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Resolving FTO Barriers in GM Canola

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Abstract
The development of intellectual property (IP) protection in plant breeding brought much needed private investment into canola research in the 1980s, but at the same time, fragmented research and IP ownership. In the 1990s, the biotechnology industry tried to addressed the growing IP fragmentation through a series of mergers and aquisitions. As we show through a survey of canola breeders, these changes reduced the sharing of knowledge in both the public and private sector, significantly increasing the cost of conducting breeding research. In the past decade, firms have clearly moved away from mergers and acquisitions and towards cross-licensing of IP. What remains to be seen, is whether these agreements get to the root of the freedom to operate (FTO) problem that exists in agricultural biotechnology.

Key words: intellectual property, freedom to operate, anti-commons, patents

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1. Introduction

Innovative discoveries in plant genomics research have fundamentally challenged the patent legislation of many, if not most, industrial jurisdictions. Patent acts in Europe and North America were written to provide protection for inanimate objects. As innovative research moved from inanimate to animate objects, solutions were required for patenting of life forms. Early forms of intellectual property (IP) protection in this area were patents for vegitatively propogated plants and federal legislation providing crop developers with the rights to protect the new variety's name. In conjunction with these actions from the early part of the 20th century, the development of plant breeders' rights was initiated in 1961 with the ratification of Union Internationale pour la Protection des Obtentions Végétales (UPOV). This international agreement provided developers of new and improved crop varieties with more defined rights and protection for such varieties. In the closing decades of the 20th century, the genomic revolution in plant breeding made it possible for researchers to apply for a patent pertaining to a wider range of plant varieties.

Strengthening of intellectual property rights (IPRs) in North America has been achieved through the development of case law. Courts in the United States, and to a lesser degree in Canada, have adopted a broad interpretation of existing patent law, allowing researchers to patent plant varieties. This interpretation of patent law allowed private firms to initiate research into plant genomic breeding and receive specific patent protection on the specialized research methods required to generate the new variety, as well as the new variety itself.

Production of knowledge through research and development (R&D) requires significant efforts in terms of time and money, involvement of private firms is justified only if the returns to research can be appropriated. Given the public good characteristics of knowledge and reproducibility of self-pollinated plants, without properly defined ownership rights the ability of innovators to appropriate rents from R&D is undermined, leading to a lack of private interest in crop research and under-investment in R&D.

Intellectual property rights are intended to correct for market failures associated with the public good nature of R&D. However, they create two key issues. First, due to the cumulative nature of crop research there are concerns that IPRs may slow down the innovation process and impose significant costs. Assigning property rights to research inputs such as germplasm, cultivars, gene sequences and markers separates building blocks for a product or line of research. When these property rights are diffused among multiple owners, the negotiation process to put the required pieces of IP together may fail, thus leading to an exclusion of plant breeders from certain areas of research, quashing promising research initiatives, and delaying breakthroughs in research industry (Walsh *et al*., 2003). Developing a transgenic plant may require fifteen to forty identifiable tangible components (Lindner, 1999). When so many IP holders are involved, each with an incentive to extract a disproportionate share of rents, negotiations over IP can easily break down – a problem labelled by Heller and Eisenberg (1998) as the tragedy of anticommons.

Second, as the IP landscape expands and the cost of accessing all required IP increases, biotech companies may engage in cross-licensing their technologies as a solution to freedom to operate issues (Smyth and Gray, unpublished data). What is of a paramount concern here is that patent pooling can lead to a concentration of wealth and power, thus questioning the ability of patents to correct for market failure associated with the public good nature of R&D as they can create more inefficiencies associated with market power.

Canola is a relatively new industry with IPRs beginning in the late 1980s. The industrial structures and innovation systems have evolved. This paper addresses the non-excludable, non-rival nature of knowledge, which in the Canadian canola industry, has created freedom to operate (FTO) concerns and market power issues.

The remainder of the paper is structured as follows. Section 2 sets up the paper by providing an in-depth review of the development of patent rights pertaining to plants in Canada. Section 3 provides the methodological framework for the paper and Section 4 discusses the analysis. The final section offers some concluding thoughts.

2. Background

Canola was bred out of rapeseed in the early 1970s, largely to ensure the development of an oilseed with lower glucosinolates and higher erucic acid levels. At this time, canola research was largely funded by public research laboratories. There was limited private sector involvement, in large part, this was due to the restricted ability of private sector firms to gain a return on investment. The oilseed market was not a large market in the 1970s and abilities to protect IP were limited. At this time, there was no legal opinion regarding the patentability of living matter. This began to change in the later part of the 1970s.

