TRIPS and Plant Varietal Protection: Economic analysis and policy choices

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This paper reviews the economic aspects of the options facing developing countries in implementing intellectual property right protection for agricultural plant varieties under the WTO TRIPS agreement (Article 27(3)b). The various provisions possible in a *sui generis* system of plant varietal protection (PVP) are summarised, including those specified in the existing Union for the Protection of New Varieties of Plants (UPOV) treaties of 1978 and 1991. The paper then examines the limited economic research that has been conducted on the impacts of PVP and that may be of use to policy makers faced with current decisions. This review finds that the research to-date has not yet demonstrated overwhelming net benefits from PVP. The evidence so far is weakly supportive of positive contributions by PVP to agricultural productivity. The paper concludes further research on this issue is necessary given the ongoing review of the TRIPS agreement and the efforts underway in many developing countries to implement such systems. The paper also identifies some of the key topics forming a research agenda of interest for developing countries. Further research should focus on the impacts of specific provisions, in particular, that of farm-saved seed, as opposed to the effects of PVP as a whole.

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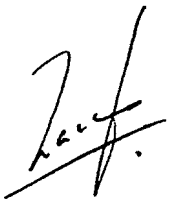
Preface

The agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) within the WTO has provided the impetus for many developing countries to adopt some form of plant varietal protection (PVP) regime. The premise of this agreement is that such protection provides incentives for the private sector to invest in the development of new varieties. Furthermore, protection is seen to be fair in terms of providing equal treatment across countries to seed breeding companies. These premises are often questioned particularly by developing countries. This study attempts to review the evidence concerning the economic benefits of PVP. Secondly, the paper assesses the potential contribution of such economic research to current policy decisions facing developing countries. In view of the ongoing review of the TRIPS agreement within the WTO, including in particular Article 27(3)b, we believe that this study offers useful and timely advice on this contentious policy issue.

This study has been prepared on behalf of both the Dutch Ministry of Agriculture, Nature Management and Fisheries under its North-South research programme and the International Development Research Centre (IDRC) under grant letter no. 101907. The research was carried out by Derek Eaton. The study benefited from comments at an international workshop held at LEI in October 2000 with researchers from India, China, Sri Lanka and the UK.

The managing director,



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Summary

This paper assesses the potential for empirical economic analysis to contribute to the policy debates surrounding IPR and agricultural plant varieties in developing countries. Under the agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) within the WTO, member countries are obligated to implement a system of patenting of plants and/or a *sui generis* system of protection of plant varieties (PVP) by the beginning of 2000.

The various provisions possible in a *sui generis* system of plant varietal protection (PVP) are summarised, including those specified in the existing Union for the Protection of New Varieties of Plants (UPOV) treaties of 1978 and 1991. It is clear that TRIPS requirements for a *sui generis* system for PVP allow considerable flexibility in the specific provisions selected. The key elements are the requirements for protection and the scope of this protection, in particular with respect to farm-saved seed and use in research and development.

There are a number of policy considerations in the design of a TRIPS-compliant *sui generis* system for PVP, including the impact on R&D, international technology transfer, monopoly powers and the distribution of benefits, farmer-saved seed, and germplasm exchange and genetic diversity management. Each of these issues can be examined from an economic perspective i.e. in terms of their efficiency and equity implications.

Almost all of the empirical work on the R&D effects of IPR for plant varieties has been undertaken in the U.S. The evidence is so far rather ambiguous, and at best weakly supportive, in terms of contributions to agricultural productivity. This type of analysis probably needs to be replicated for more crops in the US and in other countries. Given the data and measurement difficulties in undertaking such studies, it makes sense to consider at this point how such studies could be undertaken in developing countries currently implementing PVP legislation, in order to be able to monitor and evaluate its effectiveness. Such information could be valuable for the ongoing and future reviews of TRIPS. There are, as yet, no studies on the effect of PVP on technology transfer.

Attention on the possible negative effects of plant varietal protection often focuses on the resulting potential for seed providers to earn monopoly rents with a consequent redistribution of benefits between seed providers, farmers and consumers. Recent analysis of benefit distribution resulting from GMO crop introduction provides interesting possibilities for adapting such methodologies to the evaluation of the effects of specific provisions of PVP. The very limited evidence on the existence of such monopoly powers is currently inconclusive. The extent of competition for breeders depends partly on the possible allowance within PVP for various uses of farm-saved seed. The interest of seed developers in genetic use restriction technologies (GURTs) indicates an interest in reducing competition from farm-saved seed.

The relative lack of research in this area provides a rationale for increased attention to a policy issue with considerable consequences from an efficiency and equity perspective. Elements of the research agenda with particular relevance to developing countries

include effects on private breeding efforts (R&D), pricing margins on protected varieties, the distribution of welfare benefits under various PVP regimes and further examination of the impact of farmer-saved seed. Such studies should play an important role in the ongoing review of the WTO/TRIPS agreement.

1. Introduction

The extension of intellectual property rights (IPR) to agricultural crop varieties is currently advancing in many developing countries. The agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) within the WTO has provided the impetus for many developing countries to adopt some form of plant varietal protection regime. Membership of the WTO requires implementation of the TRIPS agreement, among other sub-agreements. Under this agreement, developing countries were meant to provide for patenting of plants and/or a *sui generis* system of protection of plant varieties by the beginning of 2000 [1]. A common solution is to become signatory to the Union for the Protection of New Varieties of Plants (UPOV). The consequences of not complying with TRIPS are potentially considerable and include the possibility of trade sanctions from industrialised countries.

The drive to extend IPR to plants and plant varieties comes primarily from the private sector, with backing from the governments of a number of industrialised countries. Companies undertaking plant breeding claim that such protection is necessary to promote further research and development with its consequent benefits for the agricultural sector and society at large (i.e. consumers). This argument has been strengthened by recent advances in biotechnology, which potentially promise even greater improvements in developing new plant varieties.

Against these developments, the Convention on Biological Diversity (CBD), concluded in 1992, provides for sovereign rights of states over the genetic resources found within their borders. Furthermore, the CBD calls for an equitable sharing of benefits derived from genetic resources and recognises the rights of farmers to a share of these benefits, given the traditional role of farmers as conservators and developers of genetic resources for agriculture [2]. The CBD's emphasis on national rights may lead to potential conflicts with TRIPS depending on how access and benefit-sharing provisions are implemented under the CBD, but also on the specific choices made by countries in the implementation of TRIPS (Louwaars 1998).

