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The International Trends In Plant Variety Protection

C.S.Srinivasan

Department of Agricultural and Food Economics
University of Reading
Reading , UK
aes02css@reading.ac.uk

Abstract

This paper examines international trends in plant variety protection, a form of intellectual property rights for plant varieties akin to patents. The TRIPs Agreement under the WTO has given a strong impetus for the universalisation of plant variety protection regimes with common standards of protection across countries. This paper argues that developed and developing countries are likely to adopt widely divergent approaches to the development of intellectual property rights for plant varieties. The special features of plant variety protection constrain the appropriability of economic returns from protected plant varieties. Consequently, in developed countries PVP is being seen as a relatively weak intellectual property right instrument. As stronger forms of protection for plant varieties become available, the importance of plant variety protection in developed countries may decline. Developing countries continue to debate the merits of extending intellectual property rights to agriculture, though they too are obliged under the TRIPs Agreement to protect plant varieties. Their concerns are focused on the "inequities" inherent in a system of plant breeders' rights. Attempts by developing countries to incorporate farmers' rights provisions in their PVP systems are likely to dilute the incentives for private investment in plant breeding.

Keywords*: Intellectual Property Rights, Plant Variety Protection.*

1. Introduction

The application of intellectual property rights to new varieties of plants is a relatively recent phenomenon in the long history of intellectual property rights (IPRs). The key objective of plant variety protection (PVP), a form of IPRs for plant variety innovations, akin to patents[1], is to stimulate plant variety

[1] Two important differences are that PVP generally allows for farmers' exemption and researchers' exemption, which are not allowed under patents. The former allows farmers to use to seeds of a protected variety saved from the harvest for replanting their land in subsequent seasons without payment of royalty to the breeder and the latter allows researchers to use a protected variety as an "initial source of variation" in the development of other new varieties. PVP protects the new plant variety, but not the underlying genetic resource.

innovations (Thiele-Wittig and Claus: 2003).The late emergence of PVP in the IPR arena is probably attributable to the nature of institutional arrangements required for the application of IPRs to a self-reproducing biological innovation. Given the "public good" characteristics[2] of plant variety innovations and the difficulties faced by plant breeders in appropriating returns from their innovations, it was the public sector that was dominant in plant breeding for a long period[3]. Increasing private sector participation in plant breeding, initially in the development of hybrid varieties of corn in the US, provided the impetus for an IPR framework for plant varieties for encouraging innovation and private investment. The emergence of PVP had also to be preceded by paradigm shifts regarding the applicability of IPRs to living materials. PVP has become well established in developed countries, but only over the last three decades or so. Till the early 1990s, PVP remained almost exclusively a feature of developed countries[4]. While developing countries recognised the importance of variety improvement for agricultural productivity growth, they generally relied on research by public sector institutions at the national and international level for the development of new varieties[5] (Evenson and Gollin: 2003). PVP or other forms of IPRs for plant varieties were not seriously considered as policy options for encouraging plant variety innovations. However, international efforts to harmonize IPR regimes across countries following from the international trade negotiations in the Uruguay Round have accelerated the spread of PVP systems across a whole range of countries. The key economic arguments advanced to developing countries were that (1) it would facilitate the transfer of improved (protected) varieties from developed countries (which in the absence of protection may not be offered to them at all) and (2) it would provide incentives for private investment in plant breeding. With fiscal constraints restricting the growth of public agricultural research investment in developing countries (in real terms) (Alston, Pardey and Smith: 1998) private investment was expected to become increasingly important for sustaining varietal development. In developing countries, the development of more productive varieties is an urgent need. The speed with which PVP can induce variety innovations and private investment in plant breeding is, therefore, an important issue for them. This paper first explores some of the key trends in plant variety protection in developed countries over the last three decades. It then examines the emerging scenarios for developing countries as they introduce PVP regimes. It argues that although the Agreement on Trade-related aspects of Intellectual Property Rights (TRIPs) under the WTO attempts to universalise IPR regimes for plant varieties, with

[2] The public good characteristics most specifically relate to the genetic information contained in a plant variety.

[3] This is reflected in the role played by Land Grant Universities in the United States and institutions like the Plant Breeding Institute and John Innes Institute in the UK in plant breeding since the early 1900s. The public sector still plays a key role in plant breeding in both developed and developing countries.

[4] Some countries like Argentina and Chile introduced PVP legislation quite early on. Argentina has had PVP legislation since 1978. But its implementation was seriously taken up only much later towards the end of the 1980s/early 1990s (Jaffe and Van Wijk: 1995). Argentina became a member of UPOV only in 1994.

[5] The collaborations between national public sector institutions and the International Agricultural Research Centres of the Consultative Group on International Agricultural Research (e.g., CIMMYT, Mexico and IRRI, Manila) were responsible for several spectacular breakthroughs in varietal development such as the "Green Revolution" varieties in wheat and rice. The exchange of plant genetic resources under these collaborations was unencumbered by IPRs.

common standards of protection across countries, developed and developing countries can be expected to take widely divergent approaches to the development of their IPR regimes.

Adoption of PVP

OECD countries, in particular Western European countries, have been the pioneers[6] in PVP legislation under the auspices of UPOV[7], an international convention that seeks to harmonize the standards of protection across member countries. The enforcement of PVP rights in European Union (EU) countries has been facilitated by the "Common Catalogue" and the compulsory seed certification system prevalent in most countries[8] – and more recently by the Community Plant Variety Office (set up in 1994), which grants titles valid in 15 EU countries against a single application. Figure-1 shows the economic divide that characterised the adopters and non-adopters in the early 1990s. PVP was not a feature of economies where agriculture had a significant share in output and employment. The fact that PVP involves some restrictions on the use of farm-saved seed, a long-standing traditional practice among farmers, suggests that there may be significant political constraints to the adoption of PVP till the share of agriculture in output and employment declines below a threshold level[9].

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), a part of the WTO Agreement, requires all member-countries of the WTO to establish an effective system of plant variety protection within a specified time frame. This has significantly accelerated the adoption of PVP by

[6] The United States introduced the Plant Patents Act in 1930. However, the Act applied only to asexually reproducing varieties and was, thus, largely confined to ornamentals and some horticultural species in its application. In the first half of the 20th century, the fact that plants may not reproduce "true to type" was seen as an important constraint in extending patents to plant varieties. By confining itself to asexually reproducing varieties, the US Plant Patents Act avoided this difficult question. It was the US Plant Variety Protection Act of 1970 which extended protection to agricultural and other species based on the criteria of "Distinctness, Uniformity and Stability." The US Plant Patents Act can be seen a precursor to plant variety protection legislation adopted in Western Europe and the US from the 1960s.

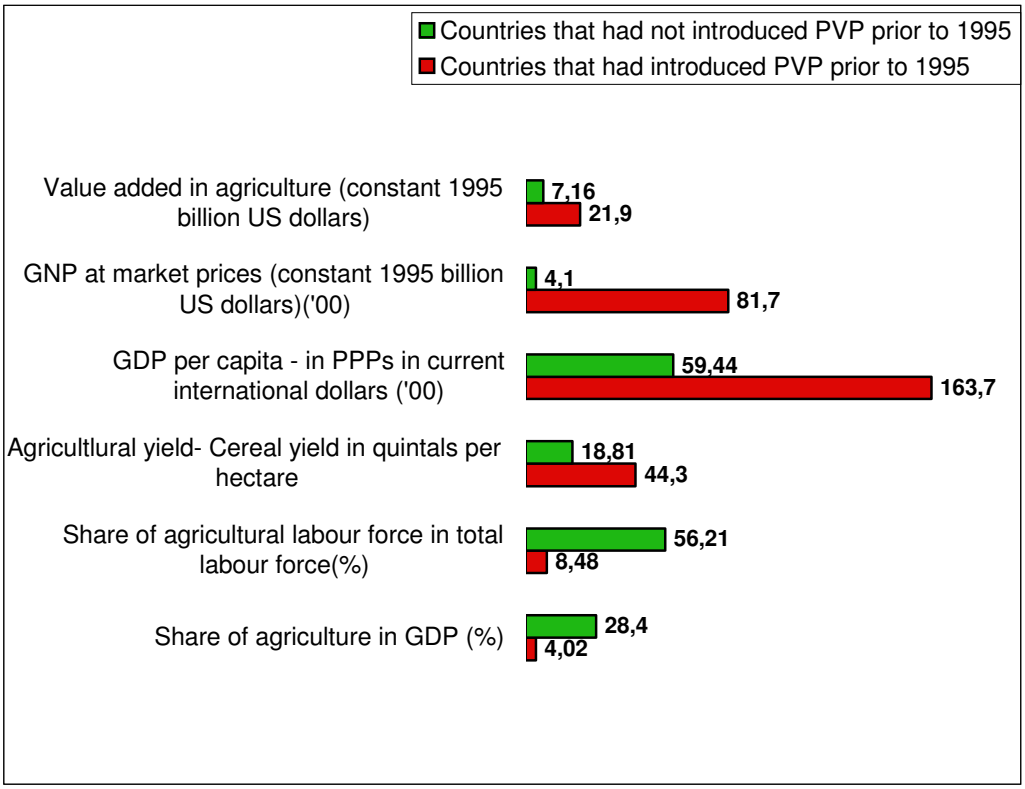
[7] International Convention for the Protection of New Varieties of Plants, Geneva. The Convention, which came into being in 1961, underwent major revisions in 1978 and 1991. Harmonisation of procedures and standards reduces the transaction costs for breeders in obtaining protection for a variety in a number of different countries.

[8] The "Common Catalogue" is a marketing regulation that requires that any variety sold in the European Union be inscripted in the European Common Catalogue after being tested for "Distinctness, Uniformity and Stability" (DUS) and "Value in Cultivation and Use" (VCU). This regulation along with the system of compulsory seed certification makes the unauthorised multiplication of seeds of protected varieties more difficult (Berlan and Lewontin: 1986).

[9] This conclusion is actually based on an econometric analysis of adopters and non-adopters. A logistic regression model using a constant and a single variable (log of the share of the agricultural labour force in the total labour force – LNAGLABF) was able to classify 95% of the pre-1995 adopters and non-adopters of PVP correctly. The addition of other variables such as GNP at market price or GNP per capita did not improve the predictive power of the model. In the post-1995 (post-TRIPs) situation, LNAGLABF alone was not a good predictor of PVP adoption. However, in the post-1995 situation, a logistic model with LNAGLABF, an LADUMMY (representing a Latin American country participating in a common trade arrangement) and a COMDUMMY (representing ex-communist transition economies) was able to classify 90% of the countries correctly as adopters and non-adopters.

developing countries and is reflected in the membership of UPOV, which grew from 27 countries in 1994 to 50 in 2002. With major agricultural producers like China, India and Brazil adopting PVP legislation, PVP countries now account for more than 80% of world agricultural production.