Abitibi Co. applied for a patent in Canada on June 16, 1976 for its assigned microbial yeast culture created from domestic sewage. The yeast was modified to digest sulfite waste liquor and was then applied to forestry pulp and paper plants, thereby allowing the effluent to be disposed of without contamination of the water system. The culture was found to be able to recreate itself on spent sulfite liquor ensuring the continued supply of the product. The process claims of creating the culture were allowed by the patent examiner; however, the examiner rejected two claims on the basis that the culture was a living thing and was therefore excluded from patentability under Section 2 of the Canadian *Patent Act*. Abitibi appealed this decision based on the rejection of these two claims.

Section 36 of the *Patent Act* requires that for a product to be patentable the inventor must be able to describe the creation such that it can be duplicated by the public schooled in the art or science under which the product was invented. In this case, the Patent Appeal Board held that Section 36 had been satisfied given that the microorganism can reproduce itself in the described medium at a level that is sustainable to supply the public with the microorganism into the future and upon expiration of the rights granted under the patent.

The Board held that the microbial yeast culture satisfied the criteria necessary to meet the test of patentability and provided its recommendation that the rejections be withdrawn.

Upon review of the findings, the Commissioner concurred and remanded the application to the examiner for execution.

The significance of the ruling of the Patent Appeal Board in Abitibi is seen in its summary review of case precedence from several jurisdictions and in its deviation from the historical practices of the Canadian Patent Office. Past practices of the Patent Office were to narrowly define patentability of lower and higher life forms such that a general ruling was that higher life forms were excluded from patentability. In its ruling, the Board provided a clear outline of the criteria for patentability of living things. Holding to Section 36, the inventor must provide a description of the method of production clearly and concisely to allow for future reproduction. Further, the organism must be a new and useful invention and not merely a stepping stone for further research. Such organisms must also possess traits that are significantly different from any known species to satisfy the requirement for inventive ingenuity. The 1982 ruling in *Abitibi* allows for the patenting of lower life forms; however, the Patent Appeal Board noted in its ruling in *Abitibi* that the patenting of higher life forms would require further debate and consideration.

The only other case that pertains to the patenting of life forms is found in *Pioneer Hi-Bred Ltd. v. Canada (Commissioner of Patents) (1989).* Pioneer Hi-Bred applied for a patent for a new variety of soybean in May 1983. The Canadian Patent Office rejected the patent as it was held that the new variety did not meet the definition of invention. Upon appeal and in a decision that avoids defining the patentability of living life forms in Canada, the Federal Court of Appeal agreed with the earlier ruling and found there was an insufficent degree of disclosure and hence, that the product did not fall within the definition of 'invention' pursuant to the *Patent Act*.

While Europe and the US do grant patents on higher life forms, Canada does not do so. However, Canada does in fact have protective mechanisms in its present legislation to afford very practical protection with the equivalent result as is obtained in Europe and the US. The protection offered by protein, gene and cell patents allow patent applicants to receive process patents in Canada, allowing protection of the entire array of methods to create a modified higher life form, but not protection of the end product. The validity of plant IP via process patents in Canada was finally confirmed by the Supreme Court of Canada in the case of *Monsanto vs. Schmeiser* (2004).

The increased IP protection for plant genomic research triggered increased investment into canola variety development (Table 1), which translated into increased acreage for privately developed varieties (Table 2). Genetically modified canola received federal regulatory approval in Canada in early 1995. The limited production acres for GM canola in 1995 and 1996 were managed through an identity preserved production system (IPPM) (Smyth and Phillips, 2001) as part of the seed multiplication process. The IPPM systems were discontinued in the winter of 1996-97 and unhindered producer adoption began in spring 1997. The adoption rate of genetically modified herbicide tolerant (GMHT) canola has been very rapid (Table 2); Roundup Ready™ and Liberty Link™ canola GMHT varieties and the Clearfield® mutagenic HT varieties rose in six years from 26% of total production in the first year of production to 92% in 2003. The adoption rate since 2004 has average over 95%.

