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I. INTRODUCTION

There has been a sharp increase in planting of genetically modified ("GM") crops in the past decade and further expansion is expected in the United States as well as other countries, as well as in new crops. Firms in this industry have substantial economies of scale due to the high costs of research and development ("R&D). As a result, there have been many mergers and acquisitions, and there are now fewer firms in some of these functional areas. Research to develop genetically-engineered ("GE") traits is high cost, very risky, takes a substantial amount of time to develop, and is subject to a great deal of uncertainty regarding trait efficiency, government approvals, market acceptability, and prospective impacts of competitor traits. Firms can spend in excess of $100 million to develop a trait and, for varying reasons, not have it commercialized. On the other hand, traits may be developed that have a high degree of trait efficiency and, if other sources of uncertainty are reconciled, these traits may have substantial market penetration.

Firms in the agbiotechnology industry confront important strategic choices. The most important choices concern spending on R&D, how that money is spent, intellectual property ("IP") protection strategies, and technology distribution strategies. Different approaches have been taken to these strategic decisions, particularly regarding R&D spending and seed and trait distribution.

This article describes the dynamics of R&D investments, IP, and the structure of the seed distribution sector. These topics are crucially important in understanding the structure and conduct of the agriculture industry. Some of these issues are the subject of recent papers,[2] pending litigation[3] and investigations,[4] and recently prompted a set of hearings by the

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[2] *See for example*, among others, D. Moss, *Transgenic Seed Platfoms: Competition between a Rock and a Hard Place?* American Antitrust Institute, Oct 23, 2009 among others. This was the topic of an August 2009 conference sponsored by the Organization for Competitive Markets, *available at* (http://www.competitivemarkets.com/index.php?option=com_content&task=view&id=1&Itemid=5).

[3] *See* http://www.monsanto.com/dupont-youbethejudge/ and *DuPont Alleges Anti-Competitive Conduct by Monsanto*, Pioneer press release, (May 5, 2009), *available at* http://www.pioneer.com/web/site/portal/menuitem.f3825e23adca22214c844c84d10093a0/ for a review of recent litigation, as well as transcripts from the initial hearing of Monsanto Company v. EI DuPont, Monsanto Company v. EI Dupont ,Transcript of Proceedings, Eastern District of Missouri Eastern Division, No. 4:09-CV-00686-ERW, *available at* http://www.monsanto.com/pdf/dupont_legal/oral_hearing_transcript.pdf

Departments of Justice and Agriculture on competition in agriculture markets.[5]

These issues also come at a very strategically important time for this industry, which is confronting several pressures. The first wave of GM traits is scheduled to come off-patent commencing in 2014.[6] Second, a new set of traits is on verge of being commercialized. These are more prolific and no individual firm is dominant. Third, the major rivals are in legal proceedings regarding, among other matters, the terms of their contracts. Finally, concerns have been expressed about excessive market power and concentration.

II. LITIGATION AMONG AGBIOTECHNOLOGY RIVALS

Many of these issues are manifested in a set of investigations and legal proceedings between two of the largest agbiotechnology companies, Monsanto and DuPont. Briefly, the claim involves licensing and interpretation of licensing agreements and restrictions. DuPont-Pioneer has had an existing licensing agreement on Monsanto's Round-up Ready ("RR"), which they have been using in their varieties. Over time, DuPont-Pioneer planned to introduce Optimum GAT Herbicide Tolerance indicating it would be more flexible and efficient than other traits. Their plan was to retire their RR varieties and replace them with Optimum GAT. Subsequently, DuPont recognized that commercialization of Optimum GAT had to be deferred because when used alone (i.e., not stacked with RR), it posed unacceptable risks to farmers.[7] As such, DuPont recently announced that commercialization of this trait would be deferred until the mid part of the next decade.

At issue are apparent restrictive covenants in the current RR licensing agreement. DuPont claims that Optimum GAT for soybeans that includes the RR is a better product and thus should be allowed to stack these traits. A "stacking restriction" contained in Monsanto's licensing agreement precludes such practices. DuPont claims it has this right, whereas Monsanto believes this practice violates their contract and patent rights. A legal ruling recently indicated DuPont had violated its contract with Monsanto.[8] This article does not seek to resolve this issue but instead to illustrate the intensity of competition among these firms as they seek to execute licensing strategies.

