STRUCTURE AND COORDINATION SYSTEM CHANGES IN THE U.S. BIOTECH SEED AND VALUE-ADDED GRAIN MARKET

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Prepared for Presentation at the
IAMA 1999 World Food and Agribusiness Congress
May 1999

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I. Introduction

Dramatic changes in the seed/biotech/chemical complex have been triggered in the last five years by the "coming of age" of agricultural biotechnology. A recent wave of mergers and acquisitions has quickly changed the landscape in the biotechnology, chemical and seed industries. Several major players in the seed/herbicide/biotech complex are emerging as leading competitors developing and/or marketing the early biotech products in the grain and oilseed industries.

First generation agrobiotechnology products have been crops with herbicide tolerance and resistance to particular insect pests. Second generation products, transgenic plants with enhanced quality traits, like changed oil composition, changed amino acid composition, etc. are fast approaching commercialization (Kalaitzandonakes and Maltsbarger).

Even the optimists among biotechnology proponents have been caught off guard by its extremely fast adoption rates at the farm level. In 1999, just four years from commercial introduction, almost 50 percent of the total U.S. corn, soybean and cotton acreage will be planted with transgenics (Kalaitzandonakes 1999a). Herbicide tolerant and insect resistant crops have created significant on-farm value, mainly through cost savings from reduced insecticide and herbicide use and improved risk management in pest control (Carlson et al., Gibson et al., James).

In this paper, we briefly summarize the structural changes in the seed/biotech/grain marketing systems, and the reasons underlying this merger/acquisition boom. Then we focus on the likely directions of change in the seed company/farmer/handler/end user vertical chain, based on interviews with managers involved in the newest product developments, and some market observers. Will the vertical system look like the Pioneer/DuPont high oil corn chain initially linked by their joint venture and contract links? Will more open markets develop for value-added commodities requiring segregated handling systems? Will long term marketing contracts or production contracts with farmers be dominant? Will computerized market information, contract or market management systems be necessary to insure traceability of a product through the system as well as effectively manage many disparate players involved in the production and marketing process?

II. Structural Change in the Seed Industry

First generation agrobiotechnology has focused on the needs of high volume markets. Competing intellectual property developers have been heavily contesting their rights in both the courts and the marketplace. A number of multiparty intellectual property disputes for key technologies, such as insect and herbicide resistance, reached the courts over the last few years and led to the invalidation of key patents or the acknowledgment that one patented approach did not necessarily infringe on another (Hayenga).

To deliver the new technologies and capture a greater part of their value, both a distribution system and the breeding program are required. In this fashion, innovative genes can be quickly incorporated into effective germplasm delivery systems. In the face of contested intellectual property rights, vertical integration into the seed business and ownership of germplasm became an almost necessary strategy of agrobiotechnology firms (Joly and deLooze, Kalaitzandonakes and Bjornson). Compared to licensing, ownership of branded germplasm allows agrobiotechnology firms to enter the market faster and capture a higher share of the value. Part of the value created from biotechnology has been transferred to seed assets in the form of lofty prices paid in recent mergers and acquisitions (e.g. Holdens, DEKALB, Pioneer).

Monsanto led the way with massive investments in biotechnology research, and with subsequent seed and biotechnology company mergers and acquisitions. Novartis, Dow Agrosciences, AgrEvo (Hoechst/Schering), and Zeneca and van der Have are all involved in similar efforts, albeit on a reduced scale. DuPont and Pioneer had been involved in a partial ownership, joint research and marketing venture (Optimum Quality Grain), but recently DuPont has made a bid to buy the remaining 80 percent of Pioneer for $7.7 billion.

Pioneer Hi-Bred International has been the leading branded seed merchandiser in the corn and soybean markets. Pioneer's market was near 40 percent in corn and 16 percent of purchased soybean seed in 1998 (Table 1). Monsanto's purchases of Asgrow and DEKALB Genetics resulted in a branded seed corn market share near 14 percent. In addition, Monsanto's purchase of Holdens gives them significant influence over germplasm sold to other companies but also encourages competition in the branded seed market. Holdens' germplasm is estimated to be part of an additional 30-40 percent of branded seed sales.

