ASSESSING ECONOMIC RETURNS FROM FARMERS' RIGHTS

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Abstract

Many developing countries are attempting to address the inequities of plant breeders' rights by incorporating farmers' rights provisions in their Plant Variety Protection legislations to reward the role of farmers' as conservers and enhancers of agro-biodiversity. Developing countries expect to generate substantial revenues for biodiversity conservation or for community reward schemes through the application of farmers' rights provisions. This paper applies a patent-renewal model to assess the economic returns appropriated by plant breeders from new (protected) varieties in developed countries. The estimates confirm a widely held view in the literature that plant variety protection is a relatively weak form of IPR protection which allows plant breeders to appropriate only limited returns from their innovations. Consequently, the application of farmers' rights provisions in a manner akin to breeders' rights is unlikely to be a source of significant revenue to developing countries.

Keywords: Farmers' rights, Intellectual Property Rights, Plant Variety Protection, Appropriability, Economic returns

1. Introduction

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) requires all member countries of the WTO to enact a system of plant variety protection (a system of intellectual property rights for plant varieties) within a specified time frame. While accepting this obligation, several developing countries, especially those rich in biodiversity, have been concerned about the inequities 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 (Grain: 2002). These provisions also draw inspiration from the Convention on Biological Diversity which recognises the "sovereign rights" of nations over their biological resources and encourages them to ensure "equitable benefit sharing " in their exchange and use. There are expectations that the application of farmers' rights provisions can generate large revenues that can be used for community reward schemes or biodiversity conservation activities (Swaminathan: 1996). This paper attempts to assess whether such expectations are realistic.

Farmers' rights provisions generally follow one or more of the following the following approaches (1) Allowing farmers or farmer groups to stake intellectual property claims over their "traditional" varieties in same way as plant breeders seek protection for their new varieties (waiving the "novelty" criterion used in most intellectual property law) (2) Limiting the returns that breeders can potentially appropriate through protection by forcing them to share these benefits with farmers or farming communities (3) Imposition of a levy on breeders' profits to create a fund for conservation activities. Under all these approaches, the revenues that can be generated through the application of farmers' rights provisions depend will depend upon the returns that are appropriated by plant breeders from conventional PVP systems (with no farmers' rights). A good indicator of the returns that can be appropriated by breeders is the private value of PVP certificates in developed countries, where levels of enforcement of intellectual property rights (IPRs) are generally high. There have been few empirical studies that attempt to estimate the private value of PVP certificates, possibly owing to the lack of data. In this paper we use a patent-renewal model to estimate the private value distribution of PVP certificates in three European countries. These models have been extensively applied to the valuation of patent rights in industrial property; but they have not been previously applied to plant varieties.

2. Renewal Model

Plant variety protection certificates are seldom marketed or traded and hence their private value is usually not observed. Using the model developed by Schankerman and Pakes (1986), we will attempt to infer the value of plant variety rights from the economic responses of PVP certificate holders. 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. A breeder will not renew protection for a variety for which he sees no commercial potential. The estimates of the private value of PVP certificates derived from renewal models can be used to supplement the data on the *number* of PVP certificates as a measure of inventive output. It is also possible to estimate how the average value of PVP certificates differs across crop groups or over time. If the distribution of the value of PVP certificates is highly skewed and dispersed, then the number of certificates granted alone may not be a good indicator of the value of breeders' innovations.

Following the assumptions of the 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 the ones actually observed.

Let us consider the case of a plant breeder who holds a PVP certificate. Let j denote the cohort year of the PVP certificate and t its age so that t + j represents the year (in which renewal decisions are made). In order to keep the certificate in force, the breeder has to pay an annual renewal fee which generally varies with the age of the certificate. Renewal fees are periodically revised, and once revised, apply to all renewals irrespective of the cohort of the certificate. Let the sequence of renewal fees (in real terms and taking into account periodic revisions) at different ages be denoted by $\{C_{tj}\}$. A breeder who pays the renewal fee earns the return to protection in the following year, which can be denoted by R_{tj}. It is assumed that R_{tj} is known with certainty at the time the PVP certificate is granted. The breeder has to maximise the net value of discounted returns by choosing the optimal age at which to stop paying the renewal fee.

