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**The Butcher the Baker the Pharmaceutical Maker:
Why the Agricultural Biotech Industry May Differ from the General Biotech
Industry**

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**Presented at the 2002 AAEE-WAEA Annual Meeting in Long Beach
July 28-31, 2002**

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Daniel A. Dierker and Peter W. B. Phillips²

Abstract

This paper explores the apparent anomaly in the patenting strategies found in the agricultural biotechnology industry, when it is compared to the literature's view of the patenting strategies in the general biotechnology industry and in the pharmaceutical industry in particular. By extending an extensive game model of the agriculture biotechnology industry, we show that, like the rest of the biotechnology industry, the integration of the agriculture biotechnology industry into several large private research firms with accompanying government laboratories can be transactions-costs limiting and thus efficient, given the existing institutional structure. A review of the literature respecting the general biotechnology industry reveals an apparent anomaly between the general industry and our findings with respect to the Canadian agricultural biotechnology industry. The literature seems to suggest, as one might expect, that the choice of patenting strategy in the general industry is dependent upon a positive probability of litigation over opportunistic patenting strategies, with the probability of facing litigation being dependent on the type of patenting strategy adopted. In contrast, we found general opportunistic patenting strategies in the Canadian agricultural biotechnology industry, independent of potential litigation. A comparison of the income elasticities of demand for food compared to other biotechnological products, particularly pharmaceuticals, can account for the apparent differences. We briefly assess the policy implications of these observations, particularly examining why the manner in which publicly funded research programs compensate the inventors of the intellectual property that they control may limit the incentives for these programs to control the apparent opportunistic behavior we perceive in the agricultural biotechnology research sector.

¹ The authors wish to acknowledge the Canadian International Development Agency which funded this research through a CIDA-IFPRI Linkage Grant.

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Introduction

In previous papers we have shown, in a static world with constrained government expenditure, that the granting of intellectual property rights (IPRs), while clearly a second best policy, are welfare enhancing (Phillips and Dierker, 2001; Dierker and Phillips 2001). We also showed, again in a static world, that while freedom to operate within the IPR system can be still further welfare enhancing, the failure to achieve freedom to operate continues to allow a Pareto improvement over a model in which there is no IPR system (Dierker and Phillips, 2001). Finally, we reported survey results that suggest that, within the Canadian agricultural biotechnology sector, those institutions designed to allow for freedom to operate have failed to provide the same (Dierker and Phillips, 2001).

This paper commences by extending the game we offered in Dierker and Phillips (2001) to include vertical integration within the agricultural biotechnology research industry. It then examines the concept that such integration, at the time of the integration, may be efficient, in that it is transaction costs limiting. Finally, we examine the conditions under which, in economic theory, the efficient integration of the industry into several large vertically integrated firms can lead to an industry exhibiting marked levels of market power.

The contrasts between the Canadian agricultural biotechnology research industry and the biotechnology industry more generally are then considered. This examination has two principal foci. First, the failure of the private firms in the Canadian agricultural biotechnology industry to provide the same level of freedom to operate, using the existing institutions, as the more general biotechnology industry will be examined. It is posited that the differences can be accounted for either through differences in the income elasticities of demand for the consumer goods that result from the research, or by differences in the expected profits that can be derived through the research as a result of differences in consumer acceptance of the consumer goods that will result. Differences in these elasticities or consumer demand will, depending upon litigation costs, render different incentives for private firms to pursue freedom to operate through the existing institutions in the different industries. Next, the incentive structure inherent in the manner that the publicly-funded research programs deal with inventors of intellectual property within the programs will be modelled. This model will show that the policy adopted for compensating inventors in the publicly funded research programs provides incentives that, again depending upon litigation costs, are perverse to attempting to force freedom to operate through the existing institutional structure.

Some Theoretical Considerations Relating to Agriculture's Apparent Differences

Extending the game from our previous paper (Dierker and Phillips, 2001) to include vertical integration in the agricultural biotechnology industry left an extensive form game that at its longest is twelve stages, and at its shortest is five stages. The extended game has over a hundred potentially non-zero payouts.