With Monsanto's acquisition of DEKALB, and DuPont's acquisition of Pioneer, these two companies combined will either own or significantly influence some 80 percent of the North American seed corn market. Historically, both Monsanto and DuPont have followed open technology architectures. Monsanto has licensing agreements for its Roundup Ready and YieldGuard technologies with a large number of seed companies and DuPont had broadly licensed its high oil corn technology. Whether such open architectures continue to be used by these leading biotechnology and germplasm suppliers in the future, remains to be seen.

Other companies have also been involved in the restructuring of the seed industry. In 1996, Novartis combined the Ciba-Geigy (one of the first marketers of Bt corn) and Northrup King seed businesses. Novartis then capitalized upon the Bt products of these companies in order to expand its corn seed market share from about 6 percent in 1995 to 9-10 percent in 1998. Dow Agrosciences recently acquired Mycogen. Mycogen has a 4 percent market share in corn seed. In addition, Dow Agrosciences recently acquired part of Illinois Foundation Seeds which provides foundation seed for another 11 percent of branded seed corn sales by regional companies. AgrEvo had purchased, then canceled the purchase of Cargill's domestic seed business, while Monsanto acquired Cargill's international seed business.

The soybean market has long been considered the low margin part of the seed business. In the soybean seed market there is no hybridization to differentiate products, and a significant amount of farmer-saved seed. In addition, public varieties from universities provide low priced competition that has limited branded soybean seed profit margins (Kimle & Hayenga, 1993). Pioneer's entry into the soybean seed market in the early 1980s, and their very large corn market shares and strong dealer system, have resulted in their emergence as the leading soybean seed company in the early 1990s. Asgrow and DEKALB were strong competitors recently acquired by Monsanto. Asgrow has capitalized on the Roundup Ready soybean demand in order to capture the largest market share (17 percent) in 1998, partly at Pioneer's expense (Table 2). After the DEKALB acquisition, Monsanto seed companies account for 23-25 percent of purchased soybean seed in 1998, up five points from 1997.

Delta and PineLand has long dominated the cottonseed market (Table 3). Monsanto became a competitor when it bought Calgene and Calgene's cottonseed subsidiary Stoneville. Monsanto's bid for the purchase of Delta and PineLand (71 percent of the cotton seed market) has not yet been approved by the Justice Department, but Monsanto has agreed to divest itself of the Stoneville cottonseed business (16 percent of the market).

III. First Generation Biotechnology: Insect and Herbicide Resistance

In 1999, just four years from commercial introduction, almost 50 percent of the total U.S. corn, soybean and cotton acreage will be planted with transgenics, either herbicide resistant or insect resistant crops. Herbicide resistant seed and related chemical packages are transforming the input supply market and the competitive arena dramatically, especially in the soybean market where 70 percent of all acreage is expected to be Roundup Ready soybeans treated with Roundup herbicide or a soon-to-be-marketed generic glyphosate equivalent in a few years. Insect resistant corn and cotton and herbicide resistant corn and cotton are also major market factors already or in the near future. When rootworm in corn, the major corn insect pest, can be controlled by genetically engineered corn in a few years, the insecticide market volume will likely drop sharply (Hayenga).

Monsanto has used restrictive contracts to capture a significant share of the value of first generation biotechnologies. Growers buying Monsanto's insect or herbicide resistant seed have had to sign contracts guaranteeing no reuse of seed in the following year. This restriction has especially added sales in soybeans where use of farmer-saved seed has historically been significant.

Growers must pay technology fees to the seed company which collects them for Monsanto and receives a handling fee. Technology fee list prices ranged from $32 per acre for Bt cotton, to $5 per unit for Roundup Ready soybeans in 1998. Some Bt competitors charge less without a contract or a separate technology fee identified.