Table 1: New Varieties developed by institution and by period

	1950-1959	1960-1969	1970-1979	1980-1984	1985-1989	1990-1994	1995-1998
B. Napus							
Total varieties by public institutions	1	4	5	4	8	8	10
Total varieties by private institutions	0	0	0	0	12	39	76
Total varieties	1	4	5	4	20	47	86
Number of active institutions	1	2	2	3	11	17	17
B. Rapa							
Total varieties by public institutions	1	2	5	1	1	4	2
Total varieties by private institutions	0	0	0	0	3	7	16
Total varieties	1	2	5	1	4	11	18
Number of active institutions	1	2	1	1	3	7	4

Source: CFIA variety registration records, as reported in Phillips and Khachatourians, 2001.

Table 2: Adoption rate for HT canola varieties (million acres)

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total canola acres	12.0	13.2	13.6	11.9	9.3	8.9	11.4	11.9	12.6	12.9	15.5
Roundup Ready	0.5	2.8	4.9	4.3	4.0	4.0	5.5	5.7	6.1	5.7	7.0
Liberty Link	1.0	1.6	2.5	1.8	1.5	1.5	2.4	3.7	4.2	5.2	6.2
Clearfield	1.7	2.2	2.5	3.0	1.9	1.4	2.6	2.2	1.8	1.4	1.7
Total HT	3.2	6.6	9.9	9.1	7.4	6.9	10.5	11.6	12.1	12.3	14.9
% HT	26.3%	50%	72.8%	76.5%	79.6%	77.5%	92.1%	97.5%	96%	95.3%	96%
Source: Total canola acres: Canola Council of Canada, 2008.											

As canola production increased in Canada and on world markets, it attracted more private investment. Prior to 1985, only 5% and 4% of new technologies and varieties, respectively, were created by the private sector, while these numbers increased to 90% and 86%, respectively, by 2001 (Gray *et al*., 2006). In 2007, 85% of the canola market were Monsanto's Roundup Ready and Bayer's LibertyLink varieties. The dominating market share of these two firms triggered some degree of consternation when both firms announced a cross-licensing agreement pertaining to their herbicide tolerant canola IP (Monsanto, 2009).

Profit-oriented private sector involvement significantly changed the IP landscape of the canola breeding industry. As Table 3 indicates, most newly developed technologies became proprietary and cannot be freely accessed. The *de facto* patent protection in Canada resulted in increased private sector investment in canola variety development. However, this increased investment and the resulting IP, fragmented the canola development market. To some extent, the period of mergers and acquisitions as seed development, chemical and pharmaceutical firms strove to become life science companies in the late 1990s and early part of the 2000s resolved the fragmentation problem in corn and soybeans, but less so in canola (Howard, 2009; Marco and Rausser, 2008; Wilson and Dahl, 2010). Recently, a series of cross-licensing agreements between the large seed development multinationals has allowed for much of the basic biotech platforms to be shared. The concern still exists that cross-licensing agreements could still frustrate the pace of research by delaying the assigning of IPRs. The next two sections will discuss the implications of keeping breeding technologies in the domain of private firms.

Table 3: IPRs in the canola crop research industry

	Key technologies	IPR regime
Genomic information	Arabidopsis genome project, amplified fragment linkage polymorphing for gene mapping (AFLP), molecular markers	Data is in public domain but AFLP technology is patented
Germplasm	Gene banks	Access restricted for private collections
rDNA strands/genes	HT genes, antifungal proteins, antishatter, fatty acids, pharmaceutical compounds	100% private patents
General transformation technologies	Agrobacterium, whiskers, biolistics, chemical mutagenesis	100% private patents except mutagenesis
Specific transformation technologies	Agrobacterium methods for brassica	100% private patents
Selectable markers	Markers for selecting specific transformants	100% private patents
Growth promoters	Constitutive and tissue specific promoters	100% patented both private and public
Hybrid technologies	In-Vigor^{TM}, CMS system, Ogura CMS systems, Lemke, Kosena system, Polima	All patented except for Polima
Oil processing technologies	Oleosin partitioning technology for separating and purifying recombinant nutraceutical or pharmaceutical proteins	100% patents or trade secrets
Traditional breeding technologies	Double haploid process, backcrossing, gas liquid specrometre analysis	All in public domain
Source: Phillips, 2000		

3. Methodology

In a private agricultural research industry, companies conduct R&D in similar areas and compete on the market for final products (i.e., plant varieties). The overlapping nature of research makes firms aware of the importance of making the best use of created knowledge before it is revealed to, or shared with, rivals. On one hand, enclosing knowledge allows a firm to take a scientific lead in the market and enjoy temporary monopoly power. On the other hand, if a firm is not self-sufficient in technologies required to develop a product, enclosing knowledge can limit a firm’s ability to access knowledge held by others. Therefore, pricing of upstream innovations and the decision whether to share the developed technologies with firms competing in the same field are strategic choice variables of the seed development companies.