Once an innovator comes up with an innovation the innovator has the choice to apply for a patent or not. If they chose not to apply for a patent they have to decide whether or not

to attempt to keep a trade secret. If they elect not to attempt to keep the secret they can elect to either publish or not and following that decision to commercialize or not. If they attempt to keep the secret and succeed then they must decide to commercialize or not, but run the risk of their competitors inventing around them and/or facing a take over. If they cannot keep the secret they have to decide to litigate or not, while, if successful or not, still facing both the commercialization decision and the risk of take over.

If the innovator opts to apply for a patent they have to decide on a patenting strategy. They can either act opportunistically, by doing something like seeking overly broad protection, or they can stay squarely within the four pillars of patentability. In either case the patent office then gets to decide whether or not to grant the patent. Subsequently the lawsuits can begin. If the patent office does not grant the applicant can bring an administrative law action attempting to force the grant, or not. Alternatively, if the patent office issues the patent the applicants' competitors can challenge the grant, or not. If the patent office refuses the grant and the inventor chooses not to sue, or sues and loses, or if the patent office issues the grant and a competitor successfully challenges the patent, the result will be the same as if the inventor was unsuccessful in keeping a trade secret. That is, the inventor would face the commercialization decision and the risk of takeover. If the patent office issues a patent and the inventor is either not sued or if sued wins, then the inventor would face a decision of whether to license or not. The ability of a patent holder to act opportunistically here is the root of a freedom to operate problem. This decision is like the rest of the game followed by the decision to commercialize and the risk of takeover.

The last complication to the game is the nature of the innovation. That is, whether the innovation is major or minor. A major innovation being one that allows the IP owner to extract monopoly rents, whereas a minor innovation is one that does not lower marginal cost sufficiently to allow for monopoly pricing and leaves the innovator pricing at his marginal cost, which should be lower than his competitors³.

A profit maximizing research firm is going to choose that strategy, in the game, that maximizes the firm's profits. As each node of the game, prior to the payout, has two options available to it, one of the events available off of any particular node is going to occur with some probability, p , between zero and one, while the other will occur with probability of one minus p . For example from the invention node the innovator will choose to apply for a patent with some probability, while the probability that the innovator will not apply for a patent will be one minus the probability that he does. Thus, these probabilities, both in terms of their absolute value and their relationship to each other are going to affect the choice of the optimal strategy to pursue in the game. For example if the probability of being sued is slight, and the probability that the innovation is major and the probability that an opportunistic patent application will be granted are both substantial. Furthermore, if these probabilities are independent of each other, then a strategy where the innovator applies for a patent and acts opportunistically will dominate.

³ The interested reader can see Shy for a more complete treatment of the difference between major and minor innovations.

As well as the probabilities, the profits that an innovator can expect are going to depend upon the characteristics of the demand curve that the innovator faces. Thus, the elasticities of demand are going to be important. Regmi, Deepak, Seale and Bernstein (2001) in estimating price and income demand elasticities find that price changes prompt substitutions between food subgroups, and that poorer countries are more price responsive than richer countries. Therefore, since the profit maximizing innovator is going to want to extract as much rent as possible, he is going to want to deal with the richer nations (i.e. there has to be some resources before the innovator can extract them), where the consumers apparently care relatively little about food prices. Thus, from the innovators perspective income elasticities of demand may be more important. Finally, consumers have to want to purchase the finished product off of the store shelf; if for whatever reason consumers are not willing to purchase the innovation, it is valueless. Therefore, it would seem that a profit maximizing potential innovator will only enter the agriculture biotechnology research industry if he perceives the probabilities, the elasticities and consumer attitudes as favourable.

Is There Any Evidence of Agriculture's Alleged Differences?

At first blush there is very little reason to expect that the agricultural biotechnology industry significantly differs from the more general industry. Both the general industry and the Canadian agricultural industry have displayed marked levels of concentration through mergers and acquisitions within the respective industries. This has left several large private players occupying the core of the industry with numerous smaller, largely public research institutions on the fringes. This merger mania has been accompanied by joint research projects being undertaken between the private firms and one or more of the public laboratories (Phillips and Dierker, 2001), and Phillips and Gustafson, 2000). This concentration has led to concerns respecting freedom to operate with respect to intellectual property, particularly among the public institutions (Dierker and Phillips, 2001). Such concerns are by no means limited to Canadian agricultural biotechnology (Barton, 2000; Heller and Eisenberg, 1998; and Lerner, 1994).

