ESO #2028

AGRICULTURAL BIOTECHNOLOGY AS AN INTANGIBLE ASSET: INCENTIVES FOR TRANSNATIONAL VERTICAL INTEGRATION IN AGRIBUSINESS

Thomas L. Sporleder (Ohio State University)
Dennis R. Henderson (Ohio State University and Economic Research Service, U.S. Department of Agriculture)

ABSTRACT

An emerging global phenomenon is the application of biotechnology to food and agricultural production. How individual firms will relate to biotechnological advances and the decisions made regarding the commercialization of biotechnology will influence the structure of the industrial landscape in global markets and international trade. The scope of biotechnology in the United States and Europe and the economic incentives for transnational vertical integration of biotechnological products or processes is examined. An economic model is used to assess the nature of incentives for the transnational vertical integration of biotechnology. The analysis argues that rights to commercial biotechnology products or processes are intangible assets which may provide incentives for vertical foreign direct investment by the firms holding such rights. The transnational character of intellectual property as an intangible asset is explored briefly. Implications are drawn from the analysis concerning transnational vertical integration of biotechnology.

LA BIOTECHNOLOGIE AGRICOLE COMME UN BIEN INTANGIBLE: STIMULANTS POUR L'INTÉGRATION VERTICALE INTERNATIONALE DES ENTREPRISES AGRICOLES.

L'utilisation de la biotechnologie dans la production agricole et alimentaire est un phénomène globale récent. L'adoption des decouvertes biotechnologiques par les entreprises et les décisions de commercialisation de cette nouvelle technologie vont influencer le marché mondial et le commerce international. L'étendue de la biotechnologie aux États-Unis et en Europe, et les stimulants économiques pour l'intégration verticale internationale des produits et des procédés biotechnologiques sont examinés. Un modèle économique est utilisé pour évaluer la nature des stimulants á l'intégration verticale internationale de la biotechnologie. L'analyse prouve que les droits sur les produits et les procédés commerciaux biotechnologiques sont des biens intangibles qui peuvent encourager l'investivement direct vertical par les entreprises étrangéres qui detiennent ses droits. Le caractère international des propriétés intellectuelles comme biens intangibles est discuté briévement. Des implications sont déduites de l'analyse de l'intégration verticale internationale de la biotechnologie.

1. Introduction

An emerging global phenomenon is the application of biotechnology to food and agricultural production. Understanding the economic forces which shape how biotechnological advances are commercialized will be increasingly important over the ensuing decade. Clearly, basic scientific knowledge in biology knows no geographic boundaries. Yet, if the consequences of basic scientific advance are to enhance the quality of life, these advances must result in commercial products and processes. How industries and individual firms in the developed world, especially agribusinesses, will relate to biotechnological advances and the decisions made regarding the commercialization of biotechnology will influence the structure of the industrial landscape in global markets and international trade.

This paper examines the scope of biotechnology in the United States and Europe and the economic incentives for transnational vertical integration by businesses which have proprietary rights to commercial biotechnological products or processes. A rather simple economic model is used to assess the nature of incentives for the transnational vertical integration of biotechnology. Rights to commercial biotechnology products or processes are held to be firm-specific intangible assets which may provide incentives for foreign direct investment (FDI) by the firms holding such rights. Some definition and description of biotechnology is beneficial in comprehending the scope of global biotechnology. In addition, the transnational character of intellectual property as an intangible asset is explored briefly. Finally, an economic model is examined which provides insight into potential incentives for the transnational vertical integration by biotechnology firms.

2. Scope of Biotechnology in the U.S. and Europe

For purposes of this paper, biotechnology is defined as the industrial use of rDNA, cell fusion, and novel bioprocessing techniques. A broader definition sometimes is used by analysts which includes any technique that employs living organisms to make or modify products, or to develop micro-organisms for specific uses,. as biotechnology. The former definition is used here and is consistent with the conventional notion of biotechnology in most scientific literature.

The potential financial reward to firms for new products or processes based on biotechnology is substantial. Recent estimates indicate that United States (U.S.) agricultural biotechnology revenues may expand from a modest $60 million in 1988 to over $1.6 billion annually by 1998, Figure 1. The data in Figure 1 indicate a compound annual growth rate of nearly 50 percent between 1991 and 1998.