A game theoretic approach was applied to understand the incentives of firms to protect their technologies and license the technology to their rivals (Galushko, 2008). The theoretical model is closely linked to the tragedy of anticommons, where Heller and Eisenberg (1998) assume that essential inputs (e.g., IP) are diffused among multiple owners and the inability to obtain at least one piece of IP leads to no output whatsoever and R&D resources are wasted. Our model differs from the tragedy of anticommons as it is assumed that there is a pathway to research. When one firm cannot access research inputs owned by the rival firm this particular pathway is blocked, however, the firm can take an alternative route and design the missing IP, but the amount required to do that will be higher than that spent by the rival firm that owns the original IP. Therefore, access to the rival's technology reduces the firm's varietal development costs.

We will not go over the details of the model as the space does not permit us to do so. Rather we will report the theoretical results and then in the next section discuss the empirical findings in light of these results.

When the industry is composed of two private firms that compete in the differentiated product market (selling two different crop varieties) they are better off by cross-licensing their technologies rather than each firm keeping knowledge private. An intuition behind this result is that a reduction in variety development costs of one firm as a result of using the already developed technology of the other firm encourages more R&D investment, thus leading to a higher quality innovation that gets paid a better price on the farm level. When the technologies are cross-licensed, both firms are able to supply a higher quality innovation to the farmers and as a result the market share of each individual firm does not suffer. When both firms enclose their technologies, R&D costs are higher resulting in a lower level of investment in varietal development. As a result, varieties coming out of the breeding programs lag in quality and receive a lower price from farmers, thus hurting the firms' profits.

When transaction costs (the costs of negotiating over IP including licensing fee) are sufficiently low (the condition defined in Galushko, 2008, p. 98), if one firm defects from the cross-licensing equilibrium, the other firm gets the least preferred pay-off, while defection yields the first best outcome to the former. An intuition behind this result is that by accessing the rival's technology and hindering access to its own gives the firm a scientific lead on the market and ensures a larger market share. However, transaction costs must be low enough for the firm to gain from defection as these costs are part of the profit. Therefore, if transaction costs are sufficiently low and if firms are rational, they will always choose to restrict access to their technology, no matter what the rival firms are doing. In other words, enclosing the technology is a dominant strategy. Thus, even if cross-licensing is mutually beneficial for firms, the outcome when both firms maintain exclusive rights over their technologies is a Nash equilibrium, which is a typical representation of the 'prisoner's dilemma'.

This result helps to explain why a tragedy of anticommons may arise. In a world where every player protects intellectual property, companies will insist on making the technology unavailable to competitors. However, this result relies upon the assumption that transaction costs are sufficiently low.

A very recent phenomenon in the plant research industry that deserves investigation is the emergence of sharing agreements in the biotech industry, for example, Monsanto and Bayer creating a patent pool. An interesting question is 'Why did it take these two firms so long to share their technologies?' A number of explanations can be put forward. First, it is possible that the companies have been able to play long enough to figure out the cooperation strategy. Second, these companies have kept their technologies proprietary for rather a long time and at this stage patents may be expiring. Third, the companies may have reached the point where the costs of having the two IP pools split have become prohibitely high. Our game theoretic model suggests that cooperation can be sustained when firms have to pay high costs to get technologies owned by others. The question is:

Is there evidence that patents have made access to research inputs more or prohibitevely costly? This is the topic of the discussion in our next section.

To answer the above question, personal interviews with breeders in Western Canada were conducted. Each interview followed a semi-structured set of questions and breeders were welcome to discuss the impacts of IPRs on their research programs. The survey was conducted as part of a bigger project and encompassed both wheat and canola sectors. The questionnaire used in this study was a joint effort by Galushko and Oikonomou,[1] graduate students at the University of Saskatchewan, the results of which are reported here. Nine breeders and two IP officers were interviewed to gain insights into the impact of IPRs in the canola sector. For a more detailed description of the interview process, interviewees' research profiles refer to Oikonomou (2007) and Galushko (2008).