Another innovative feature of Monsanto's licensing strategy is their Roundup Ready corn licensing contracts with seed companies. Seed companies are provided substantial financial incentives to have Roundup Ready corn sales reach at least 2 percent of total sales by 2000, and 85% of all herbicide tolerant sales by 2002. Restrictions have been placed on the other traits that can be stacked with Roundup resistant traits. Further, Monsanto decides the grower technology fee which will be charged each year by the seed companies selling licensed Monsanto technology. These contractual restrictions may be subject to individual company negotiation and may change over time -- possibly as part of the DOJ agreement reached in early December. These restrictions were likely a major factor influencing Pioneer's announcement in 1998 that it would not license the Roundup Ready corn technology from Monsanto (Hayenga).

IV. Second Generation Biotechnologies: Value Added Traits

The primary value-added crop on the market today is high oil corn developed by DuPont, which is marketed through the new DuPont-Pioneer joint venture -- Optimum Quality Grains. This product is not genetically engineered. Approximately 2 percent of corn acres were high oil corn in 1998 and has experience modest growth.

There are a number of genetically engineered varieties of corn and soybeans that will be entering the commercial market on a small scale in 2000. These products will come from several companies. According to industry participants, corn, soybean and canola traits likely to provide added value in the next five years include:

- high oil, high oleic acid corn; high oil, low phytate corn; high oil, high lysine corn; modified starch corn for processing or digestibility; improved amino acid (protein) corn or soybeans balanced to needs of pigs or broilers;

- soybeans with high oleic or low linolenic acid levels, low in saturates, high in stearic acid, high in sucrose (low oligosaccharide), or various food grade beans suitable for tofu, natto, or offering high isoflavone claims for the consumer end products;

- canola with high laurate, high oleic/low linoleic, and/or high erucid properties.

These genetically modified products will have improved qualities that match the needs of feeders and food processors or provide direct health and nutritional benefits to the consumer. More exotic technologies that turn plants into protein factories are also being advanced.

Value-added traits will be "stacked" with herbicide and insecticide resistance traits to provide higher value seed, which offer lower costs and/or higher yield, and increased value of the end product. These cost or revenue improvements will be shared with all contributors in the chain (or the innovation will not survive commercially).

The introduction of value-added crops is likely to involve contractual links among the seed company, the farmer, the elevator, and the end user in order to segregate the value-added product from standard commodities and to capture and preserve its added value. This is the model being followed with Optimum Quality Grain's identity-preserved high oil corn.

However, value-added trait revenues must exceed the added costs of the identity preserved system. Currently the high oil corn net value contribution is said to be small. Will the added value of each of the traits mentioned above be sufficient to be a stand-alone product that could warrant a higher cost system? Or will a package of stacked traits will collectively be necessary to provide sufficient revenue to cover the higher cost system and generate sufficient payoff to the biotech innovator, the seed company, and all other intermediaries in the chain? As the volume of value-added commodities increase, some economies of scale should also reduce the costs of the identity preserved systems required, and the incentives necessary to secure collaborators in the chain will fall to competitive levels for the assets or services provided.

V. Coordinating the Value Adding Chain

Second-generation biotechnologies will require more adjustments in the grain business than the first generation products did. The first generation products primarily had farmers as the end user. With second-generation products, the General Mills cereal manager or the Japanese soy processor may be directly involved in determining the value and the organization of the new product chain. End-users much further upstream must be able to appreciate and take advantage of the value created by quality-enhanced crops, and evaluate the process efficiency or consumer demand enhancements which influence their value to their company. Crop merchandisers must learn how to effectively segregate quality enhanced crops and how to optimize identity preserved supply chains. Feeders, through feeding trials, must experiment with and tailor these technologies to their genetics. Processors must learn how to leverage quality enhancements and build additional value around them. Consumers must learn to recognize the products and to correlate nutritional benefits and value. Other parts of the system must also adjust.