Given an assumed functional form for the distribution of initial revenues, the model derives the relationship between the predicted renewal proportions and the vector of parameters of the distribution of initial revenues and the decay rates. The functional form, which was found to best fit the sequence of the renewal proportions, was the lognormal distribution[1]. If R_{0j} (initial returns) follows a log-normal distribution, then:

$Ln\, R_{0j} = r_{0j} \sim N(\mu_j, \sigma^2)$ where N(.) denotes the Normal distribution

Using a log normal functional form for the distribution of initial revenues, the model yields the following estimation equation:

[1] The other distributions that have been commonly used in patent renewal models are the Weibull and Pareto-Levy distributions.

$$y_{tj} = \phi^{-1}(1 - P_{tj}) = \frac{-\mu_j}{\sigma_j} + \frac{c_{tj}}{\sigma_{tj}} + \frac{\sum_{\tau=1}^{t} Ln\, d_{\tau j}}{\sigma_j}$$

where $d_{\tau j} = 1 - \delta_{\tau j}$ and $\delta_{\tau j}$ is the decay rate of initial revenues of cohort j in each time period.

P_{tj} = Proportion of certificates of cohort j renewed at time t.

Schankerman and Pakes (1986) allow for inter-cohort differences in the distribution of the initial returns, by allowing cohort specific variation of μ, but maintaining a common value of σ. This is equivalent to letting cohorts of PVP certificates differ by a proportional rescaling of the initial revenues of all certificates in a given cohort. They also allow decay rates to vary across decades. Thus, if the renewal data span three decades (decade1, decade 2 and decade 3) then:

$$y_{tj} = \frac{\left(-\mu_j + c_{tj} - t_j\, Ln(1-\delta)\right)}{\sigma} - \left(\frac{\beta_1}{\sigma}\right)\sum_{\tau=1}^{t} D_{tj}^{1} - \left(\frac{\beta_2}{\sigma}\right)\sum_{\tau=1}^{t} D_{tj}^{2}$$

where it is assumed that:

$$d_{tj} = (1 - \delta_{tj}) = (1-\delta)\exp\left\{\beta_1 D_{tj}^{1} + \beta_2 D_{tj}^{2}\right\}$$

and D_{tj}^{1} and D_{tj}^{2} are dummy variables such that :

$$D_{tj}^{1} = \{= 1 \text{ if } t + j \text{ (renewal year) falls in decade 2 and}$$
$$\{= 0 \text{ otherwise}$$

and

$$D_{tj}^{2} = \{= 1 \text{ if } t + j \text{ (renewal year) falls in decade 3 and}$$
$$\{= 0 \text{ otherwise}$$

Positive values of β_1 and β_2 indicate a decline in the rate of decay during decade 2 and decade 3 relative to decade 1.The estimation of the value of PVP certificates was based on the above equation. The equation was estimated using non-linear least squares   One modification made in estimating the value of PVP certificates was that instead of allowing cohort-specific values of μ, the value of μ was allowed to vary only across decades or five yearly intervals. This was owing to the limited span of the data for some countries.

3. Description of Data

The estimation of the value of PVP certificates was attempted for France, Germany and the Netherlands for cereals/agricultural crops and ornamentals[2]. These three countries were selected for analysis because

[2] The crop groups considered were cereals and ornamentals in the case of France and agricultural crops and ornamentals in the case of Germany and the Netherlands. All agricultural crops were together considered as a group in the case of Germany and the Netherlands in order to provide sufficiently larger cohort sizes.

they have had PVP legislation since the late 1960s and are among the countries that have issued the largest number of PVP certificates. They were, thus, able to provide fairly large cohort sizes in these two crop groups[3].

The data on grant and renewal of PVP certificates was put together using a database of PVP certificates obtained from UPOV. Using this database it was possible to derive for each cohort the proportion of PVP certificates renewed at different ages. There are three important components of the total cost of obtaining a PVP certificate. These are (a) application fee (b) examination fee for DUS testing and (3) annual renewal fee for keeping the certificate in force. While the application fee is a one-time fee, the examination fee has to be paid for each year or growing season over which the variety is tested and the renewal fee has to be paid each year. Information on renewal fees applicable to different crop groups at different ages was obtained from UPOV and the PVP authorities of the three countries. The fees applicable in nominal terms were converted into real terms (1998=100) using a GDP deflator. The real fees in national currencies were converted into US dollars using the exchange rate for 1998. The data used for the analysis is described in Table-1.