III. PATENTS AND INTELLECTUAL PROPERTY RIGHTS (IPR)

Monsanto and other agbiotechnology companies defend their IP "fiercely."[9] Two

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[4] In October 2009, the Department of Justice initiated an investigation of Monsanto, particularly regarding antitrust rule. Monsanto has denied any illegal actions and is cooperating with the DOJ; *see Monsanto Investigation*, AGWEEK at 7 (Oct 12, 2009). *See also* UNITED STATES DEPARTMENT OF JUSTICE AND UNITED STATES DEPARTMENT OF AGRICULTURE, Public Workshops Exploring Competition Issues in Agriculture, A Dialogue on Competition Issues Facing Farmers in Today's Agricultural Marketplace, Des Moines Area Community College FFA Enrichment Center, Ankeny, Iowa (March 12, 2010).

[5] In late 2009 several articles created a case of excessive monopoly power by Monsanto, *see* C.Leonard, *Monsanto Monopoly?*, AGWEEK at 29 (December 28, 2009 which were refuted as reported in J. Fatka, *Monsanto seeks investigation into DuPont activities*, FEEDSTUFFS at 4 (August 31, 2009).

[6] G. Burns, *Roundup patent to expire*, MCCLATCHY NEWSPAPERS and published in the FARMER'S FORUM, at 1, (March 26, 2010).

[7] *See*: http://www.monsanto.com/dupont-youbethejudge/ and http://www2.dupont.com/Media_Center/en_US/daily_news/may/article20090506a.html and more recently, *see* Monsanto Company v. EI DuPont, *supra* note 3.

[8] Leonard, *supra* note 5.

[9] *The Parable of the Sower: The debate over whether Monsanto is a corporate saint or sinner*, ECONOMIST, pp, 71-73 (Nov. 21, 2009).

mechanisms provide protection of IP in the seed sector, the Plant Varietal Protection Act ("PVPA") and Plant Patents. The PVPA was authorized by Congress in 1970 and provides protection for varieties; however, the act has both researcher and farmer exemptions. The researcher exemption allows researchers to use plant varieties in their research, while the farmer exemption allows growers to re-use seed grown from a prior year. However, the Act precludes growers from selling seed to other growers. Normally, utility patents do not have either exception; without these exceptions researchers would have to license varieties to others to use in their research and growers could not reuse seed.

The patent law does not require the inventor to license the patented technology to anyone. Specifically, "the patent holder has the right to exclude others from making, using or selling the patented product."[10]

IV. R&D IN CROP AND SEED TECHNOLOGIES

Agbioitechnology companies are, in part, research firms that invest money to create new products or platforms for crop production. In this process, they make important strategic choices. One is how much to spend on research; another is the scope of their research spending. There is a difference between expenditures to develop agrochemicals for crop protection versus investing in research to develop seeds and traits. In the evolving competitive environment among firms in this sector, the difference in scope of R&D impacts subsequent competitive rivalry. This distinction has had a drastic impact on the structure and competitive environment now observed in this sector.

Data on firm R&D depicts the value and scope of these expenditures.[11] From 1990-2008, these firms spent about $31 billion on chemistry to improve weed and insect control. During the same period, Monsanto spent over $8 billion in seed and trait R&D to improve weed and insect control. In fact, the *Economist*[12] suggested that Monsanto created this industrial sector by its focused spending.[13]

Monsanto made a strategic choice to accelerate its spending on seeds and traits in 1996 when spending increased sharply from about $200 million/year to $600 million in 1998; it reached another peak in 2008 at over $800 million. Other agbiotechnology companies increased spending on seeds and traits but did not do so until about the early 2000s. Commencing in 2006, each of the agbiotechnology companies has further accelerated their spending on seeds and traits.

One of the outcomes of these competitive pressures is an escalation of the number and diversity of products being developed, which are in varying stages of being commercialized. This has resulted in highly innovative product choices for growers and consumers and contrasts with the claim by Moss that the quality and quantity of innovation is reduced.[14]

The prospective competitive environment can be depicted by examining the planned traits that are at varying stages of development, deregulation, or pre-commercialization, see

[10] Monsanto v. Dupont, *supra* note 3 at 11.

[11] *See* Wilson & Dahl, *supra* note 1 for details.

[12] THE ECONOMIST, *supra* note 9.

[13] Monsanto claims that they pioneered the "seeds and trait" evolution which has been a pillar for their strategy and is now being adapted by rivals. This is a strategy that is now being adapted by Monsanto Company, *see* Monsanto Co. Annual Report, (November 3, 2004).

[14] Moss, *supra* note 2.

Table 1 below.[15] These data illustrate a number of important points:

1. A large number of traits are anticipated to be commercialized in the next 10 or more years.[16]
2. In many cases the forthcoming traits would result in competing solutions for the same problem.
3. A number of these are being developed jointly by multiple developers.