The higher the investments required for the commercialization of quality-enhanced crops -- whether in learning or physical infrastructure-- the slower market penetration will be. To be sure, there is significant innovation and investment taking place in all parts of the supply chain at this time. Feeders and integrators are experimenting with a variety of quality-enhanced crops and animal genetics. Significant investments are being made in information systems for the creation of virtual markets and management systems appropriate for identity preserved supply chains. Most elevators expect that within five years 25 percent of their turnover will come from quality-enhanced crops and are either preparing for or carrying out relevant investments in storage suited for identity preservation. All these investments are in line with the high prospect values of second-generation biotechnologies. Nevertheless, they also suggest that market penetration of such technologies will likely be slower than that of the first-generation (Kalaitzandonakes 1999b).

For value added traits, some variants of coordination have emerged suggesting possible schemes for value distribution. Mycogen develops, produces and delivers proprietary high oleic sunflower seeds exclusively to AC Humko, the world's largest marketer of edible oils. Similarly, DuPont, through its bid to acquire Pioneer Hi-Bred and its acquisition of Protein Technology International (which has over 70 percent market share of the food quality soybean protein market) is preparing for tight coordination from seed to the end-user. Monsanto and Cargill are preparing to jointly develop and commercialize quality-enhanced bioengineered crops targeting the feed and other processing industries. Their joint venture combines Monsanto's extensive capabilities in biotechnology and seed with Cargill's global processing infrastructure and marketing and logistics capabilities. The DuPont-Pioneer joint venture (Optimum Quality Grain) may be a prototype.

<u>The Case of Optimum High-Oil Corn</u>

High oil corn (HOC) has been the most visible identity preserved grain to reach market. HOC averages 6-8 percent oil content compared to 3 percent for conventional corn varieties. It also exhibits increased levels of crude protein and amino acids. Virtually all high-oil corn varieties are marketed under the OPTIMUM brand developed by DuPont. In the U.S., OPTIMUM was first introduced in 1992 and was planted on approximately 1.5 million acres in 1998, indicating significant interest by end-users.

Initial estimates for HOC show added value up to $0.44/bu in livestock production. The added value stems from projected savings in supplemental fat and improved digestibility and feed efficiency. The values of HOC change with prices of substitutes, complementary inputs, or the final products.

In 1997, farmers or feeders who fed it directly to their livestock produced 70 percent of all HOC. Growers contracted the remaining 30 percent for export, sold typically at premium prices to countries where fat additives are in short supply. Widely differing market values between domestic and export markets encourage a two-tiered marketing strategy for OPTIMUM HOC. In the domestic market, value is captured by premium prices on seed corn sold by more than 80 licensed seed companies, including market leaders DEKALB and Pioneer. In export markets, DuPont/Optimum captures value by contracting with end-users and with farmers. Identity preservation and supply chain logistics are managed through a strategic alliance with Continental Grain (being purchased by Cargill), with an internet-based contract management and information system developed and managed by E-Markets Inc.

OPTIMUM contracts with farmers include a fixed premium per bushel delivered. These contracts involve few production restrictions one of which is the purchase of seed from one of the over 90 licensed seed companies that carry OPTIMUM's technology. For 1998 the premium paid for OPTIMUM HOC was $.25 per bushel, an amount which more than offset the $.07 per bushel seed premium paid by the grower. HOC may be delivered to the contracting elevator or stored on farm for an extra premium payment. Buyer-calls for delivery of grain stored on the farm allow elevators to coordinate storage and transportation and manage capacity utilization helping to avoid management error if deliveries were to arrive during peak harvest operation times. In 1997, the on-farm storage premium was $.05 per bushel for buyer-call delivery contracts.

Delivery systems coordinated through Continental Grain utilize grain stocks from elevators and on-farm storage to fulfill export agreements developed by DuPont. Grain delivered to one of over 80 export contracting elevators, is shipped in segregated loads to a port location where grain is packaged for delivery in 50,000-bushel loads. Near infrared technology is used to assess nutritional composition at each delivery point in the chain. The grain is often analyzed for oil content and other characteristics up to 3 times at elevator, rail and barge port facilities.

Thus, the series of marketing contracts at the farm, elevator, barge, and ocean freight stages of the growing and handling systems link the system together, with an internet contract management and information system to help coordinate the logistics.