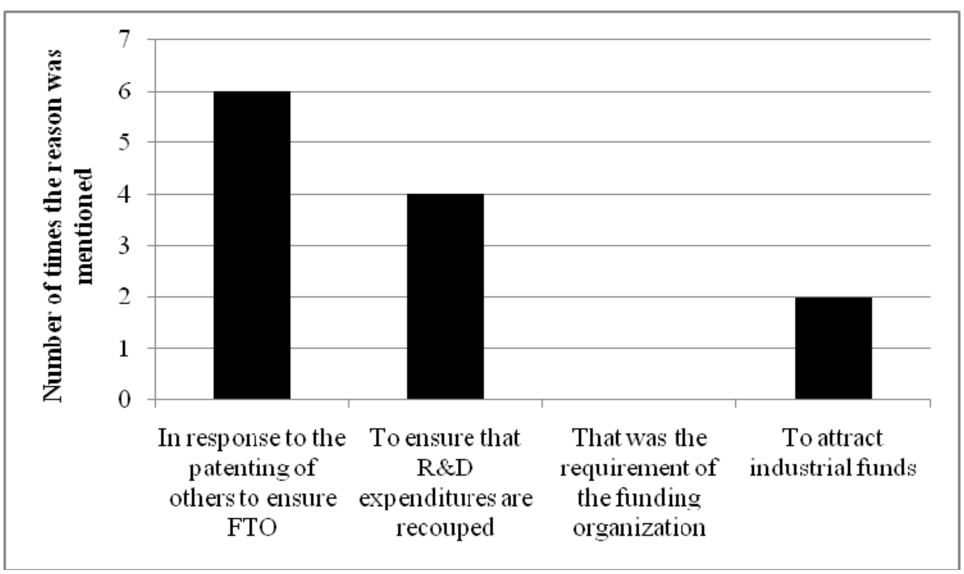
4. Discussion of Survey Results

Vehicles to Protect IP in the Canola Sector and the Main Reasons for Protection

In the canola sector, the use of DNA modification techniques and the relative simplicity of the hybridization process menas that a larger range of IP protection mechanisms are available for both germplasm and developed varieties compared to those crops that heavily rely on traditional breeding. The results support that a great effort has been invested in the canola industry to develop research tools, most of which were patentable. Five out of nine canola breeders have applied for patents within the last five years for a total of thirty-two patent applications. Almost 90% of the canola respondents reported an increase in IP protection.

The respondents were asked to identify the main reasons for a shift to stronger IP protection. Their responses and their relevance are given in Figure 1. As can be seen, the major reason for increased protection was defensive, thereby ensuring freedom to operate and the ability to use IPRs as a bargaining chip in negotiations with other IP holders.

Figure 1: Reasons for increased protection of research inputs



[1] For the questionnaire employed see either Galushko (2008) or Oikonomou (2007)

A number of breeders pointed out that patenting in the private sector is essentially different from patenting by public institutions. The public sector may patent research tools to prevent profit-seeking behaviour in the private sector and to ensure that Canadians derive the economic benefits from publicly developed technologies and unencumbered access. One IP officer indicated, that "any technology released for the public good is just a give-away and it enables others to benefit and exploit the technology for their own economic benefit with little return to the Canadian taxpayer" (Transcript C4). One canola breeder brought up a case where a public canola variety, Westar (not protected by PBR) was supplied to Monsanto. The private company then incorporated their own herbicide gene into Westar and claimed ownership over the 'new variety', ignoring any challenges from the original developers (Transcript 7). Furthermore, as private seed companies see enourmous profit-generating opportunities, the public sector is excluded from varietal development. As one breeder pointed out, "there was lobbying from private industry in Ottawa against us [public researchers] producing varieties and competing with private industry" (Transcript C2). To avoid situations like these, public researchers have extensively moved towards more protection of IP.

