# Transitions in Agbiotech: Economics of Strategy and Policy

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EDITED BY
William H. Lesser

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PART SIX: Public/Private Sector Relationships

## 32. 'Holding Up' the Public Agbiotech Research Sector over Component Technololgies

*W. Lesser*


Food Marketing Policy Center
Department of Agricultural and Resource Economics
University of Connecticut
and
Department of Resource Economics
University of Massachusetts, Amherst

# 'Holding Up' the Public Agbiotech Research Sector over Component Technologies

*W. Lesser*

Department of Agricultural Economics
Cornell University

Chapter 32

# 'Holding Up' the Public Agbiotech Research Sector over Component Technologies

*W. Lesser*[1]

## Introduction

Following decades of promises, the biotechnology sector is establishing its profit making potential only in the last part of the 20th century. Sales by value is led by pharmaceutical products, but agricultural applications are increasing in significance. Market leaders Monsanto and DuPont registered sales of $ 3.4 and 3.2 billion respectively in 1998, DuPont's sales also reflecting agchemicals (Annual Reports - available at www.monsanto.com and www.dupont.com). Sales correspond to 20.5 million hectares planted for 1998 in the U.S. and 27.8 worldwide (James, 1998, Table 3 - excludes China). It is estimated that Monsanto had a market share of 77 percent worldwide in 1998 (excluding China).

These rapid gains in market share were possible only through aggressive merger activities, particularly by traditional seed breeding companies. For 1996-98 Monsanto purchased stakes in six major agbiotech and seed firms for a combined total of $ 5.4 billion, while DuPont acquired or developed strategic alliances with six firms over the same period for a combined amount of $ 6.2 billion[2] (Moore, 1998, App. B). DuPont's $7.7 billion bid to purchase the remaining 80 percent of Pioneer HiBred, the major hybrid seed corn producer, is pending (www.dupont.com).

Such rapid application has raised concerns across a range of issues. Environmentalists have long raised warnings about possible ecological impacts of transgenic crops, including the possibilities of gene exchanges with related crops and resistance development to biopesticides[3]. While the identified concerns are certainly possibilities, a regulatory process is in place and to date there have been no significant problems reported[4]. Some groups are identifying possible health-related risks for consumption of genetically engineered foods - leading recently to a one-year ban in the United Kingdom (*Economist*, 1999). However again there is a regulatory process in place and, to date in the U.S. at least, there has been little widespread expression of concern. Finally, the rising concentration in the seed sector has reached levels where concerns regarding possible market power of firms begin. As yet though there is no evidence of the use of market power, although one of the objectives of this conference to develop a fuller understanding of competition dynamics in the agbiotech input market.

This paper is focused at a less observable level of agbiotech, the research level, and hence one which receives less public attention. Yet my focus constitutes a very real and current problem for public sector researchers. As a consequence it is a matter which

requires a near term solution, for a continuance of the current bilateral agreements threatens to undermine the necessary independence of public sector research. Conversely, a solution which does not meet the needs of the private sector is no solution at all, for the private sector is the lead agbiotech research contributor at present. Any independent action by the public sector which fails to meet the needs of the private sector will limit cooperation and the contribution which can be made by the public sector.

The focus of this paper is on the multiple-component technologies which constitute many marketable products. A single product can contain/utilize a dozen or more of these components which may serve as promoters, transformation vectors, and markers, as well as gene constructs themselves. Some the technologies are covered by patents, but many are treated as personal property with access offered based on bilateral agreements. The prevailing form is the Material Transfer Agreement (MTA), a form of contract. MTAs may take numerous forms, but at the most basic level (a) identify the materials transferred, (b) specify that further transfer requires the permission of the rights holder, and (c) allow for research use only (see Lesser, 1998, Chap. 2). Any subsequent use of the materials, including as part of a commercial product, requires a separate agreement with the owner. More restrictive, but less common, agreements might prohibit any transfer of the materials to third parties, as well prohibit as a claim of ownership over any derivative materials and related inventions.

At present, there is no overall tabulation of the extent of MTAs use by public sector researchers. Tabulations within individual institutions are often incomplete or nonexistent. A recent survey of the International Agricultural Research Centers, for example, revealed that for 40 percent of the materials received under MTAs, no record was available of any use restriction (Cohen, Falconi and Komen, 1998). Yet the potential for conflict has to a degree been established. From a 1994 survey of U.S. life science (primarily pharmaceutical) companies comes the estimate that 34 percent of the firms working with the public sector reported disputes "over intellectual property." In more than 50 percent of these cases data are required to be kept secret for longer than needed to file a patent application, often longer than six months (the NIH suggests 1-2 months as an appropriate period) (Blumenthal *et al.*, 1996).

