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Concentration and Technology in Agricultural Input Industries

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Abstract

Consolidation in the agricultural biotechnology industry can both enhance and dampen market competition. This report examines the causes and consequences of industry consolidation and its effect on market efficiency. In some cases, concentration realizes economies of scale, which can improve market efficiency by driving down production costs. The protection of intellectual property rights is integral to the agricultural biotechnology marketplace, stimulating research and development, investment, and the development of substitute markets. However, excessively broad intellectual property rights can hinder the market for innovation. Recent data on mergers, acquisitions, and strategic collaborations in the agricultural biotechnology industry, as well as the emergence of "life science" conglomerates, indicate some level of consolidation. However, the move by some companies to divest their seed operations calls into question the long-term viability of these conglomerates.

Keywords: industry concentration, consolidation, biotechnology, market efficiency, market power, intellectual property rights, agricultural input industries, mergers, acquisitions.

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Concentration and Technology in Agricultural Input Industries

Introduction

Recent innovations in genetic science and agricultural biotechnology have created commercial seed varieties that promise higher yields, reduced input use, and other desirable new properties. Adoption of genetically engineered seed and complementary farming techniques has rapidly become widespread.

However, investments in biotechnology are often risky, expensive, and long-term. Partially in response to the risk and cost associated with agricultural biotechnology research and development (R&D), recent years have witnessed consolidation in agricultural industry R&D, and the formation of so-called "life science" companies that apply biotechnology to both pharmaceutical outputs and agriculture. However, the emergence of "life science" companies in many cases has been followed quickly by divestiture of their agricultural biotechnology interests.

This report begins with a summary of the economic causes and consequences of industry consolidation. Industry consolidation resulting in highly concentrated agricultural input markets can erode competition, leading to inefficient markets and to higher prices paid both by "downstream" purchasers of inputs and by consumers. However, industry consolidation is not necessarily inefficient: in certain circumstances, the economic benefits of consolidation can outweigh the effects of the potential decrease in competition.

Another focus of this report is the special relationship between concentration and technological change. Technological leaders with successful R&D projects can take control of a market segment for a limited time by offering new or improved products.

An advantage gained through successful R&D can be maintained as long as a technological leader can stay ahead of the competition, sometimes with protection from intellectual property rights such as patents and plant variety protection certificates (PVPCs). In some cases, the economic drawbacks of concentrated, non-competitive markets are compensated by the long-term productivity growth associated with technological change.

Finally, this report examines recent consolidation behavior in the U.S. seed industry as a case study, using a sample of U.S. seed industry mergers, acquisitions, and strategic collaborations to illustrate the short-term factors behind consolidation and the possible effects on agricultural biotechnology R&D. Because of the rapid pace of technological change and industry consolidation, the U.S. seed industry has the potential to illustrate changes in industry structure arising from these two forces.

For example, recent data on industry consolidation in the U.S. market for seed and related agricultural inputs feature the emergence of "life science" conglomerates, large companies able to apply investments in R&D to both agricultural and pharmaceutical applications. However, subsequent divestiture calls the long-term viability of these conglomerates into question.

Positive and Negative Aspects of Concentration

Concentration in any industry is a concern when market power hinders the efficient operation of markets. For instance, a dominant firm with market power can raise the prices it charges consumers without fear of being undercut by competitors. A firm with market power might also be able to drive down the prices it pays suppliers, reducing suppliers' profits and distorting their incentives to produce. But industry concentration may also have positive economic benefits, including economies of scale and other effects.

Concentration can negatively affect market efficiency. An efficient market is one in which buyers and sellers arrange transactions whenever a transaction exists that will benefit both parties. When industry consolidation reduces the number of buyers or sellers to the extent that the remaining market is concentrated, the remaining buyers or sellers can gain a measure of market power. They can use their market power to limit some mutually beneficial trades, distorting prices in their favor.

For example, a firm that limits output to increase prices higher than a competitive market would bear drives some buyers out of the market. The firm could have supplied these buyers at a lower price and still achieved a profit, potentially benefiting both buyer and seller. But the firm refuses to expand the market, preferring instead to maintain the high prices it charges to remaining buyers.

In a different example, concentration of buyers of inputs might reduce the prices they pay to suppliers. Without the pressure of competing buyers to bid up prices, suppliers must take the lower prices for their products. However, low prices reduce industry supply and force some suppliers to switch into other industries or reduce output to more efficient levels. Again, price distortions of market power eliminate some volume of mutually beneficial transactions.

