Intellectual Property Rights in Plant Breeding and Biotechnology: a Comparative Institutional Analysis

Derek EATON

Researcher, LEI, Wageningen University and Research Centre

P.O. Box 29703, 2502LS The Hague, The Netherlands

derek.eaton@wur.nl

20 June 2007

Paper prepared for the 11th Annual Conference of the International Society for New Institutional Economics (ISNIE), Reykjavik, Iceland, 21-23 June 2007

Abstract:

This paper undertakes a comparative institutional analysis of intellectual property rights (IPRs) in the agricultural plant breeding sector in the EU, the US, Canada as well as evolving regimes in developing countries. The policy issue that motivates this paper is the optimal scope of legal protection to be provided for new plant varieties, including those that may contain potentially patentable biotechnological inventions such as modified genetic sequences. Countries are choosing different combinations of two types of IPRs, plant breeder's rights (PBRs) and patents in addition to trademarks and trade secrets, while there are also pressures, for example through WTO TRIPS Agreement and negotiations for a patent treaty towards harmonization. The paper illustrates how the fierce debate surrounding the granting of IPRs in this sector reflects not only the redistributive effects of such property rights but also their relationship with informal customs and norms concerning farmers' rights over their seed. From a policy perspective, a transaction-cost based analysis of these IPRs favours the European approach to the American one. The paper therefore contributes to further developing the application of the economics of property rights to IPRs, which is challenging due to the technological change that may be induced by such rights.

Keywords: transaction costs, intellectual property rights, patents, agriculture, biotechnology

1. Introduction

This paper[1] seeks to contribute to the further development of the new institutional economics of intellectual property rights (IPRs). IPRs for agricultural plants, genetic resources and associated biotechnological innovations are evolving rapidly and continue to be the focus of international policy debate (e.g. in the World Trade Organization’s Council for the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)). The principal issue of interest to policy makers in Europe as well as developing countries is the optimal scope of IPR protection for breeders of new agricultural plant varieties, including those that may contain genetic transformation constructs. Such plant varieties present a special challenge for the provision of IP protection and innovation incentives, due to the biological reproducibility (self-copying feature) of plants.

The optimal scope, or breadth, of IPR protection, particularly with respect to patents, has received increasing attention from economists in the last decade (see for example, papers by (Chang, 1995, ; Denicolò and Zanchettin, 2002, ; Hopenhayn and Mitchell, 2001, ; O'Donoghue *et al.*, 1998). The principal conclusion of this largely theoretical literature, based on industrial organization models, is that optimal breadth of patent protection strikes a balance between the static and dynamic efficiency effects arising from patents. This is thus an extension of the earlier economic theorizing about the optimal duration of patent protection (see for example, (Nordhaus, 1969)). In this tradition, patents that are too broad, in terms of implying protection against either alternative inventions serving the same purpose or subsequent inventions that build on the first one can end up restricting too much the competitive forces which are recognized as providing the main incentives for innovation. The trade-off mechanism at work here has now also been incorporated into endogenous growth models (Aghion and

[1] A longer more detailed version is available from the author.

Griffith, 2005, ; Aghion *et al.*, 2001). Although this hypothesis does not appear to have been subjected to rigorous empirical scrutiny, economists studying the performance and efficiency of the U.S. patent system have signalled warnings about patents that are too broad in scope (Jaffe and Lerner, 2004, ; Merges and Nelson, 1990).[2]

This paper examines how the new institutional economics can contribute to a better understanding of how the optimal breadth of IPR protection can be assessed. A recurring theme in the economics of patent protection is the need to examine the effects separately in specific sectors. This paper addresses IPR protection in the agricultural plant breeding sector, which is very specific indeed, and of broad interest given the developments in modern biotechnology. The second section summarizes some of the technical and legal details pertaining to IPRs in this sector. The third section then applies concepts from property rights and transaction costs economics in an analysis of IPRs in the plant breeding sector, including some thoughts on varying scope of protection. The fourth section then suggests some possible avenues for more detailed empirical research.

One important purpose of a better understanding of the effects of broader IPRs is to develop the predictive power of an economic theory of IPRs. Policy makers need a prediction of how economic actors will behave under alternative IPR regimes, as well as what the aggregate effects will be in terms of the rate of innovation and market outcomes in any given sector. In other words, how will the strategies of companies change and evolve as the rules of the game (or institutional arrangements) are altered? It may also be important to acknowledge that the rules of the game themselves tend to evolve at the instigation of some of the players (as proposed by Demsetz, 1967). In the case of plant breeding, a small group of plant breeding companies (e.g. Monsanto,

[2] Recently, there has been a “revival” of the view among some economists that in many circumstances, any form of patent serves to restrict competition and thus innovation (see for example, Boldrin and Levine (2004)).

Pioneer) actively lobby for further increasing the scope of IPR protection over plant varieties. Such details will be discussed in the next section.

2. New Institutional Economics of IPRs

Much of the existing economic research on the scope of patent protection falls within the tradition of industrial organization. As mentioned in the introductory section, the analyses of patent scope have concentrated on the trade-off between incentives for research (dynamic efficiency) and sufficient competition (static efficiency). Another strand of analysis has been developed in recent years within the law and economics tradition (e.g. Landes and Posner, 2003, ; Depoorter, 2004), which builds largely on the new institutional economics approach to property rights. This section summarizes the main concepts and insights of this literature and then applies them to the plant breeding sector.