The scene is further complicated by the new International Treaty on Genetic Resources for Food and Agriculture, concluded in November 2001, which sets the framework for international exchange of agricultural germplasm. A major debate in the renegotiation of the Treaty was the definition and possible implementation of Farmers' Rights, a reaction to the extension of private property rights to agricultural plant varieties. In general, Farmers' Rights entail a type of property right that would recognise the contribution of farmers, and especially farmer-breeders, to the development and (in-situ) conservation of agricultural crop varieties (Swaminathan 1998, Louwaars 1998). While requiring that 'Contracting

[1] *Sui generis* refers effectively to a special-purpose system for the protection of plant varieties, or *plant varietal protection* (PVP), also referred to as *plant breeders' rights* (PBR; Lesser 2000).

[2] Not all countries are currently signatories to the CBD, with the U.S. being the most notable abstaining country.

Parties should take measures to protect and promote Farmers' Rights', the new Treaty has left the issue open to various interpretations [1].

The current trends are claimed by various parties to be either beneficial or detrimental in their effects on the maintenance of genetic diversity, the sustainable development of the agricultural sector, and the livelihoods of farmers (see for example, Tansey, 1999; UNDP,1999; Acharya, 1992; Correa, 1999; Visser, 1998; Leisinger, 1996). Several industry groups and civil society organisations (CSOs) are actively lobbying policy and decision-makers in a wide range of public agencies at national and international levels. The decisions at stake may have far-reaching consequences but there is a paucity of research and empirical analysis to sort out the overall nature and incidence of these consequences (Lesser, 1997; Perrin, 1999).

The objective of this paper is to examine the potential for empirical economic analysis to contribute to the policy debates surrounding IPR and agricultural plant varieties in developing countries. First, the basic policy issues are summarised with emphasis on the likely impacts that form the basis of political discussions and international negotiations (e.g. redistribution of income between seed sector, farmers and consumers). The paper then examines the economic research that has been done to-date on these issues. A number of studies are characterised in terms of the modelling framework used, the empirical context, the data requirements, the conclusions reached and also the limitations of the approach used. Much of this research has been undertaken in industrialised countries and thus, the applicability of such methods to developing countries is also given some attention. From this analysis, several conclusions are drawn concerning the potential of such analysis to be useful for policy purposes.

This paper focuses on the economic aspects of IPR and options facing developing countries in implementing TRIPS. This is not meant to exclude other aspects from consideration by policymakers. The ethical issues surrounding IPR and biological material involve fundamental public policy issues. And the legal issues relating to compliance with TRIPS are extremely complex. But this paper focuses on the economic aspects with the perspective that, to the extent that these aspects can be better understood through applied research, then the information will assist in assessing the other issues and making policy choices.

[1] The U.S. also abstained from approving the treaty in November 2001.

2. TRIPS and policy choices

Member states of the World Trade Organisation (WTO) are required under the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS; Annex 1C of the Marrakech Agreement establishing the WTO) to provide patent protection for new inventions in all fields of technology. Exclusion of plant and animals (other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes) from patenting is permitted. But Article 27(3)b of the TRIPS agreement obliges member states to provide for the protection of plant varieties either by patents or by an 'effective *sui generis* system or by any combination thereof'.

There are essentially four policy options for member states (Leskien and Flitner 1997):

- *sui generis* system for protection of plants and plant varieties;
- patenting of plant varieties;
- a combination of the first two;
- *sui generis* system for plant varieties only.

The deadline for developing countries to provide protection of one sort or the other was 1 January 2000 while least developed countries have until 1 January 2005. Thus, many developing countries (many of whom missed the deadline) are currently examining options or even formulating legislation to implement the first option of a *sui generis* system in order to comply with the TRIPS agreement. The option of choosing for the more restrictive IPR of patenting does not seem to be an issue for discussion as many developing countries would prefer a less-restrictive form of IPR as allowed under a *sui generis* system. Leskien and Flitner (1997) note that 'not many developing countries are likely to benefit from a *sui generis* system for plant varieties conferring patent-like rights' and that 'such broad scope of protection would have severe consequences for plant breeders'. The most relevant policy questions therefore seem to be on the options that exist for members under a *sui generis* system.

Given that the TRIPS agreement does not explicitly mention the requirements of a *sui generis* system, commentators have attempted to analyse what these should be.

> 'A *sui generis* system has to be an additional IPR conferring on the right-holders a legally enforceable right either to exclude others from certain acts in relation to a protected plant variety, or to obtain a remuneration in respect of at least certain uses of the plant variety.' (Leskien and Flitner 1997, p. 30)

Thus protection in the form of trademarks, geographical indications or trade secret protection is not sufficient. According to Leskien and Flitner minimum requirements of a *sui generis* system include national treatment, most-favoured-nation treatment and an effective enforcement system.

Two existing *sui generis* systems are elaborated in the UPOV treaties of 1978 and 1991. These are essentially 'off-the-shelf' *sui generis* options available to developing countries and a number of such countries are already members of one of these treaties, or are in the accession process for the 1991 version [1]. But many other *sui generis* systems are theoretically possible based on the specific provisions for protection that are selected. Leskien and Flitner (1997) identify the various elements that involve flexibility or options for members developing a *sui generis* system. These include:

- requirements for protection;
- scope of protection;
- duration;
- relationship with other IPR;
- elements to balance rights of right-holder.

These are summarised in figure 2.1 together with requirements under the two UPOV treaties. Figure 2.1 highlights how protection was broadened under UPOV 1991 in comparison to UPOV 1978, and also shows the relative freedom facing countries in the design of a *sui generis* system.