In addition, the absence of vigorous competition lessens the pressure on producers to make efficient use of resources. As a result, market power arising from industry concentration can increase production costs, reducing aggregate economic efficiency.

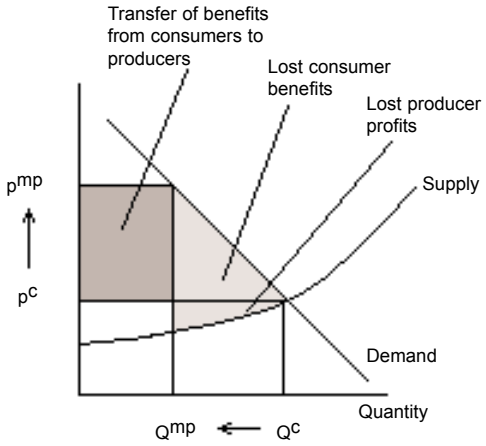
Concentration raises concerns about market equity or "fairness." In addition to price distortions that create market inefficiency, market power due to industry concentration can reallocate the benefits of market transactions. Of course, buyers and sellers who are forced out of a market by price distortions lose the chance to make beneficial trades, so the total economic value of a market decreases. But market power also redistributes the economic benefits of transactions that do take place. Firms with market power capture a greater share of the economic value of a market; consumers typically bear the burden, paying higher prices for goods of lower quality (fig. 1).

Industry concentration can have positive effects as well. Despite the decreased potential for competition, sometimes markets are more efficient with fewer suppliers. For instance, some industries are characterized by economies of scale, meaning that average costs of production decline as quantities increase. In other words, it is more efficient to have a few firms operating at high outputs than to have many firms producing a smaller market share. In such cases, the lowest cost of production is achieved in large amounts, and the most inexpensive organization of production to meet market demand involves a small number of very large firms. When competition is vigorous despite the small number of market participants, the risk of market power is lessened, and there are gains in efficiency because fewer firms incur fixed costs.

Market power can be held in check by the threat of new competitors. An important limitation to market power in any industry is the threat posed by potential new competitors. Price distortions and market inefficiency can be an incentive for new competitors to enter a market, meeting demand more efficiently. The threat of entrants can enforce market discipline, preventing firms in a concentrated industry from maintaining high prices because of the competition they might attract. In addition, markets for new products can arise over the long term, offering a substitute for the products supplied by concentrated, noncompetitive industries.

Market efficiency depends on the level of market competition, not the number of competitors. Market con-

Figure 1—Economic effects when a concentrated industry restricts output[1]



Source: Varian, 1999.

[1] When market power allows one or more dominant firms to raise the price above a competitive level (from Pc to Pmp), the quantity exchanged in the market decreases (from Qc to Qmp). This lost quantity of transactions is the magnitude of market inefficiency caused by market power, the volume of mutually beneficial transactions that do not take place. The value of these lost transactions, called the "dead weight loss," is equal to the roughly triangular shaded region. This region is composed of benefits lost to consumers and profits lost to producers. However, the higher price under market power reallocates some remaining market benefits from consumers to producers, represented by the dark rectangular region. In this example, producers profit from market concentration and consumers receive less output and pay higher prices. When buyers have market power, producers typically receive low prices and benefits are shifted to buyers. In either case, price distortions tend to reduce the aggregate amount of economic activity.

centration does not always imply market power. The presence of only a few buyers or sellers in a market does not mean that those market participants are not competitive.

On the other hand, the existence of many firms does not always imply adequate competition: if markets are highly segmented (for instance, geographically), many firms could each have inordinate market power in the market segment they control. And while market efficiency and equity may suffer when industries consolidate and become concentrated, industry consolidation can be an appropriate response to realize economies of scale or offset declining demand.

Furthermore, entry by new competitors and the development of substitute products pose important checks against the exercise of market power.

As a result, determination of the underlying causes of industry concentration is only possible with detailed, case-by-case analysis.

Concentration and Intellectual Property

Intellectual property rights restrict the number of suppliers in a market in order to provide incentives for innovation. Examples of intellectual property protection instruments are patents for inventions, copyrights for literary and artistic works, and plant variety protection certificates (PVPCs) for desirable plant traits. Because intellectual property rights restrict market entry, they result in concentrated, protected markets. However, market power arrived at through intellectual property protection preserves incentives for investment in new products and technologies that are otherwise easily copied.

