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THE ECONOMIC VALUE OF PATENTS, LICENSES, AND PLANT VARIETY PROTECTION

by

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Abstract

While biotechnology creates new opportunities for agriculture, developments are impeded by confusion in the system for awarding intellectual property rights (IPRs) over agro-biotechnological innovations. An intelligent redesign of the IPR system requires attention to how the definition of rights interacts with the market environment, generating incentives to create value. A distinction is drawn between cost-reducing innovations that increase the efficiency of producing homogeneous outputs and value-adding innovations that create entirely new types of differentiated outputs. A reform is proposed that would require the mandatory sublicensing of genes and certain core enabling technologies for creating genetically altered organisms.

Keywords: agriculture, biotechnology, intellectual property, market structure.

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1. THE OPPORTUNITIES AND CHALLENGES CREATED BY BIOTECHNOLOGY

Despite the passions and efforts of the Jeremy Rifkins of the world, biotechnology is here to stay. Its appearance creates a whole new universe of opportunities for agriculture, opportunities to increase the efficiency and productivity of farming, opportunities to create entirely new forms of niche products, opportunities to better manage risks, and opportunities to mitigate the adverse environmental impacts of agricultural production. We could spend the entire conference structuring these opportunities, but instead let's identify just a few examples.

Crop research is generating plants that grow better, that achieve higher yields, and that are more tolerant to poor conditions. Examples include corn that makes its own pesticides, and herbicide-tolerant crops, such as the Roundup® Ready varieties of soybeans, cotton, and other crops that are appearing on the market this year. In addition, biotechnology is creating foods that deliver superior quality characteristics to processors and consumers: slow-ripening tomatoes, sweeter berries, corn that produces more oil than standard varieties. Biotechnology is also aiding in the development of new biological controls, including biopesticides and natural predators, that increasingly emerge as alternatives to chemical pest control methods. Other crops are in the pipeline that can help improve environmental quality. One example is a high-phytase variety of corn being developed by Pioneer that, when incorporated into livestock feed, will reduce the eutrophying effects of animal wastes.

These opportunities challenge us to design new institutions that maximize the social advantages that they generate. Among the challenges, one of the most important is how to design our systems of intellectual property rights to address the issues raised by genetic engineering. The challenge for economics and public policy researchers is to design IPRs (intellectual property rights) intelligently, so that they align private incentives with the social good.

In designing such a system, we emphasize three themes. First, the fundamental question is not one of valuation, but of incentives. Although our title refers to the economic value of intellectual property, we do not focus on valuation techniques. Valuation is a straightforward matter, once a right is defined and the market environment in which it operates is understood. The real question is, how does the definition of rights interact with the market environment, generating incentives to create value? Second, we show how certain subtle economic distinctions can hold important implications for the appropriate design of an IPR regime. Finally, we present what we argue is the correct design for an intellectual property rights system covering genetic materials and genetically altered organisms.

2. AN ECONOMIC APPROACH TO ANALYZING INTELLECTUAL PROPERTY RIGHTS

2.1 The Current System

To set the scene, let us review very quickly the current system of intellectual property rights over genetic materials and genetically engineered crop varieties.

Figure 1 represents the research and development (R&D) process for agricultural biotechnology.[1] It shows the development of a new crop variety, starting from a search through an available stock of biological materials, to find germplasm that expresses preferred characteristics, followed by the identification and isolation of the genetic materials that code for those characteristics. These can be transferred into any of a large number of crop varieties

