some serious issues for the future of university research. Should universities only be engaging in research that has a high probability of a profitable outcome for the particular university? Should basic scientific research be left to government agencies, encouraging universities to become entrepreneurship oriented?

Without more a detailed survey of Canadian TTOs, it is not possible to state with certainty, but it is reasonable to expect that some IP is not being transferred to the private sector due to research gap concerns. One can hypothesize that some basic R&D is being transferred to the private sector in spite of the evident research gap, which indicates that the private sector values basic university research. Clearly, the private sector will place greater value on IP that is closer to being market ready than IP that requires 3–5 years of further research, but there is still value to the private sector to license IP of this nature.

As part of the effort to narrow this commercialization gap in public sector research, some funding agencies in Canada have reorganized existing grant programs or established new grant programs, requiring matching industry dollars. In these grant programs, industry has to put up a portion of the overall project budget (commonly 50%), and if the project is successfully funded, the government granting agency provides the balance of the funding. The intention of these types of funding programs is to ensure that industry is aware of, and participating in, the design and development of new research programs. The project outcomes are then more in line with the needs of industry, and the gap to commercialization is therefore narrowed.

In the agriculture sector, it is evident that new plant varieties were not considered to be a form of IP by university TTOs or government. That the number of new plant varieties released by universities was not reported and that many universities have no policy on this issue or do not require the reporting of this at the university level indicate the dismissal of agricultural innovation within innovation systems. There is an obvious lack of understanding about how the commercialization of new plant varieties works, since when a new plant variety is given registration approval, it is licensed to a private company to multiply and sell the seed to farmers. The technology of the new plant variety is transferred to the private sector, the same as a patent license would be, but in the case of licensing the production of a new plant variety, IP reporting systems have routinely dismissed plant and livestock agriculture technology transfer.

Conclusions

While it is possible to conclude that knowledge and technologies are indeed being transferred, it is less certain that this occurs cost-effectively. Licensing revenue is marginally above IP management expenses. It has been shown that increasing TTO staffing increases patent licensing activity, but evidence of a corresponding increase in license revenue is lacking. When examining staffing and patent licensing, there is a positive correlation when this is done using new patent licenses implemented during each year, but when this is compared to overall IP management, the correlation becomes negative.

With the leading metric of successful research grants being the number of patents received or patent applications filed, it raises the concern that patent applications are being made with innovative products and processes simply to satisfy reporting requirements. The rate of active patent licenses is declining. The greatest portion of university research is funded by federal granting councils, which raises the issue of whether publicly funded research should be allowed to be patented by the universities and their researchers or instead be made freely accessible.

When universities hold IP and infringement is identified, it can be challenging for universities to protect IP given the limited financial resources available. As identified above, Canadian universities started keeping track of IP litigation costs in 2003; this cost will only rise due to the increasing number of patents and amount of research occurring. Since TTOs are not revenue streams, it raises concerns about university abilities to fund litigation to the detriment of other services and possibly programs. If universities do not have the financial capability to effectively protect their IP in an increasingly litigious society, should universities hold patents?

The above question strikes at the heart of a fundamental policy question regarding public sector research and the IP that flows from the research. The welfare question that rises from university patents is whether there is a greater benefit to the university from the return on the university's IP or from the value of publishing the research in top-ranked peer-review journals. Greater study needs to be given to this important issue.

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