Figure-1: PVP Adopters and Non-Adopters (1995)



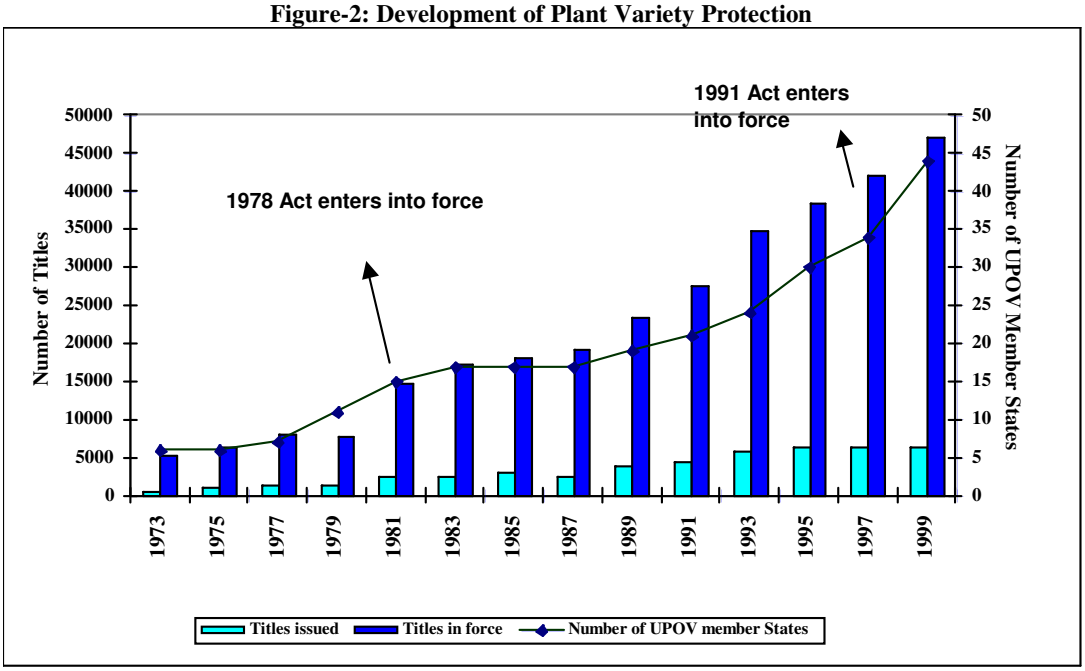
Source: Data on PVP adoption from UPOV (2000). Data on other variables from World Development Indicators 1999 (World Bank: 1999)

Trends in PVP grants

Figure-2 shows the trends in grants in UPOV member-countries over the period 1973-1999. It is estimated that out of the more than 110,000 certificates issued since the inception of legislation in all UPOV member-countries, nearly 57,000 (62.7%) have been issued in the post-1990 period. However, at the end of 1999, the total number of grants in force was 47,018, which suggests that a large proportion of certificates get surrendered before the full term of protection (17 to 25 years) in different countries. While the total number of titles issued has shown a steady upward trend owing to the entry of many new countries into UPOV, the number of titles has tended to decline or stagnate after 1995 in EU countries. In EU countries, the decline in national titles is possibly attributable to breeders opting for EU-wide protection granted by the CPVO. In the US, the number of new applications for PVP certificates has

declined steadily since 1998[10], although it is not clear whether this reflects a long term trend. It is probably due to breeders switching to stronger forms of protection like utility patents for plants. The decline in PVP applications has been accompanied by a substantial increase in utility patents granted for plants, components of plants and associated technological processes (Figure-3). It must be noted that genetically modified plants are generally protected by utility patents, rather than by PVP certificates.

Figure-2: Development of Plant Variety Protection

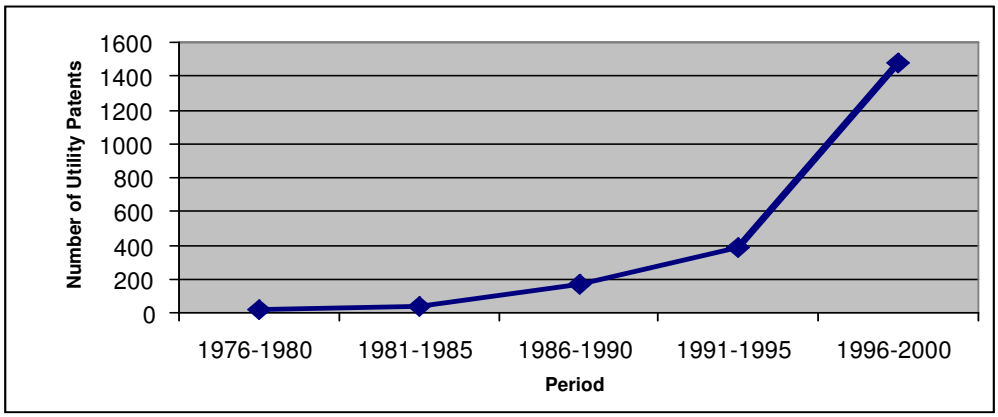


Source: Graph and data provided by UPOV.

The top six countries – United States, Netherlands, France, Germany, United Kingdom and Japan – account for nearly 70% of the currently valid grants (Figure-4). This is partly attributable to the fact that these six countries are also the countries that have had PVP legislation for the longest duration. The figures also include titles granted in the US under the older Plant Patents Act of 1930 for asexually reproducing species. In Europe, the use of PVP by breeders is extensive, though it is more pronounced in the case of self or open pollinated crops. An analysis of the varieties inscripted in the European Common Catalogue shows that 82% of wheat varieties, 90% of perennial ryegrass varieties, 84% of potato varieties 50% of soybean varieties and 36% of maize varieties are covered by protection. Expectedly, protection is less important in the case of crops dominated by hybrids (e.g. maize). Hybrids are not self-reproducing and, therefore, offer "inbuilt" protection.

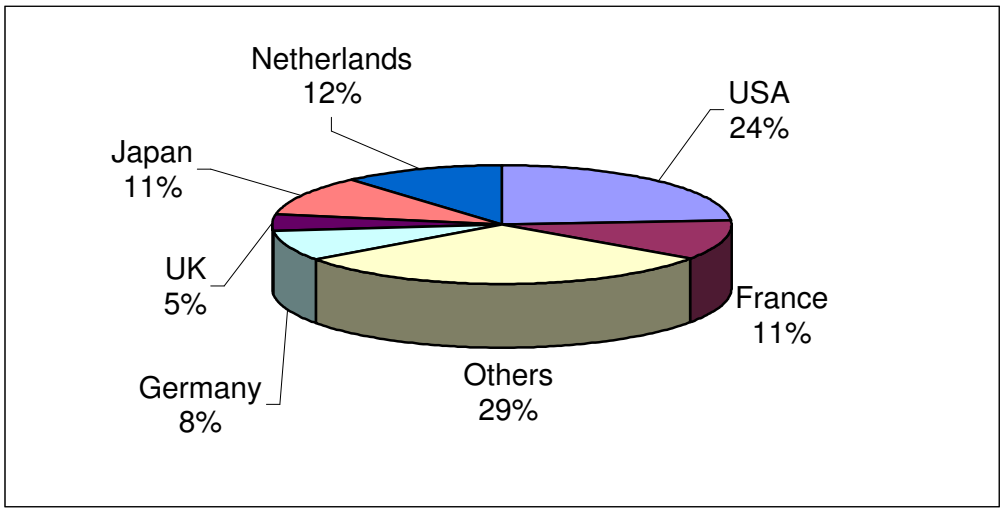
[10] The trend is less clear in the US in relation to the number of certificates issued since 1999. Annual PVP grants in the US appear to have steadily declined over the period 1992-1998, reaching a low of just 68 certificates in 1998. The numbers have subsequently recovered with a sharp upward (unexplained) spike in 2001. However, given the decline in the number of new applications, it appears likely that the number of grants will eventually decline.

Figure-3: Utility Patent Grants for Plant Technologies* in the United States



Patents related to plant technologies include (1) plant organisms, cultivars, germplasm (2) physical structure and plant function (3) agronomic applications (4) nutritional characteristics (5) Male sterility / self-incompatibility (6) other plant technologies
Source: Economic Research Service, United States Department of Agriculture. Agricultural Biotechnology Intellectual Property Database accessed from http://www.ers.usda.gov/data/biotechpatents/ on 21-3-2004

Figure-4: Share of Valid PVP Certificates in 2000

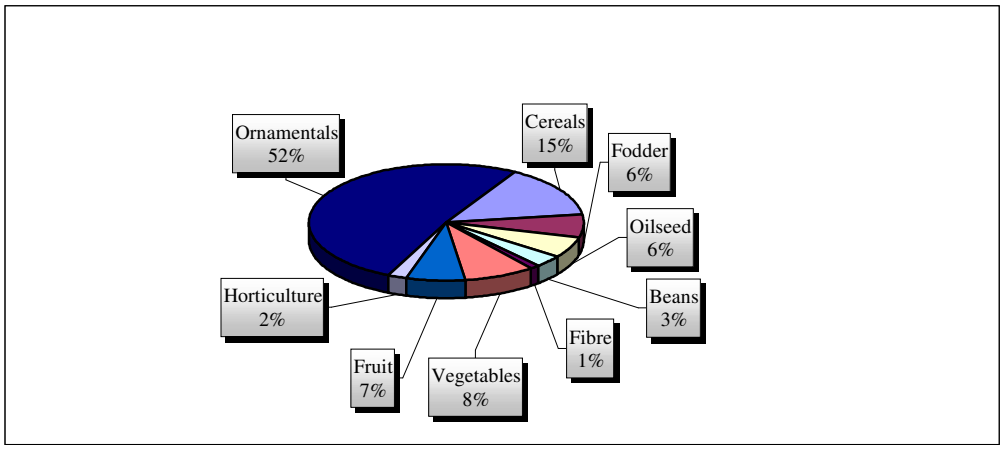


Source: Calculated from data contained in UPOV (2001).

The most striking feature of PVP grants in UPOV member countries is the very large proportion of grants accruing to ornamentals (Figure-5). For all countries taken together, horticultural crops (including ornamentals, fruits and vegetables) account for 70% of grants, while ornamentals alone account for 51.5%. The pattern of dominance of ornamentals extends to a diverse set of countries. As the debate on the impact of plant variety protection often focuses on its impact on food security for small and resource poor farmers, it is something of a paradox that PVP almost universally evokes the largest response from ornamental species. The large share of ornamentals cannot be explained by their share in the commercial market for seed/propagating material or their share in the value of crop output. It is partly a reflection of

the sheer diversity of ornamental species[11]. More importantly, it may reflect the fact that the scope of breeders' rights in the case of ornamentals is significantly different from that in other crops. The absence of farmers' exemption and the ease of detecting infringements in the case of ornamentals increase the appropriability of returns from protected varieties.

Figure-5: Share of Crop Groups in PVP Grants for UPOV countries



Source: Calculated from data contained in UPOV (2001). Data relate to 30 UPOV member countries for which data were available. No data were available for certain UPOV member countries which had joined UPOV recently.