Imitation of new technologies and creations is usually cheaper and quicker than inventing them anew, so technology leaders without intellectual property protection would be forced to compete against entrants with lower average costs. Entrants could charge lower prices and drive a technological leader out of the industry with his or her own creations. If firms refuse to invest in R&D under these circumstances, this creates a market failure in the development of new technologies and product improvements. Since long-term economic growth and productivity gains depend in part on technological innovation, intellectual property rights are an important safeguard against this market failure.

Intellectual property protection sacrifices short-term market efficiency for long-term gains. By preventing the entry of imitators and competitors, intellectual property protection actually encourages inventors to exert market power. A patented product shields its owner from competition and allows the patent holder to charge prices higher than an efficient, competitive market would allow in the short term. The resulting industry might not operate efficiently, in the sense that buyers and sellers could find more mutually beneficial trades but for the price distortions of concentration. In addition, the institutions that assign, monitor, and defend intellectual property rights are costly to support.

But the potentially large profits associated with this product are a necessary economic incentive to reward risky investment in its development. In the long term, the economy benefits from the discovery and invention of new products and product improvements. In relation to the earlier discussion of checks on concentration, intellectual property rights prevent the entry of new competitors but encourage the development of substitute markets. In essence, intellectual property rights constitute a bargain in which society tolerates short-term market inefficiency for long-term gains in quality and productivity.

An important role of intellectual property rights is to create a market for innovation. Firms with important intellectual property assets do not necessarily possess the complementary assets, commercial skills, or market presence necessary to bring their products to market. In some cases, the difficulty and complexity of innovation might require inventors to focus on their scientific and technological expertise rather than on the entrepreneurial skills necessary to successfully market the resulting products. Intellectual property rights provide inventors a negotiating tool with which to license or sell an invention to established firms better positioned to commercialize it.

Excessively broad intellectual property rights can inhibit the market for innovation. Government authorities are responsible for defining the limits of intellectual property rights. For example, the U.S. Patent and Trademark Office examines U.S. patents and the U.S. Department of Agriculture administers PVPCs. In some cases, intellectual property rights for two different parties may overlap, which could lead to litigation. Strong intellectual property rights might also hinder innovation if granted on a "research tool" or fundamental technology necessary for future improvements.

While intellectual property rights can be licensed to other parties, owners of these kinds of intellectual property rights might refuse to grant licenses for strategic reasons (e.g., to prevent a competitor from "inventing around" a market position). The problem compounds in areas of rapid and complex research in which many licenses might be necessary for further improvements, because the owner of any one of them could hold up further research. Coping with these potential problems with intellectual property rights can raise transaction

costs in the market for innovation, reducing the level of investment in beneficial technologies and product improvements.

Firms with intellectual property are sometimes purchased outright. Intellectual property rights give firms the ability to license their innovations while retaining control over them. However, firms can also be purchased outright as a means to acquire their intellectual property assets. This might be an especially expedient solution to the "hold up" problem when several intellectual property rights conflict. Acquisition of intellectual property in this way can contribute to industry concentration, with undesirable effects for short-term market efficiency. However, this is also one part of the process by which industries reorganize (and potentially consolidate) in order to realize the long-term economic value of innovations.