Blumenthal *et al.* (1997) subsequently surveyed academic researchers in the life sciences, finding that 20 percent reported publication delays of more than six months. Almost nine percent had refused to share research results or materials with colleagues, one-fifth of that number as a result of a prior informal agreement with a company. From the users perspective, one third report refusals to requests for research results or materials. Of those, genetics researchers were significantly more likely to have been refused access than were those in the other disciplines in the life sciences. Neither of these surveys focused specifically on the issue under consideration here, but they do indicate agreements with firms have affected interactions among academic researchers, including publication of results.

One could ask why researchers choose to utilize materials with unclear use rights. There are several likely explanations for their decisions. In part the matter is historical -

agreements now reaching the commercialization stage were initiated years ago before the consequences were appreciated. And in part it is an effective research strategy which limits the number of dimensions of uncertainty in an experiment. Say, for example, a researcher is interested in the effects of a particular gene. Using a known promoter, it is possible to limit the focus to the actions of the gene. With a less well-known promoter, the results could be an interaction of promoter and gene effects, which would be far more complex to understand. In still other cases, a proprietary technology is all that is available, so the choice is between using it or finding another project.

Hearsay evidence from researchers worldwide indicates a widespread and growing problem over obtaining commercialization permission for completed projects on reasonable terms. The problem may be manifested in several ways: ongoing negotiations which never reach fruition, imposition of enviable conditions, or use license fee orders of magnitude beyond standard terms. Figure 1 documents the complicated process of one such negotiation for the transfer of a virus resistant papaya from the U.S. to Brazil.

**FIGURE 1 Negotiations Status for the Transfer of Virus Resistant Papaya to Brazil**

| Component | Function | Owner | Status Terms |
|---|---|---|---|
| 1. GUS | marker | Cambria (NGO) | Completed |
| 2. MPT2 | marker | Monsanto | w/35S |
| 3. 35S | replicase promoter | Monsanto | near comp. initial + royalties |
| 4. Floragren | promoter | MIT & Diatech | comp. - royalties to paid-up level |
| 5. Gene gun | transformation | DuPont with Cornell (inventor) | special agreement |
| 6. Plant/gene | NA | Cornell | Donation |

Note: The gene gun situation is somewhat different legally from the other materials, for the gun was used only in the initial transformation. Thus Cornell University, where the transformation was undertaken, is potentially liable, but the technology is not incorporated in the product so that the user (Brazil in this case) is not infringing.

Source: R. Cahoon, Cornell Research Foundation, personal communication.

This situation is a classic example of a 'hold-up', defined as "the general business problem in which each party to a contract worries about being forced to accept disadvantageous terms later, after it has sunk an investment..." (Milgram and Roberts, 1992, p. 136). In this paper I develop further the framework of public sector MTAs as a

hold-up problem, and then explore a number of possible resolutions, both *ex ante* and *ex post*. On further consideration though, none of these six proposed approaches is found to hold much potential for overcoming the identified hold-up problem. The only workable resolution which does emerge is a joint boycott by major public sector research entities operating similarly to compulsory patent licensing provisions in many national laws. Developing a procedure, and hence a plausible deterrent threat will, however, require significant coordination and organization among public sector researchers, and an entity to organize that effort. The Rockefeller Foundation's Rice Biotechnology Program is identified as a model for ways a new procedure might be accomplished.

## Hold-Ups and Alternative Remedies

Hold-ups are associated with incomplete contractual specifications (Hart, 1995). For practical or strategic reasons, firms involved in negotiations may exclude significant contingencies from contractual specifications. Strategically, this will allow the firm with the greater *ex post* bargaining power to claim a greater proportion of the quasi-rents associated with an investment. Quasi-rents are the difference between an asset's value in the contractually-specified use and the next best alternative use (Milligram and Roberts, 1992). Practically, it may be infeasible to negotiate all the contractual details *ex ante*. That situation would seem to apply for the research application considered here.

In very round terms, the success rate for creating commercializable products is less than one in ten. Nogues (1989) estimates that only about one in fifteen patented products is brought to market. Of that number just a small percentage is successful in the sense of generating profits in the commercial market. Even ignoring early failures, the chance of finding a commercial product is less then two percent. Data on success rates for pharmaceutical products are better developed. In the case of identifying products from wild materials, any response is in the 1/10,000 range (Lesser and Krattiger, 1994, Table 1). Other products and approaches can lead to different success rates, but the overall point is that the vast majority of research efforts fail, at least in a commercial context. If each project required negotiating five complete-to-commercialization agreements, the transaction costs per successful product would be staggering, so the practical solution is to postpone the negotiation costs unless and until there is a strong indication of a marketable product emerging.