IPRs provide an interesting case for economic analysis of property rights and associated transaction costs, partly because what is being protected is an idea, as opposed to real property.[3] Furthermore, IPRs such as patents and copyrights are granted for innovations with considerable positive externalities, or spillovers, with an inherently inter-temporal character.

It is noteworthy that scholars disagree about the primary effect of IPR systems. Whereas the conventional wisdom among economists is that IPRs such as patents are offered in order to provide greater incentives for undertaking and/or disclosing innovation (see, for example, an industrial organization textbook such as Tirole, 1988, , or more specialised treatments such as), law and economics scholars have generally devoted more attention into analysing the specific purpose of IPRs. In a property rights perspective, following original contributions of Demsetz (1967) and Barzel (1997),

[3] This has led to some debate among law and economics scholars as to whether IPRs should be analysed according to the legal theory of property (Landes and Posner, 2003), as opposed to liability (Lemley, 2005).

patents are created to reduce negative externalities associated with a lack of property rights, and the associated transaction costs in the appropriating benefits from innovations through other means, such as secrecy. Many scholars now seem to agree, after various empirical studies, that patents do not seem to play much of a role in most sectors as an incentive to innovate by preventing unauthorised use (Lemley, 2005, ; Landes and Posner, 2003, ; Kesan and Banik, 2000, ; Boldrin and Levine, 2002). Frischmann and Lemley (2007) point out that the externalities associated with the spread of innovations and ideas are positive in nature, often termed “spillovers”, and thus fundamentally different from the negative externalities arising from incomplete exclusion rights to real property. In particular, whereas there may be clear a priori reasons to provide mechanisms to ensure that negative externalities are factored into decision-making, this is not necessarily so in the case of spillovers. Indeed, the disclosure function of the patent system intends to promote such spillovers. (This distinction turns out to be very relevant for the breeding of new plant varieties, as will be seen below.) On the other hand, Kieff (2004) argues that the principal purpose of patents is to reduce transaction costs associated with commercializing innovations, including licensing, as opposed to increasing the appropriability of the benefits by excluding unauthorized use. These debates highlight the various causal mechanisms by which patents might contribute to the overall efficiency of the innovation process. Nonetheless, the broader purpose of patents remains one of about promoting the generation and use of innovations. It is furthermore likely that the specific array of causal mechanisms will vary from one technology and sector to another.

A commonality to most of this literature is thus that IPRs should be assessed, at least in part, on the basis of the transaction costs associated with developing, marketing and exchanging innovations. This also provides insights into considerations of the appropriate scope of patent (or patent-like) protection. Alternative options for scope can also be assessed in terms of the resulting costs of transacting in the innovations. It is likely that these costs will depend in part on the effect of the scope of protection on spillovers. If broader scope of protection is intended to limit the extent of spillovers, then transaction costs will change for both the holder of an IPR and a potential spillover beneficiary. The former may devote fewer resources to other strategies to prevent others from benefitting from the innovation, but may need to devote more to enforcing the broader IPR. The potential spillover beneficiary, may incur higher costs in negotiating legal access to the innovation.

IPRs and plant varieties as innovations

Seed[4] is one of the most important inputs in agricultural crop production.[5] All other inputs, including even land, are managed to maximize the genetic potential of seed. Seed has been produced on-farm since almost the beginning of agriculture, with farmers selecting and maintaining seeds of their crops for sowing next season and exchange with other farmers. Observing differences among plants and experimenting with crossing, together with adaptation to various environments led to the development of different varieties or races within each agricultural crop species. The emergence of modern plant breeding in the late nineteenth and early twentieth centuries applied the then-new knowledge of the field of hereditary genetics to the process of crossing and selecting among progeny. During the last 30 years, this has been boosted by yet further advances in genetics and modern biotechnology, which as increased both the range of crosses that can be made, such as the introduction of genes from one species into another, as well as the precision with which this done (i.e. at a genetic level). With the

[4] A more generic term is “planting material” which also covers crops species which can be reproduced vegetatively, as opposed to through seed germination, such as potatoes and roses. In this paper, the term “seed” is used with such a broader interpretation for convenience purposes.

[5] Brush (2004) provides an overview of the management of seeds, or crop genetic resources in agricultural systems around the world and throughout time.

increase in scientific knowledge and the commercialisation of agriculture, plant breeding has become a specialized task that is no longer vertically integrated in farm operations in most parts of the world.

The innovative process in plant breeding consists of developing new varieties of crop species that exhibit characteristics which are of interest to either farmers (for example pest resistance, higher yield potential) or to consumers (for example, enhanced flavours, colours, or preservation qualities, or new forms such as in ornamental plants).

Agricultural plants are self-reproducing. This rather obvious biological fact is the reason why it can be difficult for plant breeders to appropriate the results of their innovative efforts. Indeed, the very purpose to which seed is put, crop production, results in multiplication of the product. Thus, imitation of the product is fairly easy, and relatively easy to incorporate into farming operations.