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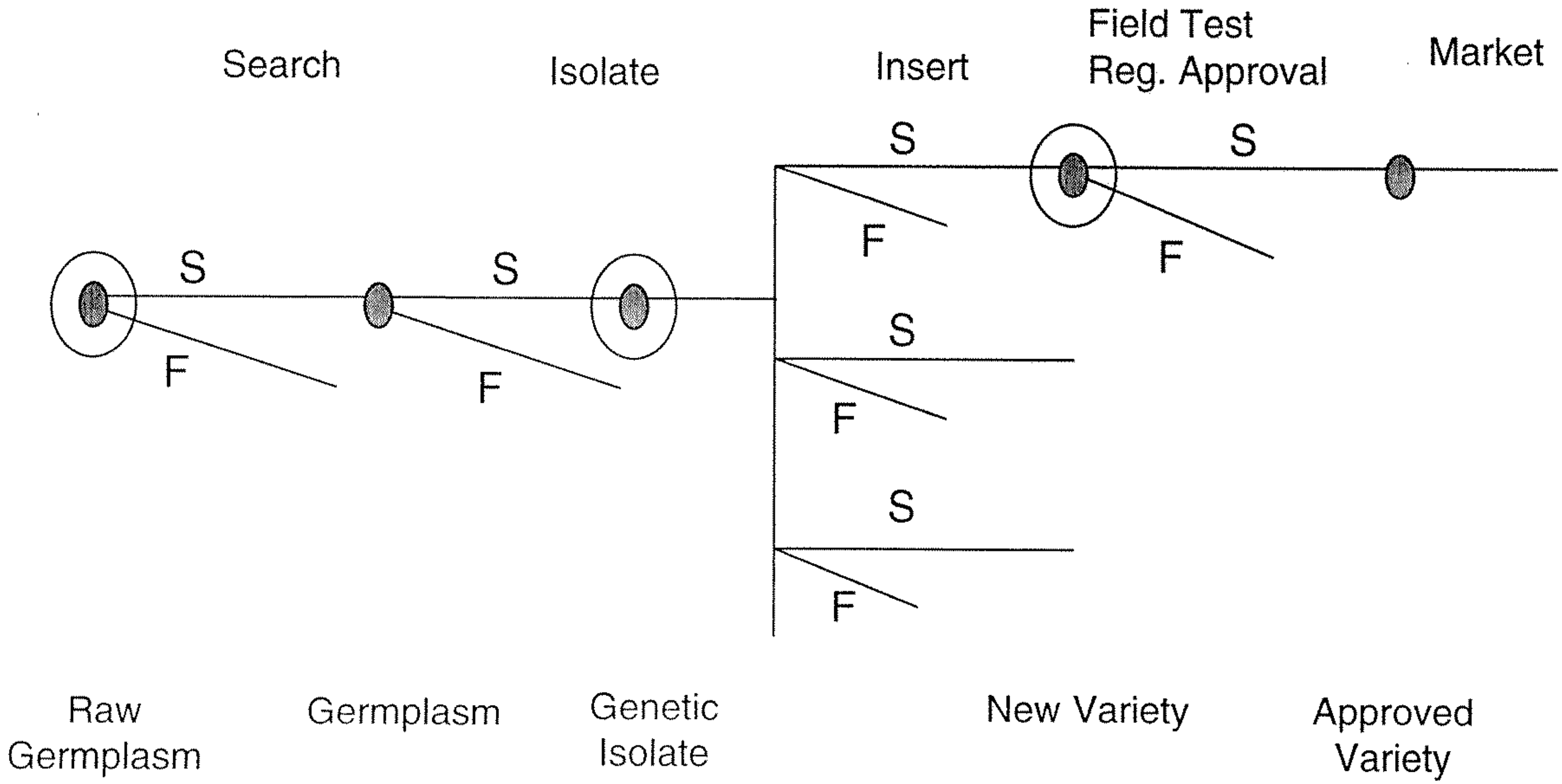
[1] This description of the biotechnology R&D process as a multi-stage lottery is based on Artuso (1994) [1].

The Ag. Biotech R&D Process as a Multi-Stage Lottery



which, after field testing and subject to regulatory approval, can be brought to market as new, finished technologies.

Intellectual property rights considerations can impact on this process at several points. Material transfer agreements covering germplasm access can restrict and complicate the opportunities available to biological researchers to carry out an effective R&D program. A researcher who successfully isolates genetic code of an identified function can, in some cases, anticipate receiving a utility patent on that gene itself, on the gene *per se*. And, of course, the finished variety can be protected by a plant patent, plant variety protection certificate, or other form of plant breeders' right [3], [8], [7]. In addition, patents can apply to the enabling technologies that allow the whole process to move forward.