At the research stage where most researchers seek commercialization permission, the researchers suffer from asset specificity. Asset specificity is the "degree to which a relationship-specific asset can be redeployed to alternative uses and by alternative users without sacrifice of productive value ..." (Gow and Swinnen, 1998). Pirrong (1993) identified multiple elements of asset specificity, as follows:

- Site
- Physical Asset
- Human Asset, and
- Temporal.

Of these, the research of concern here, that with a commercializable product but an absence of permission to use it, fits into physical asset category. This is a serious position indeed for redeployment opportunities are very limited. Use without permission risks legal action and/or loss of future access to the firm's materials, something a researcher would not wish to choose (see below). Replacing the 'held-up' materials would require repeating the development process, including the series of field trials, a lengthy and costly process. As a result, researchers in that position question the role of public sector research, which in many areas cannot function without collaboration from the private sector, but often cannot function with incomplete collaboration. From the private sector perspective, granting research access is one thing, but commercialization permission, often coming years later, is another. Among the issues considered by the firms are profits, effects on other product sales (including their own possible substitutes), agreements with other firms, and possible liability considerations.

Compounding the considerations is the likelihood that many of the involved products will have limited market value, so the return to each of the component technologies would be small indeed. Even if the firm wished to make a good will effort to accommodate the researcher, the low priority it would have in executive time scheduling for negotiating the agreement would mean lengthy delays. Indeed, the papaya case cited in Figure 1 was eventually resolved not on a payment basis, but because Cornell University offered to cross license another product which Monsanto desired. While a cross licensing resolution is a possibility for a major research university with an active IPR program like Cornell, it would not serve for smaller institutions or those such as the international agricultural research centers which do not regularly protect their intellectual property.

Thus, additional approaches are needed. Here, I identify six possible ones, four applied *ex post* and two for *ex ante* use. The six are later explored in depth. They are:

*Ex Post:*

- infringement
- compulsory licenses (primarily developing countries)
- antitrust applications to licensing terms (OECD countries)
- protect final plant product

*Ex Ante:*

- group negotiations with general standardized terms
- threat of generating duplicate public sector technologies

## *Ex Post* Approaches to Resolving the '*Hold-Up*' Over MTAs

### *Infringement and Other Violations of Contract Agreements*

Once the research investment has been made, there are relatively few legal options subject to a hold-up and open to the researcher. The researcher can, however, proceed to commercialization simply by violating the agreement. An infringement of the technology is potential, otherwise a contract violation.

Willful infringement is an approach if there is a reasonable belief that the patent underlying the materials is invalid. Infringement compels the patent owner to sue to stop the infringement and recover damages. If the patent is a weak one, there is a natural reluctance to sue as foregoing legal action may possibly result in a license agreement. Another strategy involves a suit and counter suit, often resolved as a cross license agreement (Barton, 1998). However, patent suits can be very expensive, with estimates in the $300,000-1,000,000 range, and possibly higher (Lesser, 1997). There is always a risk that a well financed firm will engage in a suit even if the grounds are questionable if it is reasoned the defendant has insufficient funds to maintain a defense, or if the case will serve as a warning to others not to infringe.

If the underlying material is not patented, the owner can file in the U.S. for a restraining order under Rule 65 of the Federal Rules of Civil Procedure (see Mills, 1999). However, the applicant must show immediate irreparable harm, which is a high standard. Otherwise, the owner must sue for contract violation with the same considerations applying as described above for patent infringement. There is, of course, a reasonable question if a firm would risk the poor public relations for suing a public sector researcher, particularly if there is little chance of significant monetary compensation. A more likely remedy would seem to be sending a warning letter requesting cessation. Thus the researcher would seem to have little to fear.

A very real concern though is the informal response of losing access to additional materials in the future, certainly for the researcher and possibly for the entire institution. Certainly a provider would be reluctant to extend valuable property to or otherwise cooperate with someone who proved untrustworthy in the past. And lack of access could prevent the completion of future work, so the informal threat is often sufficient to prevent willful violations of MTAs[5].

### *Compulsory Licenses*

All patent systems have a means of granting a patent license without the consent of the patent owner, a system known as compulsory licensing. Conceivably, a researcher with an MTA regarding patented materials could in the case of a hold-up apply for license relief.

Success would depend in large part on where the patent was held and where the rights were sought, as compulsory license provisions vary widely across nations. The U.S., for example, grants licenses only to the government and only for matters of national security (Patent Act, Section, 181, 183). In Canada grounds are broader, including consideration of non-nationals working on a commercial scale after three years with no adequate justification given, or if demand in Canada is not being met to an adequate extent. In those cases compulsory licenses may be granted (Section 65-66). (Special conditions apply to food and pharmaceuticals.) Most developing countries have requirements closer to those of Canada than to those of the U.S. which are based on the maximum permitted terms of the Paris Convention of 1883 (Article 5).