The dynamics of R&D competition are clear when examining the anticipated timing of competing traits. Examples include: 1) several forms of HT ("Herbicide Tolerant) seeds being planned; 2) several forms of drought resistance seeds being developed, with Monsanto potentially being first to market, followed by Syngenta, and later by Pioneer/DuPont; and 3) Nitrogen use efficient seeds being commercialized first by Monsanto, then Pioneer and Syngenta.

V. COMMERCIALIZATION STRATEGIES

Traits can be commercialized through internal vertical integration, by issuing an exclusive license to one downstream seed firm, or by issuing a non-exclusive license to numerous downstream firms. These are important strategic choices (as developed using game theory in Wilson and Huso).[17] Indeed the choice of licensing versus vertical acquisitions is a highly strategic decision. Given the uncertainties impacting this choice, the optimal combination would result in a portfolio of strategies (or tapered vertical integration) as a means to balance risks, costs, and control.

All of the major abgiotechology firms have varying strategies to work with vertical and horizontal partners. Syngenta recently indicated that it "has pursued a policy of working with everybody in the increasingly competitive biotech seed world."[18] On this spectrum of alternatives, Monsanto has pursued a broad-based[19] licensing strategy. Monsanto includes licenses to growers through its own seed firms, to independent seed companies, and to its competitors. This differs from other agbiotechnology companies who generally market their GE traits through their own seed firms.

An important strategy refers to trait stacking which involves inserting multiple GM traits into a single variety. Companies may choose to stack their own traits into their own varieties (if they own a seed firm) and/or to license them (out-license) to other seed firms or to other agbiotechnology companies. It has been common for traits of one firm to be stacked by a seed company with traits of another agbiotechnology firm. Traditionally, stacked varieties contained two traits. Monsanto offered a triple-trait stacked corn variety as well as Roundup Ready® Corn 2 (YieldGard® Plus, 2004). They concluded that stacking traits is a critical element of their commercial strategy[20] and were (in 2004) "offering more stacked-trait products this year than

[15] Commercialization depends on many factors, including successful conclusion of regulatory process. The release of DuPont's Optimum HT was moved to the mid-decade based on the recent announcement by DuPont (12/4/09).

[16] Tobin, in his testimony to the US DOJ and USDA indicated "there's 50 new traits in the pipeline for corn, 17 soy, and cotton," *supra* note 4 at 162.

[17] W. Wilson & S. Huso, *Trait Stacking, Licensing, and Seed Firm Acquisitions in GM Grains: A Strategic Analysis,* 33(3) J. AGRIC. & RESOURCE ECON., p. 382-401 (December, 2008).

[18] D. Pillar, *Monsanto-Pioneer Squabble May Build Syngenta Market*, DES MOINES REGISTER (Nov 25, 2009).

[19] ECONOMIST, *supra* note 9 at 72.

[20] Monsanto Company, *Stacked Traits*, (March 23, 2006), *available at* http://www.monsanto.com.

ever before"[21] More recently Monsanto is commercializing "Smart Stax" which contains eight traits and will be the new platform for commercialization.

Numerous issues impact these relationships. Most important are distinctions between a company stacking traits in their own seed vs. out-licensing (examples of each exist), inter-agbiotechnology firm agreements allowing stacking, and whether the traits are complementary vs. competitive. Restrictions that apply to stacking traits occur through the licensing agreement. It would be rare that restrictions would be placed on complementary traits, but restrictions on competing traits are common.[22]

Licensing is particularly critical to independent seed companies ("ISC's"). Indeed, without an aggressive broad-based licensing of patented products, these ISC's would have difficulty competing with GE traited varieties. Simply put, licensing gives agbiotechnology companies a mechanism to distribute their traits without the need to own 100 percent of their planned output, which would be excessively costly, risky, unnecessary, and strategically unwise. It is these licensing mechanisms that allow agbiotechnology firms to simultaneously protect their IP, and to pursue strategies of partial vertical integration for seed and trait distribution.

VI. DATA ON MARKET SHARES

Examining data on market shares sheds some light on the structural changes in this industry.[23] At the national level, the market share of the ISC's has grown by 10 percent, no doubt due to the increase in licensing. Thus, the data do not support claims that consolidation has "eliminated the numerous independent seed companies."[24] In contrast, this sector has flourished, and, in fact, is likely an important beneficiary of broad-based licensing GM traits.

Competition for seed sales is at the sub-national level; a result of bundles of traits developed by vertically-integrated seed companies as well as the strategies of agbiotechnology firms and their licensees—including their own seed units, independent regional seed firms, and giving licenses to their competitors (as discussed above).

