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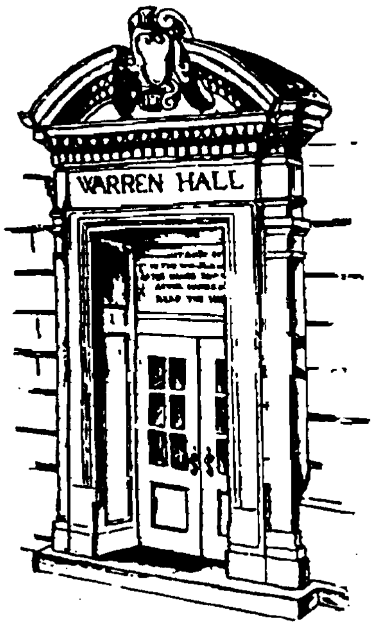

Staff Paper

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ASSESSING THE IMPLICATIONS OF IPR ON PLANT AND ANIMAL AGRICULTURE

by

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I. INTRODUCTION

Many readers, over their careers, will have shared my experience of initiating some really "innovative" work, only to learn it had been done, and done better, 30 years earlier. That is one key attraction of research on intellectual property rights (IPR) for plants and animals; they are in the main very recent, so whatever you do cannot have a direct antecedent. Indeed, to date, little economic research has been done on the implications of expanding IPR protection for living agricultural inputs. Protection in the U.S. for asexually propagated plants has been available since 1930, for sexually propagated plants for over 25 years, and for patented plants for a dozen years (see below), but it was only last year that significant acreage of patented bioengineered plants, some 2.5+ million in total, were planted, with higher levels going in the ground in the USA and Canada as this is being drafted. Those crops are primarily herbicide resistant beans, canola, and corn, *Bt*-producing corn, cotton, and potatoes, and virus-resistant squash (James and Krattiger, 1996). The crop which initiated commercialized bioengineered plants, the FlavrSavr tomato, has been temporarily withdrawn; it seems Calgene, the innovator, picked the wrong variety for delivering their delayed ripening technology. Only one livestock application (to my knowledge) has been patented, a pig in Australia with a controllable growth hormone, but it is as yet not a commercial product.

What has been explored extensively in the literature are expressed concerns about IPR on farm structure, ethics, university/industry relationships, information exchange, and related matters[1]. Nor is the debate limited to the U.S. or developed countries. The international enhancement of IPR under GATT/TRIPs, plus the associations made by some among IPR, traditional varieties and genetic diversity has led to an ongoing debate regarding IPR within the Biodiversity Convention[2]. These are for sure emotional matters, sometimes even moral issues, but many have economics dimensions as well. Yet to date there has been very little empirical information, even

[1]For a flavor of that literature, see e.g., Kloppenburg, 1988.

[2]The literature is summarized in Lesser, 1997b.

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on the level of opinion surveys of affected individuals, plus little conceptual economic analysis. Economists cannot answer all of these many issues, but they can provide direction for some of them. With a range of new products reaching the commercialization level, the opportunity now exists to substantiate some of those issues. Here, I explore ways and types of economic analysis which have and can be applied to answering at least some of the questions regarding IPR for plants and animals. Analytical approaches considered here include:

- welfare analysis: overall and IPR system components,
- static allocative efficiency,
- dynamic allocative efficiency,
- anti-trust theory, and
- trade theory.

Initially though it is necessary to establish a minimal common understanding of the types of IPR applicable to plants and animals and their functioning. Many analyzes of IPR suffer from an inadequate understanding of how they actually function, with alternatives and complementary activities. Therein lies one of the explanations for limited economics attention to IPR; the major human capital investment required to contribute to knowledge. Indeed, contributions come from a combination of knowledge of the law, economics, and agriculture. Agricultural economists possess the latter two, which makes them comparatively well positioned to provide intellectual leadership in what some would have us believe is an Orwellian world already well advanced.

II. FORMS, FUNCTIONS AND LIMITATIONS OF IPR APPLICATIONS TO LIVING AGRICULTURE INPUTS

Formal intellectual property rights, those recognizing and protecting the economic value of creations, have been traced back to Venice during the early 1400s when glass guilds attempted to limit competition by preventing apprentices from utilizing production secrets in competition with the guild, a practice which continued for some centuries[3]. Indeed, in the 1700s the first modern mechanized loom reached the U.S. from England only when an apprentice committed the plans to memory and stowed away on a vessel headed for North America. The duration of patents is said to have initiated from the length of an apprenticeship.

The term "patent" is derived from "letter patents" which were in effect Royal monopolies granted to suppliers in England with the intent of upholding quality standards. As with many such systems, they became associated with the grant of favor and so were despised, leading to the Statute of Monopolies of 1623. There, the grant of monopoly was limited to "true inventions" and so established the basis of current patent law. Closer to home, Jefferson, a prolific inventor himself, is recognized as the author of the words in the Constitution (Article 1, Sec. 8, emphasis added) stating, "The Congress shall have the power . . . *to promote the progress of science and*

[3]An excellent history of patents can be found in Walterscheid (1994) *et. seq.*

the useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

This terminology has been identified as fostering economic incentives as the objective of IPR (Anderfelt, 1971). The economic incentive approach recognizes the inventor assumes time and other costs associated with the creation process such that she/he could never compete on equal terms with copiers whose costs, minus the creation process, are lower. Hence the creator will always be undersold and has no incentive to invest. IPR legislation redresses the balance, at least in part, by prohibiting direct copying so long as the protection is in effect (the classical explanation is Machlup (1958); more theoretical development in Arrow's (1962) work on the incomplete appropriability of knowledge). Hence, IPR law is pragmatic economic policy, providing a limited, temporary monopoly right to encourage investment in creative activities. The rights granted are strictly *negative* rights, the option to exclude others from making or using the creation without permission. They do not assure a return; indeed only up to 15 percent of patents are ever commercialized (Nogues, 1989). They do not necessarily permit the use/practice of the creation. That is often controlled by regulation (biosafety) or even other patents. All IPR allow is the right to prevent direct copying.

That, however, is but one justification for IPR systems; the other is known as the personal property or "natural law" approach. The personal property approach is based on Locke's concept of a right to property being conferred by God upon all men in common (see Thompson, 1992; also Hughes 1988). This is in contradistinction to the absolute power of sovereigns. The concept, though, applies to common property, but what of personal property? Locke handles that matter by introducing the idea of labor, "he that mixed his labour with and joined it to something that is his own, and thereby makes it his property." Underlying is a view that a free person controls his labor, and a loss of the right to the product of that labor implies a loss of freedom. Property rights, including IPR, are thus a means of protecting freedom. Here, we shall emphasis the economic approach, but it is important to recognize there is not even complete agreement on the purpose, the role, of IPR.