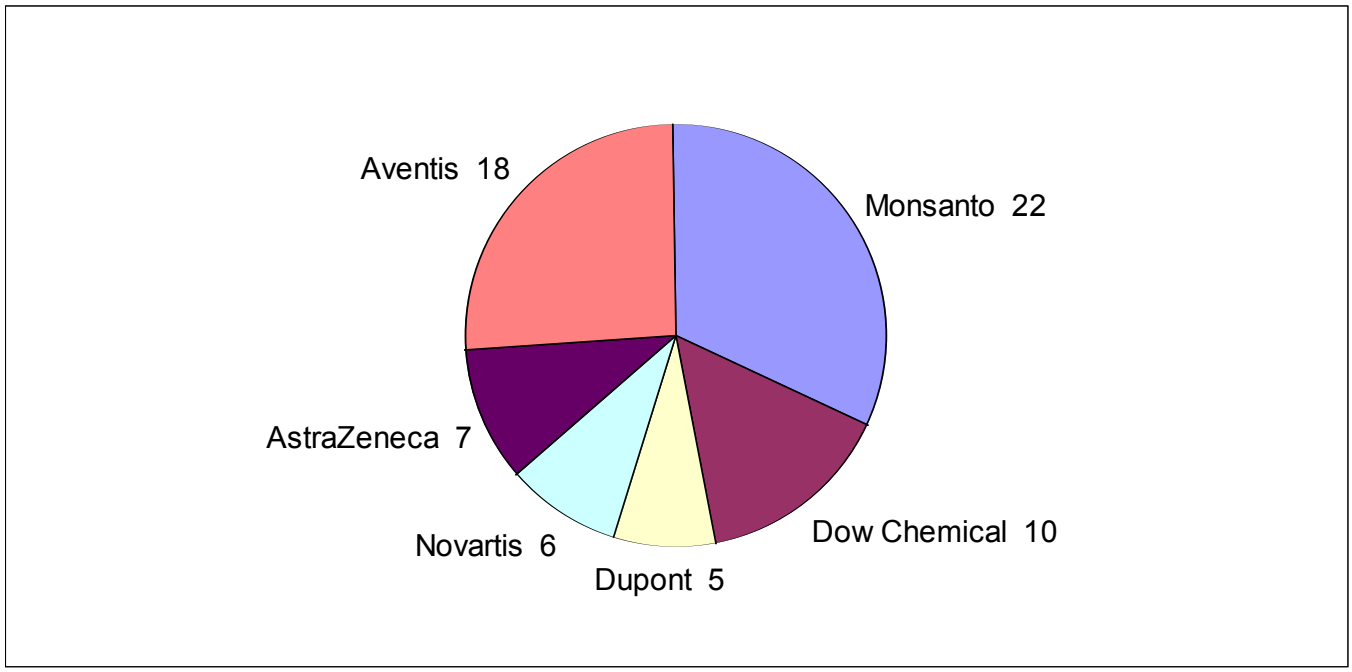
A remarkable trend in the U.S. commercial seed industry in the 1990's was rapid consolidation as smaller seed companies and plant-breeding operations were purchased by large agricultural concerns. Between 1995 and 1998, approximately 68 seed companies either were acquired by or entered into joint ventures with a handful of large multinational corporations (fig. 2). Moreover, some of the acquisitions and combinations involved companies that had previously undertaken acquisitions of their own.

Several factors may have accounted for consolidation in the seed industry. Prior to seed company acquisitions, the core businesses of most of these large, acquiring corporations consisted of either pharmaceutical or chemical products. The sale of chemical units during a period of relative stagnation in that industry during the 1980's freed up capital for diversification into new industries, through R&D or the acquisition of existing companies.

Meanwhile, biotechnology startup firms emerged in the 1980's to commercialize recent advances in molecular biology. Commercialization of molecular biology required understanding of both chemical and biological processes. More recent advances in genomics, the assay of genetic traits in plants and animals, reinforced this trend. Implementation of these techniques in agriculture relied on plant breeding operations, but also on chemical inputs to agriculture such as herbicides, pesticides, fungicides, and fertilizers.

For chemical companies already involved in agriculture, seed companies were logical acquisitions because of complementarities between their chemical inputs and new genetically engineered traits (e.g., herbicide resistance). The combination of R&D in novel biotechnology techniques in pharmaceutical and agricultural applications by firms with prior experience in industrial chemicals and other agricultural inputs prompted discussions of an emerging "life sciences" industry.

Figure 2—Seed company acquisitions by life science firms, 1995-1998



Source: Brennan et al., 1999.

Acquisition of smaller plant-breeding operations gave the larger firms quick access to a stock of cultivars and new varieties still in development, capital equipment necessary for increased plant-breeding efforts, and other important assets. Acquisition also represented an efficient means of obtaining the smaller firms' intellectual property and know-how, much simpler than replication or "inventing around" it.

