IPRs in Agriculture:
Implications for Seed Producers and Users

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IPRs and the industrial structure of the North American seed industry

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Abstract: Economic theory highlights the critical importance of excludability in encouraging private research and development in the agri-food sector. Without it, private research will languish and social welfare could suffer. Since 1970 governments around the world have recognized this and strengthened the legal protections for biotechnology processes and products (e.g. patents, plant breeders' rights and trademarks). These new rights have been integrated into a complex system of public and private protections for intellectual property in this sector. Consequently, this new policy spurred significant private investment in biotechnologies and related agri-food products, but a number of policy concerns have arisen. There are now concerns that the structure and level of intellectual property protection may be changing the structure of the industry, reducing competition, stifling socially desirable diffusion and use, impeding follow-on innovations and ultimately redistributing economic returns towards agrochemical and seed companies and way from farmers and consumers.

1. Introduction:

The global agri-food industry has reoriented in the past decade around technological change and innovation. Both farmers and the rest of the agri-food supply chain have recognized that the long-term threat to their livelihoods is other local and regional demand for land, labor and capital. Ultimately, the agri-food sector must deliver productivity gains at least equal to other domestic sectors, or mobile resources will be bid away.

While the technological imperative is not necessarily a new feature—waves of change involving machinery (1930-60) and chemicals (1950-90) have swept through the industry in the past—the acceleration of genetically based innovation since 1985 has fundamentally challenged the industry. In the first instance, governments have encouraged the search for new technologies and products with new monopoly intellectual property rights (both patents and plant breeders' rights) and by new or different forms of government subsidy and support. The scale and complexity of using this globalized science has precipitated collaborations between traditional competitors and between public and private research organizations and has forced researchers to go beyond their borders for new science, which has worked to create barriers to new market entrants. Furthermore, the results of the research—both technology and agri-food products—has been exploited in narrow monopolistic and oligopolistic situations, which on the face of it has the potential to reduce the social benefits of these investments.

This paper briefly examines the theoretical rationale for adopting new IPRs and subsidies and the corresponding concerns about how the industrial structure could influence the distribution of benefits and costs of those innovations. The paper then offers an assessment of the evidence of impacts, first, examining whether the new research environment is causing industrial restructuring and, second, whether the concentration is causing problems.

2. Theory:

Most economists from Adam Smith (1776) to today begin any discussion about development from the premise that the 'invisible hand' of self-interested actions of individuals and firms in a perfectly competitive marketplace can, under strict conditions, provide an optimal level of consumption, savings and investment. Joseph Schumpeter (1954) noted, however, that perfect markets with free flow of information are inimical to innovation. If a firm invests to create an innovation under these conditions, any resulting benefits would be bid away by new entrants to the market, thereby making it impossible for innovators to recoup their investments. A perfectly competitive market economy would, then, suffer a public good market failure due to inadequate investment in innovation. Schumpeter points out that sustained innovation requires private, exclusive-use property rights to the innovation in order to provide an incentive to invest.

In the past, the public sector has often filled the gap. Increasingly, however, the public sector has acknowledged that it does not have the financial and technical capacity and market knowledge to undertake enough appropriate research and development to keep the global agri-food sector profitable. Thus, more private capital and direction is required. As an incentive, the public sector has offered a variety of subsidies to private companies (e.g. free or low cost access to public research and infrastructure and cash transfers or tax credits) and extended new and more rigorous property rights to genes, genetic transformation systems and plant varieties through patents and plant breeders' rights.

The advent of new, private property rights and rising industrial investment in R&D has the potential to substantially alter the industrial structure. There are three arguments made by economists.

First, a number of economists argue that firms with patent rights to unique, transformative technology will act monopolistically and strategically, impeding the commercial prospects of competitors and extracting maximum profits from their inventions (e.g. they will act as Shumpeterian monopolists). Some decry this possibility (e.g. Binenbaum, et al, 2000, were concerned about constraints to follow-on research caused by pull-through patent provisions) while others advocate and promote it as a commercial strategy (e.g. Shapiro and Varian, 1999, counsel firms to exploit network effects and lock-in through strategies of versioning and branding). Whether one views such actions as good or bad, most economists recognize the potential for patents to accelerate industrial concentration and the potential for monopolistic exploitation (Lesser 1998). Apart from legal, antitrust action, there are two moderating influences on monopoly practices. First, the presence of a competing technology (even if it is not as good) will create either competition or a threat of competition that will limit a monopolist's ability to fully exploit their invention. Second, if inventions are rapidly being superceded by others, then a monopolist will have limited term to extract maximum rents.