IPR perform an additional, if less frequently discussed, economic function, that of assisting access. The IPR role can best be understood by recognizing that property rights law is strictly national, it applies only in the countries where rights have been secured. Hence firms are reluctant to allow access in countries where protection is not available or has not been secured. This would be particularly true for easily copied inventions and for those which might find their way undetected back into major markets. As many protected plants and animals are self-reproducing, IPR protection is particularly significant for agriculture.

At present, few developing countries allow patent protection for plants and animals, while protection in the European Union remains clouded. Data for 1988 gathered by the World Intellectual Property Organization, the UN agency responsible for supporting IPR and administering a number of international treaties, indicated 54 nations exclude patent protection for plants and animals (WIPO, 1990, Annex II). Those figures are dated, for the Uruguay Round

GATT agreement of 1993 incorporated IPR as a trade issue for the first time. Arguing that a major export of industrialized nations was technology, and that the absence of IPR acted as a trade barrier, Trade-Related Aspects of IPR (TRIPs) was added to the GATT agreement for the first time (MTN/FA-II-A1C). As regards plants and animals, signatories are required to (a) provide patent and/or "an effective *sui generis* system for protection of plants while (b) retaining the right to exclude plants and animals other than microorganisms from patent protection and "essentially biological processes for the production of plants and animals" (Sec. 5, Article 27(3b)), and (c) providing trade secrets legislation (Section 7, Article 39). An "effective *sui generis* system" has generally been interpreted to mean Plant Breeders' Rights (see below). As a result, countries have been modifying their IPR laws to comply. Indonesia, for example, will no longer ban plants and animals from patent protection (Patent Law No. 6, 1989, as amended, Article 7) and is expected to adopt Plant Breeders Rights in the near future (Priapantja, 1997). TRIPs contain a number of other substantiative and harmonizing requirements but they are not as directly relevant to our discussion here[4].

The Article 27 reference to "essentially biological processes" parallels closely the language of Article 53(b) of the European Patent Convention which prohibits patents for "plant and animal *varieties* and essentially biological processes for the production of plants and animals." (emphasis added). Similar language is included in the WIPO model patent law for developing countries (WIPO, 1979). This terminology was adopted before biotechnology was operationalized, which helps explain the ambiguity of interpretation. Initially, the Commission of the European Communities in a Council Directive (1988) attempted to fudge the issue by defining "variety" narrowly to mean a fixed form. That approach was effectively overruled in a 1995 appeals patent ruling where the court said in effect that any patented plant would be commercialized in the form of a variety (even though the invention may be applicable to multiple varieties) so that plants are effectively banned from patenting (*Official Journal EPO*, 1995). Several approaches are underway to resolve that conundrum (see Straus, 1995).

A. Forms of IPR Applicable to Plants and Animals

Patents: Patents, like other forms of IPR, operate as a balance between the inventor and society. Society grants a temporary, partial monopoly to the inventor. Temporary refers to the duration of protection, under TRIPs 20 years from date of application; and partial describes the scope of protection, the degree of difference required before a related development is not covered by the patent. What society receives in exchange is more investment than it is expected would otherwise occur and the revealing (disclosure) of the invention. A typical patentability requirement is disclosure "in such full, clear and concise and exact terms as to enable any person skilled in the art or science to which it appertains . . . to make, construct, compound or use it". When for living matter a written description is judged insufficient, a deposit may be required

[4]Article 27(2) does allow countries to prohibit patents for reasons of *ordre public* or morality, which has relevance to animals in particular for many people consider such patenting to be amoral. While that is a significant matter for discussion, it lies outside the focus here on economic analysis.

(Straus and Moufang, 1990). Disclosure not only permits competition soon after a patent lapses but also provides a storehouse of technical knowledge which would not otherwise exist.

An additional patentability requirement is novelty - the invention must not be previously known. Finally, and perhaps best known, the invention must not be an obvious extension of what already exists, this known as the nonobviousness or inventive step requirement. Hence it is not possible to patent any thing; the requirements are specific and exacting. Moreover, there must be human intervention in the inventive process. The mere identification of something existing in nature (technically known as discovery as opposed to patentable inventions) would not be sufficient for a patent. Examples of human intervention are the purification of a strain of microbes, or the identification of an especially rare rose mutant. It should be further noted that, to identify a specific hypothetical case, a product patent would not apply to all rice varieties. Rather, the application would apply to rice with certain characteristics, such as the built-in insecticide *Bacillus thuringiensis*.

While the first U.S. Patent Act was passed in 1790, living organisms were not explicitly protected until 1930 with the adoption of the Plant Patent Act (subsequently incorporated into the Patent Act as Articles 162-63). Plant patents apply only to asexually-propagated plants like fruit trees, roses, and bulbs. The Supreme Court in 1980 in the significant *Chakrabarty* decision extended patent protection (technically known as utility patents) to "anything under the sun that is made by man" (at 309, 206 USPO at 197). This was possible because the Act did not specifically exclude those product classes, allowing the Court to interpret Congressional intent. Specific extensions to plants[5] were not made by internal patent office decision until 1985 (*Ex parte Hibberd)*[6] and to animals in 1987 (*Ex parte Allen*)[7]. Canadian patent law, like that in the U.S., is "silent" on plants and animals meaning its applicability is a matter of interpretation. To date, plant patents have been granted, but not those for animals.

Plant Breeders' Rights: Plant Breeders' Rights (PBR) is a specialized patent-like system for cultivated plants. PBR were first systematized in 1961 under the International Union for the Protection of New Varieties of Plants (UPOV). Presently there are 31 members, but including only five developing countries (South Africa, Argentina, Chile, Colombia, and Uruguay). Others such as India, Pakistan, and The Philippines could join in the near future. Still others, minimally Kenya, Taiwan, India, and Peru, have national laws, but the degree of their implementation is not known. UPOV membership, among other steps, requires that signatories adopt national legislation along the lines of that Convention. The U.S. adopted PBR in 1970 (Plant Variety Protection Act (PVPA) of 1970) and Canada in 1990.

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[5]Patented plants, which can be reproduced by any method, should not be confused with plant patents.

[6]2 *U.S. Patent Quarterly 2d* 1425.

[7]*225 U.S. Patent Quarterly* 443.