Provisions	TRIPS *sui generis*	UPOV 1978 Act	UPOV 1991 Act
Requirements for protection	not specified	DUS [1]	DUS [1]
Scope of protection:			
Production & reproduction	optional	required	required
Sale	optional	required	required
Exporting & importing [2]	optional	optional	required
Conditional stocking [2]	optional	optional	required
Number of species protected	all	minimal list of 24	all
Breeders' exemption	optional	required	restricted [3]
Farmers' privilege	optional	required	restricted [4]
Duration of protection	not specified	15-18 years	20-25 years
Double protection (PBR + patent)	possible	not possible	possible

1 DUS = Distinctness, Uniformity, Stability
2 For one of the above purposes
3 Not foreseen for essentially derived varieties
4 Can be granted, but not automatic.
Source: Based on Leskien and Flitner (1997), table 5, p. 62, and Ghijsen (1998).

Figure 2.1 Overview of provisions under a TRIPS sui generis system and UPOV

Under requirements for protection, there are a number of specific options under a *sui generis* system. The first is whether to allow less-uniform or less-stable varieties (such as landraces which might not meet the DUS criteria) to be protected. This is not available under either versions of the UPOV Acts; protected varieties must meet the DUS criteria. But

[1] UPOV 1991 provides broader protection than UPOV 1978. New members may no longer accede to UPOV 1978, but countries could nonetheless model their *sui generis* system on the earlier version. They would then forego other benefits of actual membership in UPOV which may include institutional support.

the option of providing landraces, for example, with protection, could be a component in a package of measures (involving not only IPR) that address the issue of Farmers' Rights (e.g. Liamchanroon 1998). While appealing to those in favour of Farmers' Rights, a number of practical difficulties have been raised, including the difficulties involved in identifying the variety being protected (e.g. Lesser 2000, Louwaars 1998).

Other specific options under the requirements for protection include the possibility to insist that 'usefulness' of a new protected plant variety be demonstrated, and whether to require the disclosure of the genetic material (parental lines) from which a variety has been derived. These two issues are not addressed under UPOV Acts and are potentially interesting for countries that wish to provide specific incentives for breeding corresponding to their own priorities (usefulness) or that wish to verify that the principle of prior informed consent (PIC), as required by the CBD is respected.

With respect to scope, Leskien and Flitner (1997) argue that a *sui generis* system has 'to provide legally enforceable rights either to exclude others from certain acts in relation to the described subject matter and/or to obtain a remuneration in respect of certain uses of the described subject matter'. Here countries appear to have a range of possibilities concerning the acts that may be deemed as requiring the permission of the right-holder (summarised in figure 2.1). While protection concerning all of the possible uses needs to be considered in the development of a *sui generis* system, much of the policy debates centre around two specific limitations: the breeders' exemption and the farmers' privilege. As indicated in figure 2.1, UPOV 1991 Act further increased the level of protection for these two uses in comparison to the earlier UPOV 1978 Act.

The duration of the IPR provided to plant varieties under a *sui generis* system is also open for specification. The current minimum reference periods are 15 years as provided by the UPOV 1978 Act and 20 years as provided by the UPOV 1991 Act (in both cases, for most plant varieties). In developing a *sui generis* system, other timeframes could be considered. Leskien and Flitner argue that, in general, stronger and more exclusive rights should be granted for shorter periods. Similarly, Lesser (2000) points out that variety life is 'typically more limited by natural factors such as increasing susceptibility to insects and diseases co-evolving with the varieties than by statutory limits'.

Sui generis systems also need to address the issue of how they are related to other forms of IPR, such as patents. For example, it is possible to rule-out double protection for any given variety, as under UPOV 1978. It is also necessary to consider issues of overlapping and conflicting IPRs involving, for example, plant varieties under a *sui generis* system and patented genes inserted into a protected variety. This issue relates also to the need for clear and well-conceived legal legislation as well as a fundamental policy issue.

The inclusion of elements to balance the privilege granted to right-holders in a *sui generis* system relates more to the design of a system that might include elements that facilitate the protection of community/traditional resources, or help in the implementation of Farmers' Rights. Such elements include possibilities such as community gene funds, registers or the provision of public defenders. The latter two are related primarily to providing means to avoid or context acts of biopiracy. Community gene funds, on the other hand, could be an option for expressing the concept of Farmers' Rights (Lianchamroon 1998), and the idea has also been proposed at international levels.

TRIPS requirements for a *sui generis* system for PVP allow considerable flexibility in the specific provisions selected. Thus it appears that key elements are the first two in the list above: requirements for protection and scope. These are the basic characteristics of the protection being offered and are issues on which countries opting for a *sui generis* system have to take a decision. They have also been the subject of most controversy and discussion in countries in which PVP systems have evolved during the course of the twentieth century. They are thus probably where the most significant economic consequences of the options under a *sui generis* system are to be found.

In concentrating on PVP, this paper does not examine IPR in the form of either patents on plant varieties. There is a trend in some industrialised countries, particularly in the U.S., towards the broader protection offered by patents, supported by the increasing application of proprietary biotechnology in the breeding industry. In most developing countries, all forms of IPR tend to be viewed with suspicion, or at least those groups (particularly CSOs) with such views tend to dominate the public debate. Thus, in meeting their TRIPS obligations, most countries are focussing on the *sui generis* option. The economic efficiency and equity differences between patent protection and PVP are thus more relevant in an industrialised country context. This paper also does not address patents over non-biological processes and microbiological processes that are relevant to the production of plants and animals. This area, and in particular the interaction with a *sui generis* system for plant varieties, is extremely important for developing country decisions, as pointed out by Leskien and Flitner (1997), but beyond the scope of this paper.

3. Economic Considerations in PVP

The above discussion has summarised the principal options in the design of a TRIPS-compliant *sui generis* system for plant varietal protection. These are policy choices with various considerations: moral, ethical, legal, political, administrative and economic. In this section, these choices are related to economic considerations, which can be divided into two sets of effects, relating to efficiency or equity. Efficiency refers primarily to the productivity of the agricultural sector, including its R&D sub-sector. Efficiency considerations in the area of plant breeding and PVP are thus based on the development and diffusion of more productive varieties of agricultural crops (including via international technology transfer). Equity refers to the distribution of benefits among various economic actors that results from such efficiency improvements. The groups of particular interest are breeders/seed suppliers, consumers, and farmers, with possible distinguishing between different types of farmers.

These two considerations of efficiency and equity are thus examined in terms of the overall effect of PVP. As the discussion in the previous section highlighted, there are many options available in the design of a PVP system that are now highlighted in the general freedom allotted to WTO members in the design of their *sui generis* systems. Thus, the effect on both efficiency and equity of alternative provisions within a *sui generis* system are particularly important. The provision that stimulates the most controversy in this regard is farmers' privilege.