Agricultural crops (which include cereals, fodder, oilseeds, beans and fibre) account for only 30% of all the PVP grants. Table-1 shows the share of the top ten crops in PVP grants for agricultural species in six countries- Australia, France Germany, Netherlands, United Kingdom and the United States. The table also shows the number of other agricultural species for which grants have been made in these countries. The top ten crops account for 63-94% of the total grants for agricultural crops. Just *four* cereal crops (wheat, maize, barley and oats), *two* oilseed crops (soybean and oilseed rape), *three* forage species (perennial ryegrass, lucerne and fescue) and *two* bean/ lentil species (French bean and peas) and *one* tuber crop (potato) account for an extraordinarily high percentage of grants for agricultural crops. Considering the fact that there are nearly 240 agricultural species for which grants have been made in different countries, this represents a very high degree of concentration in PVP grants in agricultural crops. Thus, even in developed countries that provide a high level of enforcement of breeders' rights, PVP appears to generate a significant response in terms of new variety development only from the most important agricultural crops. A large number of agricultural crops appear to receive no stimulus for new variety development from PVP. From the point of view of developing countries, it is significant that millets, tuber crops like cassava and pulse crops appear to receive no stimulus for innovation from PVP.

[11] For instance, in the Netherlands while PVP grants have been made for 6 species of cereals, they have covered 240 species of ornamentals.

Table-1: Share of top ten crops in PVP grants for agricultural crops (%)

Crop/Country	Australia	France	Germany	Netherlands	UK	USA
Wheat	13	9	5.9	3.9	14.4	10.8
Barley	4.3	7	6.5	4.1	19.8	2.5
Maize		44	17.9	9.9	1.2	15.9
Sorghum		1.3				
Oats	5.1				4.1	
Rape	7.5	3.3	8.6		11	
Sunflower		12.1				
Soybean		1.4				24.3
Pea	3.4	4.7	6.1	6.8	6	
French Bean	2.8	5.8	3.8	7.9	4.6	8.3
Field Bean					2.9	
Potato	10.1	5.8	10	19.9	10.9	
P. Ryegrass	5.5		9.6	20.7	10.7	3.5
Italian Ryegrass				3.0		
Lucerne	4.5					2.7
Bluegrass			3.2	4.2		2.1
Fescue			4.7	5.7		3.1
Cotton	6.7					8.1
Total top ten agricultural crops	**62.9**	**94.4**	**76.3**	**86.1**	**85.6**	**81.3**
Others	37.1 (108)	5.6 (20)	23.7 (78)	13.9 (25)	14.4 (29)	18.7 (125)

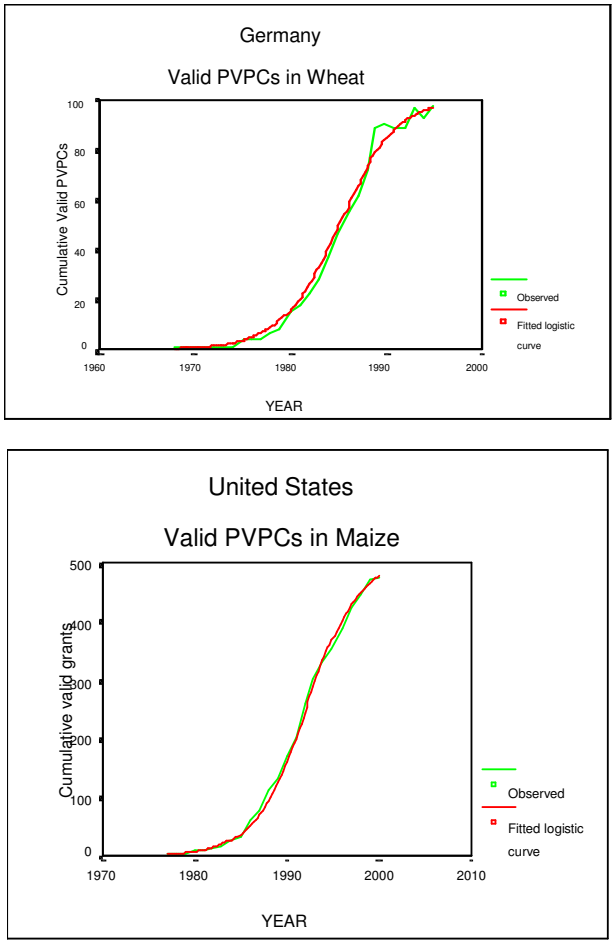
Figures in parentheses indicate the number of other species for which grants made.

Source: Calculated from UPOV (2001).

An examination of the data for UPOV member-countries also reveals some interesting empirical regularities in PVP grants. While cumulative grants in any crop keep increasing with time, the valid grants (total grants less expired or surrendered grants) follow an S-shaped pattern over time (see illustrations in Figure-6). The S-shaped time path suggests that valid grants tend to reach a "saturation" or "ceiling" level in each crop in mature PVP countries. This pattern appears to be an outcome of three factors (a) the time required for new variety development to respond to PVP, given the lags in the breeding process (b) the size of the market, which may set a ceiling on the number of varieties that can remain in commercial production, especially if total seed market volumes are fixed (or are changing slowly) (c) the gradual displacement of older "unprotected" varieties and the diffusion of new "protected" varieties following an "epidemic" model. The time taken for saturation levels to be reached

varies across countries and crops, but in general ranges from 25-35 years. Industrial crops like soybean and oilseed rape appear to produce a quicker PVP response than food crops. The full impact of the incentives provided by PVP for variety development is, therefore, visible only over a fairly long period[12].

Figure-6: Empirical Regularities in PVP Grants



Source: Data on valid PVP certificates extracted from UPOV (2001) and annual publications of PVP authorities. Valid PVP certificates for any species in any year = Total number of PVP certificates issued since inception of PVP legislation for a species - PVP certificates expired/surrendered/terminated till that year.

Concentration in ownership of PVP grants

The seed industry in developed countries has undergone a remarkable process of consolidation over the last three decades through acquisitions and mergers (Sehgal: 1995, King: 2001) – a process which has accelerated significantly with the advent of biotechnology since the mid 1980s (Kalitzandonakes and Bjornson: 1997, Hayenga: 1998). This process of consolidation has been driven by the attempts of large

[12] The implication is that policy makers in developing countries should be careful not to expect an instantaneous or rapid private sector response to PVP.

chemical and agro-chemical companies to exploit the complementarities between seed and other inputs (Butler and Marion: 1985) and later by the need to access and control IPRs related to critical biotechnology research tools and processes necessary for genetic modification (Rausser, Scotchmer and Simon: 1999, Graff, Rausser and Small: 2003). Consolidation has resulted in fairly high levels of concentration in the product market as well as in IPR ownership ("innovation" market). Several measures have been designed to measure the degree of concentration in any market –e.g., the 4-firm concentration ratio (CR-4), the Lerner Index and the Herfindahl-Hirschman Index (HHI)[13].

At the product market level, the seed industry worldwide does not appear to exhibit a high degree of concentration. In 1997, the top 10 companies accounted for about 30% of the estimated global seed market of US $ 15 billion (RAFI: 1997). The CR-4 ratio was 21% with an HHI of 351 (Goldsmith: 2001). In the agrochemicals industry, the top 10 firms accounted for 82% of a global market of US $ 30.5 billion. The CR-4 ratio was 41% with an HHI of approximately 743. Therefore, compared to other agricultural input industries, the global seed market is still relatively fragmented (Lebuanec: 1998), although concentration levels at the national level are much higher than at the global level.

There is no empirical evidence to suggest that PVP has contributed significantly to the consolidation of the seed industry. This is because conventional PVP provides for farmers' privilege and researchers' exemption. The latter allows any protected variety to be used as an "initial source of variation" in the development of other new varieties. Consequently, PVP has not been seen as creating incentives for mergers and acquisitions for the purpose of accessing protected material for further development. PVP itself has generally not been seen as having a large impact on the potential for follow-on innovations .The contrast is with the agricultural biotechnology industry, where it has been argued that the need to access protected biotechnology processes and research tools from diverse IPR holders and the large transaction costs of negotiating individual licenses may have spurred the consolidation of biotechnology firms through mergers and takeovers. However, as discussed in a later section, in developed countries efforts are being made to strengthen PVP (e.g., through the essential derivation clause[14], restrictions on farmers' privilege etc) and provide better appropriability of returns to breeders by bringing PVP closer to patents. When these provisions to strengthen PVP are put in place, then the concentration of ownership of PVP

[13] The 4-firm concentration ratio is the share of the market held by the top four firms in the industry. The Lerner Index is an index of market power, which looks at the deviation of industry price from the marginal cost. The Herfindahl-Hirschman Index is the sum of the square of the market shares of all the firms in the industry. The market shares are squared to give greater weightage to larger firms.

[14] The desire to discourage "cosmetic breeding" and the need to prevent second round innovators from appropriating the returns of first round innovators through relatively minor or unimportant modifications of existing varieties, has led to strengthening of PVP in the 1991 Convention of UPOV. The principal change is the incorporation of the "Essentially Derived Variety (EDV)" clause in PVP legislation .The effect of the EDV clause is to restrict researchers' exemption and bring PVP much closer to patents (where researchers' exemption generally does not prevail). Thus, it is conceivable that in the future, with vigorous enforcement of the EDV provision, PVP may create incentives for consolidation in a manner similar to agricultural biotechnology patents.

certificates may begin to have important implications for future innovations in plant breeding. In particular, concentration of PVP ownership may have a significant impact on competition in the seed industry through its impact on the "follow-on" development of new varieties. The concentration of ownership of PVP certificates could potentially become an important determinant of market share for seed companies.

Data on concentration of PVP holdings in 30 UPOV member-countries for six crops as at the end of 2000 and the associated HHI indices are summarised in Table-2. These are crops for which the largest numbers of PVP certificates have been issued and are major food/industrial crops grown widely in both developed and developing countries.