In place of the novelty, nonobviousness, and utility requirements of patent law, PBR uses distinctness, uniformity, and stability (DUS). Uniformity and stability are measures of reproducibility true-to-form, respectively among specimens within a planting and inter-generationally. The principal test then is distinctness, that the variety be "clearly distinguishable from all" known varieties. The DUS attributes are (excepting the USA) generally measured in growouts of the planting materials.

PBR are further distinguishable from patents by the allowance of so-called "farmers' privilege" and "research exemption", sometimes called "breeders' privilege". The farmers' privilege is the right to hold materials as a seed source for subsequent seasons (farmer-saved seed or bin competition), something which would generally be an infringement with patented materials. The research exemption refers to the right to use protected materials as the basis for developing a new variety or other research use. Research or experimentation under patents is not as well defined but is believed to be fairly broad.

Because of these differences, PBR are generally considered to provide less protection than patents. They also apply to the whole plant or the propagating materials thereof. What they do not protect is the unique characteristic (the distinguishing characteristic) of the variety. For that reason, no real protection is provided for a variety with a bioengineered gene which legally can be removed and used in another variety or with another distinguishing attribute added.

That situation will change under the 1991 UPOV text which in Article 14(5) allows for dependency. While experimental use remains unrestricted, a variety determined to be dependent on an "initial variety" can not be commercialized without the permission of the owner of the initial variety. To be dependent, a variety must be "predominately derived". It may be obtained by selection, backcrossing, genetic transformation, or other specifically-identified procedures. The actual interpretation of these general concepts is, and likely will remain, unclear until there have been some actual infringement cases (see Rasmussen, 1990). The 1991 text further allows (but does not require) countries to restrict farmers' privilege. To date, the USA like most countries will not do so.

Trade Secrets: Trade secrets, to describe them in their simplest terms, assist in the maintenance of secrets by imposing penalties (the recovering of costs) when information held as secret is improperly acquired or used. Examples of trade secrets include customer lists and practices for improving the efficiency of a breeding process. An employee going to work for a competitor typically would be enjoined from revealing sensitive information for a specified period. Unlike patents and the like, no formal application procedure is needed for a trade secret; rather the information must have some commercial value, and an effort made to keep it secret. As long as these conditions are met, protection can be permanent. For a description of the laws and their applications in the USA, see Coe (1994)[8].

[8]In the U.S., trade secret legislation is based on State, not Federal, law.

Within agriculture, F-1 hybrids may be considered a form of trade secrets. As long as the crosses and/or the pure lines are protected, the product is difficult to copy. However, the self reproducible nature of most living organisms precludes a major role for agricultural products. In other technological areas, trade secrets may substitute for, or complement, patents and PBR. When a product or process is difficult to copy, then trade secrets can be a substitute.

B. IPR Alternatives and Limitations

No economic evaluation of IPR would be complete without a consideration of alternatives and limits to those systems. As economic policy, IPR does have alternative approaches, which can act in concert or as substitutes.

a. Alternatives:

As is noted above, *trade secrets* are one alternative to patents and PBR, and are used for hybrids, for example, when the pure lines can be protected. Sometimes trade secrets complement patents when, for example, a technology is patented and the best means of implementing it are held as a trade secret. Trade secrets are not applicable when the means of creation can be divined readily ("reverse engineering"). An extreme example of that case is self-reproducible organisms. To be commercially practical, many agricultural products of biotechnology must, I have argued elsewhere (Lesser, 1987a), be self reproducible as the efficiency of transformation is low, on the order of a few percent. Large efficiency enhancements would be required to justify replacing the transaction cost savings of farmer saved seed, while for slow reproducing stock like cattle, a trait must be inheritable to be disseminated through the large standing herd. And even if the marketable product is a hybrid, if the invention is contained in a gene sequence, that sequence can be removed and inserted in another variety, if not protected in its own right. Thus, for the class of products considered here, trade secrets have limited applicability.

Rapid technological change is a form of alternative; a firm can get ahead of its competition and stay there. That in part (and part secrecy, by controlling the pure lines) is what producers of "synthetic" animal breeds do. Yet there again, if the invention is in the gene sequence, and that inventive process is costly compared to the selective breeding process, then the absence of IPR protection leaves the inventor vulnerable to having the key development appropriated. In some cases, *trademark* protection will substitute for patents and PBR. Trademarks are the reservation of a word, symbol, or phrase in association with a product or service. I have also argued previously (Lesser, 1987a) that the past application of PBR in the U.S. allowed no real control over the germplasm and permitted very small, commercially insignificant differences in protected varieties, so that what was really protected was the variety name[9]. For the more recent act with its dependency clause, that argument will no longer apply.

Another entirely different approach is that of alternative incentives, such as prizes, awards, and contests. Conceptually, once an area has been identified, a prize could be offered for the first

[9]U.S. seed laws prohibit trademarking the names of certified seeds.

successful result. That approach has contributed to technology development in at least some well publicized cases, including Lindbergh's solo trans-Atlantic flight, the first sustained human powered flight by the Gossamer Albatross, and, recently, Deep Blue's defeat of chess champion Kasparov. For Lindbergh, it is unclear if it was the prize or the notoriety or something else which was the real attraction, but clearly the Spirit of St Lewis did contribute significantly to airplane design. The longer term technological contributions of the other two cases are less clear, at least to me.

In my judgement, prizes and awards would apply best when the following conditions are held:
- clearly identified goal or objective,
- function as a marginal incentive with other benefits and/or funding support,
- identified source of funding for the prize,
- anticipated investment requirements low to moderate,
- product or technology accessible to multiple participants (e.g., not highly specialized), and
- clear use for winning product.

The final point avoids the issue of investment required for making the initial work commercially applicable (see below).

Awards could be offered in any technological area in lieu of royalties. That approach has been used by the U.S. for military applications of nuclear energy, which are excluded from patent protection. How well such a system functions has not been determined, for there are no alternatives to compare it to, but Scherer (1980, Chap. 15) considers the awards to be middling compared to value, which would reduce incentives.

Again in my judgement, prizes/awards/contests could serve in some cases, but more as a complement than substitute to IPR. This would seem to be an area which could benefit from more economic analysis, possibly using experimental economics. Prizes could serve in some cases, provided the source of the prize money was identified.