Given these apparent similarities, wherein lie the differences? Appendix A sets out a list of all the intellectual property right ownership law suits reported in electronically filed United States Security Exchange Commission forms 10-K, annual report to shareholders, filed through January of 2002, filed by or against the list of firms we report at Appendix B. We excluded class action suits launched by producer groups alleging anti-competitive behavior and patent invalidity, and suits by the firms against individual producers attempting to enforce technology use agreements. The hope of this far from exhaustive search technique was to gain a sense of whether or not the freedom to operate provision inherent in the United States Patent Act is being utilized by the firms listed in Appendix B. Using the annual report to the shareholders will at least yield those lawsuits that the executives of the reporting firms believe place the firm at risk of financial jeopardy as a result of the lawsuit. We subsequently had a colleague at the University of Saskatchewan Law School conduct a search of litigation databases available to the School. This search did not reveal any new intellectual property right ownership cases, although it did turn up

some builders' liens. Accordingly, while we cannot claim the list in Appendix B to be exhaustive, we have some confidence that it is representative. So what does this tell us?

In Dierker and Phillips (2001) we averred, from the survey data we had collected, that the probability of facing legal action is independent of the patenting strategy pursued, and appeared to approach zero. That is, that an agricultural biotechnology research firm appeared, from the survey data to be no more likely to face legal action if they pursued an opportunistic patenting strategy (claiming as broad a patent as possible, a strategy that Lerner (1994) shows to enhance the value of the claiming firm) then if it was to pursue a strategy of claiming only those rights clearly within the four pillars of patentability: inventiveness; novelty; utility; and nonobviousness. This contradicts the findings of Lerner (1994) who found the number of claims per patent, to be a significant predictor of patent ownership litigation. It does however accord with Lanjouw and Schankerman (2001)⁴. The differences between these studies may be accounted for in that Lerner concerned himself solely with biotechnology. An examination of the parties to the lawsuits reveals that the litigants tend to fall into groups that have subsequently entered into mergers. That is, the mergers appear to be between firms that were within a group of plaintiffs or a group of defendants but not between plaintiffs and defendants. This would suggest that the mergers did not advance as a means of settling intellectual property rights ownership law suits. Finally, there is a marked drop off in suit filings commencing in 1997; incidentally this drop off precedes judgment in the Mycogen/Monsanto suit, the one really big award in the sample.

Williamson (1986), in his work on governance, has shown that the type of organizational structure that you are going to observe in an industry is going to depend on the nature of the transactions between participants in the industry and the costs associated with those transactions. The more asset specific an investment and the more difficult it is to observe and assess performance of a contract the more likely it is that a firm will move away from a market governance structure towards a vertically integrated governance structure. Williamson (1986) further argues that such a shift can be efficient because the vertically integrated structure allows the firm to escape the transactions costs inherent in a market governance structure. Is biotechnological research and the resulting intellectual property a likely candidate to fall at the vertically integrated governance end of the spectrum? For a profit maximizing private firm the research process relies heavily on some fairly specific human capital. That is, you need the researchers with the good ideas. Licensing agreements, according to our survey respondents, can be difficult and expensive to negotiate and enforce (some estimate that the minimum cost is \$50K per license). The same, again according to our survey respondents, is not true of cross licensing agreements. These do, however, require that the parties to the negotiations have sufficient IP portfolios to be able to offer something of interest for what they are receiving. Thus, the biotechnology industry generally, in an attempt to economize transaction costs, may have elected vertical integration until the point that each of the life science giants had achieved an IP portfolio that rendered cross licensing cheaper than further acquisition. This would be consistent with the recently announced agreement

⁴ Lanjouw and Schankerman (2001) note that different industries tend to have different rates of patent ownership litigation with the pharmaceutical industry being the highest.

between Dupont and Monsanto, involving several cross licensing agreements and the settling of the outstanding IP ownership suits between them⁵ (AGNET, 2002). This should not be taken to preclude the possibility that the large private firms hold and exercise market power, although it clearly shows that the present market structure is possible through firm profit maximization without collusion.