Table-1: Description of Data Used in Renewal Model

	Agricultural Crops		
Part A	**France**	**Germany**	**Netherlands**
Range of cohorts	1974-1999	1988-1999	1989-1999
Range of years	1975-2000	1989-2000	1990-2000
Number of observations	324	88	75
Total number of PVP certificates in all cohorts	3666	1212	825
Mean number of PVP certificates per cohort	141	101	182
Ratio of between age variance to total variance in P_{tj} (proportion renewed)	0.91	0.87	0.88
Ratio of between age to total variance in renewal costs (C_{tj})	0.997	0.99	0.98
Ratio of between age to total variance in mortality rates	0.36	0.46	0.23
Part B	**Ornamental crops**		
	France	**Germany**	**Netherlands**
Range of cohorts	1974-1999	1988-1999	1989-1999
Range of years	1975-2000	1989-2000	1990-2000
Number of observations	283	87	73
Total number of PVP certificates in all cohorts	4836	7896	3396
Mean number of PVP certificates per cohort	186	658	308
Ratio of between age variance to total variance in P_{tj} (proportion renewed)	0.907	0.95	0.89
Ratio of between age to total variance in renewal costs (C_{tj})	0.99	0.99	0.99
Ratio of between age to total variance in mortality rates	0.34	0.75	0.51

4. Estimation of the Renewal Model

The results of the estimation of the renewal model for agricultural crops are presented in Table-2. For each of the three countries, the results of three sets of regressions are presented. Regression (1) presents the results of a model, which allows for no cohort specific variation in the distribution of initial revenues ($\mu_j = \mu$ for all j). Regression (2) allows μ_j to vary across time periods. For France, where a longer span of data was available, the μ_js are allowed to vary across three decades. That is, μ_1 represents the value of μ in the period 1974-1979, μ_2 the value in the period 1980-1989 and μ_3 the value in the period 1990-1999. For the Netherlands and Germany, where the data span was shorter, μ varies across time periods, with μ_1 representing the value of μ in the period before 1994 and μ_2 the value in the period after 1994. 1994 was the year in which the Community Plant Variety Office (CPVO) was set up, which allowed breeders to switch from national level protection to EU-wide protection. Regression (3) allows μ to vary as in regression (2) but in addition allows variation in the decay rates. In the case of France there is separate value of δ for each of the periods, 1974-1979, 1980-1989 and 1990-1999 while for the Netherlands and Germany there is a separate decay rate for the periods before and after 1994.

Table-2: Regression Results of Renewal Models for PVP Certificates-Agricultural Crops*

	France			Netherlands			Germany		
Parameters	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
μ	6.67 *(0.216)*	-	-	6.03 *(0.15)*	-	-	6.40 *(0.04)*	-	
μ_1	-	6.93 *(0.24)*	7.08 *(0.27)*	-	6.15 *(0.14)*	6.05 *(0.12)*	-	6.41 *(0.03)*	6.44 *(0.03)*
μ_2	-	6.80 *(0.21)*	6.83 *(0.21)*	-	5.81 *(0.11)*	5.85 *(0.11)*	-	6.27 *(0.07)*	6.57 *(0.11)*
μ_3	-	6.25 *(0.18)*	6.16 *(0.17)*	-	-	-	-		
σ	1.48 *(0.15)*	1.45 *(0.14)*	1.46 *(0.14)*	1.02 *(0.14)*	0.96 *(0.12)*	0.99 *(0.11)*	1.06 *(0.26)*	0.86 *(0.16)*	0.92 *(0.19)*
δ	0.17 *(0.02)*	0.18 *(0.021)*	0.18 *(0.038)*	0.08 *(0.02)*	0.09 *(0.03)*	0.039 *(0.02)*	0[#] (0.00)[#]	0.01 (0.00)[#]	0.01 (0.00)[#]
β_1	-	-	-0.023[$] *(0.03)*	-	-	0.10 *(0.02)*		-	-0.13[$] *(0.15)*
β_2	-	-	0.026[$] *(0.03)*	-	-	-		-	-
δ_1**	-	-	0.20	-		0.13		-	0.21
δ_2**	-	-	0.16	-	-	-		-	
R^2	0.81	0.82	0.83	0.82	0.85	0.88	0.75	0.82	0.84
df	321	319	317	85	84	83	74	73	72
Note:	μ_1 = Relates to 1974-1979 μ_2 = Relates to 1980-1989 μ_3 = Relates to 1990-1999			μ_1 = Relates to 1988-1994 μ_2 = Relates to 1995-1999			μ_1 = Relates to 1989-1994 μ_2 = Relates to 1995-1999		
	β_1= Relates to 1980-1989 β_2= Relates to 1990-1999			β_1= Relates to 1995-1999			β_1= Relates to 1995-1999		

* Figures in parentheses are standard errors.
**$\delta_1 = 1-(1-\delta)*\exp(\beta_1)$ and $\delta_2 = 1-(1-\delta)*\exp(\beta_2)$
A very small positive value.
$ Not significant at 5% or 10% level of significance.