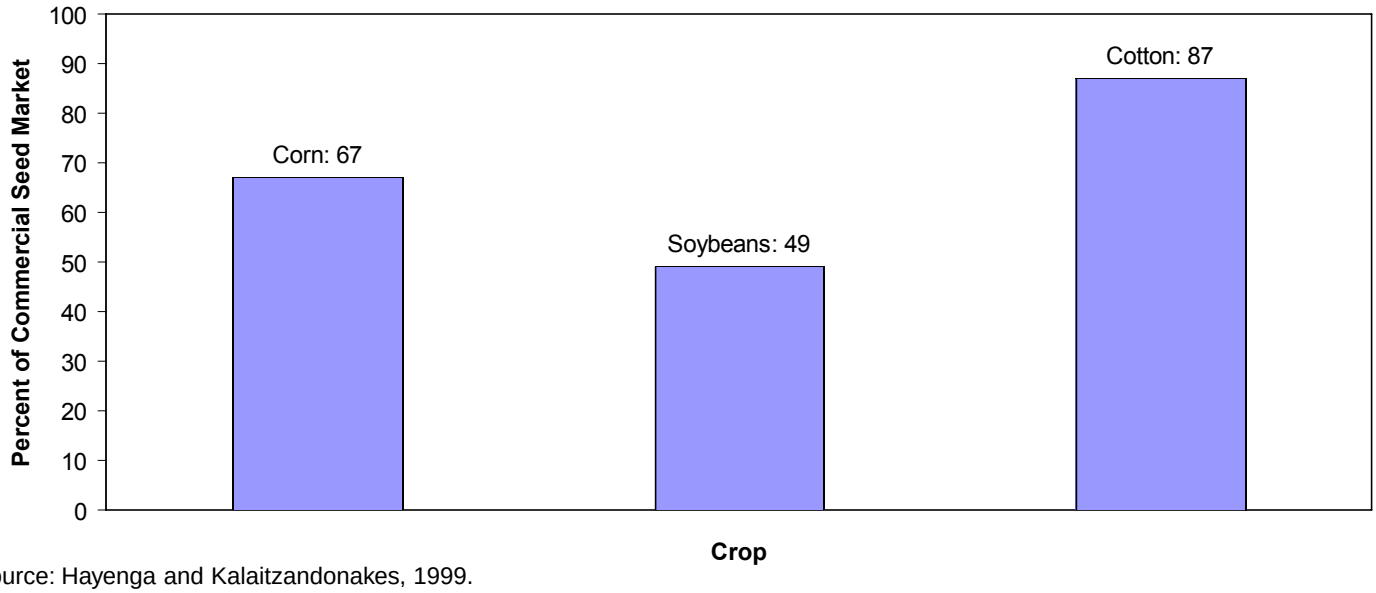
Despite these possible rationales for buying up seed companies, four "life science" corporations announced plans to divest their seed operations almost before the mergers and acquisitions that created them were complete. There were several possible explanations for the divestitures. For example, anticipated research synergies may have failed to develop. Since success in research in complex technologies depends on coordinated work by many researchers, the larger scale of R&D in the consolidated companies might have diminished the enthusiasm of pharmaceutical executives for operations in a new industry with specific research challenges.

Concerns over consumer acceptance of genetically engineered crops in the United States and elsewhere raised uncertainty about the profitability of advances in agriculture and concern about the potentially damaging effects on reputation associated with a potentially unpopular product, despite regulatory approval. For example, British retailers Safeway and Sainsbury removed genetically modified tomatoes from shelves in UK stores in 1998. The U.S. Environmental Protection Agency cited possible allergenicity concerns, leading to a recall of Aventis StarLink corn.

Finally, Federal regulatory and antitrust scrutiny of mergers affecting market concentration was another concern. When a biotechnology breakthrough in a particular crop has the potential to increase sales substantially, its acquisition by a market leader might lead to Federal antitrust investigation and subsequent action. Figure 3 shows a measurement of industry concentration called the "Four-Firm Concentration Ratio," the percentage of market share controlled by the four largest firms. With market concentration already at historically high levels for some major U.S. crops, leading firms might have encountered a disincentive for the acquisition of agricultural biotechnology firms were it to result in further consolidation.

Several of the largest "life science" firms made recent announcements that might further change industry structure. (See box, "Events Between December 1999 and Early February 2001.") The information below is current through early February 2001, based on news articles and company press releases. Due to the rapid pace of developments in the biotechnology research industry, the relevance of the following information can be expected to change over time.

Figure 3—Four-firm concentration ratios for U.S. commercial seed industry, 1998



Source: Hayenga and Kalaitzandonakes, 1999.

Events Between December 1999 and Early February 2001

Pharmaceutical Megamergers

- Novartis attempts unsuccessfully to acquire American Home Products, which in turn unsuccessfully bid for Warner-Lambert.

- Pfizer wins the bidding contest for a merger with Warner-Lambert in February 2000.

Divestiture of Agricultural Divisions

- AstraZeneca, Novartis, and American Home Products, which collectively controlled about 26 percent of the $39 billion global agricultural market, each place their agricultural divisions for sale to concentrate on core pharmaceutical businesses.

- Aventis plans to spin off Aventis CropScience, raise capital through an initial public offering, and rename the entity Agreva by the end of 2001. (See also "Further Consolidation," below.)

Monsanto Restructured, Acquired

- A new company called Pharmacia is formed by the merger of Monsanto and Pharmacia and Upjohn, with 60,000 employees, a $2 billion annual pharmaceutical R&D budget, and $17 billion estimated sales and $50 billion market capitalization in 1999.