Finally, those of us in the public sector should not overlook the tremendous advances made in agriculture based on public research funding. Varietal development alone is generally credited with contributing half of agricultural productivity advances over the past 30 plus years. Studies indicate a social return on this investment commonly in the 30 - 50 percent range (see literature review in Echeverria, 1990; discussion in Lesser and Lee, 1993). That system seems to be moving towards private investment not so much because the public sector was not productive and efficient in an economic sense, but because the taxpayer is unwilling to support it in the current 'user should pay' mode. Yet the inefficiencies of internalizing benefits of quasi-public goods like self-pollinated seeds raises substantial questions about the efficiency of the path we are advancing along.

b. Limitations:

IPR law is a form of economic policy, and agricultural economists are all too familiar with how imperfect a process is its structuring and administration. Many of those matters are discussed more formally below and so shall be only touched on here. Particularly in regards to incentives to innovate, little is understood about the creative process. Certainly, some of the profound inventions which influence our lives seem to have sprung more from a personal drive than a specific incentive. However, IPR is really more focused on the commercialization of ideas, the 'reduction to practice', or, in more prosaic terms, the "99 percent perspiration" process Edison referred to when describing the inventive process. This concept is in line with the notion of the 'useful arts', but largely overlooks the truly creative process.

A somewhat poignant example of this particular patent role can be seen with the development of penicillin, one of the most significant of recent inventions. Sir Howard Florey and Ernest Chain, its inventors, chose not to seek a patent as a contribution to humankind. Regrettably, that meant no firm had the incentive to go through the enormously expensive development and testing process estimated currently to be $250 m per successful drug. Hence, penicillin did not become available until the U.S. Government invested in it during World War II. A similar problem existed with government-sponsored inventions which typically languished for lack of an incentive to develop them. That led to the "Bayh-Dole Act of 1980 which allowed contract researchers and other interested parties to patent resultant inventions, which, in turn, led to the growth of university patenting and licensing offices. The resolution of one problem may have contributed to another, at least as seen by some.

In more pragmatic terms, the societal tradeoff of a grant of monopoly, however limited and temporary, requires fine tuning in terms of duration and scope. Economic welfare analysis is applicable here, but, as I argue below, not very profitably.

The privatization of essentially public goods such as self-reproducible plants and animals is a costly and inefficient process. Patent applications in the U.S. average about $10,000 including attorney fees, PBR less than half that. Yet it is enforcement which is especially costly. In some recent work (Lesser, 1997a) I estimate simple tracking of use of say a plant patent through reading catalogues, talking with licensees, inspecting financial records, etc. costs upwards of $1,800 a year while "genetic fingerprinting" of a well characterized plant variety costs $170, and 10 to 20 times that for heterogenous materials. Infringement suits, while rare (est. < 1% patents), cost hundreds of thousands to millions. But IPR is not the sole problem; plant breeders are now beginning to say that there is no such thing as 'hybrid vigor' for corn, the same productivity could have been coaxed from self-pollinated varieties with equivalent effort. The costs of hybridization then are largely chargeable to non-IPR protection.

IPR has been associated with misdirecting research incentives and, in the case of public research, with encouraging applied over basic research. Additionally, there is an incentive to restrict the flow of breeding lines to competitors and to slow the sharing of research results (see Kloppenburg, 1988). If true, that would slow research productivity, placing a significant drag on the system. To date, there is little if any documentation that that has occurred in agriculture, but there may be for other areas or research, especially medical (Butler and Marion, 1985; Ali, 1997; Blumenthal, Gluck and Louis, 1987).

In regards to developing countries, a range of additional issues have been raised, particularly as regards the Convention on Biological Diversity which, contains technology transfer agreements along with its focus on conservation and hence has a significant focus on IPR. Issues raised include equity, indigenous/traditional people's rights, dependency, reduction of genetic diversity and more (literature review in Lesser, 1997b). In the arena of economic analysis there is legitimate question of the appropriate stage for adopting strong IPR protection. Critics note that Switzerland did not protect pharmaceuticals and chemicals until the WWI era when they were well advanced in industrial development; Canada did not protect pharmaceuticals until 1987. They free rode on external developments, so why should other countries not be granted the same opportunity today?

Certainly few countries are major contributors at a world class level so patents held by nationals are a few percent of the total for most countries, including Canada (the USA and Japan are the exceptions, see Nogues, 1989). This has led to the charge of patents protecting "import monopolies"[10]. I have elsewhere argued that IPR also (a) enhances access, (b) fosters open disclosure rather than secrecy, possibly including plantation production, and (c) fosters incentives for developing products such as tropical plant varieties not used in temperate developed countries. But the reality is the costs of IPR in the form of royalties is easy to measure while the benefits of say earlier access are much more ephemeral.

III. ECONOMIC ANALYSIS APPLIED TO IPR

The preceding, if nothing else, should establish that there is a significant institutional/human capital component to studying IPR. Here we examine in more detail what contributions economists could make. Seven analytical approaches are considered, as follows:

- welfare analysis/overall
- welfare analysis/IPR system components
- static allocative efficiency,
- dynamic allocative efficiency,
- anti-trust theory, and
- trade theory.

A. Welfare Analysis/Overall

For purposes here, the consideration of welfare analysis will be divided into two components, the first dealing with the relationship between IPR and R&D, the second with structuring optimal IPR systems.

[10]Technically, countries can, under broad conditions, require national production by issuing compulsory licenses, but that begs the broad point being made by critics (see TRIPs, Article 31).

Does IPR stimulate R&D?: About this most basic question there is little hard evidence. Partly this is because one clear and compelling approach, before and after analysis, is not possible with utility patents. PBR, however, are relatively recent, and Butler and Marion (1985, Chap. 3) used survey information and certificate data in a straightforward manner which assumes changes are attributable to PBR protection and not other concurrent factors to assess the effects of the PVPA. They concluded (1985, pp. 38-39):

(a) R&D investments by seed companies increased most rapidly during the period 1967-70, possibly in anticipation of the passage of PVPA.
(c) R&D expenditures shifted away from corn and toward soybeans during the 1970s.
(d) The number of soybean and wheat varieties released by sample firms during the 1970s increased rather sharply.
(e) A large share of PVP certificates are held by seed companies with large plant breeding programs that were established prior to PVPA.

Taken in total, these data indicate that PVPA has had a positive effect on private plant breeding R&D for soybeans and wheat.

Perrin, Hunnings, and Ihnen (1983) also surveyed private U.S. seed companies in 1980 to determine the effects of the PVPA on breeding R&D and numbers of breeders. They concluded, "[T]here seems to be little doubt that private research on soybeans and cereals was affected positively by the PVPA." As clearly, PVPA-induced investments have been very selective by crop, with most directed to soybeans due to crop size and value, and by response to breeding inputs and geographic expanse suited to individual varieties (see Foster and Perrin, 1991). Countering claims that the observed increases are due largely to rising crop values (see e.g., Kloppenburg, 1988), they note, "Thus, when expressed in dollars of research per dollar of crop value, the evidence is still consistent with the hypothesis that the PVPA has had a significant impact on private variety research." The same conclusion is reached when computing R&D expenditures per dollar of seed sales.