Agricultural crops

The key parameters of the model μ, σ and δ all have the right signs and are statistically significant[4]. The high values of R^2 indicate that the lognormal distribution fits the data reasonably well[5]. An F-test clearly rejects the hypothesis that all the μs are equal, that is there is no inter-cohort variation in the distribution of initial revenues. The mean value of the initial distribution of revenues from a cohort of varieties is given by $e^{\mu + 0.5\sigma^2}$ in a log-normal distribution. In France (taking the figures from regression (3)), the mean value of initial revenues has steadily declined over the decades from US $3,448 in the 1970s to $2,685 in the 1980s to $1,374 the 1990s. In the Netherlands, the mean value has declined from $692 in the period 1988-1994 to $566 in the post-1994 period. In Germany, the mean value has increased marginally from $956 in 1989-1994 to $1,089 in the post-1994 period. In general, the initial distribution of revenues for agricultural crop varieties is higher in France than in the other two countries. The decline in mean values in France and the Netherlands has taken place alongside an increase in the *number* of PVP certificates issued (except in the post-1995 period when the number of certificates issued annually in these countries has not increased – possibly owing to the increasing use of EU-wide protection by breeders). Thus, while the number of innovations produced and offered for protection has increased over time, the average value of innovations has decreased over time. A decline in the mean value of initial revenues suggests that the market share likely to be acquired by the average protected variety has declined over time. This may be because of competition from a larger number of varieties in the market or because the incremental benefits from varieties in successive cohorts are declining. This, however, does not preclude the possibility of a few varieties in the tail of the distribution from acquiring very large market shares.

The degree of skewness in the distribution of initial returns is illustrated by the ratio of the mean to the median value. For the log-normal distribution this is given by $e^{0.5\sigma^2}$. The ratio is 2.9 for France, 1.63 for the Netherlands and 1.52 for Germany. The distribution of initial revenues is, thus, skewed to the right and rather sharply so in the case of France. The estimated rates of decay (regression (2)) are the largest for France (18%), lower for the Netherlands (9%) and almost zero for Germany. In the case of Germany, for agricultural crops, PVP fees are considerably higher than those of the Netherlands and France. The co-

[4] The only parameter not significant at the 5% level of significance is the parameter β_1 in the case of France and Germany and β_2 in the case of France as shown in the Table-2.

[5] R^2 is computed as 1 -(Residual sum of squares/Corrected total sum of squares). In the case of non-linear regression R^2 is not bound by 0 and 1.

efficient of variation of the distribution of initial revenues (which is a function of σ[6]) is also the lowest for Germany. Taken together, the high level of PVP fees for agricultural crops combined with possibly more stringent examination of applications in Germany results in the selection of varieties, which suffer no decay in returns, at least over the first ten years. When we allow decay rates to vary, we find that in France decay rates increased in the 1980s in relation to the 1970s, but decreased in the 1990s. In the Netherlands, the decay rates increased sharply from 4% in the 1988-1994 period to 13% in the post-1994 period. Similarly, in Germany the decay rate appears to jump from zero prior to 1994 to 21% in the post 1994 period, though it must be noted the co-efficient β_1, which produces this effect, is not significant. An increase in decay rates could reflect greater competition leading to faster turnover of varieties. However, the sharp increase in decay rates in the Netherlands and Germany is possibly an artefact of the data. After the CPVO was established in 1994, many protected varieties switched from national protection to EU-wide protection through the CPVO. But for acquiring EU-wide rights, national rights have to be surrendered or kept suspended. The large surrenders of varieties switching to EU-wide protection may be responsible for the sharp jump in decay rates after 1994 and may be a “one-off” phenomenon. Such switching would be most likely in countries where fee levels are high and close to that of the CPVO. As noted above, Germany has the highest fees for agricultural crops among individual countries (82.9% of the CPVO fees) while the level of fees in the Netherlands (43% of CPVO fees) are higher than those in France (28% of CPVO fees).

Ornamental crops

The results of the renewal model for ornamental crops are presented in Table-3. The three sets of regressions are the same as that for agricultural crops. The results for ornamental crops are a very similar to those for agricultural crops. Again, the key parameters of the model μ, σ and δ all have the right signs and are statistically significant (though β_1 and β_2 are not significant in the case of France and β_1 in the case of Germany). In the case of ornamental crops too, the mean value of the initial distribution of revenues is the highest in the case of France. The mean value in France (Regression (3)) has steadily declined over the decades from $2,735 the 1970s to $2,195 in the 1980s to $1,442 in the 1990s. If we compare the mean values for the 1990s, the value in France is almost twice that in the Netherlands and nearly six times that in Germany. In the case of the Netherlands, the mean value has marginally increased from $784 in the pre-1994 period to $816 in the post 1994 period. In Germany, over the same period, the mean value declined by 10% from $253 to $226. While we do not have estimates of the long-term trend of