The recent WTO agreement contains in the Trade-Related Aspects of Intellectual Property Rights (TRIPs) appendix (Section 5) particular references to patent law requirements for member states. Among those is the right (but not the obligation) to provide "limited exceptions" to the rights conferred by patents (Article 30), including the granting of compulsory cross licenses. A cross license for the dependent patent, which cannot be exploited without infringing the rights of the first patent, may be granted when (Article 31(l)):

> (i) the invention claimed in the second patent shall involve an important technical advance ...

These terms promise potential relief, but only under very restrictive circumstances. The material which forms the subject matter of the hold-up must be patented, as must be the resultant composite product. The product must involve an 'important technical advance', and the request must be made in a country where these optional terms have been adopted. Moreover, the resultant product must receive such a license in every country where exports may be directed. Overall, these conditions are likely to apply to but a small portion of the materials under consideration here. So, while a compulsory license may give relief in some circumstances, the general applicability will be limited.

### *Antitrust Applications to Licensing Terms*

Compulsory licensing provisions in developing countries tend to be broader than in industrialized countries. This appears to be the case in part because smaller economies are understandably concerned about the economic power of multinational firms, yet many such countries lack the legislation and legal processes for administering antitrust law. Thus, they rely on compulsory licenses to curb some possible applications of excessive market power. The U.S. is again towards the extreme with a broad body of antitrust legislation so that it is instructive to see if any relief from holds-ups will be forthcoming from that source.

Antitrust issues related to patents can, and have been, brought under both the Sherman and Clayton Acts (especially Section 3). In general, what has been found illegal is the use of patents as a mechanism for price fixing, or the treatment of a patented

product as a tying good. Receiving particular scrutiny is the patent pool — if it can be construed that the pool was structured primarily to limit horizontal competition. Similarly, patents may not be used to mandate retail price maintenance or otherwise impede vertical competition if the intent of the actions is to limit competition. While the underlying decisions were decided in the context of cases involving patents, the offense is the conduct of limiting competition, not the existence of patents *per se*. Thus, the same decisions could apply to the use of MTAs and other contractual arrangements. Indeed, the only decisions which specifically reference patents in their case development are those which forbid the continuation of royalty payments following the expiration of the patent.

The position of the Department of Justice as regards licensing of IP was codified in 1995 in the Antitrust Division's *Antitrust Guidelines for the Licensing of Intellectual Property*. Those Guidelines recognize "the principle that 'antitrust concerns may arise when a licensing arrangement harms competition among entities that would have been actual or likely potential competitors in a relevant market in the absence of the license.'" As R&D is a scarce factor, the Guidelines recognize the potential for harm from license-based restraints which could reduce competition from related inventive activity and the integration of complementary research. Nonetheless, recognizing that antitrust applications in that area are according to the Rule of Reason, a 'safety zone' has been established under which, excluding extraordinary cases, action will not be taken for non-exclusive licenses if:

(1) license restraints are not of the type typically found to be *per se* violations of antitrust laws, and
(2) the aggregate market share of the licensor and licensee does not exceed 20 percent of each relevant market affected by the restraint.

As a general matter, nonexclusive licensees will rarely result in antitrust action.

What of exclusive licenses if utilized within a concentrated market? The Division defines exclusivity according to it character. There is no presumption of exclusivity "merely because a party chooses to deal with a single licensee or licensor, or confines his activities to a single field of use or location, or because only a single licensee has been chosen to take a license."

Thus the Guidelines reflect the prevailing view at the Justice Department that vertical licenses, such as the type considered here, seldom have the capacity to harm competition. Even when there is evidence of vertical restraints, such as the practice of tying, the terms will be challenged under the Guidelines only if:

(1) the seller has market power in the tying good,
(2) the arrangement has an adverse effect on competition in the market for the tied good, and
(3) the anticompetitive effects are not outweighed by the efficiency justifications.

Overall, it is as difficult to prevail with an antitrust action which *mandates* licensing. For sure, some antitrust cases have been resolved by requiring licensing[6], but in general if the argument is for enhancing the public good, the vehicle is compulsory licenses, not antitrust law.

### *Protection of Final Product*

The researcher could, legally, patent or otherwise protect the composite product. This in itself would not permit commercialization for it would still be a violation to exercise that patent. What the product patent would accomplish is the generation of a basis for cross licensing, as discussed under II.B above. Whether the cross licensing opportunity would be useful in overcoming the hold-up depends on whether the owner of the composite technologies would be interested in commercializing the final product. Overall, there are reasons to believe that would not be the case.

It is questionable, for example, whether the owner of the 'gene gun' would have any interest in commercializing virus resistant papaya in Brazil. And even if it applied to one owner of the component products, it is highly unlikely it would apply to all owners. Among other considerations, the licenses would have to be non-exclusive, which could be problematic with a smaller market and/or if a significant investment (such as regulatory approval) were required to bring the product to market.