- An autonomous agricultural subsidiary, headquartered in St. Louis, retains the Monsanto name.

- Monsanto is to sell nearly 20 percent of its agricultural division in an initial public offering.

- Monsanto cancels a $1.9 billion deal to buy Delta and Pine Land, a deal that would have significantly increased their combined market share of cotton seed sales.

Further Consolidation

- Novartis and AstraZeneca announce a plan to spin off their farm products operations, worth $5.3 and $2.5 billion, respectively, to jointly form a new, separate entity (dedicated exclusively to agriculture) to be known as Syngenta.

- Syngenta would be the world's largest agricultural products business, with over $7 billion in annual sales, moving ahead of Aventis.

Depressed Market and Few Buyers for Agricultural Divisions

DuPont and Dow (which bought Union Carbide to become the number two chemical company after DuPont) have made no attempt to date to divest their agricultural divisions. However, they now have limited options since, if they were to attempt to reverse course, few buyers exist to purchase agriculture divisions.

- An exception is the acquisition of American Cyanamid by BASF, which acquired the agricultural chemicals unit from American Home Products in June 2000.

Mergers, Acquisitions, and Strategic Collaborations in Agricultural Biotechnology

To explore concentration in agricultural inputs in greater detail, this report analyzes a sample of data assembled from *Nature Biotechnology* reports on mergers, acquisitions, and strategic collaborations in the biotechnology industry, especially agricultural biotechnology. Brennan et al. (1999) collected the sample. Nature Biotechnology reports primarily on scientific advances in both pharmaceutical and agricultural biotechnology, but also monitors the business and regulatory environment of the industry. Announcements of mergers, acquisitions, and strategic alliances between R&D entities in biotechnology are reported in a section entitled "Business and Regulatory News."

The sample is illustrative of concentration activity in agricultural biotechnology. However, it is not a comprehensive study of all collaborations and acquisitions in the industry. First, not all preliminary activities announced were actually carried through to fruition, even though they were reported in the data. More importantly, the sample consists of deals deemed by the editorial staff at Nature Biotechnology to have a particular interest to its readership. This probably biases the sample in some way, for example, giving special attention to arrangements involving one or more exceptionally large firms and underrepresenting the entire scope of activity in the industry. Also, the sample understates the total number of mergers, acquisitions, and strategic alliances that occurred in the industry. Nevertheless, the sample captures a large number of mergers, acquisitions, licensing arrangements, and strategic collaborations from which to infer patterns about consolidation in the agricultural biotechnology industry.

Concentration can arise through many different types of business activities. Perhaps the simplest form to consider is when a firm acquires assets from another firm in the same industry, leading to greater production capacity, sales, and market share for the acquiring firm. In some cases, this can result in market power and weak competitive pressure. However, concentration can occur through more indirect business relationships as well. Contractual agreements covering aspects from production to sales can increase effective concentration in an industry. The ultimate effect on concentration depends on factors such as industry structure and the exact nature of business relationships between companies. Using the Brennan et al. (1999) data set, this section examines the most prevalent forms of business relationships found in the recent consolidation of the U.S. seed industry.