Conceivably, a longer reference period, at least than was available when the analysis of PVPA was done, could assist the analysis. That was done by Stallmann (1986) who (alone, to my knowledge) analyzed the 1930 Plant Patent Act regarding fruit tree breeding. She concluded it had little impact, due largely to (a) the lengthy breeding process and (b) the difficulty of detecting infringement. Results could be different for horticultural products, a major recipient of plant patents in the U.S. That indeed seems to have been the case for the U.K. for which Penna (1994) found a "significant impact" for roses and strawberries, but not for snap beans, apples, and green peas.

For developing countries, the only substantial evidence is available from Argentina, and there for but a few years when the legislation was enforceable. "But rather than encouraging additional R&D investment, PBR protection would have prevented these companies from reducing or even eliminating their breeding programmes and enabled the reactivation of soya bean breeding." (Jaffè and van Wijk, 1995, p. 48).

Much of this analysis was done using quite simple, often graphical techniques, but the limited record for the use of more analytical approaches has not been very encouraging. Foster and Perrin (1991) developed a theoretical model which included the degree of appropriability of the benefit as a component, something proxied in the empirical models in part as crop supply and demand elasticities. The results though were not significant.

Additional information on the incentive effects is available in cases of the removal of protection. In India, pharmaceutical R&D fell 40 percent from 1964-70 to 1980-81, something Deolalikar and Evenson (1990, p. 237) attribute to the weakening of patent protection in 1970. An ancillary point, and one particularly relevant to agricultural applications, is that of adaptive research. Deolalikar and Evenson (1990, p. 251), again referring to the case of India, conclude, "If anything, the relationship that is often observed is one of complementarity." In Evenson's view (1988, p. 152), "Indirect transfer does not take place without research capacity in the destination country."

The available information supports theoretical expectations that IPR does indeed increase R&D investments, but that is only one aspect of welfare analysis. Additional required information is on (a) the quality of the IPR-fostered varieties and (b) the price effects (considered in subsection C below).

Quality of PBR-protected varieties: Does PBR legislation lead to improved varieties or only cosmetically-improved ones, as some have charged? Records of the U.S. Plant Variety Protection Office indicate an increased number of private varieties, particularly for soybeans, and varietal planting data indicate greater usage. But is that because private varieties are superior or because they are promoted, as suggested by Stallmann and Schmid (1987)?

Perrin, Hunnings, and Ihnen (1983) examined this issue using varietal test results for soybeans from North Carolina, Iowa, and Louisiana. Using a simple splice function hinged on 1970, they found a weak improving trend in the latter period. This is a fairly weak test due to the limited number of protected varieties in the mix and the absence of an adjustment for the date of the breeding work as opposed to varietal release, but the test can and should be redone with more recent data. My guess is that the protected varieties will be shown to be good performers.

B. Welfare Analysis/IPR System Components[11]

Economists began seriously to analyze the optimality of components of IPR systems with Nordhaus' (1969) analysis of optimal patent life. While many other aspects of the patent system, as well as other IPR systems, have been analyzed, the duration issue represents well the approach and contributions of this literature.

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[11] Literature reviews in Primo Braga (1990) and Scherer and Ross (1990).

Nordhaus (1969) considered patent lifespan as a societal welfare maximization problem (the additional producer surplus during the duration of the patent and the consumer surplus gain subsequently). Results (not surprisingly) proved to be highly sensitive to model parameters including the social discount rate and the assumptions about the relationships between R&D and innovation. Overall, optimal patent life is found to be negatively related to the significance (e.g., cost saving potential) of the invention when demand is relatively elastic. The duration analysis, of course, assumes patent scope ('breadth') is constant, for the two are imperfect substitutes.

The (again unsurprising) conclusion is that fixed term patents are non-optimal. That, though, is not a very useful result for several reasons. Patent scope is dynamic, tending to be broader for new technologies (biotechnology) and narrower for mature ones (pipe fittings), yet institutionalizing those differences presents conceptual and practical problems, not the least of which would be definitional. Institutionally, the GATT/WTO has recently succeeded in an harmonization effort for 20 year (from date of application) patent terms as a simple means of securing comparable protection availability worldwide. Variable terms are not in the cards.

Most significantly, the pertinent question today is not the statutory limit but the optimal renewal fee structure. Essentially all countries now have a fee structure for maintaining patents, and many of those fees rise rapidly over time to encourage the abandonment of non-profit making patents. Current U.S. fees are modest ($6,150 over the life of a patent) at least compared to the DM 10,000 for Germany in the 1960s when Scherer (1980, Chap. 16) notes less than five percent remained in force for the full duration permitted under the law. Schankerman (1991, Table 4) did use patent renewal data to estimate the worldwide value of patents in key sectors. His findings were for low median values - $1,594 for chemicals (in 1980 US $) but a very skewed distribution - the top one percent accounts for 15 percent of total value.

The best assessment of patent scope I am aware of has been done by lawyers, not economists. Merges and Nelson (1990) for example distinguish between regular and pioneering inventions, noting that the scope granted pioneering patents allowed greater financial rewards than needed to bring forth the invention. Moreover, broad patents discourage improvements. Breadth and newness are institutionally related, for patent examiners under many national systems must show cause (e.g., cite literature) to disallow broad claims. This has been an issue in agriculture with patents granted for means of transforming cotton and soybeans, meaning any transformation process is covered (Barton, 1997, Chart 1). While such system attributes are costly (the most infamous was for the Seldon auto patent covering the basic engine/clutch/transmission layout), they are at least self correcting as the literature expands, and more immediately so with internal reexamination and (in the USA) Supreme Court appeals.

C. Static Allocative Efficiency

Are producers getting value for their money or are critics correct that reduced competition, both due to IPR and to mergers in the seed industries, results in rents being paid to breeding companies? Butler and Marion (1985, pp. 61-62) surveyed public and private breeders for their opinions on price effects, finding "slight to substantial increases". But on the more relevant question if the increases were justified they concluded, " . . . if anything, the opposite is true -- that is, farmers are willing to pay a premium that is much lower than is justified." Knudson and Hansen's (1991) work, which considered farmers-purchased vs. bin-run winter wheat seed source decisions, would concur with that. Using data from the Cropping Practices Survey in linear yield models, they found two significant results indicating yield losses associated with saved seed of 3.5 and 6.1 bu/acre. The results, though, were not consistent for all regions and periods examined which, in addition to the specific explanations given, is perhaps not surprising given the annual vicissitudes of yields. In any event, farmers do not seem disposed to overpay for seed.