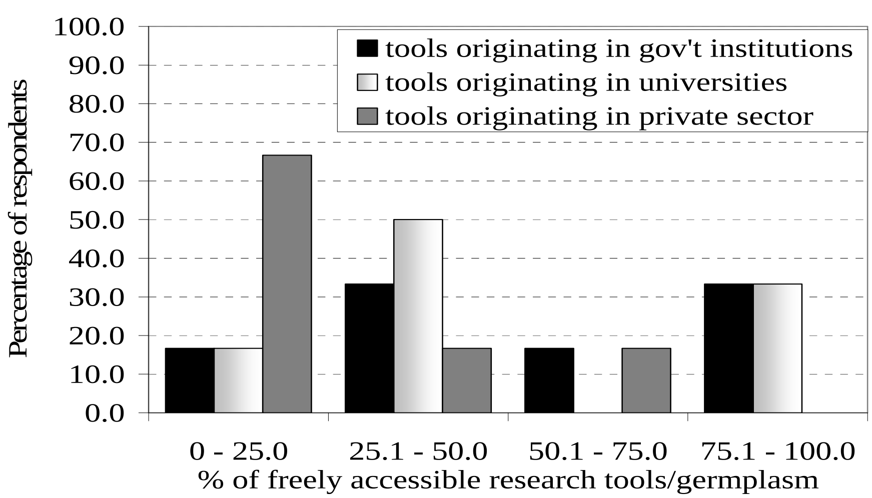
Technology and Germplasm Sharing

There is no doubt that IPRs have reduced the quantity of research inputs freely available to the breeding community. To gain insight into this issue, the breeders were asked to estimate the proportion of research tools/germplasm freely accessible to them. A summary of the responses is presented in Figure 2.

As can be seen from the graph, access to private industry's tools is the most restrictive. One canola breeder indicated that the year 2000 was the last time when canola breeders could freely access material or germplasm (Transcript C1).

An important aspect in plant breeding is when research materials become available. As was pointed out by an interviewee, "eventually most of germplasm becomes freely accessible but if it is the first time you hear about something you probably will not be able to access it. You have to wait longer" (Transcript C9).

Figure 2: Accessibility of research tools/germplasm in the canola industry by breeding institutions

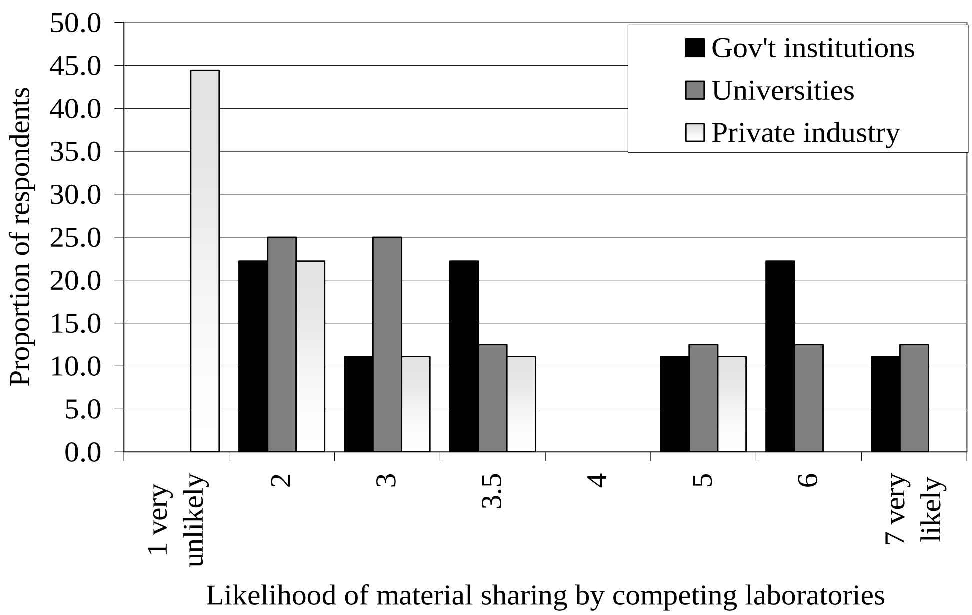


As private companies acquire more patents, public institutions become more aware of the importance of protecting their own research materials to gain a stronger bargaining power in the negotiation process and ensure greater freedom to operate. The result of increased protection on the part of both private industry and the public sector has been an enclosure of knowledge and reduction in sharing materials (Streitz and Bennet, 2003).

Even though there has been a shift to making upstream technologies proprietary some degree of sharing should still be expected within the breeding community. Because breeding companies are not self-sufficient in breeding technologies, they should allow at least partial access to their technologies to ensure access to others' technology. To assess the extent that unwillingness to share with other researchers is a problem, respondents were asked, 'How likely is it that the laboratories competing in the same field would provide the research tool/germplasm if you asked for it?' The results are reported in Figure 3.