Baumol, Panzar, and Willig (1982) demonstrated that for a position of market power to be sustainable it is necessary to have some barrier to entry in place. Failing a barrier to entry the market becomes contestable and the threat of entry is sufficient to render a competitive outcome. Thus, while profit maximization on the part of the individual firms is sufficient to create the current industry structure without collusion, it remains possible that the portfolios of IP held by the current private industry participants could form a barrier to entry and allow for the exercise of sustainable market power. This possibility may underlie a great deal of the mistrust of the large life science firms in the popular press, particularly in the less developed world.

Similarly the dearth of IP ownership litigation may also be explainable through firm profit maximization. Since Adam Smith, economics has held that firms act to maximize profits. Thus, the failure of firms to pursue an active litigation agenda suggests that the firms do not perceive litigation as profitable. This can only occur if the expected benefits of litigation fail to exceed its costs. Given that the same life sciences firms engage in litigation over IP ownership in their pharmaceutical division (Lanjouw and Schankerman, 2001), while they appear to be hesitant to pursue a similar strategy in their agricultural biotechnology divisions, suggests that they must view the expected benefits differently. How dissimilar can the costs be to litigate the ownership of a gene whether it is used to create herbicide tolerance or to promote some anti cancer agent? Intrinsically there would seem to be very little reason to expect the actual litigation costs to differ greatly, thus it would seem that the differences must lie with the expected value of the patents.

Why might the expected value of agricultural biotechnology patents differ from biotechnology generally, and pharmacological biotechnology specifically? Consider the income elasticities that Regmi, Deepak, Seale and Bernstein (2001) report, that is the percentage change in the quantity of a good demanded for a one percent change in income. It is relatively clear from the data in table 1 that people throughout the world are far more likely to part with their hard earned income for medical care than for food, which suggests that it should be unsurprising to find that the same corporations view their pharmacological IP as more valuable than their agricultural IP.

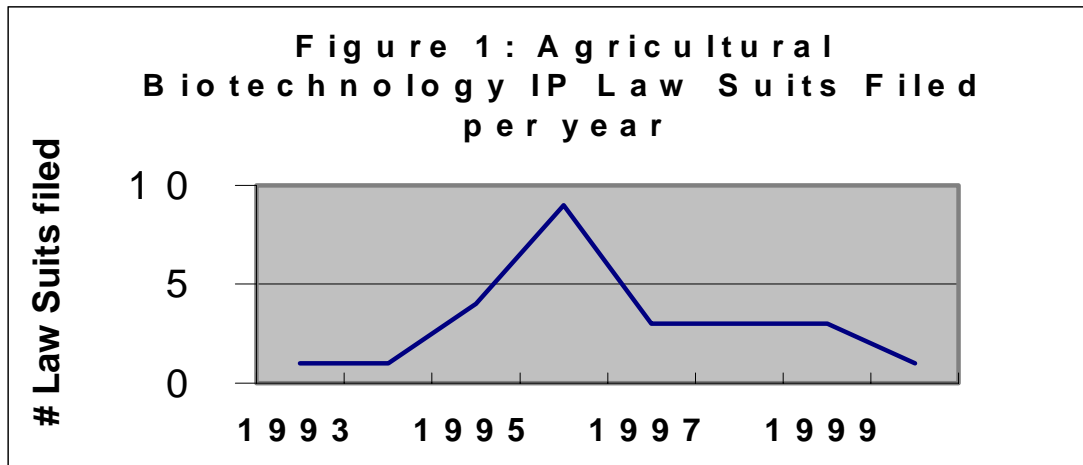
⁵ The cynical reader could be forgiven for suspecting that fear of the United States' Department of Justice was involved in the decision to cross license rather than merge.