Second, some economists argue that the nature of biotechnologies changes the structure of transactions in the industry (e.g. the transactions cost approach detailed by Williamson and Mahoney). Previously the agrochemical and seed businesses for the most part simply produced inputs that they transferred to farmers, marketers and processors, who managed down-stream value. Most of these supply chain relationships were governed by arms-length, spot market transactions. Now, the value of proprietary functional genes is inextricably tied to agronomic practices on farm (e.g. genes are tied to proprietary chemicals and quality assured markets), which can only be realized by managing the exchanges in a supply chain. The view is that the increasing ability to program production methods, the inseparability of contributions to ultimate value of different actors in the supply chain and the potential for opportunistic actions against actors with specific, fixed assets all necessitate vertical integration or coordination in the supply chain.

A third view is that the nature of biotechnology innovation creates natural barriers to entry that contribute to greater corporate concentration. A number of factors would support that view. The costs of entry are high (R&D costs per trait exceed US$1.5M), the probability of actually getting to market is low (25,000 trials, involving 10 traits categories and >60 species in 1980-1996 yielded only 51 varieties involving 4 traits in 15 species so far), regulatory costs are long and time consuming (they cost on average US$1-5 million and take minimum 3 years) and commercial success is uncertain (only a handful of varieties in four species have been commercially successful). Another constraint on smaller ventures is that the high capital costs require a large market area, which necessarily means either producing in multiple countries or exporting to a number of markets, both which require more regulatory effort. Given the uncertainty of the science, markets and regulation, larger more diversified firms are more likely to attract capital and be able to sustain their efforts. Hence, there should tend to be few if any small, entrepreneurial firms entering or operating in the sector.

3. The evidence:

The international seed market has been the focal point for most crop biotechnology research in recent years. Researchers are attempting either to capture a larger share of the existing market (either by changing attributes or locking in buyers) or to expand the market by adding new traits.

Table 1: Estimated values of the commercial markets for seed and planting material for some countries

	$ millions	**% of total**
US	5,700	23%
Rest of Americas	3,194	13%
Europe	8,180	34%
China	2,500	10%
Japan	2,500	10%
Rest of Asia	1570	6%
Africa	653	3%
Total	24,297	100%
- Developed countries	14,800	61%
- Developing countries	9,497	39%

Source: G. Traxler , 2003; drawn from FIS/ASA data sources.

As one might anticipate, the focus varies depending on the investor. Only about 4% of the R&D expenditures on crop biotechnology in 2001 were targeted at developing countries, even though they make up 39% of the global seed market (table 1). Most of that research is undertaken by public agencies. In contrast, about 96% of the research (more than 70% financed by private companies) are targeted on developing country markets (table 2). This could conform with all three theoretical reasons; first, IPRs are more established and effective in developed countries, which allows them to exploit monopoly power; second, transactions costs tend to be higher in LDCs; and third, the economies of scale may be less important in the larger developed country markets than in smaller LDCs.

Table 2: Estimates of Global R&D Expenditures on Crop Biotechnology; 2001		
	$ millions	% total R&D
World Total	4,400	100%
Of which:		
Private	3,100	70%
Public	1,120	30%
Industrial Country Total	4,220	96%
Developing Country Total	180	4%
Source: James, 2003.		

This increased activity is increasingly being managed and exploited through a more concentrated industry (Hayenga 1998). Agrochemical companies are at the center of the new industry. Most of the small entrepreneurial startups (e.g. Calgene, PGS, Mycogen, Mogen) which owned many of the proprietary genes and technologies have been bought by the large chemical companies while many agrochemical ventures have either bought or strategically aligned themselves to seed companies. Meanwhile, the agrochemical enterprises themselves have been in play, with all of the enterprises engaging in a least one merger, partly to consolidate IP and partly to consolidate market share. Downstream, these new integrated gene-seed-chemical ventures have undertaken more extensive contracting with farmers, offering packages of seed, chemicals, agronomic advice, financing and delivery options. So far, that is the extent of the key consolidations. There have been a few moves, however, where supply-based systems have linked up with processors to more finely develop and deliver specific quality inputs to the food and feed sector. As the industry investigates more value-added traits, including industrial and biopharma options, the vertical supply chain linkages are likely to tighten.