As indicated above, plant varieties constitute a special form of innovation, and an assessment of IPR systems needs therefore to take this into account. This section elaborates the basic issues involved. In comparison to most fields of industrial innovation, innovation in plant breeding results in a self-reproducing organism as much as in an idea. Moreover, the spillover benefits consist of making available the resulting innovation, the variety, as opposed to the information as to how that was achieved, in contrast to the situation say for a mechanical invention.

Indeed, this was clearly recognized in the original design of PBRs.

Breeders have a number of means by which they can capture part of the benefits from the cultivation of their new variety, rather than these falling into to public domain. These can be examined in terms of the different groups whose use of the variety breeders are attempting to restrict: other breeders, seed producers and farmers. The two most important strategies are probably the use of hybrid technology and contracts with both seed multipliers and farmers.

This strategy of enhancing excludability with the use of hybrid technology has been applied to a number of sexually-reproduced crop species, such as corn[6] and various vegetable crops. For many crops though, either the technique has not been successful, or it entails costs (particularly in seed production) that exceed the income stream that can be derived from the additional attributes. This is the case for major food crops such as wheat, rice, soybeans, rapeseed. Such sexually-reproduced crops can be termed open-pollinated varieties (OPVs), to distinguish them from cross-pollinating varieties, which facilitates the hybridization process. A third group of crop species consists of vegetatively-produced crops such as potatoes and other tuber crops, and also many ornamental species, such as roses, that can be propagated from cuttings.

The key difference of interest here between these three types of crops, is that the breeder of hybrid crops, in contrast to either OPVs or vegetatively propagated varieties (VPVs), can capture more of the income generated by the attributes of a newly-developed variety. This is done by biologically reducing the self-reproducibility of the plant or in effect broadening the extent to which others can be excluded from using it.[7] These alterred excludability characteristics of the hybrid parent varieties can also be enhanced by the use of other IPRs, in particular trade secrets, which are not discussed further here.[8]

The second important approach for the breeder to secure a greater portion of benefits from a plant variety innovation is the use of contractual agreements with

[6] Griliches (1957, ; 1958) devoted considerable attention to hybrid maize (corn) in the U.S. as an example of technological diffusion.

[7] This, of course, involves a whole series of economic property rights between individuals working for the breeding company and possibly reproducing seed. This paper avoids such details as they are not essential for the arguments developed here.

[8] Although trade secrets are technically not IPRs, they are often analysed as such (Landes and Posner, 2003).

farmers. Such agreements, which form part of the seed sale transaction, can stipulate that the farmer will not replant harvested seed, or multiply a vegetatively-propagated crop, without permission of the breeder. In essence, the farmer agrees to cede the right to do so, that would normally be associated with seed that comprised his own physical property. Such agreements are common for example in the ornamental sector, regardless of whether IPRs are also employed or not.

The use of these strategies entails transaction costs, meaning that the stream of benefits accruing from the innovation will not be completely captured by the breeder.

3. Comparative institutional analysis of PBRs and patents

The section now proceeds to analyse PBRs and patents as alternative IPR institutions for plant varieties. This begins with an examination of PBRs, in which various alternatives are examined in terms of scope of protection, followed by patents.

General background on Plant Breeder's Rights (PBRs)

Whereas patents are one of the principal means of protecting industrial inventions, a separate form of IPR has been developed for the agricultural crop breeding sector. Plant breeders' rights (PBR, also referred to as plant variety protection, or PVP) emerged in various European countries between 1930 and 1960.[9] PBRs are similar to patents in that they are granted only if certain technical requirements are fulfilled. These are referred to as DUS criteria which mean that a *new* variety must be Distinct (from other varieties), Uniform and Stable (identifiable from one generation to the next). In essence, the DUS criteria can be seen as an attempt to tailor the general requirements for patent protection (novelty, utility and nonobviousness) for the specific circumstances of crop breeding.

[9] The United States introduced a similar form of protection in 1930, called a "plant patent" which is available for vegetatively-propagated crops (with the exception of potatoes). This IPR still exists today but given its similarity to PBR, and its very specific circumstances, it is not subjected to detailed attention here.

PBRs consist of exclusive rights, for a limited duration, for production and marketing of a protected plant variety. But the scope of protection provided by PBRs is not as broad as that of patents. Two important differences exist. First, PBRs do not restrict competing breeders from using a protected variety in further breeding programs. This *breeder's exemption* is based on the recognition that further breeding necessitates the physical use of existing plant varieties as an intermediate input and the view that this cumulative innovation process benefits from facilitating as much crossing of varieties as possible. Second, PBRs only place limited or no restrictions (depending on the specific legislation) on the use of the harvested product resulting from the sowing of the protected seed variety. This is referred to as the *farmers' privilege* to replant harvested seed on their own farms. The farmers' privilege may also permit farmers to exchange (a limited amount of) seed with neighbours.