However, the current system is evolving continually, with court decisions and international treaties sharpening the definition of existing rights and creating entirely new forms. For example, just a few years ago, the Uruguay Round of the GATT led to an agreement that imposed a new requirement on many developing countries to recognize plant breeders' rights when they had not before. (See also the recent *Imazio* decision over the definition of plant patents [5].)

There is reason to suspect that change is desirable, that our current system can be more effective. There is confusion and uncertainty over how patent claims will be treated by the courts and by the patent office. Many researchers are unsatisfied with what they perceive to be onerous restrictions on their ability to carry out their development programs [4]. Furthermore, the system creates, in come cases, perverse incentives for developers to expend resources creating and patenting new technologies solely to assure that they never come to market. As a consequence of such shortcomings, we should expect continued public discussion about what property rights system we want. We should expect that the system under which we will be operating in 20 years will have changed from what we have now in ways that affect the incentives and outcomes of R&D.

2.2 How to Approach the Reform Process

Now, let us step back and ask the big-picture question: How should the IPR regime be designed?

First, we should be willing to think outside the box imposed by the current system of laws, particularly the constraints imposed by the utility patent statues. We should be willing to imagine that an entirely new property rights regime could be developed that is tailored to the needs of genetic R&D, a system that would operate in parallel with our systems of patents, copyrights, and other forms of intellectual property protection.

As we design a new system, we should resist the urge to offer one another easy answers based on glib distinctions such as between "natural" versus "artificial" crop varieties, between big bad multinational firms versus wholesome mom-&-pop outfits, or between the technology-rich North versus the technology-poor but gene-rich developing countries of the South. Instead, we must focus on the first principles.

So rather than just provide the "answers" to the dimensions of an IPR regime, let's walk you through how economists approach the question. To an economist, an intellectual property rights regime is an *incentive system*. It rewards a socially desirable activity—the development of new goods—by allowing a socially undesirable activity—the limited exercise of monopoly power over the goods so created. The fundamental question an IPR regime must address is how to balance this incentive effect *ex ante*, before the research program is undertaken, against the problems associated with anti-competitive behavior *ex post*, once the new technology is on the market. This point is important, so it bears repeating: *The fundamental problem that an IPR system must address is how to balance the benefits of strong incentives ex ante, against the social costs of monopoly power ex post.*

To answer this question, we need to do two things. We need first to define what we mean by the (public) good, so as to specify up front which outcomes we prefer. Are we trying to maximize the rate of innovation? Do we want cheaper food? Higher quality food? To what extent do we care about how the rewards of the innovation process are distributed to the various players? In order to chart a course, we must first have clearly in mind our desired destination.

Second, we need to develop frameworks that allow us to analyze and compare the effects of alternative proposals—in particular, the economic effects on rates of innovation and wealth generation. These relationships are not obvious. The cost structure of the R&D process affects the number and size of firms in the innovation industry[2]. Legal constraints impact the freedom that firms have to strike mutually advantageous contracts. And the amount and kind of research being conducted by the public sector has a large influence on the direction and profitability of private sector innovation. Sorting through this complex web of relations, to identify the effects of alternative IPR regimes on research incentives and social welfare, requires careful economic analysis.

3. COST-REDUCING VERSUS VALUE-ADDING INNOVATION

To clarify this point, consider an extended example that demonstrates how valuation of intellectual property is conditioned on the form of rights and on the effective strength of the monopoly power they provide. It shows how it is not possible to discuss intellectual property valuation without recognizing how technology ownership confers market power.

Let us make a distinction between two classes of innovation. Recall the list of innovations mentioned earlier. Some of these, such as pest-resistant crop varieties, are going to have the effect of reducing the cost or the risk of producing standard, homogeneous commodity outputs. Other innovations, such as Calgene's Flavr Savr® tomato, create new kinds of differentiated products that delivers specified quality characteristics, for which some segment of the consumer

[2]Coakley (1992) [2] argues that the advent of biotechnology has encouraged a consolidation of the seed corn industry.

market is willing to pay a premium price. We argue that the economics of these two classes of innovation are quite different, and imply different strategies for generating high returns.