[6] For a log - normal distribution, $CV = (e^{\sigma^2} - 1)^{1/2}$

mean values in Germany and the Netherlands, it is likely that they have been declining as in the case of France. There has been a steady upward growth in the number of certificates in each of these countries, especially in the late 1980s and till the mid-1990s. Therefore, as in the case of agricultural crops, the number of new varieties or innovations produced every year has increased over time, but the value of the *average* innovation has decreased. The number of new varieties protected and the mean value of initial revenues appear to have moved in opposite directions. This again may be the result of a larger number of varieties competing for market share.

Table-3: Regression Results of Renewal Models for PVP Certificates-Ornamentals*

	France			Netherlands			Germany		
Parameters	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
μ	5.93 *(0.25)*	-	-	6.10 *(0.09)*	-	-	5.18 *(0.17)*	-	-
μ_1	-	6.46 *(0.33)*	6.33 *(0.34)*	-	6.11 *(0.09)*	6.06 *(0.09)*	-	5.25 *(0.18)*	5.23 *(0.18)*
μ_2	-	6.11 *(0.27)*	6.11 *(0.27)*	-	6.07 *(0.1)*	6.10 *(0.09)*	-	5.12 *(0.16)*	5.12 *(0.16)*
μ_3	-	5.64 *(0.23)*	5.69 *(0.24)*	-	-	-	-	-	-
σ	1.73 *(0.21)*	1.78 *(0.21)*	1.78 *(0.22)*	1.10 *(0.08)*	1.09 *(0.08)*	1.10 *(0.08)*	0.78 *(0.13)*	0.78 *(0.12)*	0.78 *(0.12)*
δ	0.18 *(0.02)*	0.21 *(0.02)*	0.19 *(0.04)*	0.09 *(0.01)*	0.095 *(0.01)*	0.07 *(0.01)*	0.00# *(0.00)#*	0.00# *(0.00)#*	0.00# *(0.00)#*
β_1	-	-	-0.014$ *(0.04)*	-	-	-0.05 *(0.01)*	-	-	-0.019$ *(0.02)*
β_2	-	-	-0.039$ *(0.04)*	-	-	-	-	-	-
δ_1**	-	-	0.20	-	-	0.12	-	-	.01
δ_2**	-	-	0.22	-	-	-	-	-	
R^2	0.78	0.80	.80	0.94	.94	.95	0.85	.86	.86
df	279	277	275	84	83	82	71	70	69
Note: →	μ_1 = Relates to 1974-1979 μ_2 = Relates to 1980-1989 μ_3 = Relates to 1990-1999			μ_1 = Relates to 1988-1994 μ_2 = Relates to 1995-1999			μ_1 = Relates to 1989-1994 μ_2 = Relates to 1995-1999		
	β_1= Relates to 1980-1989 β_2= Relates to 1990-1999			β_1= Relates to 1995-1999			β_1= Relates to 1995-1999		

* Figures in parentheses are standard errors.
**$\delta_1 = 1-(1-\delta)*\exp(\beta_1)$ and $\delta_2 = 1-(1-\delta)*\exp(\beta_2)$
A very small positive value.
$ Not significant at 5% or 10% level of significance.

The distribution of initial revenues is skewed to the right in the case of ornamentals as well. The mean to median ratio (from regression (2)) is 4.87 for France, 1.83 for the Netherlands and 1.35 for Germany. The decay rates based on regression (2) are the highest in France (21%) followed by the Netherlands (9.5%)

and nearly zero for Germany. The coefficient of variation is once again the lowest for Germany, which reinforces the conclusion that the German PVP system 'selects' varieties that suffer almost no decay in returns in the first ten years. When we allow for variation in decay rates (regression (3)) we find that decay rates have increased marginally in France from 19% in the 1970s to 22% the 1990s. It must be noted, however, that the co-efficient of β_1 and β_2 are not significant at the 5% level of significance. If β_1 and β_2 are not significantly different from zero then the decay rate has not changed over the decades. In Germany too, the decay rates have remained at zero for the 1989-1999 period (co-efficient of β_1 is not significant). In the Netherlands, the decay rate has increased from 7% during 1988-1994 to 12% in the post 1994 period.