In the following discussion, these issues are summarised. Then, in the following section, the potential to illuminate these considerations through economic research is taken up and at the same time, the principal evidence that has been accumulated to-date is reviewed. For the most part, these are all issues which relate to the establishment of plant varietal protection rather than to specific options of a PVP system. The discussion below attempts, where appropriate, to comment on the usefulness of such research for developing countries developing a *sui generis* system. This issue is then returned to again in the conclusions.

Impact of PVP on R&D

The positive effect expected from PVP is increased research and development by breeders of improved agricultural plant varieties. PVP is seen as providing the incentive to undertake this R&D and to market the varieties to distributor and farmers, leading to higher agricultural productivity. With PVP, breeders are able to recoup a greater share of their sunk costs in R&D. This greater appropriability of the benefits should justify more investments in R&D that otherwise would not be profitable.

The extent of this efficiency impact, in terms of both increases in R&D followed by increased productivity, has been the subject of considerable study and debate without a clear verdict emerging, as discussed below. It is therefore worth taking this into account in considering the additional impacts of the various options that can be pursued in the devel-

opment of a *sui generis* system. Because of the successive nature of plant breeding, concerns about the need to balance the incentives to the breeder with those for future research are the rationale behind the breeders' exemption in PVP, which parallels the research exemption under patent systems (Lesser, 2000).

International technology transfer

PVP is also seen as providing the incentive for foreign breeders to import and market their products. This issue is particularly relevant for developing countries where the breeding sector tends to be much less developed, given the smaller seed markets (at least in monetary terms). Private sector breeders of improved varieties claim that they require a financial mechanism to capture more of their research benefits if they are to make their technology available in other countries, either directly through sales or through agreements with local breeders for further local adaptation. This issue acquires more importance with the advances in modern biotechnology as these are increasingly being dominated by large agrochemical concerns due to the increased investments necessary and the IPR granted to many of the processes or products involved. The diffusion, or restriction thereof, of improved plant varieties can also be expected to have effects on trade patterns in agricultural crop products.

Monopoly powers and the distribution of benefits

The most prominent negative economic effect under discussion from the creation of PVP and other agricultural IPR is the granting of monopoly powers to the right-holder and the creation of incentives for concentration in the seed sector. Monopoly rents benefit breeders at the expense of farmers or consumers and constitute the classic trade-off in the granting of IPR in general. Society provides the monopoly powers in exchange for the technological benefits with the presumption being that some technological benefits cannot be realised without the incentive created by the monopoly powers. If monopoly powers vested in seed companies allow them to restrict competition or entry into the market, then they will be able to earn monopoly rents. Of course, the breeders' exemption is intended to limit this possibility.

As seen in the following section, the empirical question is the extent to which PVP allows seed suppliers to charge farmers excessive prices. This is an issue of both efficiency and equity. Excessive pricing leads to an inefficient allocation of resources while also resulting in the redistribution of welfare between consumers, farmers and the seed industry. The creation of monopoly powers and the provision of incentives towards increasing concentration in the sector can, at least in theory, both be influenced or attenuated by the options chosen for in the design of the plant variety protection system, particularly with respect to the scope and duration of protection.

Farmer-saved seed

A key option in the design of a *sui generis* PVP system is the farmers' privilege, which may well have the single largest effect on the extent of benefit appropriation (Louwaars

1998, Rabobank, 1996). In terms of efficiency, the reduced appropriability from the farmers' privilege might provide a serious disincentive for investments in breeding. On the other hand, they may also permit more local experimentation and breeding by farmer-breeders. From an equity point of view, the consequences of removing or restricting the farmers' privilege may be particularly negative for smaller, resource-poor farmers. This issue has recently been debated especially in the context of developing countries where large numbers of farmers, particularly small-scale farmers, are estimated to rely to some extent on farm-saved seed. But it has also been a long-standing issue in industrialised countries where the extent of the practice varies among countries and crops.

Germplasm exchange and genetic diversity management

An important concern arising from the granting of IPR protection to plants and plant varieties is the exchange of germplasm among breeders and between farmers, genebanks and breeders, with potential consequences for R&D in breeding and agricultural productivity. The breeders' exemption in PVP was intended to ensure that exchange and further use of improved varieties was possible. The granting of IPR in the form of patents over plant varieties could inhibit the use of protected material for breeding purposes, maybe simply by complicating the process of exchange due to the need for more complex material transfer agreements (MTA)[1]. From an efficiency point of view, this results eventually in less R&D, or R&D that is based on less genetic diversity, and thus possibly slower growth in agricultural productivity or less stability/resilience in agro-ecosystems.

A broader concern is the effect of the increased private appropriation of germplasm resources on the conservation and management of genetic resources. Farmer-breeders could be further restricted from practising their own local breeding (Louwaars, 1998). Furthermore, if farmers see that companies are able to protect varieties based in whole or in part on landraces that farmers have developed, conserved and shared over time, then farmers may become more reticent to share their landraces with researchers and organisations working on the conservation of genetic resources. From an equity perspective, this issue also provides the basis for the promotion of Farmers' Rights.

Another issue is the contribution of PVP to the spread of monoculture and thus the erosion of genetic diversity on farms. This issue is a fundamental one concerning different visions of agricultural development. It has also been argued from another perspective, and even backed with empirical data, that the development of improved varieties contributes to increasing the genetic diversity in the parent lines of the predominant varieties grown in a particular area (Smale, 1998). Thus, the expected effects on genetic diversity also depend on the level at which diversity is considered (e.g. intra-specific genetic diversity, species diversity, ecosystem diversity) as well as the scale.

The issues listed above can be examined from an economic perspective i.e. in terms of their efficiency and equity implications, indeed as has been highlighted in the discussion. Concerns relating to the genetic diversity conservation and management, while important in their own right, are rather difficult to examine with economic analysis, particularly if this is to be empirical in nature. Such issues demand complementary types of

[1] Such a result could also develop if the breeders' exemption under a *sui generis* system were further restricted than current UPOV requirements, admittedly not currently a likely possibility.

research and analysis which needs to be weighed up together with economic and other research [1].