More formally, I (Lesser, 1994) used a hedonic pricing model to examine the marginal price associated with PBR certificates for soybeans in New York State. Netting out yield differences and other quantified factors in the varietal trials, certification contributed only a (statistically-significant) 2.3 percent to price. My state certainly is not a major soybean producing area so this analysis should be replicated elsewhere, but it does support my earlier (Lesser, 1987a) conclusion that U.S. PBR certified varieties are very similar so the monopoly rent extractable is small. Indeed, if anything, the early investment may have been over optimistic[12], but that may change under the recent version with its 'dependency' clause (see II.A above). The analysis should also be replicated in Europe, where quantified varietal testing is conducted by the national offices (see Lesser, 1987b for a description of those activities) and Canada where the applicant must conduct supervised growouts.

One of the component reasons monopoly rents are low is because of the reduced appropriability due to farmer saved seed competition. Hansen and Knudson (1996) in an intriguing analysis considered this situation for soybeans. Using a regional yield model and likelihood test to contrast the constrained (saved seed and grain value are equal) and unconstrained models, they conclude there is indirect appropriation by seed companies. In simple terms that means firms are able to charge a price which reflects future as well as current season seed value. (Soybean growers on average return to the market for new seed every third to fourth season.) While that conclusion seems appropriate and well justified, their conclusions may go beyond the statistical results, "bin-run seed can exist without decreasing incentives for varietal development." That is, the results indicate some indirect appropriation, but not necessarily complete appropriation. This point is not intended to favor restricting farmer saved seed use, but more as a caution on what we know of profitability.

If farmer saved seed is not providing significant competition to private varieties, then the role of the public sector in producing commercial materials becomes particularly critical. For both the U.S. (Butler and Marion, 1985) and Canada (Loyns and Begleiter, undated) strong arguments are

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[12] Some companies including Stine Seed Company have not been pursuing PBR in favor of sales agreements. At typical agreement would read in part, "Purchaser hereby acknowledges that the production from the Stine Brand Seeds herein sold . . . will not be used or sold for seed, breeding, or any variety improvement purposes."

made for the maintenance of major public breeding programs. This is particularly timely for concerns have been expressed that the existence of PBR would, alternatively, shift the public breeding focus to more basis research or lead researchers to protect varieties as a potential income source, which would facilitate a reduction in public support (see Butler and Marion, 1985). Knudson and Pray (1991) looked at the impacts of PBR on U.S. public sector funding using a model including social benefits, use of PBR by the public sector, and industry support with private investments. Estimated societal benefits were found to be positive and significant, but PBR were positive and significant only under some specifications, leading to the conclusion, "There is some support for the argument that the new opportunities for income provided by the PVPA have influenced the direction of public research [toward the major commercial crops]." Emphasis here should be on *some support* for the analysis does not consider the change in the commercial importance of alternative crops nor does it assess total funding, but overall the results are as expected.

D. Dynamic Allocative Efficiency

Dynamic allocative efficiency in this context refers to the degree of technological advancement of an economy. It is often measured in empirical analysis using R&D personnel or investments (inputs), or patent numbers (outputs), which is the connection here. Technological competency is of great interest nationally and is tracked regularly by the U.S. Department of Commerce.

Scherer (1984, Chap. 9) identifies two principal difficulties with patents as a measure of technological status as (a) propensity to patent varies across industries and (b) the quality or importance of patents varies greatly. The latter matter is exacerbated in cross-national analyses where patent scope can vary dramatically. Japan until a fairly recent change operated on a single-claim-per-patent system (claims describe what the invention is) so that direct comparisons were meaningless. Even now there is a tendency there to apply for more patents for the same level of innovation than in North America.

That said, in the area of biotech applications to plants and animals, the U.S. is a clear enough leader that no analysis is needed, at least to this historical point (see James and Krattiger, 1996). Moreover, *consideration must be* given *to* the uncertain patent scope in Europe (see Section II above) plus Luxembourg has banned production and sale of genetically modified corn while Italy has prohibited its sale. The Swiss next year will vote on a constitutional amendment banning nearly all genetic modifications of plants and animals[13] (NABC, 1997).

E. Anti-trust Theory

Industrial organization economics is associated with IPR in two respects, (a) misuse of patents rights, and (b) effects of IPR on industry structure.

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[13]Ciba has long done all its genetic modification research across the border in France.

Patent misuse has been found in the U.S. under both the Sherman and Clayton Acts. Violations typically involve the use of a patented object as a tying good, or a conspiracy to 'pool' patents from multiple owners so as to create a monopoly, or to limit the pricing discretion of licensees. Overall, while the basis for market power, the patent, is different from other antitrust violations, the misuse of that power breaks no new legal or economic ground (although the technical questions can be complex). Applications to plants and animals, and to PBR, have, to my knowledge, not occurred, but are possible as straightforward extensions.

A far less well understood area is the effects of anti trust-type restrictions placed in the patent laws of many countries. The Indonesian Patent Law (Law # 6 of 1989, Article 78, as amended) for example prohibits license agreements "to contain provisions which may directly or indirectly give rise to effects which damage the Indonesian economy . . ." Enforcement is through the registration of licensing agreements with the Patent Office. Of particular concern has been the use of a patent as a tying good (see detailed, if dated, discussion in Roffe, 1974). Little presently is known about the application (and possible misuse) of this governmental authority in countries lacking other effective anti-trust laws.

A second form of relief from the effects of patent monopolies is that of compulsory licenses, a compulsory license being the granting of authority to utilize a patent without the permission of the owner or licensee. TRIPs (Article 31) allows compulsory licenses for supplying the domestic market and for allowing the working of dependent patents, conditional on "adequate remuneration" and judicial review. Canadian law (P-4, Section 64-65) allows compulsory licenses for lack of working within three years and "if the demand [] is not being met", but U.S. law (35 U.S.C. Section 181) provides only for maintaining national security. The Brazilian Patent Act (No. 9,279, 1996, Section III) is typical of laws in developing countries, allowing licenses for the "abuse [of] economic power" such as through not-working without good cause for one year.