Farmers will treat cost-reducing innovations as alternatives to their existing systems for controlling pests and, more generally, for managing risks and lowering costs. Insofar as these innovation substitute for one another, they will enter the market in competition with one another and with the systems that provides these services currently. Three implications follow.

First, because it is safer to enter an existing market than to develop an entirely new one, it should not surprise us that the lion's share of the development that has gone forward to date has been focused on innovations of this type. Second, insofar as these systems are substitutes for one another, the margins that any one can command is limited. Since the entire fixed cost of the R&D program has to be recovered from those premium prices, there is a strong logic to focusing efforts on the major crops—corn, soybean, and others that are planted on a very large acreage, and therefore can provide a large revenue base. Third, there are incentives for firms to try to prevent price competition by controlling, not just one or a few, but as many of these technologies as possible. We should, therefore, expect that these technologies will be delivered by a decreasing number of large firms and that there will emerge entities that attempt to monopolize the market for innovation as a means to keep returns high. Indeed, Department of Justice antitrust guidelines encourage enforcement officials to recognize that there is this potential for monopolization in the market for innovation.

Now, let us consider the other class of innovation—what we call the value-adding technologies. For these we have a different story. These innovations create new products that are differentiated from standard crop commodities, and the premium that a developer can command for these varieties will be determined, not so much by competition between these varieties, but by the willingness of some segment of the consumer market to pay a premium for the targeted delivery of these preferred quality characteristics.

We should not find it surprising that, in the short run, we see less innovation of this value-adding type than of the cost-reducing type, because creating a new market is risky. Will consumers buy? How much extra will they be willing to pay? These are things we can estimate before product introduction, but it is hard to know for sure until you take the plunge. Because creating a new market is riskier than entering an existing one, fewer of these opportunities are going to be pursued in the short run.

There are, however, large potential opportunities in the long run. Table 1 presents some numbers that illustrate this point. Here we have taken a few crops that are important to California agriculture but are not the major commodities traded on international markets —things such as lettuce, walnuts, and pistachios. We pose the question, how much money could an innovating firm expect to make from a project that adds value by creating an improved version of one of these crops? We go through a calculation in which we assume that the area planted to each crop in California stays fixed, but half of the acres are planted in this new, differentiated variety. We then compute how much extra wealth would be created if the consuming public would be willing to pay a premium price of various amounts.

Let us pick out just one example. Suppose a new kind of lettuce were developed that would, say, wilt more slowly and which could, therefore, command a 30 percent premium price at the farm gate. If this variety were planted on half the acres in California, lettuce farmers would take in an additional $100 million in revenue per year, a surplus to be divided between the farmers and the biotechnology firm. If half, or even a quarter, of that amount were returned to the developer, that could pay for an R&D program with a very nice return. Returns would, of course, grow even higher as the variety was sold in national and international markets. We should expect, in the coming years, much more effort targeted to these "lesser" crops, in ways that add value by developing new niche products.

A third feature of these value-adding innovations is that there is less incentive, in comparison with those in the cost-reducing class, for any one firm to try to command the entire waterfront, to try to control all of these technologies. These innovations will not compete with each other in a market of fixed size. Rather, each innovation will be rewarded depending on how much value it adds to some market segment. There will be less logic spurring attempts to

Table 1. Introduction of High-Value Varieties: Potential Revenue Effects for California

Crop	Average for 1990-1994: Average acres[a]	Yield per acre	Unit Price ($)	Revenues ($M)	Revenue increase[b] ($M) on price premium of 10%	20%	30%	100%
Grapes, wine	301,000	7.4 tons	357	799	40	80	120	399
Almonds	404,400	1,444 lbs	1.32	772	39	77	116	386
Lettuce, head	146,140	348 cwt.	14	690	34	69	103	345
Strawberries	22,860	487 cwt.	45	499	25	50	75	249
Walnuts	177,400	1.3 tons	1,186	280	14	28	42	140
Tomatoes, fresh	37,600	263 cwt	28	274	14	27	41	137
Broccoli	94,000	111 cwt	24	255	13	25	38	127
Tomatoes, processed	289,400	12.4 tons	51	182	9	18	27	91
Garlic[c]	26,000	165 cwt	34	144	7	14	22	72
Pistachios	54,760	2,272 lbs	1.06	132	7	13	20	66

[a]For wine grapes and nuts, includes only bearing acres.