The economic issues can be related to the policy choices in formulating a *sui generis* discussed in the previous section. Essentially all of the key policy choices have potential economic impacts. These impacts are summarised as impact on R&D, technology transfer, distribution of benefits/welfare impacts, and the restriction of scope of protection with respect to farmer-saved seed.

[1] There may nonetheless be a role for economists within multidisciplinary teams examining these issues.

4. Economic Analysis

This section examines each of the economic issues in turn and summarises the research that has been undertaken in each area. In summarising the research, attention is paid to methodology, data required, the issues analysed, the conclusions, limitations and possible applicability. Furthermore the relevance of the research to the policy choices is also highlighted. For the most part, this section summarises the salient aspects of the research. There has been very little research undertaken and much of it has been reviewed by various authors recently (see, in particular, Lesser, 1997; Rangnekar 2000a and Srinivasan, 2000).

Impact on R&D

The biggest area of work on the economics of IPR has concerned the incentive effects for increased R&D. This has been examined at both the input stage consisting of investment in R&D efforts, as well as at the output stage of varieties produced and their productivity benefits. As mentioned above, the provision of IPR for plant varieties by all WTO member countries is required. Thus, this issue is not really a policy choice. But it is worthwhile examining this important area, not only because it has been the focus of much economic research. The R&D benefits of IPR are the principal rationale for offering such protection. It is therefore worthwhile knowing to what extent they have been realised. In addition, the options facing policy makers in meeting their TRIPS obligations involve choices that could affect (either positively or negatively) the extent of this principal benefit of IPR.

Almost all of the empirical work on the R&D effects of IPR for plant varieties has been undertaken in the U.S. where such protection has been offered since 1970 for sexually propagated plants [1]. But the amount of research has been quite limited. Lesser (1997) states that there is 'surprising limited analysis of the effects of IPRs on R&D investment....The matter is...less well documented for developing economies....'

R&D: Inputs

Research that has concentrated on the effects of IPR on R&D inputs in the breeding sector has looked at expenditures on R&D, the number of research programmes and the investment in terms of human resources (scientists). This research also tends to look at the output in terms of certificates granted for plant varieties. The following are the key studies looking at research inputs and the granting of certificates:

- Butler and Marion (1985) used data on certificates and a survey of breeders to examine changes in breeders' behaviour as a result of the U.S. Plant Variety Protection Act (PVPA) enacted in 1970. The study estimated R&D investments and found a rapid increase in the period leading up to the act (possibly in anticipation). The study

[1] Protection for asexually propagated plants has been offered since 1930.

found evidence of increased investment in a few specific crops (also concluded in a follow-up study by Butler, 1996). The number of soybean and wheat crop varieties released in the 1970s also increased. The study is generally perceived as indicating (though not really confirming) that the PVPA had a positive effect on R&D incentives for a limited number of crops.

- Perrin, Hunnings and Ihnen (1983) surveyed seed companies for data on research expenditures. They also found evidence of a significant increase in research expenditures for a number of crops. This study also looked at investments as a percentage of seed sales, and in terms of dollars of research per dollar of crop value. The general conclusion was that the PVPA stimulated a marked increase in these investments.
- Surveys of private sector breeding efforts were carried out by Kalton and Richardson (1983) and Kalton et al. (1989) on investments and scientists involved. According to Srinivasan (2000), the important point was that investments were not confined to hybrid crops alone [1].
- Frey (1996) also surveyed investments in financial and human resources to plant breeding in the US in 1994, including both the public and private sector. Neither of these studies though really attempted to look for changes that could be attributed to the PVPA.
- Jaffe and Van Wijk (1995) examined the impact of PVP on R&D in Argentina using a survey of plant breeding firms. While this study found that investments had increased between 1986 and 1992, survey answers pointed much more to changing economic policies and liberalisation as an incentive, rather than the introduction of plant breeders' rights.
- Venner (1997) [2] analysed the trends in both public and private investments in wheat breeding in the US up to 1994, more than 20 years after the introduction of the U.S. PVPA. While private expenditures remained relatively static, public expenditures on wheat breeding actually more than doubled in real terms. Venner also found that the premium of wheat seed price over the wheat commodity price, 'an upper-bound estimate of the royalty rate', decreased in real terms over the period 1954-1994, thus providing no evidence of an increase in appropriability of research expenditures in wheat breeding.

These studies are relatively straightforward but generally involve time-consuming surveys of plant breeders activities. Such research is obviously of most interest in countries where there is significant potential to undertake breeding for the local market, as opposed to simply importing varieties. In some developing countries, the question may be more one of access to foreign-developed varieties, though adapting these to local conditions could conceivably be stimulated by the availability of IPR.

[1] By their nature, hybrid crop seeds offer a form of built-in protection that restricts the uses of the purchase. In particular, replanted hybrid seed does not breed true, making farm-saved seed much less valuable than the original seed.

[2] Summarised in Alston and Venner (2000).

Rangnekar (2000b) has argued that investments in R&D and even the production of varieties are a very inaccurate indicator of the effect of PVPA, primarily because of the other factors and trends influencing R&D decisions. Lesser (1997) also acknowledges the difficulty or impossibility of having a proper before-and-after study due partly to the long timeframes involved in plant breeding. These timeframes include other important developments in the area of plant breeding, such as advances in modern biotechnology, that may shift considerably the trend line of R&D. Indeed, even identifying what the underlying trend line was before the introduction of IPR is almost impossible due to the lack of (historical) data. Sorting out the relative effects of the different influences on R&D is extremely difficult.

It seems reasonable to suppose that the studies of R&D investments and even the production of protected varieties can provide an indication of trends in this area. But sorting out the specific effect of IPR on these investments is realistically feasible in only some instances. The question is then the following: is such information still useful for policy purposes in the area of IPR? The answer is yes, if one recognises that policy making in many areas often has to be based on very partial information, due to scientific uncertainty. As one of the principal desired effects of IPR for agricultural plant varieties is a stimulation to R&D, it seems relevant to know what the developments in those areas are. Conclusions on the relative effectiveness of legislation and the influence of other developments would then have to be drawn from a more qualitative reasoning that will always be open to several interpretations and criticisms. Interestingly, the stakeholders who have the most interest in providing such information are presumably the strongest advocates of IPR: the private sector plant breeders and some governments.