A second consideration is the cost of patent protection. In the U.S. a patent can easily cost $20,000 and more, primarily for attorney fees, plus maintenance charges (Abbott, 1993). Costs for a single patent worldwide now exceed $500,000 (Meller, 1998). Plant Breeders' Rights (PBR) are far less costly, but are inadequate to protect a bioengineered gene (see Lesser, 1998, Chap. 2). The inventor could patent the transformed gene itself rather than the transformed plant, but costs would be similar, with no real advance in overcoming the hold-up.

### *Conclusions*

The preceding discussion fails to identify any really effective *ex post* steps which can be taken to overcome a hold-up based on a MTA. The few opportunities which were identified appeared limited in generality: the use of cross licensing restricted to large institutions with a broad patent file, and just possibly antitrust action when the technology in question established a monopoly position with discriminatory licensing terms. Little seems to compel licensing except compulsory licensing provisions, where they exist, and then only if the component technology is protected by a patent. The same does not apply to contractual agreements like MTAs.

In respect to *ex post* arrangements, the hold-up is effective, for there is little to be done to overcome it. Yet it is not efficient as often there is no appropriation of quasi

rents - the product simply remains unused. In short, everyone loses. We turn now to possible *ex ante* approaches.

## *Ex Ante* Approaches to Resolving the '*Hold-Up*' Over MTAs

*Ex ante* approaches as identified here are fewer in number, but need to be considered after no *ex* post approaches considered are deemed effective. We consider first group negotiations, followed by the threat of generating duplicate technologies.

### *Group Negotiations Leading to Standardized Terms*

The concept here is a simple one, the reduction of transaction costs by the prior establishment of a widely-accepted base agreement. Economists have long acknowledged that transaction costs in a large measure determine the structure of an industry. In early work, Williamson (1971), building on Arrow (1962), for example identified vertical integration as a means of bypassing transactional complexities and incomplete information available through spot markets. "The dilemma posed by once-for-all contracts is this: lest independent parties interpret contractual ambiguities to their own advantage … contingent supply relations ought exhaustively to be stipulated. But exhaustive stipulation, assuming that it is feasible, is itself costly." (Williamson, 1971, p. 115). This proposed *ex ante* approach is a means of reducing those costs by partially pre-specifying the contract terms, at least those which can be stipulated.

In mature technology fields, an understanding of standard license terms has emerged. Thus, a patented but incompletely-developed technology requiring further investment may receive a base payment of (say) two percent, while one ready for commercialization earns five percent, and an exclusive agreement a little more. Agbiotech functions differently for several reasons, including (a) the negotiation is over parts, not a final product, (b) the market is new, so standard values have not emerged, (c) many public sector entities are inexperienced negotiators meaning agreements proceed more slowly, and (d) the negotiation stance of many of the public sector parties is not known so that firms may wish to consider a general strategy along with the particulars of an agreement. Several of these points require more attention.

Consider first the problems inherent in negotiating payment rates for multiple components in a joint product. One difficulty is pyramiding, which occurs when the sum of the individual requests exceeds the total value. Firms seeking a higher return would have the incentive to hold out, as every landowner on a city block wishes to settle last with the developer who is attempting to gain control of a development site. Thus there is an incentive to delay agreements. Or, faced with a large and inflexible request, other participants may have to agree to a lower return for their components if the agreement is to be concluded. At the extreme, this is a bilateral monopoly problem with the outcome dependent on the relative bargaining power of the participants (see McKie, 1959, Ch. 2).

The inexperience of public sector negotiators (Point (c)) specifically identifies the skewed reward system for public sector employees, where credit for a successful agreement may be reflected elsewhere, but blame can always be directed to the initiator. Moreover, public sector employees not familiar with the commercial value of their products are often reluctant negotiators. Certainly, no one wishes to be accused after the fact of agreeing to a poor arrangement, even if it was reasonable at the time of establishment. Taken together, these characteristics mean public/private sector negotiations are often lengthy, and public sector negotiators are often dissatisfied in the end. That then has to make public-private sector negotiations a low priority for the use of scarce private sector management time. Negotiations may never begin, let alone conclude.

Once under way, it will be useful to determine, even approximately, what is the value of the individual contributions to the whole. That quest has proven largely or completely illusive. A classic example, although one not directly related to MTAs, is the valuation of contributing parts of improved plant varieties. There may be many such contributing parts; by one count, the parentage of the popular IR64 rice variety has materials from over 75 distinct sources including 20 landraces from eight countries, and derivative varieties would generally be additive to that number (see Swaminathan, 1995). Should any claim be made for the individual components, there is no obvious means for identifying the partial contribution, nor any assurance the claims would sum to the whole.