[b]Assumes one half of acres planted in the high value variety, total acreage unchanged.

[c]Figures are averages for 1992-1994

Source: California Agricultural Statistics 1994, California Department of Food and Agriculture monopolize the market for innovations of these kinds. We should expect to see, not a few large firms trying to control this market, but rather a diversity of firms, of different sizes, some perhaps highly specialized.

This distinction, between cost-reducing versus value-adding innovation, is enlightening both in itself and as an example of the kinds of considerations that feed into an analysis of an intellectual property rights regime for agricultural biotechnology.

4. A DESIGN FOR A NEW REGIME

Now we want to present what we claim is the correct approach to the design of an appropriate incentive system. We present preliminary results from a research program we are carrying out at the University of California in the College of Natural Resources [6]. This research explores the relationship between IPR strength, R&D incentives, and social welfare in a model tailored to the agricultural biotechnology industry.

What do we want in an IPR system for genetic innovation? We assert that it should do two things. First, it should link closely the rewards the system provides to the value that researchers add, so as to generate the "correct" alignment of incentives that encourage research. Second, it should minimize possibilities for monopolization of the innovation process itself that could block the development and dissemination of useful technologies.

The correct approach would keep plant breeders' rights, over single varieties, much as they are now. It would also allow property rights over genes *per se*, and over the core enabling technologies, but with a mandatory licensing provision, so that all developers would be able to gain access to genes, germplasm, and the fundamental enabling technologies. A default licensing contract would be specified for cases in which the parties could not negotiate a preferred alternative. The form of this default contract would, in effect, set a price ceiling on the license fee. The government, by the way it fixes that ceiling, could alter the way that the rewards of the research process are allocated to the various parties that make it possible. There could also apply, either a research exemption or mandatory licensing to researchers on very relaxed terms.

There are, of course, questions about how such a system would work, details to be worked out. But we would like to highlight two ways in which it would, for public-sector researchers particularly, improve on the present system of utility patents.

One problem with patents is that they are all-or-nothing instruments. You either get the monopoly right, or you get nothing. Such a system fails to reward adequately the role of public-sector basic research in creating value. Right now, as you know, an all-too-common story is that a university research program makes a fundamental breakthrough that allows the development of a range of new crop varieties, after which private firms move in and "patent around" that breakthrough, securing claims on the lucrative technologies it makes possible. The private sector gets the feast, while the university gets the table scraps. This is a big reason why public-sector agricultural research—which has been shown in study after study to yield returns on investment of 20 percent, 50, even 90 percent—still struggles for funding. A system with mandatory licensing would make possible appropriate rewards to those who add value through basic research.

Second, a system with mandatory licensing assures public-sector researchers of access to the genes and technologies they need to carry forward their research programs, and provides an orderly, predictable scheme to handle technologies over which they themselves might wish to assert claims. The losers would be those who wish to monopolize the innovation process and keep technologies off the market, and those who currently reap windfall profits by "patenting around" the breakthroughs generated in public-sector research.

5. CONCLUSION

What we want you to take away is not just this idea for a mandatory licensing scheme, nor just this distinction between cost-reducing versus value-adding innovations. What we have tried to convey is an appreciation for the kinds of economic questions we should be thinking about as we formulate proposals for reforming our IPR system. We have to trace out carefully the way that an IPR system creates incentives for innovation, and how those incentives interact with the complex web of economic relationships that characterize modern agriculture.

This analysis requires hard work. We should resist the temptation to shirk, retreating to the comfort of easy answers. The payoff, the creation of an incentive system that unlocks the expansive opportunities presented by biotechnology, more than justifies our effort.

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