5. Private value of PVP Certificates

The parameters of the renewal model estimated for agricultural crops and ornamentals can be used to derive the private value of PVP certificates i.e. the returns that are appropriated by the titleholder. The present value of a single PVP certificate denoted by V is given by:

$$V = \sum_{t=1}^{T} \frac{R_t - C_t}{(1+i)^t} = \sum_{t=1}^{T} \frac{[R_0 (1-\delta)) - C_t]}{(1+i)^t}$$

where R_t - C_t is the net return from holding a PVP certificate during age t, i is the discount rate, δ is the decay rate and T is the optimal life span of the PVP certificate based on the renewal rule discussed earlier (i.e. the certificate will be renewed only if $R_t > C_t$). The assumption of a log-normal distribution for the initial revenues (R_0) for a cohort of certificates leads to a distribution of V. The estimates of the parameters μ, σ and δ are used to generate the distribution of V by simulation. To do this, 50,000 random variables were drawn from a log-normal distribution with the estimated values of μ and σ and V was calculated for each one of them using the decay rate, the renewal fees applicable in any given year and the renewal rule. From this derived distribution of V, the quantiles of the private value of PVP certificates could be derived. Tables 4 and 5 present for agricultural crops and ornamentals respectively the distribution of the private value of PVP certificates for the 1989 cohort in each country. In the case of France the estimates for a cohort of 1980 are also provided.

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

*The simulations were based on the values of the parameters μ, σ and δ from Regression (2) in Table-2

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 simulations were based on the values of the parameters μ, σ and δ from Regression (2) in Table-3

The key feature of the value distribution for both agricultural crops 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 is only $698 in France, $156 in the Netherlands and $1364 in Germany. For the 1989 cohort of ornamentals the median value is $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 are 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[7]. 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.

Interestingly, in France, the mean value of private returns appropriated from ornamental varieties was nearly the same as that appropriated from agricultural crop varieties. In the Netherlands, the mean value of ornamentals was more than twice that of agricultural crops. This is a surprising result considering that the volume of seed sales in agricultural crops is of a completely different order of magnitude[8] from that in ornamental crops. In most countries PVP grants are dominated by grants for ornamental varieties. The absence of farmers' exemption (plant back rights) in the case of ornamentals and the ease of detecting IPR infringements are likely to considerably increase the appropriability of returns from protected varieties of ornamentals. The estimates of the discounted value of returns from ornamental varieties in Table-5 show that the absolute the value of returns from protected ornamental varieties matches or exceeds that of agricultural crop varieties. This may explain the large number of grants for ornamentals in most countries. This also illustrates the loss of revenue to breeders, which takes place due to farmers' exemption in the case of agricultural crops.

The estimated total discounted value (at 10% discount rate) of plant variety protection for all the certificates issued in the 1989 cohort can be obtained by multiplying the mean value in Tables 4 and 5 with the number of grants made in that year in each country. The estimated discounted value can be compared with the level of R&D expenditures for agriculture in each country. This has been attempted in Table-6 below. We do not have the break-up of R&D expenditure between agricultural crops and ornamental crops. Therefore, the estimated discounted value shown in Table-6 is based on the mean value for agricultural

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[7] 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.

[8] No figures are available on the volume of sales of seeds or planting material of ornamental crop; however, comparisons in terms of value can be made. The estimated value of agricultural crop output in France in 1997 was approximately FFR 163,481 million, while the output of flowers and ornamental plants was FFR 6306 million. Given that there are a much larger number of protected varieties of ornamental plants than there are of agricultural crops, a common value of mean of estimated returns for agricultural and ornamental crops implies that the share of the value of output appropriated by breeders is much greater in the case of ornamental crops.

crops (Table-4) or for ornamental crops (Table-5) whichever is higher. Choosing the higher of the two values implies that the estimated total discounted value of the cohort is biased upward. This will only reinforce the implications that follow. Though the estimates are provided for a single cohort, the results are not sensitive to the choice of cohort.

Table-6: Returns from PVP Certificates and Agricultural R&D Expenditure (1989)

(All values in constant 1998 US dollars)

	France	**Netherlands**	**Germany**
Number of PVP grants made in 1989	483	751	309
Estimated mean discounted value of PVP grants of 1989 cohort	3797	1863	4521
Total estimated value of the whole cohort of 1989 (= mean value x number of grants)	1.833 million	1.399 million	1.396 million
R&D expenditure on agriculture by business enterprises[a]	159.90 million	82.52 million	28.83 million
Public sector R&D expendture[b]	601.45 million	111.48 million	293.49 million
Total R&D expenditure	639.57 million	194 million	322.32 million
Discounted value of PVP grants as a percentage of total R&D expenditure	0.24%	0.72%	0.43%