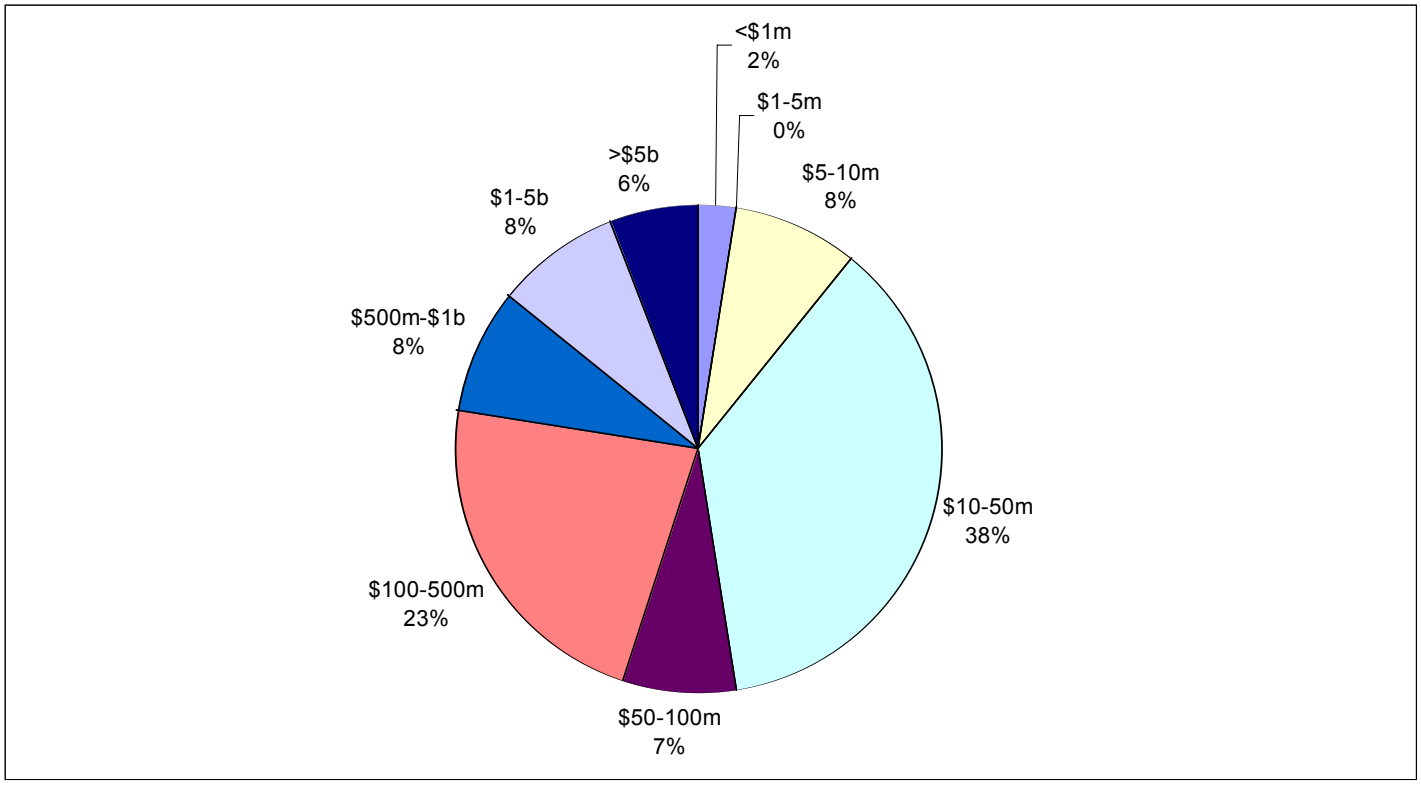
Acquisitions of Existing Businesses and Business Units

The sample included observations of several distinct types of new business activities and relationships. By far, the most commonly observed activity occurred when one firm acquired another—238 of 381 observed strategic collaborations involved a transfer of equity ownership of existing businesses or business units. At least 200 of these were outright acquisitions in which 100 percent of ownership equity changed hands. Approximately 15 other observations involved the transfer of at least a 50-percent stake in the acquisition target. Whether these acquisitions have significantly increased concentration in the U.S. seed industry is difficult to determine, since the acquired firms represent different aspects of seed production in various crops and growing regions. However, the number and value (fig. 4) of transactions clearly indicate that significant change in the ownership of assets is taking place.

Mergers. About 20 observations were identified as mergers. Mergers accounted for three of the deals valued at over $1 billion identified in the sample. These three mergers were: the 1996 merger of Novartis with Ciba-Geigy and Sandoz Chemicals ($63.7 billion), the 1998 merger that created AstraZeneca ($35 billion), and the 1989 merger of Bristol Meyers with Squibb ($11.5 billion). These blockbuster deals contained significant involvement with the pharmaceutical sector.

Joint Ventures. Twenty-six observations were identified as joint ventures. Research joint ventures can result in the development of new products to compete with existing ones, reducing market power. However, joint ventures can stifle competition as well. For example, a dominant firm could use a joint venture to co-opt a potential competitor. At the same time, joint ventures

Figure 4—Share of mergers, acquisitions, and strategic alliances in the U.S. seed industry, by value, 1980-1998



Source: Brennan et al. 1999.

are a flexible way for two firms to collaborate on a potentially promising avenue of research while maintaining control of their respective organizations.

The most common form of joint venture in the sample resulted in a new research enterprise controlled equally by its founders. Joint ventures are a form of industrial organization well suited to biotechnology: parties engaging in expensive and risky research projects benefit from sharing risk with a venture partner, and the difficulty and complexity of innovations encourage firms to find partners with complementary expertise.

Licenses. Licenses are an extremely important business relationship among firms in the agricultural biotechnology sector. Licenses give firms greater access to patented technology, in exchange for a licensing fee, royalty, or some other consideration. Not only does the exchange of technology through licenses promote the diffusion of useful technology and enable the development of further innovation, but licensing fees paid to the owners of patented technology provide another way for firms to be rewarded for successful research and development.