Table-2: Concentration of PVP Certificates in UPOV member-countries (2000)

CROPS	Wheat	Maize	Soybean	Potato	P. Ryegrass	Oilseed Rape
Total PVP grants in UPOV countries	**2600**	**5382**	**1503**	**2650**	**1650**	**1923**
Rank of companies (in PVP ownership)						
1	**Monsanto** 258 *9.92%*	**Pioneer** 893 *16.59%*	**Monsanto** 228 *15.17%*	**Coop De ZPC** 223 *8.41%*	**Cebeco** 259 *15.70%*	**Svalof** 306 *15.91%*
2	**US Univs/SAES** 144 *5.53%*	**Monsanto** 600 *11.15%*	**Novartis** 206 *13.17%*	**Agrico** 225 *8.49%*	**Advanta** 217 *13.15%*	**Monsanto** 301 *15.65%*
3	**Svalof** 113 *4.35%*	**Limagrain** 565 *10.50%*	**Pioneer** 181 *12.04%*	**Hettema Zonen** 159 *6.00%*	**DLF** 136 *8.24%*	**Deutsche Saat** 197 *10.24%*
4	**Benoist** 112 *4.31%*	**KWS** 445 *8.27%*	**US Univs/SAES** 149 *9.91%*	**Saka Ragis** 113 *4.26%*	**Barenbrug** 147 *8.90%*	**Nordeutsche** 146 *7.59%*
5	**Advanta** 92 *3.54%*	**Novartis** 327 *6.08%*	**Advanta** 52 *3.45%*	**Germicopa** 89 *3.36%*	**Deutsche Saat** 109 *6.61%*	**KWS** 89 *4.63%*
6	**Limagrain** 92 *3.54%*	**RAGT** 271 *5.04%*	**Argentinian PSUs*** 44 *2.93%*	**Boehm** 70 *2.64%*	**Dutch Institute** 69 *4.18%*	**Limagrain** 89 *4.63%*
7	**Cebeco** 83 *3.19%*	**Maisadour** 251 *4.66%*	**Soybean Research Foundation** 43 *2.86%*	**Wolf and Wolf** 68 *2.56%*	**Pure Seeds** 38 *2.30%*	**Pioneer** 81 *4.21%*
8	**GAE** 80 *3.08%*	**Agri-Obtentions** 191 *3.55%*	**Japanese PSUs*** 30 *2.00%*	**Nord kartoffel** 61 *2.30%*	**Mommer steeg** 34 *2.06%*	**Serasem** 75 *3.90%*
9	**KWS** 79 *3.04%*	**Dow** 149 *2.77%*	**Nidera S.A** 29 *1.93%*	**LB. Kartoffelfond** 54 *2.03%*	**Nordeutsche** 33 *2.00%*	**Novartis** 63 *3.28%*
10	**Verneuil** 78 *3.00%*	**COOP de PAU** 147 *2.73%*	**Delta and Pineland** 27 *1.80%*	**Norika** 55 *2.07%*	**KWS** 33 *2.00%*	**Aventis** 53 *2.76%*
PVP certificates held by top ten institutions	**1131**	**3839**	**989**	**1117**	**1075**	**1400**
Share of top ten institutions	**43.50%**	**71.33%**	**65.80%**	**42.15%**	**65.15%**	**72.80%**
HHI	**229**	**690**	**686**	**235**	**645**	**754**

*Public sector institutions.

[#]Note: Figures in each cell in the table show the name of the company, the number of certificates owned by the Company/Group and its percentage share of the total number of certificates in the particular crop. The names and location of the headquarters of the companies are given in the appendix.

The key patterns that emerge from the data are summarised below:

(a) *Concentration in the ownership of PVP certificates is high at the level of individual countries.* The share of certificates owned by the top ten institutions/firms worldwide for the six crops ranges from a little over 40% in wheat and potato to over 70% in the case of oilseed rape and maize. The CR-4 ratios are low for wheat (20%) and potato (27%), while they are considerably higher for maize (47%), soybean (50%), perennial ryegrass (45%) and oilseed rape (50%). The CR-4 ratios tend to suggest that for four out of the six crops considered, concentration levels in PVP ownership are moderate to high[15]. However, the HHI indices for all crops are well below 1000, the level beyond which anti-trust concerns would be warranted under US Department of Justice guidelines[16]. The picture changes significantly when we consider concentration levels in individual countries. The data for leading PVP countries[17] is summarised in Table-3.

Table-3: Concentration in PVP Certificate Ownership at Country Level (2000)

		USA	UK	France	Germany	Netherlands
Wheat	CR-4 (%)	**67.45**	**52.85**	**52.53**	25.38	19.58
	CR-10 (%)	**89.79**	**54**	**73.44**	**62.09**	**81.82**
	HHI	**1658**	**2509**	**1042**	**269**	**222**
Maize	CR-4 (%)	**85.09**	-	39.19	**58.44**	**60.58**
	CR-10 (%)	**95.45**	**-**	**75.23**	**85.90**	**84.12**
	HHI	**2755**	-	**647**	**1206**	**1178**
Soybean	CR-4 (%)	**73.90**	**-**	**63.33**	**52.38**	-
	CR-10 (%)	**87.01**	**-**	**88.89**	**100**	**-**
	HHI	**1256**	**-**	**1162**	**1201**	-
Perennial ryegrass	CR-4 (%)	**51.19**	33.43	**75.86**	47.73	**72.11**
	CR-10 (%)	**66.67**	**63.58**	**100**	**85.33**	**92.76**
	HHI	**826**	**445**	**2128**	**943**	**1470**
Oilseed rape	CR-4 (%)	**66.17**	45.55	**77.56**	**64.98**	**62.85**
	CR-10 (%)	**95.59**	**75.07**	**94.63**	**84.81**	**91.43**

[15] In the industrial organisation literature, a CR-4 ratio of 40-60% in any market is taken to represent moderate to high levels of concentration.

[16] Under the U.S. Department of Justice guidelines, an HHI of less than 1000 represents a relatively unconcentrated market and the Department will not investigate a merger if the HHI is in that range. An HHI between 1000 and 1800 represents a moderately concentrated market and the Department would closely investigate the competitive impacts of mergers that would result in an HHI in that range. Markets having an HHI greater than 1800 are considered highly concentrated, meriting serious anti-trust concerns.

[17] Countries that have issued the most PVP certificates.

	HHI	1338	685	2132	1596	1257

Source: Estimated from data contained in UPOV (2001). Concentration was calculated at the level of seed company or company group. PVP certificates belonging to subsidiaries, affiliated group companies, companies taken over or acquired were treated as belonging to the parent company group.

Concentration in PVP ownership is significantly greater at the national level than it is at the international level. Though data are presented here for only five countries, it must be noted that concentration levels in smaller UPOV countries are even greater (probably because there is less competition in smaller markets). In wheat, PVP ownership is concentrated (CR-4> 50%, HHI> 1000) in the US, UK and France. The figures for the US need to be interpreted cautiously because all US Universities/State Agricultural Experiment Stations (SAES) have been clubbed together as a single institution. PVP ownership in maize is highly concentrated in the US, Germany and the Netherlands. Concentration levels in France are probably lower because of the significant participation of the public sector (INRA) and large co-operatives in varietal development. Concentration levels in soybean and oilseed rape are high in almost all countries, while HHI indices are generally lower for perennial ryegrass.

(b) ***A very large proportion of grants is held by a limited number of large transnational seed companies***, *viz*, Monsanto, Pioneer (Du Pont), Novartis (Syngenta), Advanta, Aventis, Limagrain, KWS, and Cebeco. Some French and German cooperatives also have a large number of PVP grants. The above eight large transnational companies account for 53% of PVP grants worldwide in maize, 43% in soybean, 31% in perennial ryegrass and 35% in oilseed rape, while accounting for only 20% of grants in wheat and none in potatoes. The top five positions in several crops are occupied by these companies, e.g.,

(i) Monsanto in wheat, maize, soybean and oilseed rape.
(ii) Pioneer in maize and soybean.
(iii) Novartis in maize, soybean, oilseed rape.
(iv) Limagrain in maize and oilseed rape.
(v) Advanta in wheat, soybean and perennial ryegrass.
(vi) KWS in maize and oilseed rape.

Therefore, the concentration of ownership of PVP certificates in the hands of transnational companies cuts across crops.

(c) ***The overall level of concentration is less in the case of crops where public sector or cooperative institutions have played a substantial role in plant breeding***. The public sector has traditionally been strong in breeding new varieties of self/open-pollinated crops, possibly because it was expected that the private sector would not be keen to invest in non-hybrid crops. In wheat, soybean, perennial ryegrass and potato (all non-hybrid crops) the degree of concentration is less than it is in maize and oilseed rape. Maize is a crop currently dominated by

hybrids and it is well documented that in the United States the public sector has almost completely withdrawn from the development of finished cultivars of maize. Oilseed rape is another crop where hybridisation has been relatively successful, allowing the private sector to play a major role in the development of new varieties. In the case of potato, the strong presence of European cooperatives appears to have prevented concentration of PVP certificates in the hands of major transnational seed companies. In general, the participation of public sector and cooperative institutions in plant breeding appears to serve as a check on concentration in PVP ownership.

(d) ***Concentration in the ownership of PVP grants has mainly come about through mergers and acquisitions, especially those that have taken place in the 1990s, rather than through the acquisition of a dominant share of new certificates by the major seed companies***. Many major seed companies have acquired a large part of their PVP portfolios through mergers and acquisitions. The classic case is that of Monsanto, which occupies a leading position in wheat, maize, soybean and oilseed rape. 96.5% of its wheat PVP certificates, 76.7% of maize certificates, 94.2% of its soybean certificates and 27% of its oilseed rape certificates have accrued to Monsanto as a result of acquisitions. In fact prior to the mid-1980s, Monsanto was not primarily a seed company at all; it was mainly in the agro-chemicals and pharmaceutical business. Similarly, Dow, which is now estimated to be among the ten largest seed companies in the world, acquired its entire maize portfolio through acquisitions. Companies that were originally focussed on one set of crops have acquired leading positions in the ownership of PVP certificates of other crops through mergers and acquisitions. Limagrain, France, which is now the fourth largest seed company in the world, was originally a maize company. Its entire wheat PVP portfolio has been acquired by taking over the European operations of Nickersons. Similarly, KWS, Germany, which is a major maize company owes its entire wheat portfolio to the take over of Cambridge Plant Breeders, Twyford, and Lochow-petkus GmbH, whereas only a small proportion of its maize portfolio has been derived through acquisitions. Clearly, it is the consolidation of the global seed industry through mergers and acquisitions that has led to a high degree of concentration of IPRs for plant varieties.

We do not have the data to examine the empirical relationship between IPR ownership product market shares. However, it is likely that ownership of IPRs over plant varieties does translate into commercial seed market shares. IPR ownership may be a good leading indicator or predictor of seed market shares.

PVP Impacts

Though Europe has been the pioneer in PVP legislation, there have been no studies of the economic impacts of PVP on European agriculture or research. Most of the empirical studies have focused on the

United States and some on Latin America[18]. We do not propose to review the literature on empirical studies of PVP here. However, the key findings of these empirical studies can be summarised as under:

a) PVP grants (which may be taken as an indicator of innovative activity) in any country vary systematically with the size of the market for seeds, the strength of the IPR regime and the size of the domestic research system. (Perrin, Kunnings and Ihnen: 1983, Srinivasan: 2001)

b) PVP has accelerated varietal turnover in several crops (e.g. soybean in the US, providing more choice to farmers) but there is little evidence that it has led to any increase in the trend rate of yield gain. (Perrin, Kunnings and Ihnen: 1983, Alston and Venner: 1998)

c) PVP facilitates private sector participation in plant breeding of *certain specific* non-hybrid crops. However, the stimulus of PVP does not extend to a wide range of crops. (Butler and Marion: 1985, Perrin, Kunnings and Ihnen: 1983, Butler: 1985, Frey: 1996).

d) The incentive effects of PVP for investment in plant breeding may be fairly weak as appropriation of returns by breeders is constrained by farmers' and researchers' exemption. (Butler and Marion: 1985, Butler: 1995, Janis and Kesan: 2002).

e) PVP does appear to play an important role in facilitating change in the institutional framework for plant breeding research. In the context of fiscal constraints, it forces a reappraisal of the role of the public sector in plant breeding and its relationship with the private sector. (Butler: 1985, Knudson and Pray: 1991)

f) PVP has not been an important factor contributing to the concentration and consolidation trends in the seed industry worldwide[19] (Butler and Marion: 1985, Srinivasan: 2003b).