Although narrower than patents, the scope of PBR protection, in terms of exclusive rights, has been broadened in recent decades in some industrialized countries as seed markets have matured, and also in response to technological developments, more specifically in the field of agricultural biotechnology. The criteria for granting protection as well as the scope and duration have been harmonized among countries that are members of the Convention of the International Union for the Protection of New Varieties of Plants (UPOV). This treaty has been revised on several occasions since the original version signed in 1961, and each of the subsequent acts is denoted by the associated dates with 1978 and 1991 being the most significant in terms of scope. The general characteristics are summarised in Table 1, and compared to utility patent protection. In terms of scope of protection, the UPOV 1991 Act transformed the farmers' privilege into an option that could be provided by governments but which was otherwise no longer automatically included. This change has been an important political issue in the agricultural sector.[10]

Table 1: Key characteristics of UPOV PBR systems as compared to patents

Characteristics	**UPOV 1978 (Canada, various developing countries)**	**UPOV 1991 (E.U. and member states, U.S.[1])**	**Utility patents (available in U.S.)**
Protected subject matter	Varieties of species listed by country	Varieties of all genera and species	Varieties of any sexually reproduced plant
Duration of protection	Minimum 15-20 years (depending on crop)	Minimum 20-25 years (depending on crop)	20 years (from filing date)
Disclosure	Description of DUS variety otherwise through availability for breeding	Description of DUS variety otherwise through availability for breeding	Enabling or best mode disclosure plus deposit of novel material
Exclusive rights	Multiplication of variety for commercial purposes	Multiplication of variety for commercial purposes Use of harvested product for planting[1]	Multiplication of variety for commercial purposes Use of harvested product Any other commercially-related use (incl. breeding of new variety)

Notes:
1. Under UPOV 1991 the farmers' privilige was removed although a member country is permitted to make exceptions. The U.S. still allows a broad farmers' privilege, while the E.U. has restricted it considerably (see discussion below).

The U.S. and the E.U. have pursued notably different policies in last two decades with respect to IPRs for plant breeding. In addition to offering PBRs, plants and plant varieties are also eligible for (utility) patent protection in the U.S., and double

[10] The 1991 Act also introduced the concept of "essentially derived variety" (EDV) which is meant to refer to a plant variety that differs from a parent variety only due to the insertion of a specific gene or gene sequence. This was done to reflect developments in modern biotechnology in the 1980s, which added this possibility to the breeding innovation process. An EDV is not developed using the classic conventional approach to breeding of crossing two or more different varieties and the view was that, while such a variety should be eligible for protection by PBR, there should still be an obligation to the holder of a PBR over the original variety.

protection using both forms of IPRs is also possible.[11] The E.U., which has a relatively stronger and broader PBR system compared to the U.S. (see discussion below), has decided that plants and plant varieties are not eligible for patent protection. But biotechnological inventions, which may be inserted/contained in plants, are eligible for patent protection, and this is the case with genetic modification of crop varieties consisting of a patented genetic transformation event (which itself would also be patentable under U.S. patent law). This results in some uncertainty about the implications for the scope of a PBR covering a plant variety that also contains a patented gene sequence. The PBR would normally permit other breeders to use the variety for further breeding under the breeder's exemption, but this would possibly constitute an infringement on the patented invention. The European Commission and several member states have attempted to clarify this situation with the intent of maintaining some form of the breeder's exemption, and also farmers' privilege. But the feasibility of this approach has not yet been tested given the hesitant attitude of European markets towards genetically modified crops. In summary, overlapping protection between the two forms of IPRs thus differs between the U.S. and E.U. IPR regimes.

Developing countries are also dealing with decisions concerning IPRs for the plant breeding sector. While trying to weigh up the two approaches of the U.S. and the E.U., many countries are also being actively lobbied by these two to imitate their respective IPR systems, most often in the context of bilateral trade agreements. Under the WTO TRIPS Agreement, developing country members are required to implement either PBR or patent protection for plant varieties, or both. PBR does not have to imply

[11] The option of patent protection for plants and other living organisms in the U.S. was effectively initiated with the landmark Supreme Court ruling on Diamond vs Chakrabarty case in 1980. For plants, this was specifically confirmed in a recent ruling in 2001 on the case, Pioneer Hi-Bred International vs J.E.M. Ag Supply Inc. For a summary of IPR developments in the U.S., see Wright and Pardey (2006).

that these countries join UPOV although the majority have done so, with a number electing to implement protection conformant with the 1971 UPOV Treaty due, among other reasons, to its broader farmers' privilege. Almost no countries have elected to offer patent protection for plant varieties. Developing countries are also required, however, to offer patent protection for biotechnological inventions.

As indicated, the scope of PBRs has been increased through the UPOV Convention on numerous occasions. There are now proposals that have been tabled within the plant breeding sector to restrict the breeders' exemption by introducing a waiting period during which time other breeding companies are not permitted to use a protected variety in their own breeding research. This has been referred to by some as a "phased-in breeder's exemption". For example, if under PBR protection, a new variety is protected for 20 years, then a phased-in breeder's exemption of 10 years would imply that other breeders would be required to wait ten years before being able to use the protected variety. This proposal has come from some of the largest breeding companies, but is not yet being discussed in PBR offices or UPOV.

Economic rationale of PBRs

The main economic purpose of PBRs are to enhance the ability of a breeder to capture a larger portion of the additional benefits generated by the cultivation of a new variety. This is a relatively clear difference compared to patents, which also have important disclosure functions.