Data on market shares of the top four seed-selling firms ("CR4") were analyzed at the CRD ("crop reporting district") level for the years 1998 and 2008.[25] See Figures 1 and 2 below for the 2008 distributions. First, the results indicate that the CR4s in most regions range from .5-.7, i.e., the top four seed-selling firms have 50-70 percent of market share, which is comparable to many other segments of the agricultural marketing system. Second, for both corn and soybeans, there have been changes from 1998 to 2008. The average CR4 (i.e., average across CRDs) for corn changed from 83 to 76 percent; the comparable values for soybeans indicated a change from 68 to 70 percent.[26] Specifically, the level of concentration has decreased in the case of corn indicating more competition in the more recent period. The level for soybeans was essentially unchanged.

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[21] Monsanto annual report, *supra* note 13 at 2.

[22] Many of these issues are discussed by the parties in Monsanto Company v. EI DuPont.

[23] The data in this section are from the dmrkynetec data set on agricultural input, *see* Agriculture market studies (2009), *available at* http://www.dmrkynetec.com/Contact-Us/Americas.aspx. Details are provided in Wilson & Dahl, *supra* note 1.

[24] Moss, *supra* note 2 at 13.

[24] *See* Wilson & Dahl *supra* note 1 for details on this data and results.

[26] Some CRDs had missing values and these were excluded from this derivation. These figures are simple averages; and the results were comparable with weighted by total expenditures.

The data were also summarized by measuring the number of seed firms from which producers purchased seed. These data were only available at this level for 2008 at the CRD level. Results illustrate a number of important facts. For most CRDs, each of the major competitors is represented, including Pioneer, Monsanto, Syngenta, and Mycogen. Second, and of particular importance, in most CRDs during 2008 farmers purchased corn and soybean seed from a minimum of 4-7 different companies, with some of the greater producing CRDs having as many as 21-30 seed companies represented for corn and 16 -22 for soybeans.

Thus, even though GM traits may be dominated by only a few firms, these results illustrate that there is fairly wide distribution of these traits. The mechanism by which this occurs is through licensing. It is critically important that Monsanto choose to broadly license its biotechnology traits, primarily to independent seed companies as well as, to a lesser extent, its competitors. This is not universally true across all agbiotechnology companies, but broad licensing is important since it provides choice to growers. Indeed, had it not been for this broad based licensing strategy, there would be far fewer seed companies providing technologies to growers.

VII. SUMMARY AND DISCUSSION

Agbiotechnology has become very important to agriculture and its impacts are apparent. It is particularly important in the United States, which typically benefits first from this technology (in part due to its IP protection regime), and demonstrates the greatest and fastest penetration of traits. As a result of this technology growth, numerous changes in the industry are occurring and are being challenged on a number of fronts, both legal and political. Ultimately what is being challenged is the impact of the patenting system, and the interpretation of some anticompetitive practices.

Five sets of issues are of particular importance:

1. The substantial growth in R&D expenditures in this sector.
2. The increasing amount of technology and Intellectual Property (IP) that needs protection. In the United States, there are several mechanisms in which IP can be fairly efficiently protected.
3. Firm consolidation has produced a more concentrated industry.
4. Firms have pursued different strategies of distribution for their technologies. Most important is licensing which is increasingly common. Some companies have pursued broader-based licensing to their competitors, whereas others have pursued less broad-based strategies. Ultimately, this is the mechanism that allows firms to protect its IP, and to induce investment in developing new technology.
5. Disputes are now erupting among firms regarding their interpretation of licensing agreements.

The regime of seed and traits has evolved to be an important aspect of agriculture, producing a number of choices for growers. Since agbiotechnology firms have pursued licensing of traits to growers, seed companies, and, in some cases, to competitors, the number of choices has escalated. Growers must choose which crops to grow, which technology to use, which companies' technology to plant, and which competing seed firm to buy from. This set of choices is critical and results in an intensely fierce competitive environment. Indeed, if it were not for competitive battles in R&D spending and broad-based licensing strategies, growers would have fewer choices, and the independent seed company sector would likely see its role diminished.