As can be seen below a general feeling in the industry is that private industry is very unlikely to share research materials. But it should also be noted that this unwillingness to share is not confined to the private industry. As one canola breeder indicated that Agriculture and Agri-Food Canada's desire to capture the benefits from patenting and PBRs "has made the exchange of basic material much more difficult than it ought to be" (Transcript C7). Furthemore, sharing has not only shrunk in quantity, but also in quality. As one canola breeder noted, "with all the changes in the patent system we don't tend to give our best material" (Transcript C6).

Figure 3: Sharing of research tools/germplasm by competing laboratories



Secrecy

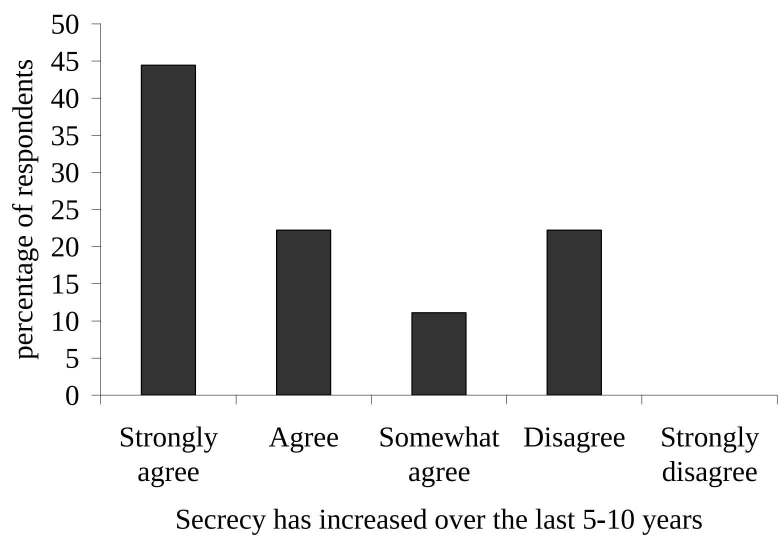
King (1993) argues that as transnational corporations took over the plant breeding industry, patents and corporate secrecy became the norm. Even university scientists now have to compete for corporate funding, and do not share information among themselves. One of the reasons mentioned by the public and university breeders to justify keeping information secret was preventing the private sector from using valuable ideas, bringing them to life and then patenting the results, thus undermining the ability of generating public benefits.

To get a sense of how stronger IPRs affected willingness of researchers to discuss their research ideas and results, the respondents were asked whether secrecy has increased over the last five years. As Figure 4 shows, responses from canola breeders leave little doubt that secrecy has increased.

The quotes from the canola breeders support the view that secrecy has become a problem in the sector: "Everybody knows what everyone else is doing but nobody talks about it. Secrecy has increased to ridiculous levels" (Transcript C5).

A number of canola breeders have associated an increase in secrecy with the presence of private research industry: "There are two groups of breeders. Public may talk to each other, private don't. They don't want others to know what they are doing, they don't want to share it" (Transcript 10); "When we collaborate with the private sector we have confidentiality agreements that we sign so that we can openly discuss what we have, what they are interested in, what kind of germplasm they might want to utilize from us".

Figure 4. Views on secrecy in the canola sector



Although it is clear that a vast majority of public breeders do not approve of the poor level of information sharing, they seem left with no choice. Many research institutions' policies prevent disclosure of information related to research, and the pressure to keep information secret comes from the business office. As one public canola breeder pointed out, "a number of years ago we had meetings where the breeders would describe what they were working on. Now we don't say anything. We have prior knowledge here and we can’t go and discuss it elsewhere because the business offices are concerned about patents and FTO issues” (Transcript C3).

However, it is worth mentioning that a number of canola breeders declared that the situation is beginning to change, that research organizations are undertaking steps towards faster disclosure of information. One IP officer stated, “What we try to do nowadays is to share everything; additionally what we do is we file as soon as we find something and we don’t have scientists wait until the patent issues, we let them publish/talk about it as soon as it is filed” (Transcript C4). This was also confirmed by a canola breeder: “You can disclose as much as you can. Ten years ago our orgazniation was encouraging us not to disclose anything but now if you cannot patent then you are encouraged to disclose as quick as you can” (Transcript C1).

Impacts of Restricted Access

Restricted access to upstream innovation may generate significant costs to society in terms of lost opportunities for technological improvements. While IPRs foster innovative activity in general, they discourage scientists to get involved in areas where a portion of intellectual property is proprietary. As one public canola breeder pointed out, “IP is becoming very aggresive, IP filing is happening extremely early in development projects. What it has done for us is reduced our research depth because we won’t step in that pool if there is a potential patent out there” (Transcript C1). Another breeder confirmed “Germplasm exchange has become a particularly sensitive issue and unfortunately it has become, at least with canola, a real constraint to making significant industry wide improvements” (Transcript C7).