VI. Contemplating Future Chain Coordination Systems

What are the factors expected to influence the type of industry organization and coordination, control, and the gains from the new technology? We would argue that the owner of the intellectual property and the end user will likely gain the most. They will also determine how the system will be organized and what the share of value distributed to the various chain participants will be. Concentration and product differentiation among technology and germplasm suppliers may secure, at least temporarily, above normal returns. Under the more competitive structure at the farm, elevator, barge, etc., levels these parts of the product chain will likely earn lower competitive returns on assets and services.

From an industry-wide or system perspective, the value of traits relative to their cost to the ultimate customer and the efficiency of the marketing system in passing appropriate incentives/signals back through the input supply-production-marketing-processing system are important performance dimensions. A variety of organizational forms could facilitate production and distribution but we expect that marketing contracts will likely be commonplace. Owning farmland ties up a lot of capital at usually low returns, so corporate ownership is unlikely even in areas where laws do not proscribe that. Production contracts with farmers involve more assets and oversight provided by the contractor. Such contracts emerge only where the production process is extremely complicated, or where special incentives or monitoring are necessary to protect high value germplasm or product integrity (e.g. seed corn production contracts may be analogous).

The ability to measure the added value trait effectively and quickly in the ordinary course of business will determine whether marketing contracts or open markets would be feasible organizational alternatives. "Certify but verify" may be applicable here. An inability to quickly measure the valued trait will often require self production or production contracts at the farm level to insure quality of the end product.

For open markets, there would have to be some liquidity in the market, which means enough suppliers and customers to arbitrage market imbalances at relatively low cost or risk. Speedy measurement systems would therefore be essential. Open markets may work for traits where there are a large numbers of buyers and sellers, high volume, and effective substitutes (e.g. corn and fat for high oil corn) which limit the downside risk from adverse price moves or product shortages. Open markets are not likely where the opportunity costs associated with supply-demand imbalances for very distinctive products are too high; contract assurances may be essential, at the least.

The difficulty and expertise required in production, handling, or processing, and ability to monitor effectiveness of effort, may affect the degree of control or ownership of the intermediate products exercised by the owner of the intellectual property at each stage of the process. Similarly, the speed of and incentives necessary for producer and grain handler adoption of new practices and acceptance of the new technology may determine whether self-production or handling is necessary

Vertical integration would be likely when measurement and monitoring aren't feasible, when incentives necessary for contract partners are too expensive, and when protection of intellectual property or trade secrets is paramount.

None of these chain organizations have farmers in control, even in the markets scenario that involves more independence and more risk. All have varying degrees of independence lost by farmers, grain handlers, processors, in return for incentives offered. All will have the residual value captured for the patent period by the intellectual property owner, though the payoff will depend on: (a) the ultimate value of the trait to the final customer; (b) the costs and risks incurred in the food chain to supply the trait; (c) the effectiveness, cost and speed of substitutes becoming available.

Table 1. Seed Corn Market Shares in the US, 1998

Company	Percent
Pioneer Hi-Bred	39
Monsanto *DeKalb* *Asgrow*	**15** *11* *4*
Novartis	9
Dow Agrosciences / Mycogen	4
Golden Harvest	3
Cargill	4
Advanta	3
Others	20
Source: Industry Estimates	

Table 2. Purchased Soybean Seed Market Shares in the US, 1998

Company	Percent
Monsanto *DeKalb* *Asgrow*	**24** *8* *16*
Pioneer Hi-Bred	17
Novartis	5
Dow Agrosciences / Mycogen	3
Stine	4
Other brands	39
Public varieties	10
Source: Industry Estimates	

Table 3. Cotton Seed Market Shares in the US

Company	1997	1998
Monsanto *Delta & Pine Land* *Stoneville*	**84** *72* *12*	**87** *71* *16*
Other	16	13
Source: Agricultural Marketing Service. (1997;1998). Cotton Varieties Planted. Washington, DC: United States Department of Agriculture.		

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