Table 1: Budget shares and income elasticities of aggregate consumption categories

Consumption categories	--- Budget shares ---			--- Income elasticity ---		
	Low income <15% of U.S.	Middle income 15-50% of U.S.	High income >50% of U.S.	Low income <15% of U.S.	Middle income 15-50% of U.S.	High income >50% of U.S.
Food	0.47	0.29	0.13	0.73	0.58	0.29
Beverages & tobacco	0.04	0.05	0.04	0.97	0.97	0.97
Medical care	0.04	0.08	0.11	1.74	1.35	1.26
Number of countries	32	41	26	32	41	26

Source: Regmi, Deepak, Seale, and Bernstein (2001)

But this can not be the complete answer. Regmi et al (2001) argue that income elasticities for food are fairly stable over time.⁶ They make the argument by comparison to 1980 estimates. This suggests that there is nothing about the elasticities themselves that should lead one to expect litigation patterns with pronounced spikes. Yet that is what we observe by plotting the number of law suits launched per year, reported in Appendix



Source: Search of SEC Electronically Filed Forms 10-K conducted in January 2002

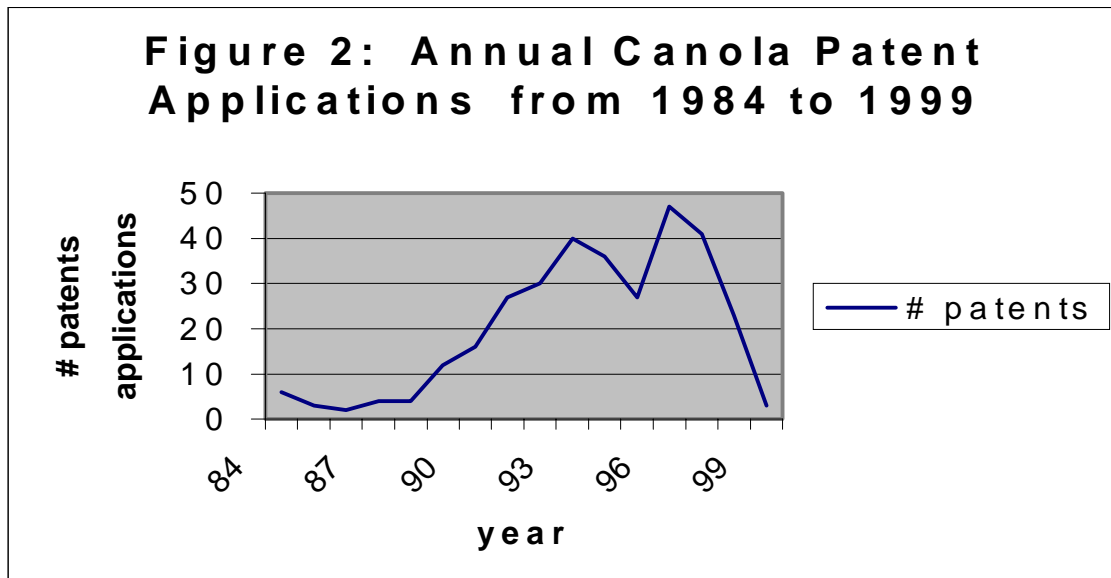
B, against time as we have done in figure 1.

Figure 1 could be different depending upon how the two lawsuits launched in 1999 and joined with the 1996 action are classified. In Figure 1 they are treated as separate cases. If they were treated as a correction of a 1996 oversight, the number of cases in 1999 would drop to one from three. In either case the 1996 spike still raises questions about why there was a spike in 1996 and a sharp fall-off in litigation afterwards. It would seem that something might have occurred to prompt the industry to amend downward its expected profits.

The questions then becomes is there anything else that suggests that 1996 might have wrought a change in the way in that the private agriculture biotechnology industry viewed the world? Should there be any additional evidence the question then becomes: what occurred about 1996 that might account for a change in view on the part of the

⁶ The interested reader should see table B-2 in their paper.

industry? The graph of canola patent applications between 1985 and 1999, shown in figure 2, does not rule out that something monumental may have occurred in 1996. If patent applications are a lagged function of expected profits and if something occurs in 1996 to call future profits into question, patent applications, analogously to the decision to litigate, could be expected to fall off as they did.



Source: Search for canola related processes and products in CIPO Canadian Patent Database, December 1999

What happened in 1996? The phenomenon that springs immediately to mind is the British, so-called, “mad cow disease” scare. The accompanying rise in consumer distrust of food safety regulators may suggest an answer. The **EuroBarometer 2000 Summary Report** after setting out that the European Union has witnessed a “significant decline in trust of all sources of biotechnology information”, from its 1993 apex, goes on to conclude:

4 Support for GM crops has declined since 1996. However, support for medical applications of modern biotechnology in the areas of pharmaceuticals and genetic testing remains high, and does not appear to have been affected by the controversies over GM crops and foods. Even the potentially controversial use of cloning techniques for human cells and tissues attracts moderate support. Hence the lower expectations for the future regarding biotechnology is as a result of attitudes towards particular applications and not to gene technology as a whole.