PBRs enhance appropriability primarily through restrictions on the unauthorized production of the variety, which has the most effect on (other) seed producers. Even if such producers are able to acquire seed of a PBR-protected variety through a commercial transaction, the PBR-holder would be able to seek damages if such producers were to reproduce the seed without a license.

The purpose of the breeder's exemption in PBRs is, in economic terms, to promote spillover benefits from the plant variety innovation. It is recognized that in the case of plant varieties, that access to the variety itself is the only means to enable follow-on innovation in the form of further breeding.

The "simplest" version (or least broad scope) of PBR protection includes a farmers' privilege, which means that farmers may save and replant seed they harvest from a first generation of a (purchased) protected variety. This is traditional agricultural practice and the term "privilege" disguises the fact that such a PBR does not confer any additional exclusive rights to the PBR holder. A breeder can attempt nonetheless to include restrictions on saving seed into the purchase contract, but then has to incur the costs of enforcing this contract.

This discussion highlights the importance of examining the costs associated with securing and enforcing not just the IPRs but also other strategies used to capture a higher portion of the economic benefits. These transaction costs play a role in determining the overall effectiveness of such IPRs (a point made already by Alchian and Demsetz (1973) in relation to rights to real property, and elaborated by North (1990)). Empirical research on PBRs supports this approach and help to explain the complex patterns of behaviour associated with these IPRs.

Interviews with a number of breeders in Europe indicate that PBRs do allow breeders to receive a higher share of the benefits resulting from the innovation (Eaton and van Tongeren, 2004). But there are differences among various types of crop species according to the propagation methods discussed above: hybrids, OPVs and VPVs. The propagation method affects the transaction costs of enforcing PBRs as well as other strategies to capture economic benefits associated with the attributes of the plant variety. The value of the decrease in such transaction costs that arise due to PBRs will be assessed by the breeder relative to these other costs. The effect of PBRs on the breeder's decision-making will therefore vary, a fact that can help explain much of the mixed incentive effects of PBRs.[12]

There is quite some variety across countries in the costs of acquiring and enforcing PBRs, for example in the application and renewal fees charged for PBRs and breeders indicate that these fees do play a role in their decisions about how to claim their economic property rights (Eaton and van Tongeren, 2004).

Table 2: Restrictions from IPRs according to uses and actors in seed sector

Actors	**No IPR**	**PBR with Farmers' Privilege**	**PBR without Farmers' Privilege**	**PBR with Essentially Derived Variety (EDV)**	**PBR without Breeders' Exemption**	**Patent**
Research and breeding (*Breeders*)				Not permitted if resulting variety is "too similar"	Not permitted	Not permitted
Production of seed (*Seed Producers*)		Not permitted	Not permitted	Not permitted	Not permitted	Not permitted
Saving and re-using seed (*Farmers*)			Not permitted			Not permitted

Notes:
No entry means the use is generally unrestricted, although this does not reflect restrictions that may be included in sales contracts.
Not permitted means that a permission or a license is required.

[12] Case studies in developing countries indicate that the recent creation of PBRs is not leading to a clear surge in investment in plant breeding (Louwaars *et al.*, 2005). Yet at the same time, many companies, particularly multinational seed companies, emphasise that these PBRs are an important factor in their decision-making. One possible explanation is that, while the establishment of a new PBR system does not immediately allow for the increased protection possibilities, it may provide a signal to seed companies of commitment on the part of the country's government to improve the overall environment for contracting in this sector.

Increasing scope of PBRs

Table 2 summarizes the possible variations in scope of protection under PBRs, which has been increased over time, primarily in terms of restrictions on uses by farmers. Thus, the farmers' privilege to save, re-use and exchange seed has been reduced in revisions of the UPOV Convention (recall Table 1 above), and even eliminated for some crops in Europe, meaning that farmers may not save and reuse their own seed without permission from the PBR holder. This effective restriction on the property rights of the farmer concerning her own harvested product is intended to provide farmers with a greater incentive to purchase new seed each season, partly for quality reasons, but also to increase the portion of benefits accruing to the breeder. Restrictions to the farmers' privilege can also be limited to the exchange and sale of harvested seed (termed "brown bagging" in the U.S.), while not restricting re-use on one's own farm.

Note that, similar to the discussion above, the breeder can also endeavour to contract with the farmer to achieve the same goal. But a PBR without a farmers' privilege removes the necessity to strike such a contract in theory but requires, on the other hand, that the farmer contract for permission from the breeder if she wishes to re-use seed. To reduce the transaction costs of doing this, the European PBR system provides an indicative norm for the level of the royalty that is to be paid in such cases, which is 50% of the royalty paid on new seed. Furthermore, in many European countries, farmers' organisation are contracted by breeders to undertake this collection of royalties on re-used seed.

The European system also differentiates its limitations to the farmers' privilege according to the type of crop and the size (area) of the farm holding. This effectively means that only very small, essentially non-commercial, farms of cereal crops are permitted to re-use seed without permission or payment of a royalty.

In contrast the American and Canadian systems of PBRs still maintains a wider farmers' privilege which permits re-use on one's own farm, but not exchange or sale.

The breeder's exemption has not yet been restricted in revisions to PBR systems, but proposals are currently circulating, as mentioned above, to limit this provision from becoming active until a certain number of years of protection have passed.[13] A phased-in breeder's exemption would enhance the ability of the breeder to receive a greater share of the benefits from the use of a plant variety innovation in further breeding research.