R&D: Outputs

Perhaps more important from a policy perspective is the effect of IPR on R&D outputs in the form of higher quality plant varieties. This implies characteristics such as higher yields, better pest resistance, etc. There have been a couple US studies of the effect of the PVPA on crop yields:

- Perrin, Hunnings and Ihnen (1983), in addition to examining R&D inputs, also analysed the yields of soybean varieties in yield test plots in North Carolina, Iowa and Louisiana. They used econometric techniques (a regression with a spline function hinging on 1970) to test the effect of whether the variety was released before or after 1970 on the yields observed. The analysis found evidence of a weakly-improving trend after 1970. Lesser (1997) observes that such analysis should be repeated with more recent and comprehensive data (there were, at the time, only a limited number of protected varieties in the sample).
- More recently, Alston and Venner (2000) have estimated the effect of the PVP Act on US wheat yields using both commercial and experimental yield data from a number of states and for various principal varieties. Again, econometric analysis was used to model annual wheat yields in a range of states as a function of a variety of factors, including dummy variables for the PVP Act. There was no statistically significant evidence of an increase in either commercial or experimental yields as a result of the PVP Act. This may be partly explained by the conclusion (noted from

Venner 1997, above) that private sector breeding activities also did not increase as a result of the PVP Act.

The evidence is so far rather ambiguous, or at best weakly supportive, in terms of contributions to agricultural productivity from IPR for plant variety protection. This type of analysis probably needs to be replicated for more crops in the US and in other countries having plant varietal protection in place for some time. Again, there are limitations to the extent to which one can draw conclusions, as with the R&D input studies, but the econometric methods employed for the above studies are somewhat more rigorous. It seems, given that this is the key benefit sought after by IPR protection, rather important from a policy perspective to undertake more research on this issue.

The extent to which such analysis could be undertaken in developing countries is determined by the availability of data. With only limited data, particularly due to for example, a very recent introduction of IPR for plant varieties, econometric analysis will not yet be very robust. For countries that have not yet, or are only just now, implementing PVP systems, there is no point. For those with established *sui generis* systems, it might make sense to consider how such a study could be undertaken in the near future and to begin with ensuring data collection.

It is conceivable that the generation of more results concerning the impact of *sui generis* systems in the form of breeders' rights on the improvement of plant varieties could be a critical piece of information in further reviews of TRIPS, in particular Article 27(3)b.

The effect of the breeder's exemption on R&D is an issue that has not been examined empirically. The arguments in favour of the breeder's exemption have been considered to be so strong that PVP systems have always maintained these, although the UPOV 1991 Act has introduced some restrictions concerning essentially derived varieties. Particularly for developing countries, there is not likely to be much use for research on the additional benefits and costs of this impact. Many plant breeding activities would simply be eliminated. One possible line of enquiry might involve surveying the activities of public and private breeders to estimate the amount of activity that would be eliminated without the breeder's exemption. This could then be used in arguments with those arguing for such a move. This is however not the most urgent topic of debate.

Trade and technology transfer issues

Some of the analysis mentioned above has examined the effects of IPR regimes in terms of promoting technology diffusion. This has usually been done in such a manner that the incentive effect of IPR to promote technology transfer or spillovers is taken as a given, as opposed to examining the empirical basis for this relationship. The analysis therefore focuses on how producers and consumers in different regions of the world will be affected by the diffusion of new technology, such as that embodied in a new biotechnologically engineered plant variety. Thus from a policy perspective, this research shows what the benefits and costs might be to a country's consumers and producers if that country either chooses access to such technology by implementing IPR or not. Such analysis probably does not provide much assistance to policy makers attempting to fulfil their obligations to Art. 27(3)b of TRIPS. But it is useful for the wider policy debates.

Policy makers might be more interested in knowing how the specific options available for a *sui generis* system would affect technology transfer. More bluntly, they might also wish to know what the potential is to free-ride without an IPR system? No empirical economic research has been conducted in this area and would be quite difficult, particularly if it were to focus on plant varieties, given the lack of situations to analyse. It may nonetheless be possible to analyse the extent of transfer of improved varieties by the private sector to or among developing countries. Some have only recently signed up to UPOV while many others are, of course, not members. This could allow either a before-and-after or a cross-sectional analysis of the effect of a *sui generis* system on technology transfer. Given the fact that such technology transfers are rather discrete events that occur rarely, any analysis would have to rely more on qualitative reasoning.

A different approach is taken by Zilberman (1998) who has developed a theoretical model to examine the adoption and impact of biotechnology under different IPR regimes. He models an agricultural sector with highly heterogeneous producers, all producing one crop, and looks essentially at how different IPR regimes will affect the adaptation of the biotechnology invention to the needs of different farmers. Here Zilberman is examining the case of patents though this type of analysis could also be interesting for plant varietal protection [1]. The model supports the argument that IPR are needed not only to stimulate the development of technology, but also to promote its marketing and eventual use. This issue is particularly interesting for developing countries, as it concerns the extent to which they could free-ride on northern biotechnology by having less effective IPR. Some economists (Lesser, 1997; Perrin, 1997) have argued that the access issue may be more important for developing countries than the R&D effect. Zilberman does not discuss empirical applications of his model in the form of simulations of specific sectors. This form of analysis would be very hypothetical given the manner in which IPR issues are simplified but may be useful, for example, in elucidating the scale of benefits potentially involved.

Distribution of benefits and welfare effects of IPR

Attention on the possible negative effects of plant varietal protection often focuses on the resulting potential for seed providers to earn monopoly rents with a consequent redistribution of benefits/welfare between seed providers, farmers and consumers. This issue has been categorised differently by various authors as, for example, 'static allocative efficiency' by (Lesser, 1997), the 'distribution of economic benefits' by (Moschini and Lapan, 1997) or 'appropriation of return from investment' (Srinivasan, 2000). From an economic perspective the issue is the redistribution of welfare benefits (in the static allocative framework of consumers and producers surpluses) accompanying the introduction of new production technology, in the form of improved varieties.