[a] Source: OECD Basic Science and Technology Statistics 1999 (R&D Expenditure by business enterprises on "Agriculture, Fisheries and Forestry")
[b] Source: OECD Basic Science and Technology Statistics 1999 (Government budgetary outlays on R&D for the socio-economic objective "Agriculture")

Table-6 shows that the value of private rights created by PVP range from 0.24% to 0.72% of the research expenditure under the head "agriculture, fisheries and forestry". In the literature on evaluation of returns from agricultural research, estimates of rates of return of 30% and above are quite common (see for instance the survey by Alston et al: 1998b). These estimates relate to the total social returns from R&D and not to private returns alone. These studies also vary considerably in the elements of agricultural research expenditure that they include in the analysis. Nevertheless, an important conclusion that can be drawn is that a large part of the returns from agricultural R&D do not result from the ability of plant breeders/titleholders to secure protection for new plant varieties[9]. If private returns to PVP certificates constitute less than 1% of agricultural R&D expenditures, then it is clear that breeders are able to appropriate only a very small fraction of the total returns (social plus private) that they generate. Therefore, in tune with what has been argued in the rest of the literature, PVP emerges as relatively weak IPR measure because it allows private appropriation of only a small fraction of the returns generated by an innovation[10].

[9] Similar conclusions about the role of patents in the context of industrial products were reported by Taylor and Silbertson (1973) on the basis of an extensive study of UK industry.

[10] It is true that the figures of agricultural R&D expenditure used in Table-6 do not relate to plant breeding expenditures alone, though it is important to note that they do not include R&D expenditures on agro-chemicals or "food and beverages" which are included in agricultural research expenditures in many studies (see for instance Alston et al.: 1998a). If agricultural R&D expenditures are restricted to plant breeding expenditures alone, then the percentage of estimated discounted value of PVP

The weakness of PVP as an IPR measure has certain other implications as well. If plant breeders have stronger alternative modes of protecting their varieties, they will switch to them and the use of PVP is likely to decline. This trend is most sharply visible in the U.S. where the number of PVP certificates issued every year has declined from about 300-400 to about 60-70 in the late 1990s, while the number of utility patents issued for plant varieties has steadily increased. This trend is not yet very apparent in European countries possibly because of the legal uncertainties surrounding the patentability of plant varieties[11]. As alternative modes of protection become available, the switch away from PVP can be expected in other countries as well. Thus, while developing countries currently in the process of enacting PVP legislation are worried about the monopoly profits that plant breeders may reap, in developed countries the use of PVP is likely to decline because it facilitates only limited appropriability. As private participation in plant breeding increases in developing countries, they too will face demands for strengthening of PVP or for stronger modes of protection of new plant varieties.

6. Implications for Farmers' Rights

. The results of this paper show that for the bulk of PVP certificates, the economic returns appropriated by plant breeders or titleholders are fairly modest. The problem with PVP is not that it provides large monopoly rents to plant breeders, but that it allows insufficient appropriability. If the intention of developing countries is to encourage investment in plant breeding by facilitating appropriation of larger returns from innovation, then there is clearly a case for making PVP stronger. This may involve strong enforcement of breeders' rights, restriction of farmer-to-farmer exchanges to strictly non-commercial transactions and possibly restrictions on the use farm-saved seed for large farmers. Owing to problems in enforcement of breeders' rights, appropriability in developing countries is likely to be poorer than in developed countries. Unless PVP is strengthened, it will simply not have the effect of stimulating private investment in plant breeding of non-hybrid crops.

Large monopoly rents could possibly be a feature of protected varieties in the tail of the value of distribution. In practice, if the distribution of initial revenues in a cohort of protected varieties depends on

rights to agricultural research expenditures would no doubt increase. But this would not alter the basic conclusion that by using protection plant breeders are able to appropriate only a small portion of the total returns that their innovations generate.

[11] The European Patent Convention does not allow plant varieties to be protected. However, the position may change as the result of the European Union's "Directive on the Protection of Biotechnology Inventions (Directivr 94/44EC) which contains specific provisions on the patentability of genetically engineered biological material including plants and animals. However, there are still a number of unresolved issues (see Eratt et al.: 2000)

the market share attained by each[12], then what this means is that there will be a limited number of varieties that will acquire large market shares and hence earn large profits. But even in the case of varieties in the tail of the distribution, the return appropriated by the breeder is still likely to be a small fraction of the incremental agricultural output generated through the use of the new variety[13]. The potential for monopoly profits from a variety protected under PVP should be carefully distinguished from that of a transgenic or genetically-modified (GM) variety. The GM varieties are invariably (in the U.S.A.) protected by patents that allow no farmers' and researchers' exemption and carry a price premium that goes under the name of a "technology fee". The reuse of seed by farmers is prevented by stringent contractual terms, which are monitored intensively by the giant "life-science" companies. The appropriability in the case of GM varieties is, therefore, entirely different from that of a variety protected under conventional PVP. The problem of monopoly profits accruing to a very limited number of protected varieties can also be addressed by the judicious use of compulsory licensing provisions that are a part of PVP legislation in most countries.