PVP and appropriability of returns

The effectiveness of plant variety protection in stimulating innovative effort or research and development expenditures for the development of new plant varieties is likely to depend on the extent to which it allows plant breeders to benefit from their innovations. Empirical studies suggest that the impact of PVP on private R&D expenditures has been rather modest because PVP facilitates only limited appropriability of returns for breeders. Butler and Marion (1985) observe from their study of the US PVP Act that the PVPA resulted in "modest private and public benefit at modest private and public costs" (p.79). Perrin et al (1983) found that the post-PVP period in the US saw increased private investment in the breeding of soybean and other non-hybrid crops – but that this increase was much smaller than the increase in research investment for hybrid crops. In a more recent review of empirical studies of the US PVP Act, Janis and Kesan (2002)[20] observe:

[18] Some relevant studies are Butler and Marion: 1985, Perrin, Kunnings and Ihnen: 1983, Butler: 1985, Kalton and Richardson: 1983, Kalton and Richardson: 1989, Frey: 1996, Alston and Venner: 1998, Jaffe and Van Wijk: 1995.

[19] However, patents and IPRs associated with biotechnology innovations may well have made a decisive contribution to this trend.

[20] This study has been relied upon extensively in UPOV document **WIPO-UPOV/SYM/02/8** dated 3-10-2002 (UPOV: 2002)

> "However, more recent studies now confirm misgivings about the PVPA's capacity to provide adequate *ex ante* incentives…. We agree with the assessment that the PVPA does not stimulate R & D spending" (p.775).
> "We draw a number of conclusions from these studies. First, the history of plant variety protection regimes in the United States and abroad reveals that the role of plant variety protection in the overall intellectual property scheme has mutated greatly without any fundamental changes to the general statutory approach to plant variety protection. Whereas plant variety protection was initially designed as the primary (or even exclusive) form of intellectual property protection for seed-grown plants, the coming of plant biotechnology, and the dawning acceptance of utility patents for plants, has relegated plant variety protection to a secondary role. Modest statutory amendments to the PVPA have shown no real promise of lifting the PVPA up from this secondary status. Second, our empirical assessment of licensing and enforcement activities concerning U.S. plant variety protection certificates confirms that the PVPA regime as presently constituted plays only a marginal role in stimulating plant breeding research in the United States. Our assessment strongly suggests that the PVPA does not provide patent-like *ex ante* innovation and investment incentives and that the PVPA has not generated substantial *ex post* licensing and enforcement activity. Instead, its role in the United States appears to be very modest: it may serve as a marketing tool…. "(p. 777-778)

If limited appropriability is the problem in stimulating plant variety innovation, then there is a need to strengthen the protection offered to breeders under PVP. At the same time, a large part of the resistance to the introduction of PVP in developing countries stems from the apprehension that PVP will enable breeders to earn larger monopoly rents from the sale of protected varieties to farmers. The appropriation of monopoly rents by breeders is also considered inequitable because breeders' innovations are dependent in large measure on the plant genetic resources conserved and maintained by farming communities. Many developing countries are, therefore, attempting to limit the returns that breeders could appropriate through protection by forcing them to share these benefits with farmers or farming communities. Even though developing countries may be adopting PVP legislation to fulfil their obligations under the TRIPs Agreement, they still have to address these equity concerns and make a case that PVP will increase net social benefits.

Plant variety protection certificates are seldom marketed or traded and hence their private value is usually not observed. However, it is possible to infer the value of plant variety rights from the economic responses of PVP certificate holders (Schankerman and Pakes: 1986). In almost all countries with PVP legislation, certificate holders must pay an annual renewal fee in order to keep the certificate in force. If it is assumed that certificate holders make their renewal decisions based on the value of returns they obtain from the renewal, then the data on renewal of PVP certificates and renewal fee schedules contains information on the value of PVP rights. Such a renewal model implies that protected plant varieties for which protection is more valuable (e.g. because it commands a larger market share) will be protected by payment of renewal fees for longer periods of time.

Following Schankerman and Pakes (1986), it is assumed that each cohort of PVP certificates is endowed with a distribution of initial returns, which decay deterministically thereafter. The model allows both the initial distribution and the decay rate to vary over time. It is assumed that certificate holders choose the

lifespan of the certificates so as to maximise the discounted value of net returns (i.e., current returns minus renewal fees). Schankerman and Pakes show that, for a given schedule of renewal fees, these assumptions imply a sequence of renewal proportions over age for each cohort. The proportion of PVP certificates renewed in each year depends on parameters, which determine the initial distribution of returns and the decay rates. Their model estimates a vector of parameters, which makes the renewal proportion predicted by the model as close as possible to those actually observed. Once the parameters of the distribution of initial returns and the decay rates are estimated, the private value distribution of PVP certificates is obtained by simulation.

We present below some estimates[21] of the private value of PVP certificates based on a renewal model for three European countries, which have had PVP legislation for more than 20 years[22]. The estimates were prepared separately for agricultural crops and ornamental crops in France, Germany and the Netherlands for a range of cohorts of PVP certificates from 1979-1999. The estimates of the private values of holding PVP certificates for the 1980 and 1989 cohorts in France and the 1989 cohort in Germany and the Netherlands are presented for agricultural and ornamental crops in Tables 4 & 5 respectively.

Table-4: Value Distribution of PVP Certificates - Agricultural Crops*

(All values in constant 1998 U.S. Dollars)

	France 1980 cohort	France 1989 cohort	Netherlands 1989 cohort	Germany 1989 cohort
Mean	7113.24	3708.02	863.76	4521.98
Minimum	.00	.00	.00	.00
Maximum	720521.31	413864.00	55211.94	187109.45
Percentile 25	378.18	124.22	.00	243.70
Percentile 50	1726.19	698.17	156.03	1364.29
Percentile 75	6028.70	2858.86	732.90	4422.26
Percentile 95	28079.44	15139.61	3880.55	19305.17
Percentile 99	89076.82	49844.01	11093.53	45620.16
Range	720521.31	413864.00	55211.94	187109.45

[21] Details of the estimation and the schedule of PVP application and renewal fees are available from the author.

[22] For details of the renewal model see Schankerman and Pakes (1986). The estimates of the private value of PVP certificates are based on Srinivasan (2003a).

Table-5: Value Distribution of PVP Certificates - Ornamental Crops*

(All values in constant 1998 U.S. Dollars)

	France 1980 cohort	France 1989 cohort	Netherlands 1989 cohort	Germany 1989 cohort
Mean	5942.71	3797.88	1863.15	505.60
Minimum	.00	.00	.00	.00
Maximum	1170011.03	768484.66	118026.04	23884.90
Percentile 25	120.34	57.12	33.91	.00
Percentile 50	794.98	435.30	400.00	94.21
Percentile 75	3564.38	2156.71	1662.08	492.44
Percentile 95	22455.89	14494.68	8151.09	2166.29
Percentile 99	90858.15	59430.69	22374.78	6076.59
Range	1170011.03	768484.66	118026.04	23884.90

The key feature of the value distribution for both agricultural and ornamental crops is the sharp skewness. There is a high concentration of PVP certificates with very limited economic value. For the 1989 cohort of agricultural crops, the median value of a PVP certificate was only $698 in France, $156 in the Netherlands and $1364 in Germany. For the 1989 cohort of ornamentals, the median value was $435 in France, $400 in the Netherlands and just $94 in Germany. There is a sharp rise in the value of PVP certificates in the third quantile, but most of the value of PVP certificates is concentrated in the tail of the distribution, especially in the top 1%. For agricultural crops, only 1% of the protected varieties were worth more than $49,844 in France, $11,093 in the Netherlands and $45,620 in Germany. For ornamentals just 1% of the protected varieties were worth more than $14,484 in France, $8,151 in the Netherlands and $2,166 in Germany. The inescapable conclusion is that the bulk of PVP certificates provide only very limited economic returns to breeders[23]. For agricultural crops, only 40-60% of PVP certificates survive for more than five years and less than 30% survive for more ten years. Only a very small fraction of certificates (less than 3%) survive for the full term. The highly skewed distribution of private value of PVP rights is consistent with the results of studies of the values of patent rights for industrial products[24] (Schankerman and Pakes: 1986, Schankerman: 1998, Taylor and Silberston: 1973). Private returns to PVP grants are less than 1% of the agricultural R&D expenditures in these countries.

[23] It must be clarified that these results do not imply that international seed companies do not make large profits on the sale of new varieties. The results only suggest that the returns to holding IPRs (that too in the form of PVP and not patents) are modest. There are other sources of economic returns in the seed business, e.g. market power.

[24] Given that PVP certificates are likely to provide weaker protection than patents, we would expect the private values of PVP certificates to be lower than that of patents. This is broadly what we find when we compare the private values of PVP certificates in this study with the private values of patents in the Schankerman and Pakes (1986) study. However, comparisons of the private values of different IPR instruments are likely to be meaningful only when they are made across similar sectors/technology fields. Plant variety innovations constitute a relatively homogenous groups of innovations whereas the patents data used in the Schankerman and Pakes (1986) study relates to diverse sectors/technology fields.

The mean value of private returns appropriated from ornamental varieties was greater or nearly the same as that appropriated from agricultural crop varieties, even though the volume of seed sales of ornamentals is only a fraction of that for agricultural crops. This surprising result underlines the difference in appropriability between ornamentals and agricultural crops.

The private values of PVP certificates estimated above do appear to be rather low. However, it must be remembered that what renewal models estimate are the "pure" returns to IPRs and do not reflect the entire returns from the development and marketing of a new variety. The following arguments are relevant in this context:

(1) The low average private value of IPR holdings and the highly skewed distribution of private value are not unusual in the literature and are not unique to PVP certificates. A large number of studies on the private value of patent rights (a much stronger form of IPR protection) for different sectors of the economy have found very similar results. (Schankerman and Pakes: 1986, Schankerman: 1998)

(2) IPRs are only one way of protecting an innovation. Several other methods of protecting an innovation are available (e.g., trade secrets, first-mover advantage etc) which inventors/businesses can and do use. The returns to IPRs estimated using renewal models measure only the *incremental* private value that accrues to an inventor owing to IPR protection. Returns to IPR protection have empirically been shown to form a relatively small percentage of the total returns from inventive activity (Schankerman and Pakes: 1986, Schankerman: 1998).

(3) An important reason for the low estimated private values of PVP certificates is that IPRs alone are not sufficient for capturing value from plant variety innovations. IPRs need to be combined efficiently with other complementary assets to capture value. There is significant evidence of market power in the seed industry and all the market power is not attributable to variety ownership. Large profits of seed firms are consistent with low private values of IPR holdings.