These conditions for allowing compulsory licenses are essentially economic questions, but Reichman (1993, pp. 204-10) notes that what constitutes abuse is a source of considerable controversy, frequently being confused with 'public interest' and 'anti-competitive practices'. In the final analysis, compulsory licenses are rarely granted, but if that is due to an absence of need (possibly associated with the deterrent effect of an available resource) or political pressure or the cost and complexity of establishing a case is not well understood. This is an area in rich need of further economic analysis.

The second thrust of economic analysis associated with anti-trust has to do with the effects of IPR (or more generally R&D) on industry structure. This is an area of some theoretical assessment by Schumpeter and Galbraith and substantial (if not particularly current) empirical analysis (good reviews in Kamien and Schwartz, 1982; Scherer, 1984).

Structural issues regarding patenting revolve around the question of whether large firms have an inherent advantage over smaller ones (e.g., capital formation, spreading risk over several projects, attracting the most talented researchers with higher salaries, and size economies in research). Economists have evaluated these issues with no conclusive results. Theoretically, a strong case can be made for and against a large firm bias. Empirically, the results are middling. However, the results vary greatly by industry so that they say little about individual sectors.

Concerns have been expressed about the concentration of grants of PBR certificates in the U.S., but (see Section III.C. above) those concerns have not been associated with excessive prices, possibly because seeds are a productive input sold on merit. The production of genetically engineered organisms is still too recent for empirical analysis of structure/performance issues. But I believe we are already seeing a different structure emerging of, in part, biotech innovation by smaller firms and universities, with product development by larger ones, much along the lines of the 'boutique' pharmaceutical industry. Agbiotech, at least at this stage, is a costly and risky process, Monsanto having invested hundreds of millions before finally getting some return during just the last few seasons. Yet the economic value of those products and their durability, biologically and competitively, remains unknown at this stage. There is a distinct likelihood that agrotech product markets will be dominated by a few firms which risks monopoly rents. Already there are signs that rBST is overpriced for the returns it provides (Tauer and Knoblauch, 1997). The fundamental question here is if farmers are treating agbiotech products similar to seeds and other traditional inputs, or if suppliers are extracting proportionally greater rents. Cost of production studies would be a place to begin the assessment.

Barton (1997) (a lawyer) is somewhat less cautious in this regard than are we economists. He (1997, Chart III) points to the large number of recent mergers in agbiotech, raising the spectra of monopoly. Of particular concern is the concentrated holdings of patents by firms which may restrict entry by "not offer[ing licenses] on reasonable terms to other firms." This is a particular issue with agbiotech because a single product will often involve five or six patents, the gene vector itself, promotor(s), transformation vectors, and claims from the 'gene gun', if employed. Larger firms cross license patents among themselves, but small/new entities lacking a patent portfolio would be excluded. Canadians could, if the situation warranted, issue compulsory licenses, but the U.S. lacks such broad statutes, and antitrust laws can require licensing on fair and nondiscrimatory terms, falling far short of mandatory licensing. Thus, for the U.S., merger limitations would be a first line of defense, although the 'failing firm' exemption would seem to apply in the Calgene/Monsanto merger, while others have involved swaps among the giants. In short, the climate does not seem ready for major antimerger actions.

As economists we must consider whether such actions would be warranted, that is, what is the nature of competition in these new product markets. Clearly, Monsanto dominates them with Round-up Ready beans and *Bt*-producing cotton, potatoes and corn, plus the FlavrSavr tomato (temporarily withdrawn). The *Bt* crops are, from an economic perspective, cost reducing by reducing pesticide use, so that there is a clear ceiling on their value. The Round-up products are tying goods as the herbicide patents expire; indeed, users must sign agreements to purchase the Monsanto product and not a generic. But to the farmer whether Monsanto takes the profit as herbicide or seed sales is immaterial; what is important is the value of the additional weed control afforded. While recognizing that a ceiling to rent payments is not the same as no market power, the current situation with first generation products is, in my judgment, not yet critical. Some of these products are already showing weaknesses - *Bt* cotton for example did not produce sufficient toxins under some dry conditions to prevent severe damage - so that it is with succeeding generations of the technology we must focus our attention.

Important issues include the possibility that firms are conspiring to use patents to limit entry as opposed to the startup issues of identifying appropriate licensing terms for multiple technologies in single final products. If the former then antitrust action is needed, if the latter some forum to help the industry move more rapidly to a standard base agreement for license terms. I also see a special role for university licensing here. Universities are led for financial reasons to exclusive licenses, but that can exacerbate the concentration problem. This is something our licensing officers should take into consideration.

F. Trade Theory

IPR is rather loosely associated with trade as a form of non-tariff barrier (Stern, 1987); many products and services, the argument goes, cannot be traded with or produced in countries where piracy is not controllable through intellectual property protection so that their absence serves as a hindrance - a non-tariff barrier. That said, the concept and especially the political economic force behind it, the U.S.A., was sufficiently convincing to have IPR incorporated within the GATT/WTO (see Section II above). Indeed, the principal international focus of IPR has shifted from the World Intellectual Property Organization, a UN agency, to the WTO.

Strictly speaking, the application of IPR to trade theory is incomplete, for uncontrolled piracy acts in ambiguous ways with foreign direct investment (FDI). IPR legislation may enhance trade through FDI by, for example, allowing the concentration of production in a few countries (as the production of world car parts are now centralized and exported for final auto assembly) or, conversely, by substituting local production for imports (for say pharmaceutical products in India). These matters will not be fully resolved until an integrating theory for trade and FDI is developed and international investment is regulated by the equality of treatment standards of the WTO (expected in the next round).

From a different perspective, IPR will enhance the market power of the owner, leading to higher prices which reduce trade. Conversely, by inhibiting local imitation, trade may be increased. These diverse effects have implications for social welfare which are country-specific as determined by national production and R&D capacity and investment. That diversity of influences will not be sorted out for some time, but for the present there are a few industry-wide empirical studies giving general insights into effects (studies admirably reviewed by Primo Braga, 1995, references therein). Relevant studies' findings include:

1. Intra-firm trade is greater to countries with weak IPR as a means of protecting proprietary information.
2. Non-firm-specific trade is increased as IPR protection is stronger (the market-expansion effect dominates the market-power ones).
3. Countries with strong patent regimes import proportionally more.
4. U.S. FDI flows increase with respect to the perceived strength of the IPR regime.
5. For all manufacturing, IPRs have a positive effect on U.S. investment abroad, but the sectoral studies are less robust.
6. Contributions of IPRs to economic growth increases with the openness of the economy.