In the context of the the Indian legislation which provides for all the three approaches to operationalising farmers' rights – protection of farmers' varieties, compulsory sharing of benefits with farmers and a levy[14] on breeders' profits- the results of this paper lead to a fairy pessimistic view about the potential success of these approaches. If the bulk of protected varieties yield only modest private returns, then there may not be any benefits to share. The introduction of compulsory benefit-sharing arrangements will probably only discourage innovation (by reducing breeders' returns even further), while at the same time providing no significant benefits to farming communities. Similarly a levy on breeders' profits is also unlikely to generate significant revenues even if we include varieties in tail of the distribution. The total discounted value of the

[12] Theoretically, the discounted value of returns from a variety will depend on the price of the new variety, its market share (i.e. volume of sales) and the cost of production. The cost of production of a protected variety is not likely to be very different from that of competing varieties. There is also some evidence to suggest that protected varieties do not enjoy any significant price premium over non-protected varieties (Lesser: 1990). Therefore, the returns from a variety are likely to be a function of the market share of a variety and the seed replacement behaviour of farmers, which we assume does not change in the short run.

[13] For instance, in our simulation the maximum value appropriated by the breeder of an agricultural crop variety is approximately US $ 720,000 in France (Table-4). Let us take the case of a very successful wheat variety in the tail of the distribution, which attains a peak of market share of 10 per cent. If we assume that a successful variety must have an incremental yield gain of 0.5% above other competing varieties, then it can be shown, *ceteris paribus*,(assuming a total wheat area of 5.11 million hectares in France, current yield level of 6.6 tonnes per hectare and a wheat price of $140 per tonne) that the annual value of incremental output would be $2.36 million and its discounted value at 10 per cent discount rate over a period of 5 years $6.7 million. The breeder, thus, appropriates just 10.7% of the discounted value of incremental output. It must be remembered that even this happens only in the case of a highly successful variety.

[14] The option of an international levy on protected varieties to raise funds for conservation was considered in the context of the FAO's Global Plan of Action for the Conservation and Sustainable Utilisation of Plant Genetic Resources for Food and Agriculture" (FAO :1996)

1989 cohort of PVP certificates in France in Table-6 is approximately US $1.83 million (in 1998 constant dollars). Even a 10% levy on breeders' returns[15] would yield only $183,000, which is quite small in relation to the requirement of funds for conservation activities. The amounts generated in developing countries may be much smaller. The administrative costs of implementing such a levy would likely be high as it involves monitoring variety-wise sales /profits on a national basis for all protected varieties. The fundamental problem in giving effect to farmers' rights is that PVP allows only very limited appropriability of returns breeders in the first instance.

7. Conclusions

In this paper we have used a renewal model to estimate the distribution of private value of PVP grants. The most striking feature of the value distribution of PVP grants is their sharp skewness, which indicates that there is a large concentration of PVP rights with very little economic value. PVP emerges as a relatively weak IPR measure, which allows the private appropriation of only a small fraction of the total returns from an innovation. In developed countries, there are already signs that PVP is being replaced by stronger forms of IPRs as the instrument of choice for protection. A large part of the returns from agricultural R&D expenditures are not attributable to the ability of plant breeders to secure protection for their new varieties. From the perspective of developing countries, apprehensions that breeders (on an average) will secure abnormal monopoly rents are not warranted. The bulk of protected varieties provide only modest returns to breeders and PVP can even be viewed as a relatively low-cost method of stimulating innovations in plant varieties. If the policy intention of developing countries is to stimulate plant breeding, then there is clearly a case for strengthening the level of protection provided by PVP rather than weakening it, as some developing countries are attempting to do. Given the modest appropriability associated with PVP, attempts to give effect to farmers' rights through mandatory benefit-sharing arrangements or a levy on breeders' profits are unlikely to prove fruitful.

[15] The proposal for a levy on *sales* of protected varieties to raise funds for conservation activities is discussed in Swaminathan (1996). It must be noted that only a portion of a levy on the sale of protected varieties will be borne by breeders depending on the elasticity of demand for the variety.

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