Smale *et. al* (1998) is one of a few attempts at a detailed accounting of the value of contributing germplasm to seeds, in that case wheat in the Punjab of Pakistan. Value is measured as the effect on the mean and variance of yield with the genetic resource component measured by two variables. One is the number of landraces in the ancestry, the second the number of parental combinations, a measure of the contribution of (modern) plant breeding programs. The average number of landraces in the parentage of a variety was found to contribute significantly to lower yield variations in rainfed areas. That finding suggests at least a possible methodology for identifying the value of component contributions, even if aggregated. However, "Because these landraces are in the genetic background of the varieties, … any direct effects on adaptability across environments or over time cannot be inferred." (Smale *et. al*, 1998). That is, because the landrace genetic materials do not act directly on yields, it is not possible to ascribe any particular effects to them.

This brief overview of efforts to value the component contribution of germplasm is relevant because of the limited successes achieved to date. Now certainly the number of materials in a variety covered by MTAs will be much fewer than the components of a variety, but in some senses the difficulty of calculating the component contributions under MTAs will be more, not less, difficult. That is because many of the contributions apply to the development of the final material (transformation technologies, promoters, markers) rather than the expression of value in the field. And in any regard there is no assurance that the price sought from the negotiations will be related to some external concept of value; the only real value of importance is what a party is willing to pay.

Barton (1998) has suggested that cross licenses are often utilized by biotech firms precisely because they obviate the need to determine value.

Without any means of calculating component part value contributions, or even insuring the use of a known value, there seems little potential for substantial reductions in negotiations costs. I do believe that greater negotiation skills by public sector representatives would advance the process. And a better understanding between the public and private sectors of objectives and approaches would similarly advance negotiations. But these contributions would be at the margin only, not adequate in themselves to overcome hold-up problems.

### *Threat of Generating Duplicate Public Sector Technologies*

Hold ups, of at least one kind, are motivated by an interest in improving financial position through capturing quasi-rents. A way to counter those hold-ups is to cause the rights holder to earn less rather than greater profits — in short by developing duplicate products which are made available on favorable terms. If, for example, a public sector experiences particular problems with licensing Monsanto's 35S promoter, then a substitute promoter may be developed and distributed by the public sector on concessional terms. That, in turn, would erode the value of Monsanto's property and limit future hold-up behavior.

In many respects, succeeding with my strategy is similar to implementing successful predatory pricing – the party must establish a reputation for being a fierce competitor (Carlton and Perloff, 1994, Chap. 10). There are numerous practical problems to exercising such a strategy. The number of technologies which reasonably can be replicated is small so that it is essential to identify clearly and early the key bottleneck technologies. That is never easily done - Cornell University, for example, seems to have underestimated the importance of the gene gun technology when initially licensing to DuPont for a flat fee of $1 million. Moreover, the identification and replication must be done quickly (and possibly secretly) enough so that the original supplier cannot make a monopoly gain for an extended period, then drop the terms low enough to deny any return for the competing public sector product.

Second, there must be a funding source for the necessary research and development work, plus the protection and defense of the intellectual property rights. Third, the substitute product must function sufficiently well at a low enough cost to cause at least some users to switch to its use, and possibly to replicate the research with the new materials. And finally, the effort must be sufficiently frequent and real to create a legitimate threat to the hold-up firms. To do that, it must be done collaboratively with a substantial number of public sector research institutions.

The conditions for success identified here are indeed severe: good projection capabilities, rapid deployment, accessible funding, creating a real threat, and operating collaboratively for the development of alternatives and would not generally be viable for

any single player. Overall, the probability of success would have to be considered as small.

### *Conclusions*

The preceding discussion fails to identify any compelling *ex ante* solutions to the hold-up problem over MTA. Group negotiations lack both a basis in estimating the value of individual components and a means of requiring their use even if known. The threat of creating duplicate technologies would too often be hollow, as the identification of key target materials, requisite cooperation across research entities, and financing needs are just too great to be believable.

This leaves a dilemma indeed, for none of the *ex post* or *ex ante* approaches considered here can be considered to have a great likelihood of halting hold-up behavior. Small contributions can be made toward mitigating the problem, but I judge the aggregate effect to be inadequate. But, before reconciling public sector researchers to a victim role for hold-up behavior, I want to explore the possible role of joint behavior.

## Cooperative Approaches to Resolving 'Hold-Up' Behavior

The preceding analysis suggests that there is very little the individual researcher, or research institution, can do to redress the hold-up problem of MTA. The matter is largely one of bilateral monopoly where the sharing of benefits is determined by the relative bargaining strength. With asset fixity under a MTA, however, the firm supplying the materials has the bargaining power. However, before reconciling the public sector to an exploited role, it is useful to consider how joint action might be employed.