The arguments of proponents of a breeder's exemption are that biotechnology, in particular the use of molecular markers, has reduced their the share of economic benefits, relative to competitive breeders. Or in other words, it has made it much more costly, even in the case of hybrid crops, to capture such rents. It is interesting to note that the technological developments that provide a driving force behind proposals for a phased-in breeder's exemption, are also necessary in order to make such a change workable; this technology would also be needed to verify whether a new variety of a breeder had made use of another variety from a competitor.

The proposal for a phased-in breeder's exemption has come from a small number of large companies, while most other breeding companies have reacted negatively, with some even saying that such a restriction would effectively eliminate their ability to compete. A phased-in breeder's exemption would then reduce the spillovers from new varieties, potentially raising the costs for competing companies to

[13] As mentioned earlier, the revision of the UPOV Convention in 1991 did introduce a limitation on the breeder's exemption with respect to essentially-derived varieties (EDV). It can be argued that this has been until now of almost no practical importance, partly because of the difficulty in defining the concept, but also because it is of most relevance for genetically modified varieties. These have been largely restricted to the U.S., in terms of countries with relatively effective IPR systems, where such varieties are protected by patents. While the case of EDVs can also be analysed from the perspective adopted in this paper, it is left for future work.

make use of the protected variety in research by means of a license, or requiring them to delay such use.

Table 3: Relative costs of IPRs according to stages of transaction

Transaction stage		**No IPR**[1]	**PBR EU**[1]	**PBR US**[1]	**Patent**[2] **US**
Application acquisition and maintenance (15 years)[3]	*Official fees*		$11,232[4]	$4,344	$9,600[5]
	Legal fees		*	*	**
Licensing to farmers			*		**
Licensing to breeders					*
Enforcement	*Detecting infringement*		**	*	**
	Litigation		*	*	***

Notes:
1. No entry means that relatively no costs are incurred (excluding other contractual provisions).
2. For a patent, it is assumed that the patent-holder wishes to restrict both the farmers' privilege to re-use seed and the breeders' exemption.
3. The costs of application and acquisition of a PBR right are calculated for a period of 15 years, not the maximum permissible 20 years, as the commercial life of most plant varieties is shorter than the period of protection.
4. Converted at Euro 1 = US$ 1.34
5. Based on 2007 fees, assuming application with more than three independent claims, and not including application for internation protection through PCT.

The important question that policy makers may face is whether such a reconfiguration of IPRs and spillovers will lead to reduced or enhanced competition among the remaining firms. This challenges the predictive power of the new institutional economics of IPRs. While this point is highlighted again in the conclusions, it is first instructive to continue with the comparative institutional analysis of institutions by considering patents, as these do already completely eliminate the spillovers from a breeders' exemption.

Patents

Plant varieties can be protected in the U.S. by utility patents (even if a variety does not contain a patentable biotechnological invention).[14] It can be argued that protection of plant varieties by patents involves higher transaction costs than the use of PBRs. Table 3 indicates that although the official fees for obtaining patent protection are relatively comparable to PBR protection, at least in the EU, the legal fees, not only for application, but for enforcing these rights tend to be much higher. Exact figures cannot be offered but this observation is based on remarks of legal specialists in plant breeding companies.

The institutional system of PBRs differs from the patent system in a number of ways that serve to decrease transaction costs in acquiring and enforcing IPRs. This is largely due to the fact that a PBR much more specifically defines the protected subject matter, the plant variety, being protected and distinguishes this from other protected subject matter. As patents are available for effectively all range of inventions, the scope of allowable claims is potentially much larger, but also less precisely delineated. (Bessy and Brousseau (1997) examine the reasons why the patent system does not lead to a complete delineation of exclusion rights.) This leads to considerably higher costs of licensing and enforcement.

If patents involve higher transaction costs than PBRs, why do plant breeders use them at all? The decision likely involves the comparison of the higher costs with the potentially increased benefits due to the wider exclusion rights. But, recall that patent protection (without a genetically modified variety) is only possible in the U.S., where PBR includes a broad farmers' privilige. The possibility of protecting plants and plant varieties with patents in the U.S. arose apparently more out of jurisprudence than a

[14] This is separate from protection under the U.S. Plant Patent Act of 1930, which can best be seen as an early form of PBR for certain vegetatively-propagated species (Wright and Pardey, 2006, ; Evenson, 2000).

regulatory or legislative decision. Demsetz (1967) pointed out that new legal rights are "created in response to new economic forces that increase the value of the rights". In the plant breeding sector, these forces included technological developments in biotechnology that arguably increased the economies of both scope and scale in plant breeding.[15] These economic forces are also behind the proposal to increase the scope of PBRs, as well as more general issues for IPRs in the plant breeding sector, posed by developments in biotechnology.

Biotechnology

The discussion above has elaborated somewhat on how the new tools of biotechnology effectively raise the costs for breeders of protecting plant variety innovations, as well as lowering the costs of capturing spillovers by a competitor. But biotechnology has also led to the development of a new type of plant variety innovation, a genetically-modified variety which may be protected by a PBR, but in which a biotechnological invention, such as a transformed gene sequence, is protected by a patent. This can lead to a situation where the farmers' privilege and breeder's exemptions may no longer be available as the uses allowed under these provisions would violate the scope of protection allowed by the patent.