5 Food production is regarded as that application of biotechnology carrying the greatest risk, whereas the detection of diseases the least.

Industry has to be aware of these declines. It would seem that consumer acceptance of the final food products has to be a key element of the industry’s expected profits function, and that expectations of profits must surely have begun to fall from 1993 levels in 1996

and may well have continued to fall. This suggests that rationally formed expectations of profits are likely higher for pharmacological patents than for agricultural patents, based not only on elasticities of demand, but on consumer acceptance as well. If one cannot sell their products in Europe, what are one's expected profits?

If profit maximization provides a rational reason for private investors to fail to fully utilize the freedom to operate provisions open to them, why would the public sector, a significant player in this game, not intervene to insure freedom to operate? This query has two potential answers. The first is that the public sector does not perceive there to be a freedom to operate problem. This proposition is belied by our survey responses, which suggest that the public sector research institutions perceive serious freedom to operate problems. The second is that the structure of public sector research initiatives and the manner in which public sector researchers are compensated for developing IP combine to render the transaction costs of generating freedom to operate beyond the benefit that any single public sector research institution perceives from increased freedom to operate.

Public sector research institutions tend to have three things in common. First, they tend to be, all things considered, relatively small, particularly compared to their private counterparts. Second, they tend to reward innovation by paying some percentage of the licensing fees they receive for their IP to those individuals who developed the innovation (Phillips and Gustafson, 2000). Third, they tend to face both financial and personnel constraints (Phillips and Dierker, 2001). While preserving freedom to operate is *Pareto* improving (Dierker and Phillips, 2001), the fact that we fail to observe the public sector acting to do so suggests that individual public research institutions' managers see the benefits to their individual research institution being superceded by the litigation costs associated with using the legal system to enforce freedom to operate. IP litigation is expensive, both in terms of financial outlay and employee time. Our survey results indicated that the public sector institutions have generally not been as successful as they would like at cross licensing, the preferred way to transfer technology in the industry – cross licenses have fewer enforcement problems as both parties to the license have an incentive (access to technology they need) to not cheat. Several of the respondents attributed part of the blame for this limited success to the compensation structure for the researchers that the institutions employ and the somewhat fractured nature of the public research sector. In essence the complaints centered on the difficulty involved in putting together a portfolio of IP that will be attractive in the cross license market place. According to our survey, a credible cross licensing agreement would involve attaining the consent of numerous different individual researchers, who may well work in several different individual public institutions, whose best interest is served by a cash license (the individual researchers typically get a percentage of any cash license) rather than by a cross license, which may or may not give them access to IP that can be used to further their own research agenda. Colloquially, it is difficult to get people to “take one for the team.” In economic terms the fractured structure of the public research effort and the method of researcher compensation have established an institutional structure where the transactions costs of entering into cross-licensing agreements are high enough to largely drive the public sector out of the cross-licensing marketplace.

Some implications

If the above observations contain some merit—and we are not on the corner of the map that a middle ages cartographer would have, in beautiful calligraphy, marked with the warning “*hic dragones*”—some implications flow.

If the fall off in canola patent applications and in patent ownership litigation are indicative of concern in the private sector about profitability in the agricultural biotechnology research sector, and not due to the fact that they have found everything they think they need and are really very happy with the status quo, the implications for the industry could be profound. It is axiomatically true in economics that firms are profit maximizers. Thus if there are no expected profits there is likely to be very little private investment. If private investment completely leaves the agricultural biotechnology research industry freedom to operate concerns may be a moot issue. Patents have limited lives, and some of the earlier agricultural biotechnology patents are approaching the end of those lives. Thus, if there is no further private investment aimed at improving the technology contained in these lapsing patents, the world of agricultural research could return to a state of largely public goods research, unless, of course, the public sector research institutions continue to seek IP protection. Such a strategy may have some appeal, particularly for developing countries who could develop new technology, patent in wealthier countries and recover some of their development costs through patent rents. This would require that consumer acceptance is not going to become a problem in at least some of the developed nations and that this form of price discrimination is not going to cause trade problems that render such a strategy too costly.