With respect to point (3) above, it has been well recognised in the literature that IPRs by themselves do not ensure the capture of value (Rausser, Scotchmer and Simon: 1999, Teece: 1987). In order for the innovator to appropriate returns from his/her innovations, IPRs have to be combined with a range of complementary assets[25]. In the case of innovations in plant breeding, the key complementary asset is a marketing and distribution network that can reach the innovation to farmers. A relatively weak appropriability regime and the existence of market power in the ownership of complementary assets may mean that the incremental returns appropriated by the innovator on account of IPRs are low. A large part of the returns from an innovation may accrue to the owners of the complementary assets. The limited appropriability of returns from PVP also implies that farmers' rights provisions being designed by some developing countries are unlikely to yield significant economic returns to farming communities.

[25] Complementary assets are assets with which the innovation must be combined in order to make the innovation useful and valuable to the consumer. Teece (1987) distinguishes between three types of complementary assets. "Generic assets" are general-purpose assets that do not need to be tailored to the innovation in question. "Specialised assets" are those with unilateral dependence between the innovation and the complementary asset. "Co-specialised assets" are those with bilateral dependence.

Efforts to strengthen PVP

The limited appropriability of returns from PVP has led to efforts to strengthen PVP law and bring it closer to patents. Some of these efforts are reflected in the changes made to the UPOV Convention in the 1991 revision.[26] The key changes in relation to the 1978 UPOV Convention are (1) Mandatory extension of protection to all species of plants within a specified time frame, as against coverage of a prescribed minimum number of species (2) Increase in the minimum duration of protection to 25 years for trees and vines and 20 years for other plants (3) Extension of breeder's right to all production and reproduction of a protected variety, as against "production and reproduction for the purpose of commercial marketing." Farmers' privilege to use seeds of a protected a protected variety saved from the harvest for replanting can, however, be provided as an exception to breeders' rights (4) Extension of the right of the breeder to the harvested material in cases where he/she has not had an opportunity to exercise rights over propagating material of the protected variety (5) Introduction of the essential derivation clause to discourage "cosmetic breeding." The essential derivation clause seeks to prevent other breeders from appropriating returns from a protected variety through minor (agronomically unimportant) modifications (see Box-1).

Box 1: Essentially Derived Varieties

"Essential Derivation" clauses have been introduced in the PVP legislation of countries that are signatories to the UPOV 1991 Convention. The principle of essential derivation in UPOV 1991 was stated as follows:

A variety shall be deemed to be essentially derived from another variety ("the initial variety") when

(1) It is predominantly derived from the initial variety, or from a variety that is itself predominantly derived from the initial variety, while retaining the expression of the essential characteristics that result from the genotype or combination of genotypes of the initial variety.
(2) It is clearly distinguishable from the initial variety and
(3) Except for differences, which result from the act of derivation, it conforms to the initial variety in the expression of the essential characteristics that result from the genotype or combination of genotypes of the initial variety. [Article 14 (5) (b)] (UPOV: 1994)

The economic principle behind this clause is that when an innovation has spillover benefits for other innovations- for example, it could reduce their cost or provide a necessary foundation-then from a social perspective, the first innovator should share in profit from subsequent innovations. Otherwise the earlier innovator will have deficient incentives to invest. The second innovator will be induced to share his profits with the first innovator only if the second round innovation (a new variety) infringes the rights of the first innovator. The objective behind the essential derivation clause is to define a set of circumstances in which such an infringement will be deemed to have occurred. However, if the later innovator knows that he would infringe a prior PVP right, he may be dissuaded from investing by the threat of ex-post hold up for high licensing fees. This hazard might stifle second-generation products or reduce incentives for follow-on development of new varieties (Scotchmer: 1991).

The above attempts to strengthen PVP are mainly intended to improve the appropriability of returns, which are generally constrained by farmers' privilege and researchers' exemption. The essentially derived variety (EDV) clause attempts to strike a balance between breeders of protected varieties and those who wish to introduce new varieties that are based entirely on the genetic structure of protected

[26] These changes will get reflected in national PVP legislation as more countries accede to the UPOV Convention of 1991.

varieties. The precise technical definition of essential derivation is still a contentious issue and as yet there is very little experience of enforcement of the provision even in developed countries. However, the EDV provision could have significant implications for future innovation in plant breeding, where almost all new varieties are based on pre-existing varieties. It has been argued that a very broad interpretation of the EDV provision could simply stifle the development of new varieties based on protected varieties (Scotchmer: 1991).

The quest for stronger protection has led to plant varieties being protected through patents. In the U.S., plant varieties became patentable as a result of a series of judicial decisions reinterpreting the existing patent laws The US Supreme Court decision in *Diamond vs. Chakrabarty* was a land mark case. This trend has been reinforced by decisions of the United States Patents and Trademark Office (*ExParte Hibberd* and *ExParte Allen* are two important cases) (Goss: 1996). Patents provide stronger protection because they are not subject to farmers' privilege and researchers' exemptions. The scope of utility patents is wide because it allows a breeder to exclude others from *making, using* or *selling* the seeds of the patented variety. Patent protection is expensive to obtain. A breeder must prove several elements (1) that the variety is novel and useful (2) that it is "enabled" (currently this requirement can be satisfied by a deposit of the seeds of the variety in the U.S.) and that (3) it is not an obvious improvement upon an earlier protected variety. On account of the difficulty of proving that these requirements have been met, patents are frequently more difficult to obtain and take longer to obtain than PVP certificates. Notwithstanding these difficulties, in the U.S. during the last few years there has been a decline in the number of applications for PVP certificates, while utility patents for plants have maintained a rising trend.

In the U.S., seed companies have also devised a number of contractual arrangements (e.g., purchase contracts, label notices etc.) to prevent farmers from reusing the seeds of protected varieties. The emergence of "terminator technology" [27] can be seen as a technological solution to the problem of enforcing IPRs over a self-reproducing innovation. While the concept of terminator seeds has been deeply unpopular with developing countries (because of its implications for farmers' livelihoods), it nevertheless brings into sharp focus the limited degree of appropriability afforded by current PVP regimes.

PVP and transferability of varieties

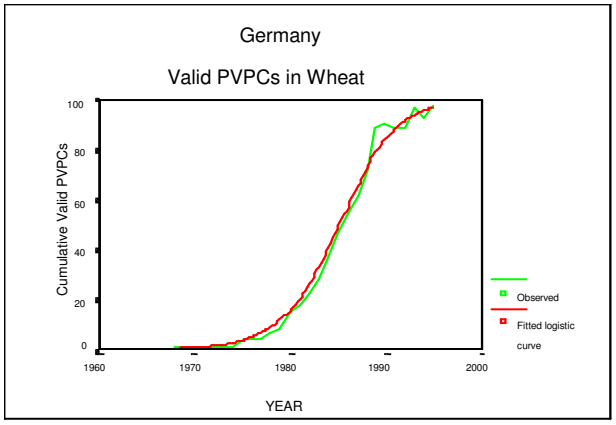
One of the key arguments advanced to developing countries for the introduction of PVP has been that it facilitates the transfer of superior varieties bred in developed countries. It was argued that that in the absence of IPRs, superior varieties bred in the developed world (increasingly proprietary or protected varieties developed in the private sector) would not be offered to them at all, given the fear that any

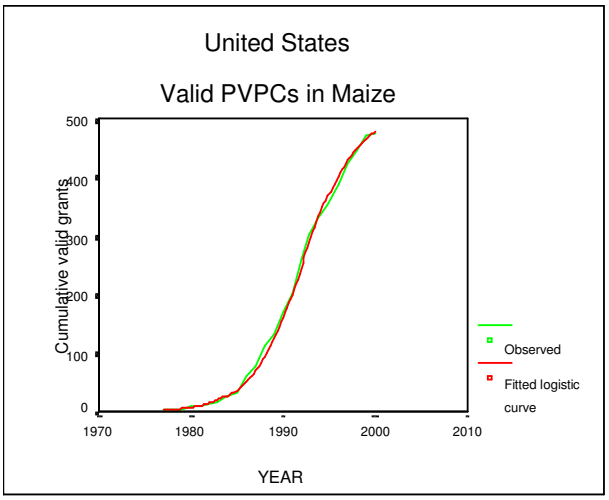
[27] "Terminator technology" refers to technology which renders farm-saved seed sterile and, hence, unsuitable for replanting.

competitor could freely replicate and sell these varieties. Complaints by large seed companies in the developed world regarding loss of sales due to "piracy" and the "transfer of technology" argument underpinned the inclusion of PVP in the TRIPs Agreement. Both these arguments implicitly assume that plant varieties protected in one country have large potential markets in several other countries. This requires that plant varieties be transferable across a range of countries/agro-climatic environments. The economic literature on plant varieties, on the other hand, has tended to emphasise that plant varieties are highly location specific in their agronomic performance and varieties developed for one microenvironment are unlikely to perform well in other microenvironments (Evenson: 1994). The location specificity of varieties mainly arises from two factors (a) adaptation to agro-climatic conditions and (b) adaptation to local pests and pathogens. The successful transfer of a variety bred for one location to another requires that the two locations should have similar agro-climatic conditions and that the variety must also be adapted to the biotic and abiotic stresses in the new location. Transferability of varieties also varies considerably by crop. The influence of PVP on transferability of varieties is, therefore, essentially an empirical question.

A useful indicator of the impact of PVP on inter-country movement of varieties is the multi-country incidence of protection. Plant variety rights obtained under PVP legislation are national in scope, i.e. rights granted in one country are independent of rights granted in any other country. When a breeder in country i decides to protect his variety by getting a PVP certificate in country i, he/she has also the option of obtaining (for a cost) a PVP certificate in country j. Decisions regarding the exercise of this option are informative regarding direct international spillovers between country i and j. Data on the multi-country incidence of protection for some important crops are given in the Table-6 below.

Figure-6: Empirical Regularities in PVP Grants





Source: Data on valid PVP certificates extracted from UPOV (2001) and annual publications of PVP authorities. Valid PVP certificates for any species in any year = Total number of PVP certificates issued since inception of PVP legislation for a species - PVP certificates expired/surrendered/terminated till that year.

Even the figures in the table above overstate the extent of inter-country movement of varieties because 90% of it is accounted for by the intra-European flow of varieties[28]. When UPOV member-countries are grouped into regions – Asia, Australia, Africa, Europe, North America and South America – and the data on multi-country incidence of protection is recast on a regional basis, then it is seen that less than 3% of varieties move across regions. PVP-induced movement of varieties is, therefore, very limited.

The foregoing is not intended to suggest that transfers of all plant genetic resources between countries are limited. It only suggests that the movement of finished plant varieties, *which are the only elements of plant genetic resources currently subject to IPRs*, is limited. Extensive transfers of germplasm, breeding lines and even landraces take place between public sector institutions in different countries and international public research institutions[29], which probably dwarf the transfers of finished varieties facilitated by PVP[30] (Evenson and Gollin: 2003, Fowler, Smale and Gaijy: 2001).

[28] As already noted, this intra-European flow is facilitated by the "common catalogue" and the seed certification system.