Proposals such as those in the EC to effectively limit the exclusive rights defined by patent protection in such cases can be justified partly on transaction cost grounds. Although the patent may allow the breeder to attempt to capture the economic benefits associated with the second generation of seed, this may be too costly in many cases, and the provisions of PBRs might be more efficient. With respect to other breeders though, the proposal to maintain a breeder's exemption, with the understanding that all of the genetic material in the plant variety with the exception of the patented gene sequence, is

[15] In this sense, biotechnology may constitute what is termed a "drastic" innovation in the industrial organization literature (Tirole, 1988).

intended to ensure spillovers. These suggestions have reportedly not been yet been tried in practice, partly because of the slower pace of acceptance and adoption of genetically modified crops in Europe. But an additional reason might be that the costs of measuring and enforcing IPRS among breeders in such circumstances could be rather high. Breeders in some sectors have reportedly agreed a "gentlemen's agreement" as to how they will operate; this amounts to an informal rule, emphasising the need to look at the wider institutional system in which IPRs are embedded.

The issue of overlapping protection also poses the question of whether a phased-in breeder's exemption might be a more efficient form of protecting plant varieties with genetic transformations than patents. If PBRs have an efficiency advantage relative to patents, in the sense of lower transaction costs, perhaps these advantages also apply to the case of a plant variety containing a biotechnological invention in the form of a genetic transformation.

Note that a complete discussion of the implications of biotechnology in plant breeding for IPRs should also address the patent protection of process innovations, such as the use of molecular marker technology to improve the efficiency of the breeding process. The concluding section compiles the list of such topics that have been highlighted throughout the paper and also poses some questions concerning empirical research in this area.

4. Concluding remarks

The preceding discussion has emphasised the importance of examining the role played by IPRs together with other activities undertaken by an innovator in determining the resulting configuration of exclusive rights, appropriability and spillovers. These insights are not necessarily new but their detailed application appears to be missing in the literature on agricultural IPRs, which are controversial political issue, even if this is limited to a relatively small group of interest groups. While it seems clear that taking a property rights and transaction costs perspective helps develop a more consistent understanding of IPR issues in this sector, this should only be seen as a beginning. The preliminary comparative analysis of IPR systems for plant varieties in the E.U. and the U.S. indicates that the E.U. system has efficiency advantages, but the analysis is complicated by the differences in market and political acceptability of genetically modified crops.

Some of the issues not that have only been touched on, but which probably need to be included in a more comprehensive examination of IPRs in plant breeding include:

- the private and public institutions that contribute to the governance of IPRs in plant breeding and also condition their use (Brousseau and Bessy, 2005), including a comparison of patents and PBRs;[16]
- the various ways in which exclusive rights to second-generation seed (farmers' privilege) are negotiated and exchanged;
- the implications of biotechnology in terms of the interaction between appropriability and spillovers for both process and product innovations (including a treatment of essentially derived varieties);

A natural avenue would be to look at ways of measuring transaction costs associated with enforcing PBRs and patents in the plant breeding sector, even if only in a relative sense. This may be more straightforward in the case of PBRs than patents, given the special characteristics of the former which have been emphasised above (that is PBRs are less costly to define and enforce). A constraint that needs thoughtful

[16] Note in this regard that public plant breeding organisations are important players in the sector as well, in some cases at the level of more fundamental, or basic research (for example, pre-breeding), but also in some cases as providers and marketers of new seed varieties. This latter case leads to the conjecture that this may occur in crop sectors where the capture of economic property rights is too costly to interest private sector breeders.

consideration is the high degree of secrecy with which plant breeders operate; almost all information is perceived as having potential (strategic) value.

A key policy issue is the balance that IPR policy should strike between appropriability and any limitations in spillovers. Can NIE assist in assessing what scope of legal protection is optimal, picking up where industrial organisation stops? In the case of plant breeding, will competition between breeders be reduced if IPR policy changes to reduce spillovers to other breeders? This is simply one specific example of an issue confronting competition authorities in many sectors where there is rapid technological advance (such as ICT).

Furthermore, in the absence of evidence that the U.S. approach to IPRs for new plant varieties is more efficient than the European approach, the question then arises: why does the U.S. maintain this approach? In this regard, it is notable that the companies that openly use and favour patents for plant varieties are primarily the largest players in the U.S. market. This leads to the hypothesis that such companies are able to capture additional economic rents through the broader scope of protection afforded by patent protection, and possibly at the expense of smaller market players. Is this good public policy, or a case of regulatory capture?

5. References

Aghion, P. and R. Griffith. (2005). *Competition and Growth: Reconciling Theory and Evidence*. Cambridge, M.A. and London: MIT Press.

Aghion, P., C. Harris, P. Howitt, and J. Vickers. (2001). "Competition, Imitation and Growth with Step-by-Step Innovation", *Review of Economic Studies*, 68(3): 467-492.

Alchian, A.A. and H. Demsetz. (1973). "The Property Right Paradigm", *Journal of Economic History*, 33(1): 16-27.