Although many different licensing agreements can be negotiated, the distinction between exclusive and nonexclusive licenses is particularly important in a discussion of industry concentration. When a firm acquires a nonexclusive license, it gains permission to use the patented technology. When a firm acquires an exclusive license, it also secures a promise that the owner of the technology will not license it to other parties. Exclusive licenses might impede the diffusion of technologies that can result in further innovation and the development of competing products.

Collaborations, Research Agreements, and Research/Strategic Alliances. The differences between collaborations, agreements, and alliances reported in the sample are not immediately obvious. Some of them probably represent self-identified nomenclature describing roughly the same thing as a joint venture, creating a

Table 1—Consolidation activity for 10 most active biotechnology firms, 1998

Company	Mergers	Acquisitions	Joint Ventures	Other	Total
Monsanto (USA)	1	15	4	17	37
AgriBiotech (USA)	1	30	0	5	36
Novartis (Switz.)	3	21	1	0	25
AgrEvo/Aventis (Germany)	2	15	3	2	22
AstraZeneca (UK)	0	14	1	1	16
Limagrain (France)	0	15	0	1	16
Empresas La Moderna/Savia (Mex.)	1	10	0	5	16
Rhone-Poulenc Agro (France)	3	6	2	2	13
DuPont (USA)	0	3	2	8	13
DeKalb Genetics (USA)	0	11	0	0	11

Source: Brennan et al., 1999

jointly owned research enterprise. Other agreements probably involve sharing of resources and personnel for the purpose of accomplishing a specific research goal.

Concentration of Business Activities

Just 10 firms accounted for almost half of the observed mergers, acquisitions, joint ventures, and strategic alliances reported in the sample (table 1). The 10 firms with the most activity were involved in 186 of the 382 observations in the sample, a further indication that some consolidation has taken place in the industry.

Moreover, Monsanto (with 37 deals) successfully acquired the remaining 60 percent of outstanding shares in DeKalb Genetics (with 11 deals) in 1998; Empresas La Moderna (with 16 deals) merged with DNA Plant Technology (an active research concern with distribution channels through Bionova); the firm Aventis was formed from a combination of AgrEvo and Rhone-Poulenc; and a new company called Syngenta was formed when Novartis and AstraZeneca (itself the product of an earlier merger) divested and combined their agricultural units. These developments further increased the concentration of strategic alliances.

Summary

Consolidation in the U.S. commercial seed industry provides an opportunity to examine issues related to concentration and technological change. While the data presented in this report are insufficient to make final determinations about the extent of concentration in the industry, they do shed interesting light on several relevant policy areas.

Consolidation leading to concentration and market power is important because of the tendency to erode competition. Competitive markets are an important incentive for efficient aggregate production, and prevent distortions that result in inequitable allocation of economic benefits.

Aside from the magnitude of consolidation, another interesting aspect to consider is the diversity of business relationships and strategic alliances that have emerged. Although mergers and acquisitions were most common, firms found it advantageous to negotiate more sophisticated arrangements as well: licenses, joint ventures, contract research agreements, etc. These arrangements can potentially restrict competition as easily as more obvious forms of consolidation.

However, it is likely that other aspects of the competitive environment in which these firms operate influence the types of arrangements that are ultimately negotiated. It is possible that some arrangements were motivated by an attempt to work around intellectual property protection: through licensing agreements, outright acquisition of firms with intellectual property rights, establishment of joint ventures, etc., when licensing deals could not be made.

Both consolidation and the formation of diverse and complex business arrangements occur against a backdrop of rapid technological change. The "life science conglomerate" is one business model that was created to quickly incorporate technological advances into new products. Despite the continued existence of large corporations with significant research experience in pharmaceutical, agricultural, and chemical applications, the divestiture of agricultural units (Monsanto from Pharmacia, Syngenta from AstraZeneca and Novartis, etc.) signals that the industry will take a different tack in the future.

Another influence of technological change on seed industry structure is the nature of new business relationships forged between companies. While some of the largest firms in the industry have sought mergers, they have also acquired or contracted with small startup firms with promising R&D projects. Small firms have also negotiated strategic alliances between themselves. The choice of business relationships probably reflects an effort on the part of companies to share risks and rewards from research in complex technologies.

A final point about the role of technological change and industry structure is that technology, and the industry response to technology, affects not only present competitive circumstances but also the new markets in which firms will compete in the future.

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