One way to examine this issue is to analyse the prices paid for improved seed varieties and to compare any margin over existing varieties with yield and other performance factors from trials. If there are monopoly powers in the hands of a seed supplier as a result of IPR, then the most obvious manifestation of these would be in the form of 'excessive margins' on seed prices. The only systematic study in this area appears to be that of Lesser

[1] The issue of patenting is, in any case, relevant to TRIPS and the obligations on developing country members.

(1994) who estimated, using econometric techniques (hedonic pricing) the marginal price associated with protected varieties of soybeans in New York State. He found evidence of only a small margin of 2.3% associated with soybean varieties with PVP. Lesser (1997) suggests that such studies should be replicated with other crops and elsewhere, particularly where quantified varietal testing is necessary as part of the granting of the protection (for the availability of data).

Another approach to this issue is to use static welfare analysis to examine the distribution of benefits between farmers, consumers and the seed sector. The traditional framework for evaluating the welfare benefits of technological progress in agriculture (Alston, Norton and Pardey 1995) assumes competitive input markets, including the market for seed. Moschini and Lapan (1997) developed a framework that recognises the monopoly situation created in seed input markets by intellectual property rights over plant varieties in the form of patents. A number of recent studies have applied this framework empirically, focussing particularly on genetically-modified varieties such as Roundup Ready® soybeans, and Bt crops. While not focusing specifically on PVP, the frameworks are relevant for the issue as they could allow an examination of the potential effects of more restrictive forms of PVP on the distribution of benefits.

Falck-Zepeda, Traxler and Nelson (2000a) examined the distribution of welfare from the introduction of Bt cotton in the United States in 1996. The study thus estimated the distribution of benefits from the adoption of the technology among US farmers, seed suppliers, US consumers, foreign consumers, and foreign producers. Data was taken from experimental plots as well as a survey of farmers. The analysis modelled the US cotton sector within the framework of a large open-economy with no technology spillovers [1]. A large share of the benefits was found to accrue to US farmers (more than half) while the seed providers received about a quarter. US consumers enjoyed rather modest benefits, while foreign consumers benefited somewhat more. Foreign producers were modest losers.

- Pray, Ma, Huang and Qiao (2001) have examined the distribution of benefits from the diffusion of Bt cotton in China, referring specifically to resulting from the 1999 crop. The data was based on a survey of farmers and the modelling framework was simplified to allow for simple vertical supply curves [2]. The main economic impact of Bt cotton came about as a result of the reduced cost of production (14-33% per kg) as there were not yet any observed effects in the output price markets. Almost all of this benefit (about 80%) was captured therefore by the predominantly smallholder farmer sector as much of the seed planted had been exchanged among farmers under a weak system of IPR [3]. This study therefore provides an interesting comparison of how things work out under weaker IPR protection. Although again, the evolution of the legal framework and of markets needs to be borne in mind in interpreting these results. In addition to the benefits enjoyed by smallholder farmers, the study also argues strongly that a major environmental and health benefit of the adoption of Bt cotton in China was the reduced use of pesticide.

[1] i.e. the US was the only producing country using Bt cotton.
[2] Given the lack of data on the cotton sector, such as supply and demand elasticities in China.
[3] The study did not actually estimate rents, only revenues, which are of course greater than rents, accruing to seed suppliers.

- Moschini, Lapan and Sobolevsky (1999) applied the Moschini and Lapan framework to the soybean complex to estimate the expected distribution of benefits from the adoption of Roundup Ready soybeans in 1999-2000. Their analysis considered three regions, the US, South America and the rest of the world. In this study, consumers and adopting farm regions benefited while the welfare position of non-adopting regions worsened. The estimated monopolist profits for the seed supplier were sizeable (45% of the global welfare gain). This study also compared the impact of IPR by comparing the simulation of the model with parameter values that could be expected under competitive supply of Roundup Ready soybeans. The estimated efficiency loss from the exercising of market power is extremely small (0.2% of the original net efficiency gains). The authors attribute this to the relatively inelastic supply and demand functions for soybeans [1]. But the size of the monopolist benefits is such that were the technology of Roundup Ready soybeans to be competitively supplied, the originating country (the US) would lose considerably while producers in other countries would benefit.

The methods and issues arising from these studies are as interesting as the empirical results, which must be properly interpreted. These studies generally involve the first years of introduction of a genetically-modified crop. It is not clear how the price strategy of the seed supplier will evolve. Given the debates around GMOs and restrictions placed on farmers by the seed sellers, the latter may well have a strong incentive to price the new technology at a discount, in order to acquire market share. On the other hand, the seed supplier might be motivated equally strongly by other possibilities developing as competition and thus be more concerned with generating monopoly profits while they exist.

An interesting empirical question relating to these studies relates to the sensitivity of results to the supply and demand elasticity's of the output markets, which are usually taken from other studies. In terms of thinking about extending such analysis to more developing country situations, it is likely that the availability of robust estimates of supply and demand functions for agricultural output markets is much more restricted. This is borne out by the experience of Pray et al. (2001) who worked with vertical supply curves in their study of Bt cotton. Whether these assumptions affect considerably the outcome of the analysis deserves further analysis, particularly since the collection of farm-level data, an expensive undertaking, is also a requirement. Moschini et al. (1999) do run some sensitivity analysis, for example, and it appears that underlying parameters have a considerable effect on the analysis. While qualitatively the results do not change, the quantitative results are quite sensitive. Furthermore, the distribution of benefits turns out to be quite sensitive to the size of yield benefits associated with the new technology. Such differences are, of course, particularly interesting for policy makers. The authors therefore conclude that the qualitative results and the orders of magnitude of the welfare effects are the most relevant and robust results of such an analysis.

The above studies provide an interesting analysis of the distribution of welfare benefits from the introduction of genetically-modified varieties (GMVs). They allow the comparison of the expected order of magnitude of the welfare effects on producers, con-

[1] As well as the fact that the model does not take into account land allocation decisions, i.e. the movement of land in and out of soybean production.

sumers and technology suppliers. It is even possible to examine how these change under different IPR regimes. These approaches seem to offer promise and potential for further work that can be of interest to policy makers concerned with IPR and plant varieties, particularly since simulations can be undertaken of hypothetical policy options (e.g. IPR versus no IPR). But to apply this framework fruitfully to this purpose, it is necessary to conduct prior empirical work on the relationship between various IPR options, including PVP variants, and the creation of monopoly powers in the agricultural input markets. This could then be fed into the framework which would be more sophisticated than the simple assumption of monopoly pricing behaviour.