Table 3: Market shares of new technologies						
	New crop traits 1992-date	% US acreage in crop planted with GM seed	% Cdn acreage in crop planted with GM seed	% global acreage in crop planted with GM seed	# independent owners of traits	Monsanto share of traits
Canola	17	na	66%	11%	4	24%
Corn	22	~20%	20%	7%	5	41%
Cotton	7	>76%	0	20%	3	71%
Soybeans	7	>66%	40%	46%	4	14%
Total	78	Na	na	13%	12	36%
Sources: Agbios.com; James, various						

The evidence is that markets have been consolidating. The US is the country where the largest number (51) of the 78 new trait crops have been introduced (Canada has introduced 44 new of the traits); most of the rest of the countries only have a small set of new introductions. Furthermore, the big 4 crops (canola, corn, cotton and soybeans), which account for 70% of the new trait introductions and 99% of the GM acreage in the first 9 years of adoption, have large market shares that are controlled by a small number of firms. Table 3 shows the number of new traits adopted in each crop (ranging from 7-22), the adoption rate for the new varieties in the US, Canada and globally (ranging from 7% to 75% of total acreage), the number of independent owners of the traits in each crop (ranging from 3-5) and Monsanto's share of the new traits by crop (ranging from 14% to 71%).

The key question is whether this market concentration implies monopoly profits are being extracted. Table 4 shows that in line with rapid market adoption, the value of technology fees has gone up to $3.8 billion in just 7 years. On the face of it, one might conclude that Monsanto's dominant role (49% of technologies and approximately 92% of the GM seed market) would imply significant profits. The evidence is inconclusive. Hugh Grant, CEO of Monsanto reported in 2001 that Monsanto's free cash flow was negative every year between 1996 and 2000, totaling -$8.3 billion over the period.

Table 4: Area and value of GM technologies used in food and industrial crops

	Area planted to GM crops (Millions of hectare)	Value of GM technology fees (US$ million)
1996	1.7	235
1997	11	670
1998	27.8	1,600
1999	39.9	2,100
2000	44.2	3,000
2001	52.6	3,800

Source: James, various.

There is more general evidence of this in other areas. Phillips (2003) estimated that the industry was just breaking even with their gross investments in GM canola in Canada in 2000 (without discounting the losses caused by cannibalized herbicide markets) and that it would take another 3-5 years (about the period remaining of their IPRs) to earn a market rate of return on their investments. There are three reasons returns may be less than anticipated. First, these are highly competitive and expensive research races with uncertain returns. Second, the new trait crops have competitors both from existing traditional varieties and from successor varieties, which limits the monopolistic possibilities. Third, the seed stock is continually being adjusted and new varieties introduced, with the result that innovators continually need to provide incentives for farmers to adopt their varieties. Each of these constrains an innovator's ability to extract maximum profits.

Ultimately, the question is whether the crop biotechnology is creating value and who is gaining that value. A range of recent studies of the economic impact of biotechnology suggest that gross returns are significant and, furthermore, that while the inventors/ biotechnology industry is capturing between 12% and 57% of the total returns, a large portion is being shared with producers (13% to 88%) and some is flowing into the hands of consumers through lower prices (0% to 53%). If we compare this to before the advent of biotechnology, we see that yield enhancing benefits (which these four crops offer) tended to generate significant short-term benefits to producers (up to 50%) and large short and long-term benefits for consumers (up to 70% in the short run and 100% in the long-run).

Table 5: Distribution of economic gains from new GM crops					
Crop (trait)	Year	Annual Gross value	Industry Share	Producer Share	Consumer share
Canola (Herbicide tolerant) (a)	2000	C$170M	57%	29%	14%
Cotton (Bt)					
- US (b)	1997	US$190M	44%	42%	13%
- China (c)	1999	1,292 M RMB	12%	88%	0%
- Mexico (d)	1997-8	Na	16%	84%	0%
Soybeans (Roundup Ready) (e)	2001-2	>US$1B	34%	13%	53%
Sources: (a) Phillips, 2003; (b) Falk-Zepada, 2000; (c) Pray and Huang 2003; (d) Traxler et al 2001; (e) Traxler 2003					

4. So, should we worry?

Some argue that the reason we haven't seen more biotechnology crops or more competition is the lack of freedom to operate caused by IPRs and monopolistic practices of companies. Solutions offered include changing patent or anti-trust regulations or creating new institutions to pool IP or to invent around monopoly positions (e.g. Binenbaum et al., 2000; Graff and Zilberman, 2003). While there are a number of discrete examples where companies have not made their technology available to competitors or public programs (esp. in LDCs), it is not clear that their actions have enhanced their market power and ability to earn profits. Many of those cases had less to do with exerting market power and more to do with managing potential liabilities in less rigorously regulated markets. Some have in fact argued that virtually all technologies are technically available, but that transactions costs of effecting legal transfer are so large that they impede small entrepreneurial startups and most public research programs (Phillips and Dierker, 2001). Perhaps the biggest problem of all is that the industry is still at such an early and risky stage that the only actors that can hope to succeed are larger enterprises. Dierker and Phillips (2003) have gone so far as to suggest that the absence of accessible markets and visible profits is impeding firms contesting Monsanto's market dominance and that if, or when, significant monopoly rents arise, we may see more firms contest the market.

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