Barzel, Y. (1997). *Economic Analysis of Property Rights*. Cambridge: Cambridge University Press.

Bessy, C. and E. Brousseau. (1997). "Brevet, Protection Et Diffusion Des Connaissances: Une Relecture Néo-Institutionnelle Des Propriétés De La Règle De Droit", *Revue d'Economie Industrielle*, 79(1).

Boldrin, M. and D. Levine. (2002). "The Case against Intellectual Property", *American Economic Review*, 92(1): 209-212.

Boldrin, M. and D.K. Levine. (2004). "2003 Lawrence R. Klein Lecture: The Case against Intellectual Monopoly", *International Economic Review*, 45(2): 327-350.

Brousseau, E. and C. Bessy. (2005). "Public and Private Institutions in the Governance of Intellectual Property Rights", in *Intellectual Property Rights: Innovation, Governance and the Institutional Environment*. B. Andersen ed. Cheltenham, U.K.: Edward Elgar.

Brush, S.B. (2004). *Farmers' Bounty: Locating Crop Diversity in the Contemporary World*. New Haven, CT and London, UK: Yale University Press.

Chang, H.F. (1995). "Patent Scope, Antitrust Policy, and Cumulative Innovation", *Rand Journal of Economics*, 26(1): 34-57.

Demsetz, H. (1967). "Toward a Theory of Property Rights", *American Economic Review*, 57(2): 347-359.

Denicolò, V. and P. Zanchettin. (2002). "How Should Forward Patent Protection Be Provided?" *International Journal of Industrial Organization*, 20(6): 801-827.

Depoorter, B. (2004). "The Several Lives of Mickey Mouse: The Expanding Boundaries of Intellectual Property Law", *Virginia Journal of Law and Technology*, 9(4).

Eaton, D.J.F. and F.W. van Tongeren. (2004). "Mixed Incentive Effects of IPRs in Agriculture". Paper presented at the 8th Annual Conference of the International Consortium on Agricultural Biotechnology Research (ICABR), Ravello, Italy, July 8-11.

Evenson, D.D. (2000). "Patent and Other Private Legal Rights for Biotechnology Inventions (Intellectual Property Rights - IPR)", in *Agriculture and Intellectual Property Rights*. V. Santaniello, R.E. Evenson, D. Zilberman and G.A. Carlson eds. Wallingford, U.K.: CABI, pp. 11-25.

Frischmann, B.M. and M.A. Lemley. (2007). "Spillovers", *Columbia Law Review*, 107(1): 257.

Griliches, Z. (1957). "Hybrid Corn: An Exploration in the Economics of Technological Change", *Econometrica*, 25(4): 501-522.

Griliches, Z. (1958). "Research Costs and Social Returns: Hybrid Corn and Related Innovations", *Journal of Political Economy*, 66(5): 419-431.

Hopenhayn, H.A. and M.F. Mitchell. (2001). "Innovation Variety and Patent Breadth", *Rand Journal of Economics*, 32(1): 152-166.

Jaffe, A.B. and J. Lerner. (2004). *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It*. Princeton N.J.: Princeton University Press.

Kesan, J.C. and M. Banik. (2000). "Patents as Incomplete Contracts: Aligning Incentives for R&D Investment with Incentives to Disclose Prior Art", *Washington University Journal of Law and Policy*, 2: 23-54.

Kieff, F.S. (2004). "The Case against Copyright: A Comparative Institutional Analysis of Intellectual Property Regimes", Stanford, CA, Stanford Law and Economics Olin Working paper No. 297.

Landes, W.M. and R.A. Posner. (2003). *The Economic Structure of Intellectual Property Law*. Cambridge, MA: Belknap Press.

Lemley, M.A. (2005). "Property, Intellectual Property, and Free Riding", *Texas Law Review*, 83(4): 1031-1076.

Louwaars, N.P., R. Tripp, D. Eaton, V. Henson-Apollonio, R. Hu, M. Mendoza, F. Muhhuku, S. Pal, and J. Wekundah. (2005). "Impacts of Strengthened Intellectual Property Rights Regimes on the Plant Breeding Industry in Developing Countries: A Synthesis of Five Case Studies", Wageningen, The Netherlands: Wageningen University and Research Centre. February.

Merges, R.P. and R.R. Nelson. (1990). "On the Complex Economics of Patent Scope", *Columbia Law Review*, 90(4): 839-916.

Nordhaus, W.D. (1969). *Inventions, Growth and Welfare: A Theoretical Treatment of Technological Change*. Cambridge MA: MIT Press.

North, D.C. (1990). *Institutions, Institutional Change, and Economic Performance*. Cambridge: Cambridge University Press.

O'Donoghue, T., S. Scotchmer, and J.F. Thisse. (1998). "Patent Breadth, Patent Life, and the Pace of Technological Progress", *Journal of Economics and Management Strategy*, 7(1): 1-32.

Tirole, J. (1988). *The Theory of Industrial Organization*. Cambridge MA and London: MIT Press.

Wright, B.D. and P.G. Pardey. (2006). "The Evolving Rights to Intellectual Property Protection in the Agricultural Biosciences", *International Journal of Technology and Globalisation*, 2(1/2): 12-29.