[29] The reference here is to the institutions of the Consultative Group on International Agricultural Research (CGIAR) like CIMMYT, Mexico and IRRI, Manila etc.

[30] Plant genetic resources (PGR) for agriculture include not only the "finished" products of plant breeding, but also "primitive cultivars, landraces, wild and weedy relatives" (Sedjo: 1988), breeding lines and germplasm in gene banks. Of these, only finished plant varieties are currently subject to IPRs. The international exchange of other elements of plant genetic resources (not currently subject to IPRs) has been dominated by exchanges between national and international public sector institutions (mainly between National Agricultural Research Systems (NARS) and CGIAR[30] institutions). The exchange of these resources in the future is likely to depend on the nature of emerging institutional arrangements governing such exchanges. Till quite recently, PGR were regarded as a "common heritage of mankind" (FAO: 1983) – i.e., as a public good to be freely exchanged between countries. However, this concept has undergone a significant change in recent years owing to the actions of both developed and developing countries. As developed countries have increasingly applied IPRs to finished products of plant

A related issue pertains to the incentives created by PVP for foreign participation in domestic plant breeding research. The transfer of "finished" plant varieties, advanced breeding lines, germplasm and breeding technologies can come about as a consequence of foreign direct investment (FDI) in the seeds sector or through technical collaboration agreements between domestic and foreign firms. In the absence of an IPR regime that allows sufficient appropriability of returns from new varieties, foreign participation in domestic plant breeding may be discouraged. Analysis of WIPO/UPOV data on PVP grants made to nationals and foreigners in UPOV countries shows that over the period 1975-1997 nearly 37% of grants were made to foreigners and this proportion has increased over time. The proportion of grants made to foreigners in selected developed countries and in developing countries is shown in Figure 7. Though the direct transfer of varieties across countries is limited, PVP does elicit a significant response from foreigners seeking to get their varieties protected. This suggests that transfer of plant material and germplasm as an adjunct to foreign participation in the domestic seed industry is a more important mechanism for transfer of technology.

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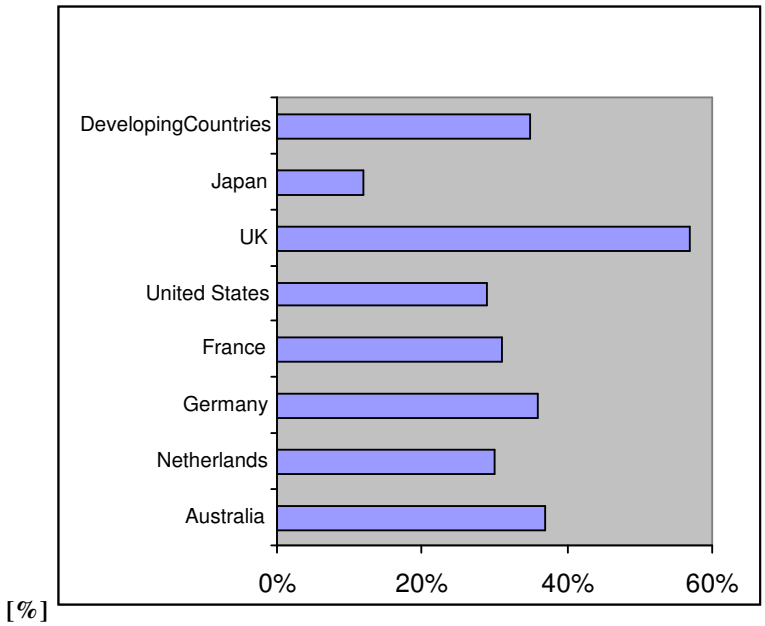
breeding, developing countries have come to feel that the system of free international exchange of PGR is inequitable because it provides no rewards for the PGR that they have conserved and make available to developed countries[30]. Drawing inspiration from the Convention on Biological Diversity which recognises “sovereign rights” of countries over their biological resources and encourages them to ensure “equitable benefit sharing” in their exchange and use, developing countries have responded by attempting to enact access legislation to derive rents from the ownership of PGR. Falcon and Fowler (2002) argue that most access legislation is “laden with restrictions to access, designed more to prevent abuse than to maximise benefits” (p. 209). They also argue that the new institutional arrangements emerging at the national and international level are likely to seriously constrain international exchange and restrict access to PGR for crop improvement, especially for developing countries. Therefore, a more restricted regime of international exchange of plant genetic resources does appear to be emerging. While PVP presently applies only to finished products of plant breeding, in the emerging scenario IPR-mediated exchanges of PGR may become more important.

Figure-7: Share of Foreigners in PVP Grants (1975-1999)



Source: WIPO (1975-2000).

Public sector and PVP

The response of public sector research institutions to PVP has always been a matter of considerable interest in countries where the public sector has been dominant in plant breeding. With government funding for the public research system declining in most countries (Alston, Pardey and Smith: 1998), IPRs could be seen as a source of revenue and public sector institutions may choose to actively protect their new varieties. However, given their mandate for the wide and extensive dissemination of new technologies and varieties, these institutions could also choose not to protect their varieties. Clearly, there could be conflict between the revenue generation and diffusion objectives. PVP could also lead to a redefinition of the role of the public sector in commercial cultivar development. It has been argued that with PVP providing incentives for private investment in plant breeding, the public sector should withdraw from commercial cultivar development (a "near-market" activity) to avoid "crowding out" private investment. At the same time, from the point of view of the public sector, the visibility and apparent commercial utility of cultivar development may be more useful in securing government funding compared to the results of basic research that may be less well understood.

We examine data on the share of the public sector in PVP certificates for three countries – Australia, France and the United States- where traditionally the public sector has played an important role in plant breeding (Table-7). In the United States, after some initial hesitation, the State Agricultural Experiment Stations and land grant Universities have shown the same propensity to protect their varieties as the private sector. In general the share of the public sector in PVP certificates has tended to decline for self and open-pollinated crops (except in the case of wheat), though the extent of the decline varies. Even 20-25 years after the introduction of PVP, the public sector continues to be a significant player in new

variety development in these crops. The public sector, however, does tend to get virtually eliminated from new cultivar development in crops where hybrids are dominant (e.g. maize). PVP has not been a major source of revenue for plant breeding research in public sector institutions and there is little evidence that PVP has affected the research priorities of these institutions in a significant way (Knudson and Pray: 1991). There is some evidence that PVP has tended to restrict germplasm exchange between the public and private sectors (Falcon and Fowler: 2002, Price: 2000)

Table-7: Public Sector Share of PVP Certificates (%)

Australia	**1990**		**1995**		**2000**	
Wheat	100		100		93	
Barley	50		44		68	
Oats	100		85		95	
Soybean	40		50		38	
Canola	66		75		83	
Cotton	100		88		60	
Potato	50		33		26	
P. Ryegrass	50		22		26	
France	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**
Wheat	20	13	18	21	18	16
Durum Wheat	-	39	36	32	33	34
Barley	22	14	15	12	9	8
Oats	44	33	23	17	13	11
Maize	83	51	34	25	24	21
Soybean	-	25	20	20	16	14
Rapeseed	-	29	15	8	3	3
Potato	3	5	6	7	10	11
Flax	40	67	56	54	55	60
Fodder Sorghum	-	-	33	23	35	35
United States	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**
Wheat	29	31	28	31	33	35
Maize	-	16	18	4	1.7	1.8
Soybean	48	37	28	24	26	25
Oilseed rape	-	-	22	33	27	24
Cotton	8	13	13	13	12	11
P.Ryegrass	100	100	100	100	100	100
Alfalfa	-	-	29	21	17	16

Source: Estimated from data contained in UPOV (2001). Public sector consists of public research institutions, public R&D companies (e.g., in Australia), and agricultural universities (e.g., Land Grant universities and State Agricultural Experiment Stations in the US). For public sector institutions, which have been privatised (e.g., Plant Breeding Institute in the UK) the ownership of PVP certificates has been classified as public or private depending on the status of the institution on the date of grant.

Emerging Scenarios for Developing Countries

The provisions of the TRIPs Agreement represent an effort to universalise PVP regimes with common standards of protection across countries. However, in analysing international trends in PVP, it is important to note the sharp divergence in the perspectives of developed and developing countries on PVP. In developed countries, where PVP has been well established for nearly three decades, the focus has been

on the appropriability of economic returns permitted by PVP. Farmers' privilege and researchers' exemption, which are important provisions built into PVP legislation, are seen as constraining the appropriation of economic returns by breeders and reducing private incentives to invest in plant breeding. Consequently, as discussed earlier in the paper, developed countries have attempted to strengthen PVP law and move towards stronger forms of protection that improve appropriability but may curtail farmers' privilege and researchers' exemptions. This trend toward stronger forms of protection has been reinforced by the increasing importance of biotechnology based innovations in plant breeding, which are protected by patents. In fact, in developed countries, it should not be surprising if conventional PVP systems decline in importance and are replaced by stronger IPR regimes flowing from legislative changes or (more likely) judicial reinterpretation of existing IPR law.

By contrast, in most developing countries, the TRIPs obligation has led to a divisive debate about the fundamental desirability of extending IPRs to agriculture and their potential economic impacts. Developing countries have been concerned about the "inequities" inherent in a system of plant breeders' rights. A key concern has been that while plant variety protection (PVP) systems reward plant breeders' for their innovations, they provide no rewards to farmers or farming communities that have conserved and enhanced agro-biodiversity over generations – the very biodiversity that constitutes the critical resource base for plant breeders. To address this imbalance, many developing countries are attempting to incorporate farmers' rights provisions in their PVP legislation with the objective rewarding farmers/farming communities for their role as conservers of biodiversity (Srinivasan: 2003a). Drawing inspiration from the Convention on Biological Diversity, which encourages countries to assert their "sovereign rights" over biological resources, many developing countries are also enacting access legislation in an attempt to garner rents from the plant genetic resources that they provide to the developed countries (GRAIN:2002). In developing countries, the impact of farmers' rights provisions and access legislation may well be to limit appropriation of returns by institutional plant breeders thereby reducing private incentives to invest.

We have noted earlier that the key economic arguments advanced to developing countries for adoption of PVP systems were that if would facilitate transfer of improved varieties from abroad and also provide incentives for private investment in plant breeding. The data examined in this paper shows that PVP-induced transfers of "finished" plant varieties have generally been too small (even across developed countries that provide high standards of enforcement) to be significant. While this may be reflecting only the location-specificity of plant varieties – it also suggests that there may be simply no large stocks of plant variety innovations in developed countries for developing countries to borrow or access. Moreover, the incentives for private investment in plant breeding are likely to be diminished not only by developing countries' attempts to address "equity" issues but also by their limited capacity to administer and enforce IPRs effectively. Therefore, it would be unrealistic for developing countries to expect large IPR-induced flows of private investment in plant breeding.