Basically, joint action could strengthen the bargaining position of the individual researcher or institution, raising the cost of hold-up behavior. If, for example, the assumption of quasi-rents was possible only with the loss of future access to public sector research, the option would be less attractive. The system could function if there were an agreed joint boycott of research agreements with any firm with which there had been prior efforts to obtain authorization from the right holder on reasonable commercial terms and conditions, and the efforts had been unsuccessful within a reasonable period of time. If there were an agreement, the rights holder would be granted reasonable compensation[7]. Operationally, the issue is how to structure such an arrangement so as to pose a credible threat with clear costs and effects while minimizing free riding. First though it is important to establish that the public sector in aggregate can provide expertise and personnel of value to private agbiotech firms.

The public research sector, particularly universities in industrialized countries, is a major contributor to agbiotech discovery, including several key inventions such as the gene gun, and the replicase technology for virus resistance in some crops. Presumably that is why Novartis recently agreed to a $25 million commitment for the right to first

review of inventions from U.C.-Berkeley, and particularly in the area of microbiology. Nor is the interest limited to universities in developed countries - Embrapa, the Brazilian Ministry of Agriculture, for example, owns soybean varieties which Monsanto is interested in licensing for use with its Roundup Ready herbicide resistant technology. Hence it is quite clear that the private sector is dependent on the public sector for innovation and for products, at least at this stage of agricultural biotechnology development.

Procedurally, some kind of review body would be required to determine if the prior efforts to reach a voluntary agreement were indeed sufficient, or the terms offered were not reasonable in a commercial context[8]. That task could be accomplished through a mediation procedure[9], or by a public sector body such as the Association of University Technology Managers (AUTM). The owner of the material could be permitted to participate with a statement, but the decision would be directed to and binding on the public sector consortium members.

Perhaps most difficult would be compelling the members to meet their prior agreement of a joint boycott. It is certainly conceivable that any one decision could go against the interests of a consortium member and there would be a defection, one defection leading to another. Clearly one component for success would be selecting members based on a roughly equal size research activity so there is some parity between the likelihood of being the basis for a claim, of being required to join a boycott, and the significance of the boycott to the owner of the material. Multiple participants would increase effectiveness, but would also increase the number of likely boycotts, which would be a significant cost to the research institutions. The consortium members then must see some direct connection between their actions and effects on themselves and colleagues. Among other aspects, there should be a degree of moral suasion.

Moral suasion though is unlikely to be sufficient in itself - there needs to be an external aspect promoting participation in boycotts, which provides an immediate and tangible benefit for participation in a boycott. Developing a procedure, and hence a plausible deterrent threat will, however, require significant coordination and organization among public sector researchers, and an entity to organize that effort. The model selected here is that of the Rockefeller Foundation's Rice Biotechnology Program[10].

### *Rockefeller Foundation Rice Biotechnology Program[11]*

In the early 1980s, Rockefeller Foundation staff recognized that traditional rice breeding technologies had matured, but no one outside Japan was applying the (then) new biotechnologies to rice production. Thus the decision was made in 1984 to apply about half of the Foundation's agriculture program funding on a long term basis to enhancing work on rice biotechnology. Eventually, some $93 million were expended. The initial focus was on training developing country scientists in laboratories of industrialized nations, provided their national governments promised to provide appropriate research positions on completion of training. Selected scientists were identified as Fellows and

given the opportunity to return to the training lab for three month periods for a minimum of three years. Subsequent needs were met with shorter-term training programs.

For purposes here, though, the focus is on means used to develop a shared research agenda. That effort began with a series of priority-setting workshops where desired traits were identified and which served as Program targets. While that was the official objective of each workshop, the unofficial one was "a new set of research proposals which reflected those recommendations and involved collaborations amongst participants in the workshop" (Toenniessen, 1995). That funding was in addition to the initial grants given to support individual projects, with the collaborative aspect required for continued or additional funds.

Program organizers, while recognizing the importance of funding, credit much of the success to the creation of the "opportunity to be part of a larger mission-oriented programme" (Toenniessen, 1995). The Program reviewers attributed a successful strategy, which initially attracted premier scientists with the offer of funding, while envisioning an "overall trajectory" from capacity building to the creation of the international collaborative effort (Bell and Harrison, 1993).

My personal view, based in part on conversations with involved scientists, is that the success is attributable to a carefully constructed system. Central to that system is the cooperative group which met annually to exchange results and interact. Attaching relatively small amounts of funding to the maintenance of cooperative activities was critical for the system because it provided an immediate benefit for cooperating. And the identified Program targets allowed scientists to feel they indeed were all participating in the same activities. That is, the Program has a mutually-developed focus which is maintained through a regular flow of collaborative research funds. Conversely, continued participation is jeopardized by inappropriate exclusive exchange inside or outside Program membership.