From these results, Primo Braga (1995) concludes that "TRIPs will have a net trade creating impact" and there will be "more North-South transference of technology", but the analysis is "model specific and should be interpreted with care." Among the model specifications which must be considered with care is the method of indexing the 'strength' of national IPR legislation. Results from PBR in Argentina (see Section III.A.) indicated strongly that effectiveness depends critically on enforcement, which is difficult to assess in a general way. More work is needed in that area.

Protected plants and animals would fall in the 'sensitive to IPR' category along with the commonly evaluated chemicals and pharmaceuticals. Hence, although the reported results do not apply directly to plants and animals, the general expectation is for increased investment and trade of technology (but not products due to the need for local adaptation) among countries which allow relevant protection (see above). While PBR are coming into place, patents for plants and animals will be very limited in many countries for the foreseeable future, and patentability for gene constructs remains uncertain. Thus the situation should not be expected to change greatly under TRIPs. More relevant in my view is the need to demonstrate that broad IPR has positive economic benefits in these areas. Complicating the analysis is the characteristic of these products where imitation (e.g., piracy) can occur independently of technology transfer. Fundamental are questions of how transfer is added with easily accessible and imitated products and what substitutes (including FDI) exist. Overall, trade theory does not apply well to such products.

Some of the existing studies cloud rather than illuminate the issues; Rapp and Rozek's (1990) work is more along the lines of economic propaganda than serious analysis. They for example assess the role of IPR in economic development by regressing measures of development (per capita GDP, prop. homes with electricity, etc.) on an index of effective IPR protection, concluding, "Modern economic growth requires property rights [ ]. And without such protection, development is thwarted." Clearly that applies at some stage of economic growth, but in which direction does the causality flow? Noting that Japan did not protect pharmaceutical products until 1976 emphasizes that point. Free riding indeed does pay under some circumstances and with IPR we do not know exactly what those circumstances are.

Rapp and Rozek continue to note (1990, p. 19), "Pharmaceutical R&D is conducted in those countries where intellectual property is protected." The Canadian experience shows that IPR is neither necessary nor sufficient. Their (1990, Table 6) data show U.S. pharmaceutical firm R&D investment there prior to the adoption of patent protection in 1987 while Canadians were sufficiently concerned about the future the government negotiated a 10 percent R&D transfer with the major firms in exchange for the adoption of pharmaceutical product protection. Rapp and Rozek's (1990, p. 17) statement that the absence of pharmaceutical IPR leads to "fewer new pharmaceutical products, reduced future growth of the domestic industry and, most importantly, poorer health for the country's residents" demonstrates no recognition of the opportunities to establish a generic industry based on "pirated" products, as India has long done, nor any acknowledgment that some three quarters of the world's peoples are said to rely entirely on natural products with no contact with modern pharmaceuticals, largely for financial reasons. The benefits of IPR are not so easily established as Rapp and Rozek (1990) purport.

IV. CONCLUSIONS

IPR, while traceable in its economic policy roots back more than half a millennium, relates to a sphere of human activity, creativity, little understood. Nevertheless, many aspects of IPR are appropriate for economic analysis, yet even our understanding of those components is incomplete. For agriculture where extensions to living plants and animals has been far more recent, the dearth of knowledge is particularly evident. Until recently no empirical basis for analysis of those products existed, but that is changing rapidly. This paper is a call for agricultural economists to become more involved in assessing those issues from academic and policy perspectives. IPR is currently expanding rapidly on a worldwide basis, due largely to commitments made in the last GATT round, as its use is increasing, in part as the public sector continues to withdraw from research funding, including agriculture. Together these mean there is a narrowing window of opportunity to identify and apply directive or corrective actions, as needs warrant.

Given the importance of the issue, there is surprisingly limited analysis of the effects of IPR on R&D investment. More is clearly warranted but, that said, what exists supports the expectations that protection encourages private investment in developed economies, particularly for easily copied products like living plants and animals. The matter is, to my mind, less well documented for developing economies where access seems a more significant issue than investment. The role of IPR in access, particularly the strategies of private firms, is incompletely documented and analyzed. We also know relatively little about seed selection behavior in the current environment where the market for many crops is dominated by private varieties. Evidence points to small monopoly rents in the USA, but there the scope of protection is quite narrow. Studies are urgently needed in Canada and Europe where protection scope is broader. Finally, let me endorse the *ex anti* analysis which has been done; while often unsystematic analytically, I find the predictive capacity to be quite good. The next challenge is projecting the implication of the 1991 UPOV Act with its designation of dependent/initial varieties. That is a complex but important matter, one which (unusual for IPR) allows a marginal contributor to gain some property rights over composite material not developed by them. A student recently (Faucher, 1994) attempted an innovative application of game theory to this question, but a tractable model was insufficiently robust to give deep insights into real world issues. I also have not found attempts to identify an optimal IPR system to be of much practical use.

PBR rents have been analyzed from multiple perspectives, including surveys, hedonic pricing and appropriability. That work needs replication across crops and locations to confirm the available tentative results of no excess margins. While the analysis of IPR effects on R&D is complex, the matter of product quality can be readily analyzed using public performance reports. This needs replication as well. More complex conceptually and analytically is the matter of bioengineered plants, which have become widely available within only the past two seasons, but are spreading rapidly. Very preliminary reports suggest greater margins are asked, and received, than has been true for seeds. Focused studies of that market, including understandings of purchasing behavior, are needed now. Of particular relevance is the near monopoly position of a few major firms, led by Monsanto. If there are entry barriers, they would be control of patents of multiple-application technologies like promotors and transformation vectors. Investigating that issue would involve a combination of science, economics and law. For countries with broad compulsory licensing conditions, and especially those lacking other antitrust statues, their effectiveness for restraining monopoly urgently requires economic analysis. What does not seem to need to be analyzed is the relative progressiveness of national research programs; the U.S. is clearly the leader in ag biotech worldwide, and is likely to remain so compared to the EU and Japan where regulations and public acceptance are less supportive.

Looking beyond North America and, more broadly, the OECD countries, very little hard information exists on the benefits of IPR to developing countries, particularly those at a second tier of industrial development behind Brazil, India and Indonesia, among others. It is clear that IPR is most economically beneficial at a certain level of development, that free riding does pay off to some point, but what is that level? Additionally, what is the real effect of IPR on access to inventions which do not need to be traded to be copied? These are highly relevant matters for countries now in the process of complying with the GATT/TRIPs requirements for enhancing IPR, but economics has little specific guidance to provide. In the absence of a more formal methodology perhaps something akin to Gardiner Mean's industry studies would be useful in providing insights to what has happened in the past and how firms develop IPR and technology transfer strategies.

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