Table 1. Traits in the Deregulation and Pre-Commercialization Phase

Year	Corn Traits			Soybean Traits		
	Developer	*Trait*	*Trait Type*	*Soybean Developer*	*Trait*	*Trait Type*
2009	Monsanto	VT Triple Pro	Production	Bayer Monsanto	Liberty Link RR2	Producer Producer
2010	Syngenta	Broad Lep MIR 162	Production	Pioneer/ DuPont	High Oleic	Consumer
	Monsanto/ DOW	Smart-Stax	Production	Monsanto	High Stearate	Consumer
	Syngenta	Corn Amylase	Processor	Pioneer/ DuPont	GAT/Glyphosate-ALS	Producer
	Monsanto/ BASF	Drought Tolerant	Producer	Monsanto	Omega-3	Consumer
2011	Syngenta	Drought Tolerant	Producer	Bayer	Glyphosate & isoxazole tol.	Producer
	Monsanto/ BASF	High yield	Producer	Monsanto, Pioneer/DuPont	High Beta-Conglycinin	Consumer
	Pioneer/ DuPont	Increased yield	Producer		High Stearate	Consumer
	Pioneer/ DuPont	Improved feed	Processor	Pioneer/ DuPont	Low-Phytate	Consumer
	DOW	Herbicide Tol	Producer	Monsanto	High-oil soy	Consumer
	Syngenta	RW Dual Mode of Action	Producer		Dicamba Tolerant	Producer
	Pioneer/ DuPont—12/4/09	Optimum HT	Producer		Low Sat	Consumer
	Pioneer/ DuPont	Triple-mode Herb. Tol.	Producer		Bt/RR2Y	Producer
	Monsanto/ BASF	Nitrogen Utilization	Producer		Modified 7S Protein FF	Consumer
	Syngenta	Increased Ethanol	Processor		Omega-3 (EPA/DHA	Consumer
	Pioneer/ DuPont	Nitrogen Utilization	Producer	DOW	Herbicide tol.: 2,4-D and aryloxyphenoxy propionate herbicide	Producer
	Pioneer/ DuPont	Drought Tolerance	Producer	Monsanto/ Pioneer	Disease	Producer
201X	BASF	Improved feed	Processor		Soybean Cyst Nematode	Producer
	Pioneer/ DuPont	Increased Ethanol	Processor		Rust	Producer
	Syngenta	Insect Traits	Producer	Syngenta	Disease Resistance	Producer
	Syngenta	Nitrogen Utilization	Producer	Monsanto/ Pioneer	Disease Resistance Soybean Cyst Nematode	Producer

Source: Adapted from industry sources, and as summarized recently by Sipple at the CNMA (available at http://www.canadagrainscouncil.ca/public/CGCDocument/www_view_public?dgid=2). The estimated commercialization pipeline of corn and soybean biotech events was prepared by the U.S. Grains Council and the American Soybean Association, November 2007. Updated March 2009.

Figure 1. Corn 4 Firm Market Shares for Expenditures, 2008.

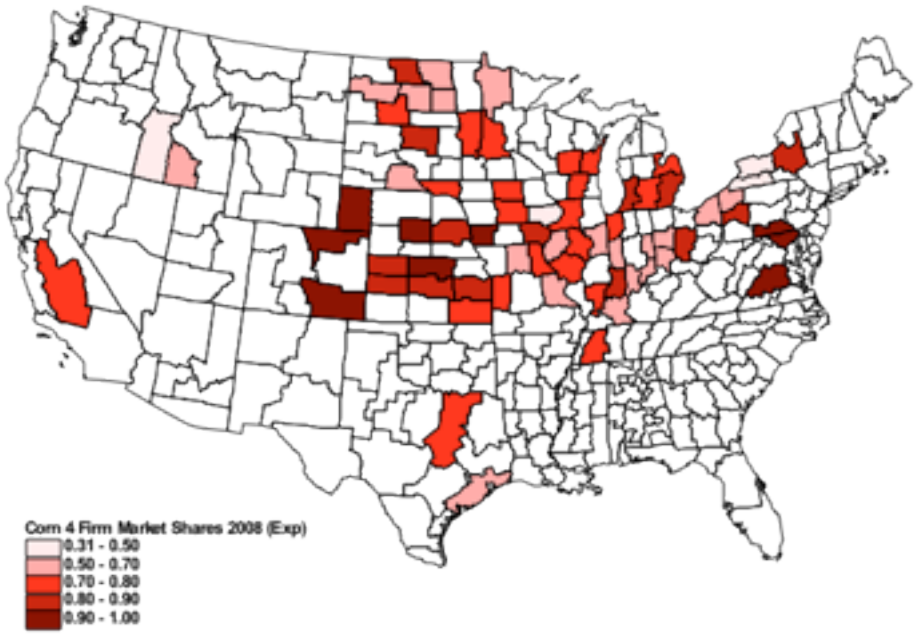

Figure 2. Soybean 4 Firm Market Shares for Expenditures, 2008.