### *Application to the Holding-Up Problem*

The particular genius of the Rockefeller Program structure is the creation of specific and immediate incentives for scientists to do what they wished to do anyway. For sure, the funds available were too limited for imposing a major change in focus on preferences. Additionally, and as important, it imposes penalties for short term opportunistic behavior, such as treating communal information as exclusive.

For the holding-up problem which is the focus here, participants will similarly recognize a creditable boycott threat as a benefit, but can be distracted from its implementation by short term expediency, particularly avoiding the loss of research funding from the boycotted institution. Coordinated funding could overcome those non-cooperation problems in the following ways:

- conducting workshops for the identification of critical technologies which have, or are thought to be, the basis of holding-up activities,
- identifying funds for the duplication of technologies which have been identified as serious hold-up problems. The technologies would become the property of the funding agency which could then control use in a coordinated way,
- providing a pool of special grant funds which would make up, in part, for lost funding opportunities, and possible loss of donor funding for participating in an agreed boycott.

In these ways it is possible to establish and manage a creditable threat of a broad public sector boycott. Remaining is to identify what that central donor/coordinator might be - and what better choice might there be but the Rockefeller Foundation?

## Conclusions

Hold-ups based on research MTAs are a significant determent to public/private sector cooperation with biotechnology. The extent of the problem has not been well documented, and should be, but available related information, and hearsay evidence, indicate its significance. Yet even more difficult than confirming the problem is identifying a resolution.

My efforts here to identify unilateral *ex post* or *ex ante* approaches were unsuccessful — once a potentially commercializable product has been identified, the balance of negotiating power is so skewed to the technology providers as to stymie the public sector researcher. Seemingly more successful will be a joint effort approach in the form of a public sector boycott of firms imposing a hold-up on public sector researchers. Such boycotts cannot be undertaken lightly so considerable preparation will be required. Initially, participants will need to agree on the importance of the technology involved. They will also need to believe the production of a replacement technology is possible, and that the costs of the boycott in terms of lost funding is not too great. Here I suggest a major funding body (the Rockefeller Foundation?) could provide the monies and coordination required.

Perhaps though there will remain questions if the hold-ups are so significant to warrant such a response, and if it is operable anyway. Beyond the specifics identified here, this is really but one aspect of an evolving public/private sector relationship. Over the past decade, the public sector has made major changes in its operations to accommodate the requirements of the private sector. These changes occurred first in the industrialized countries as taxpayers withdrew financial support from agriculture, and is now extending to major developing country agricultural nations where the combination of economic problems and deregulation is reducing public funding. The private sector has, to a large degree, controlled this transition through its spending priorities.

For the longer term though the case by case opportunistic funding decisions made by firms may be inadequate for the maintenance of a viable public sector research effort. Holds-ups are one example of that. The maintenance of crop breeding programs for training future breeders is another. Biological scientists undoubtedly could extend the list. In this context, a joint boycott agreement serves the wider goal of signaling the private sector of the need for a more collaborative arrangement between the two major contributors to agbiotech. Until that comes about, as it has in many engineering fields and eventually must in biotech as well, the public sector needs to act proactively.

## Endnotes

[1]Professor, Department of Agricultural Economics, Cornell University.

[2]For a slightly longer period, James (1998, Table 13) estimates the value of Monsanto's acquisitions to be $8.6 billion.

[3]See e.g., web page for Union of Concerned Scientists at www.ucsusa.org/Gene.

[4]Recently reported evidence that pollen from Bt-producing corn could damage butterfly populations could change that situation, but at this time there are no field-level data available.

[5]Klein, Crawford and Alchian (1978) note that the enforcement mechanism of the threat to withdraw future business is a common one with business. Here I am implicitly arguing that, while university researchers potentially can make the same threat, their effectiveness is less, at least if researchers operate independently.

[6]At the time of writing, a non-exclusive compulsory licensing agreement was being considered as a possible remedy for the Microsoft antitrust case, should there be a finding against the company.

[7]The terminology is a paraphrasing of the allowable conditions for offering a compulsory patent license under the TRIPs appendix to the WTO (Article 31(b) and (h)).

[8]This would be similar to the court review required under TRIPs (Article 31(j)).

[9]Multiple mediation services exist, including the International Chamber of Commerce, and the American Arbitration Association, among others. Fees for the proceedings are typically in the $2,000-5,000 range in the US (see Lesser, 1997).

[10]I would like to thank Gary Toenniessen of the Foundation for providing documents on the functioning of that Program.

[11]Information for this subsection is drawn from Toenniessen (1995), Toenniessen (1997), and Belle and Harrison, 1993.

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