Interestingly, the studies do not generally look at the welfare changes from the impact of the new technology in relation to welfare measures of producer and consumer surpluses prior to its introduction. This should be relatively straightforward and would be interesting. For example, do the welfare gains from Roundup Ready soybeans represent a 1, 10 or 100% improvement?

The studies reviewed in this area also tend to treat the producing sector in one country as either completely adopting or not adopting the new technology. Moschini et al. (1999) is an exception. They allow the partial adoption of the technology, but then the framework still does not allow the breakdown of the welfare effects among adopting and non-adopting farmers, potentially a critical issue, particularly under different IPR regimes. To examine this, it may be possible to adapt the type of framework used into a two-sector model.

Restriction of scope of protection - farmer-saved seed

Lesser (1997) reasons that one reason for a low pricing margin on protected varieties (discussed above), which is an indication of limited monopoly powers, is because of the 'reduced appropriability' of the exclusive right due to competition from farmer-saved seed. Srinivasan and Thirtle (2000) have proposed a theoretical model to examine the effect of this reduced appropriability on the returns to research. Pray and Basant (1999) report from interviews with major seed firms in India that the inability, even with PVP, to restrict farmer-saving of seed provides a major disincentive to the initiation of major breeding programs for the Indian market.

It can also be reasoned that, as a result of this, seed suppliers may seek to capture an even larger margin with seed sales in order to compensate lost benefits due to farm-saved seed in future plantings. Hansen and Knudson (1996) developed a framework for econometrically testing this hypothesis and applied it to the soybean industry in the US. They found statistically significant evidence of indirect appropriation and conclude that farmer-saved seed in the soybean sector does not decrease incentives for varietal development. This implies that farm-saved seed does not provide as much competition for private varieties as might be claimed, at least for soybeans. It is worth noting that this analysis was undertaken before the introduction of Roundup Ready soybeans, a genetically-modified organism (GMO), in the US which would probably offer an interesting opportunity for revisiting the analysis.

This area of research is particularly relevant for the policy choices concerning the scope of protection under a *sui generis* system. As mentioned above, a key consideration is

the farmers' privilege, with the UPOV 1991 Act admitting the possibility of greater restrictions on this privilege. The very limited empirical analysis undertaken in the US would suggest that maintaining the farmers' privilege does not impinge on the incentives for R&D and does not even form a serious form of competition. Thus, due to other benefits it provides (e.g. food security), there would be little economic basis for excluding or restricting this exemption from a *sui generis* system. But the studies need to be undertaken for other crops and in other countries. As Lesser (1997) points out, it is essentially an empirical issue. The interest of some seed developers in the genetic use restriction technologies (GURTs) indicates a concern about competition from farm-saved seed. With this issue, it is possible to contemplate studies in countries that have only introduced IPR for plant varieties more recently, as the longer historical time series of data, while always more robust, is not as necessary as with the R&D studies summarised above.

5. Conclusions

A general conclusion is that there is still a relative lack of research in this area, as noted by other commentators (Lesser, 1997). This applies to research in industrialised countries as well as those in developing countries. Such a situation provides a number of opportunities for a research agenda to be elaborated. But in this case, the elements could apply almost equally to industrialised countries, as to developing countries. The main difference is that it is developing countries that have not yet implemented a PVP system compliant with TRIPS that are generally faced with more urgent policy choices.

As has been mentioned on several occasions, the focus of much economic research on PVP has been on the impact of such protection as a whole. On the other hand, it can be argued that the immediate issue facing policy makers now in many developing countries concerns the options to choose in the design of a PVP system to meet the *sui generis* requirements of TRIPS Art. 27(3)b. Such a state of affairs might be interpreted as meaning that the economic research has pronounced decisively in favour of the overwhelming net benefits of PVP. As the review of studies above has shown, this is not necessarily the case.

The extent to which PVP actually demonstrates economic benefits for developing countries is still an open issue. Given that these countries are now required, as part of WTO membership, to implement PVP, it seems especially relevant to pursue empirical research on the expected or realised impacts. A compelling reason for such research is that future changes to the TRIPS agreement cannot be ruled out as indicated by the mandated reviews of TRIPS, or individual articles, such as 27(3)b. Such reviews are interpreted by many industrialised countries as occasions to further tighten the protection requirements mandated under TRIPS but this is certainly not the perspective of many developing countries. Further research on the overall impact of PVP should still be able to help inform these debates.

Given the uncertainty over the extent and scale of economic benefits of PVP, it seems even more important to examine in further detail the likely impacts of the options that need to be addressed in the design of a *sui generis* system. In this regard, the opting for restrictions, and their extent, on farmer-saved seed appear to be a crucial topic for research. In addition, there is probably a role for some comparative studies involving more industrialised studies (aside from the US) that have adopted various options (concerning requirements, protection, scope, duration, etc.) in their PVP systems.

Figure 5.1 attempts to summarise some of the key topics forming a research agenda of interest for developing countries. These are organised according to the relevant economic issue (discussed above) and then related to the policy choices in the framework of TRIPS Art. 27(3)b.

Research topic	Economic issue	Policy choice
Changes in R&D as a result of UPOV accession (especially by industrialised countries)	Impact of PVP	Endorsement of PVP
Costs of varietal production in relation to pricing: reasonable or excessive margins?	Distribution of benefits and welfare effects (monopoly)	Endorsement of PVP
Static modelling of distribution of benefits	Distribution of benefits and welfare effects (monopoly)	Endorsement of PVP
Basic quantification and characterisation of practice of farmer-saved seed	Farmer-saved seed	Scope of protection
Studies of indirect appropriation	Farmer-saved seed	Scope of protection

Figure 5.1 Items forming a research agenda

This paper has concentrated on the components of an emerging research agenda on the economic aspects of PVP and obligations under TRIPS Art. 27(3)b. The review presented above has been undertaken with a view to identifying areas of research that are potentially feasible but, more importantly, of relevance to policy makers. The paper has not however addressed the important issue of how such information or knowledge stemming from this kind of research can best be made available to policy makers. Given the highly political nature of the policy debates, it is necessary to consider at some point how researchers in this area should engage in the policy process.

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