However, it must be noted that even in the absence of IPRs for plant varieties, developing countries (e.g. India, Mexico, Brazil, Argentina) that have opened up to foreign direct investment in the seeds sector have witnessed a significant restructuring of the domestic seed industry in a relatively short span of time. For a number of strategic and economic reasons (Srinivasan: 2003b, Morris: 1998), foreign direct investment in the seeds sector has proceeded through acquisition of domestic seed companies by seed MNCs creating significant levels of market concentration in market for hybrid seed varieties of important crops. In developing economies open to foreign direct investment, direct control of seed multiplication and distribution by foreign firms may provide a substitute for IPRs. In the case of genetically modified varieties (for which no IPR protection is currently available in most developing countries), it has been documented (Pray, Bengali and Ramaswami: 2004) that MNCs are attempting to use the relatively slow regulatory and approval processes in developing countries as a means of protecting their innovations against competition. The key implication is that incentives for private investment in plant breeding in developing countries are likely to be determined by the openness to foreign direct investment, potential market power, the degree of control that can be exercised over seed supply chains and the ability to influence the (non-IPR) regulatory environment, rather than by a system of weakly enforced IPRs.

A PVP regime is unlikely to provide a significant stimulus by itself to private investment in plant breeding or to the transfer of varieties from abroad. This is likely to be particularly true for small/poor developing countries with limited commercial markets for seed. These countries may have to continue to rely on public sector research institutions – both national and international – for variety development for their farmers. Improved varieties, particularly those aimed at resource poor farmers, may turn out to be a genuine 'public' good.

Many developing countries like China, India and Brazil have built up large National Agricultural Research Systems (NARS) with an impressive record of variety development. The "Green Revolution" varieties developed for South Asia and Latin America resulted from fruitful collaboration between the NARS and CGIAR institutions (Evenson and Gollin: 2003). The future role of NARS in these countries will depend not only on the level of funding support provided to them, but also on mandate given to public research institutions in the post-PVP situation. If NARS institutions are mandated to generate revenue through IPR/PVP protection of new varieties, then the public sector could potentially be faced with a conflict of objectives. Generation of revenue through protection of innovations (possibly coupled with exclusive licensing) is likely to conflict with the objective of the widest possible dissemination of new varieties. The success of large NARS has also depended on free and unrestricted access-national and international- to plant genetic resources critical for plant breeding. Access to international plant genetic resources has been greatly facilitated (Fowler, Smale and Gaijy: 2001) by the flow of material between NARS and the gene banks of CGIAR institutions unencumbered by IPRs. This access to material in the

gene banks of CGIAR, which developing country NARS have enjoyed, will probably continue, enabling them to pursue variety development through conventional plant breeding. But if, as feared by a number of analysts (e.g., Falcon and Fowler: 2002) the spread of IPR regimes coupled with the use of access legislation by developing countries, leads to a more restrictive international regime of exchange of plant genetic resources, then the ability of NARS to produce new varieties could be hampered. Interestingly, the ability of NARS to access plant genetic resources at the national level could be constrained by farmers' rights provisions in PVP legislation or benefit-sharing provisions in access legislation. More importantly, with the increasing use of biotechnology in plant breeding, the ability of the public sector to innovate may be constrained by the lack of access to biotechnology research tools and processes (and even genomic information) which are largely in private hands in the developed world. The transaction costs and time of negotiating access to protected biotech research tools and processes owned by a number of different companies could be considerable.

International research institutions of the CGIAR could continue to be a source of innovation for developing counties in general and for the poorer countries in particular. But it must be noted that two key factors will affect their ability to produce new varieties and disseminate them widely in developing countries. We have alluded to the possible emergence of a more restricted international regime for exchange of plant genetic resources. There is already some evidence that with the spread of IPR regimes and access legislation, the flow of accessions to the gene banks of the CGIAR has declined (Falcon and Fowler: 2002). The CGIAR institutions too need to access IPR-protected biotechnology research tools and processes for the development of new varieties that can compete with the varieties developed by the private sector. These institutions are probably in a much better position to negotiate access to protected technologies than the NARS, but their research efforts too could be constrained by the difficulties and transaction costs of procuring access. This is reflected in the fact that CGIAR institutions have so far played a minor role in the development of genetically modified varieties. The challenge for the international research institutions in the public sector is to devise institutional and legal arrangements which will allow them to use proprietary technologies in the development of new varieties, which they should then be able to disseminate freely in developing countries.

Attempts by developing countries to address the "equity" issues through farmers' rights provisions and access legislation are unlikely to be very successful in the near term. Farmers' rights provisions attempt to compel breeders to share a portion of their returns from protection with farmers/farming communities that have provided the plant genetic resources used by breeders. The limited appropriability of returns allowed by PVP systems implies that the returns to be shared with farmers may not be large. Even obtaining a share of the limited returns is rendered difficult by the administrative and scientific complexity of implementing these provisions. These complexities involve tracing the origin of specific plant genetic resources to individual farming communities, identifying the contribution of a specific resource to the development of a new variety, deciding on benefit-sharing norms when new varieties

have complex pedigrees with contributions from a large number of existing varieties and deciding how far back in time to go in recognising the conservation role of farmers. Similarly, access legislation will yield little unless developing countries acquire the ability to develop comprehensive inventories of "native" plant genetic resources relevant for plant breeding, establish "ownership" or proof of origin, estimate the potential economic or market values of a diverse set of resources, regulate the exchange of these resources through material transfer agreements (MTAs), monitor the use of material as it flows through a maze of national and international transactions and enforce MTAs in an international context through legal systems of other countries. Therefore, developing countries are unlikely to secure significant economic returns from access legislation, not because the underlying principles are flawed, but because these countries have not yet built up the enormous scientific, technical and administrative capacities required to meaningfully implement its provisions. At the same time, efforts to address "equity" issues can reduce incentives for institutional plant breeders and restrict international exchange of plant genetic resources, which has hitherto been very useful for development of new varieties. This is the fundamental dilemma that developing countries face.

The International Treaty on Plant Genetic Resources for Food and Agriculture, negotiated under the auspices of the FAO, addresses some of the concerns regarding the emergence of a more restrictive regime of international exchange of plant genetic resources as a result of the expansion of IPR laws and legislation relating to biodiversity conservation and exchange in developed and developing countries. The Treaty seeks to promote the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of benefits from their use. It seeks to achieve these objectives by establishing an "efficient, effective and transparent" multilateral system to facilitate access to plant genetic resources for food and agriculture – especially for the most important agricultural crops and a number of important forages. However, while the Treaty has come into effect, the detailed mechanisms for the proposed multilateral system of access and benefit sharing through appropriate "Material Transfer Agreements" are yet to emerge. Compliance mechanisms also have to be developed. The implementation of the Treaty is dependent on individual countries developing legislation and regulations to implement the Treaty. The challenge for many developing countries is to devise legislation that will be consistent with, and complementary to, the emerging IPR/PVP regime and legislation giving effect to the provisions of the Convention on Biological Diversity. However, application of the Treaty's framework for equitable use and benefit sharing at the national level can provide a basis for the implementation of Farmers' Rights. The administrative and scientific difficulties associated with the implementation of Farmers' Rights are nevertheless likely to remain formidable in the near future.

Conclusions

Plant variety protection has become established as an instrument of protection of plant variety innovations in developed countries over the last thirty years, even as developing countries continue to

debate the merits of a system of IPRs for plant varieties. The TRIPs Agreement has given a strong impetus for the universalisation of PVP regimes. But the experience of developed countries with PVP and the current concerns of developing countries suggest that developed and developing countries are likely to take widely divergent approaches to the further development of IPR regimes. In developed countries, as stronger forms of protection become available and the role of protected biotechnological processes in plant breeding becomes more important, PVP is likely to be displaced as the instrument of protection favoured by breeders. Developing countries are likely to find that PVP provides at best only a very modest stimulus to private investment in plant breeding or for transfer of varieties, even as it raises troubling equity issues. In attempting to address these equity concerns, they are likely to further dilute the incentives for innovation provided by conventional PVP systems. Continued reliance on public research institutions for variety development may have to remain an important element of their policy. Yet the provision of incentives for plant variety innovation for agricultural development is not an issue that they can ignore.

Acknowledgement

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Appendix

The names and location of the headquarters of the companies listed in Table 2 are given below.

Group	*Name*	*Country*	*Remarks*
Advanta	Advanta (AstraZeneca)	(Sweden and UK)	
Agrico	Agrico B.A.	(The Netherlands)	
Agri-Obtentions	Agri-Obtentions	(France)	Part of the Institut National de Recherche Agronomique (INRA)
Aventis	Aventis	(Germany)	Hoechst + Rhoune Poulenc
Barenbrug	Barenbrug Holdings B.V.	(The Netherlands)	
Benoist	Benoist C.C.	(France)	
Boehm	Boehm KG Kartoffelzucht	(Germany)	
Cebeco	Cebeco-Handelsraad	(The Netherlands)	
COOP de PAU	Coop de PAU (PAU Semences)	(France)	
COOP-DE-ZPC	COOP-DE-ZPC	(The Netherlands)	
Delta and Pineland	Delta and Pineland Company	(U.S.A)	
Deutsche Saat	Deutsche Saatveredelung Lippstadt-Bremen GmbH	(Germany)	
DLF	DLF-Trifolium	(Denmark)	
Dow	Dow Chemicals	(U.S.A)	
Dutch Institute	Dutch Institute of Plant Breeding and Genetics	(The Netherlands)	
GAE	Groupement Agricole Essonois	(France)	
Germicopa	Germicopa	(France)	
Hettema Zonen	Hettema Zonen Kweekbedrijf B.V.	(The Netherlands)	
KWS	KWS SAAT AG	(Germany)	
LB. Kartoffelfond	Landbrugets Kartoffelfond	(Denmark)	
Limagrain	Groupe Limagrain	(France)	
Maisadour	Maisadour Semences	(France)	
Mommersteeg	Mommersteeg International B.V.	(The Netherlands)	
Monsanto	Monsanto Corporation	(U.S.A)	
Nidera	Nidera S.A.	(Argentina)	
Norddeutsche	Norddeutsche Pflanzenzucht Hans-Georg Lembke KG	(Germany)	
Nordkartoffel	Nordkartoffel-Zuchtgesellschaft	(Germany)	
Norika	Nordring-Kartoffelzucht-und Vermehrungs GmbH	(Germany)	
Novartis	Syngenta	(Switzerland)	
Pioneer	Pioneer Hi-Bred International	(U.S.A)	Now owned by Du Pont (U.S.A)
Pure Seed	Pure Seed Testing Inc.	(U.S.A)	
RAGT	RAGT Semences	(France)	
Saka Ragis	Saka Ragis Pflanzenzucht Gbr	(Germany)	
Serasem	Serasem	(France)	
Soybean Research Foundation	Soybean Research Foundation	(U.S.A)	Industry supported research organisation
Svalolf	Svaloef Weibull AB	(Sweden)	
Verneuil	Veerneuil Semences	(France)	
Wolf and Wolf	Wolf and Wolf B.V.	(The	

Netherlands)

Source: Details of PVP certificates and ownership from UPOV (2001). Details of subsidiaries, group affiliations, takeovers and acquisitions were obtained from a number of different sources including RAFI (1997) and websites of different companies.

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