Intellectual property rights are very often associated with increased duration of research. Even before a project is initiated, a researcher has to search for all possible IP to learn which research inputs can be freely used and which are proprietary. When the proprietary inputs are identified, the researcher has to negotiate the terms of use with the owners of the IP to ensure FTO in case the research output proceeds to commercialization. On occasion, it can take years before an agreement is reached and all pieces of IP are obtained.

Out of nine canola breeders, six identified cases where their research programs were delayed due to inability to access research inputs. For example, one canola breeder said that “there was one case that took 3 or 4 years. Just because of the inability to negotiate with the competitor” (Transcript C1). Another canola breeder reported a delay of five years (Transcript C9).

Some breeders reported that they never had to negotiate any IP because they tended to stay away from protected materials and limited their choice to publicly available inputs. One canola breeder stated, “I don’t think I was ever delayed in what I wanted to do because I never had to obtain IPs. But the time it takes for commercialization of that research is certainly longer. It may take years to negotiate agreements” (Transcript C2).

In the canola sector, 55% of the respondents reported cases where their research projects had to cease due to the inability to get (negotiate over) some pieces of IP. The most frequently mentioned reason for inability to access the IP and a subsequent termination of the project was the unwillingness of the owner to even negotiate. One canola breeder shared his concerns, adding, “What I would like to see is that anyone who has a patent has to license it at a reasonable cost. I think a lot of people don’t even try to license ... and that has been probably the biggest problem in the canola industry” (Transcript C9). One canola breeder mentioned a case where one party was unwilling to share because, as a public company, they did not have a commercial arm (Transcript C5).

Summarizing the above, there is a strong evidence that IPRs in the canola industry have created a lot of controversies such as increased secrecy and the termination of projects for FTO reasons. The industry has reached the point where information/technology flows have significantly shrunk, limiting the researchers’ ability to engage in high quality research. Some breeders have indicated that the whole system has moved too much towards protectionism and a step back is required. One breeder noted that the patent frenzy seems to be coming to an end with the US Patent and Trademark Office having moved to limit the scope of awarded patents to ensure that overly broad claims do not block subsequent innovations. In an effort to enhance FTO some universities and government research institutions have created an organization called the Public Intellectual Property Resource for Agriculture (PIPRA). Another canola breeder indicated that “negotiating with private industry to increase the portion of technologies going into the public domain is a normal thing that we do with the new projects, to ensure that a portion of the sequence data will be publicly available” (Transcript C11).

5. Conclusions

The ability to patent the process to create a genetically modified plant in Canada and the ultimate *de facto* plant protection changed the IP landscape in canola. The ability of firms to protect IP and capture value from innovations attracted a great deal of private investment, with many firms initially holding key pieces of IP. Private firms gained FTO and economies of scale and scope through mergers and aquisitions. Public institutions created their own protected research platforms. More recently, cross-licensing of technologies has become more common, evidenced by the two largest firms agreeing to cross-licence their herbicide tolerant traits.

While this is a rapidly evolving situation and this is but a snapshot in time of that situation, it does raise two points. First, the timing of cross-licensing agreements will have a substantial impact on innovation. If a new trait is successfully inserted into a new canola variety, the sooner this is accessable to the broader industry, the greater the level of innovation. The potential spill-over benefits will only be heightened if IP pertaining to innovative knowledge is shared early in the innovation cycle. Late stage sharing, possibly at the post-commercialization stage will certainly dampen the potential spill-over value.

Second, the dominant market power resulting from the cross-licensing of herbicide tolerant traits IP between Bayer and Monsanto gives rise to concerns about the potential for cartel-like behaviour. The canola varieties of these two firms account for over 85% of the market, leading independent observers to question pricing policies. While there have not been any actions to date that would suggest that collusion is occurring, the fact that the competition watch-dog in Canada is demonstrably weaker than in the US, means that the situation merits careful and close observations for the foreseeable future. We show that these changes in the canola sector have had a profound effect on how much knowedge is shared and when it is shared. No doubt this slows down the process of combining new knowledge. It does raise the important questions of how much does it slow innovation? and what if anything can be done to foster earlier exchanges of knowledge?

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