Before dusting off the textbooks that address how to ensure an efficient supply of public goods, it should be recalled that consumer rejection, and particularly European Union consumer rejection, underpins the above argument. Should current concerns over GM foods dissipate, particularly before all of the present technology enters the public domain, it may be that expected profits could prove high enough, particularly given the current structure of the industry, to bring forth substantial private investment and therefore give rise to heightened freedom to operate problems. While the current trend in Europe seems clearly to be toward ever increasing consumer resistance, that is not a certainty. Should some highly desirable output trait come along, it is conceivable that consumer attitudes could transform, almost literally, over night. Should that occur, economic theory would predict that a highly concentrated private sector would act to protect an asset that has appreciated markedly in value. If this should occur the patent wars could be on.

Conclusions

The agricultural biotechnology research industry is different from the general biotechnology research industry, and particularly different from the pharmaceutical industry. Given the differences in elasticities of demand, agricultural biotechnological research is never going to have the profit potential of pharmaceutical research. Given this, the incentives for private participants in the industry to vigorously attempt to force

freedom to operate are never going to be as great in the agricultural sector as they are in the pharmaceutical sector. This also suggests that the incentive for private participants in the industry to act rapaciously, if only just a little, are going to be greater in the agricultural sector. This can potentially take two forms. First, patent applicants are likely to seek opportunistically broad protection. Second, competitors of the patent holders are going to be more likely to infringe, knowing that, if the expected profits are low enough, the holder has a far greater incentive to license than to sue. Finally, all of this hinges on consumer acceptance of the final food products that arise out of the system. Should consumer acceptance continue to wane, private research and development investment could be driven from the industry. Alternatively, should consumer acceptance begin to rise, expected profits will rise and private firms should be more inclined to protect their own rights and challenge the rights of their competitors.

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APPENDIX A

PLAINTIFF	DEFENDANT	YEAR
Enzo	Calgene	1993
Mycogen	Monsanto	1994
Plant Genetic Systems NV	Mycogen	1995
Monsanto Inc.	DNA Plant Technology Inc.	1995
Mycogen	Monsanto	1995
Mycogen	Monsanto	1995
Mycogen	Monsanto	1996
Mycogen	Monsanto, DeKalb & Delta Pineland	1996
DeKalb	Hoechst	1996
DeKalb	Pioneer Hi-Bred Int. & Mycogen	1996
Plant Genetic Systems	DeKalb	1996
DeKalb	Northrop King Co.	1996 ¹
DeKalb	Pioneer Hi-Bred Int. & Mycogen	1996 ¹
DeKalb	Becks Hibrids & Country Mark Co-operative Inc.	1996 ¹
DeKalb	Agrevo	1996 ¹
Mycogen	Ecogen	1997
AgrEvo	DeKalb	1997
Rhone-Poulenc	DeKalb	1997
Zeneca	Monsanto	1998

¹ Consolidated

Pioneer Hi-Bred Int.	Cargill, Asgrow Seeds & DeKalb	1998
Novartis	Monsanto & DeKalb	1998
Monsanto	Novartis	1999 ²
Pioneer Hi-Bred Int.	Monsanto, DeKalb & Novartis	1999 ³
DeKalb	Pioneer Hi-Bred Int.	1999 ³
Mycogen	Monsanto Australia Ltd. & Delta Pine Australia Ltd.	1999 ⁴
Aventis	Novartis	2000 ²

² Settled within a year

³ Joined with 1996 action in an apparent attempt to correct a erroneous filing

⁴ Litigating in Australia, under its **Patent Act**, a question largely settled in the United States

APPENDIX B

LIST OF FIRMS SEARCHED

1. Calgene
2. Enzo
3. Monsanto
4. Pioneer Hi-Brid
5. DeKalb
6. Dupont
7. Novartis
8. Mycogen
9. Delta & Pineland
10. Hoechst
11. Plant Genetic Systems
12. Northrop King
13. Becks Hibrids
14. Country Mart Co-opertive
15. Agrevo
16. Rhone Poulanc
17. Pharmeca
18. Dow