Forecasts of global markets for agricultural biotechnology are equally impressive. By 2000 the size of the global market for applications of biotechnology to agriculture may exceed $10 billion, Figure 2. The largest market segment within the total global market is expected to be pharmaceutical production at $4 billion annually. Other significant market sectors are expected to be transgenic plants, animal health products, and microbial pesticides.

Typically firms engaging in biotechnology research and development are categorized as start-up companies dedicated to biotechnological products, called dedicated biotechnology companies (DBCs), and major corporations with significant investment in biotechnology. DBCs are mostly a U.S. phenomenon and funded initially by venture capital. In 1988, the Office of Technology Assessment of the U.S. Congress, verified that there were 403 DBCs in existence and over 70 major corporations with significant investment in biotechnology (OTA, 1991, p. 5). However, the largest DBC in the U.S. is Genentech which was acquired in the late 1980s by Swiss-owned Hoffman-LaRoche.

Europe is a substantial player in global biotechnology. Information on European activities presented here is drawn largely from a 1991 OTA report. This report indicates that in Denmark, industrial biotechnology efforts are made primarily by well-established pharmaceutical firms and that over 90 percent of all production is exported. Denmark, however, has relatively little activity in food.

Germany is a biotechnology leader within Europe. Major firms include Bayer, BASF, Hoechst, Boehringer Ingelheim, and Boehringer Mannheim. There are approximately 40 DBCs. German firms have been particularly aggressive in licensing agreements and acquisitions involving U.S. firms. For example, BASF recently acquired U.S.-based Inmont (OTA, 1991, p. 234).

France has over 700 firms engaged in some form of biotechnology. OTA estimates that about 100 of these play a major active role in research and development.

By comparison, the Netherlands has 4 large firms engaged in commercial biotechnology (AKZO, DSM, Shell, and Unilever) and about 34 DBCs. The Dutch firms tend to concentrate on the food and dairy sectors.

There are approximately 40 firms in Sweden engaged in biotechnology and these firms are quite active internationally. The strengths of Sweden's firms tends to be in fermentation, carbohydrate-based substances, and pharmaceuticals.

The United Kingdom has nearly 300 firms involved in biotechnology research and development, but only about 40 of these firms are leaders in biotechnology. These firms are primarily engaged in genetic engineering or monoclonal antibody engineering.

3. Intellectual Property Rights As Intangible Assets

Innovation in biotechnology leads to the creation of intellectual property. Modern intellectual property law includes several areas of law: patent, copyright, trademark, trade secret, and breeders' rights (OTA, 1990, p. 4). Patents, trade secrets, and plant variety protection laws are particularly important to biotechnology. Trademarks are expected to become increasingly important as biotechnology products become commercialized.

Patents provide financial incentives to inventors by granting an exclusive right to the inventor for a period of time (17 years in the U.S.). There are international agreements which protect biological inventions. These include the Paris Convention for the Protection of Industrial Property, the Patent Cooperation Treaty, the Budapest Treaty, the International Union for the Protection of New Varieties of Plants (UPOV), and the European Patent Convention (EPC). There are 19 member nations as part of UPOV and 14 countries are part of EPC (OTA, 1991, p. 208). These agreements provide significant legal protection for inventions created through the use of biotechnology.

Some difficulties prevail in transnational intellectual property right protection. The issue of what constitutes patentable micro-organisms, plants, and animals has become more arduous because of evolving legal treatment in the U.S. The EPC, in Article 52(1), defines patentable subject matter broadly as "inventions which are susceptible of industrial application, which are new, and which involve an inventive step" (OTA, 1990, p. 160). This definition is ambiguous in ascertaining when a process is "essentially biological," a critical criterion for determining biotechnology patentability. Currently, key to a process being deemed "essentially biological" is the extent of technical human intervention in the process. If human intervention plays a major role in determining or controlling the desired result then the process is patentable. Thus, EPC does not protect essentially biological processes or specific plant varieties produced either by breeding or genetic manipulation. However, EPC does not exclude microbiological inventions from patentability.

Certainly some differences do exist among major developed nations in their treatment of intellectual property. International agreements regarding the patentability of animals do not exist, even though U.S. law has evolved to the point where the Patent and Trademark Office issued a 1987 policy statement which indicates "nonnaturally occurring nonhuman multicellular living organisms, including animals, to be patentable subject matter" (OTA, 1990, p. 93). On balance however, biotechnology patents, trade secrets, and the plant variety protection laws assist in creating firm-specific intangible assets and these intangible assets tend to be recognized on a global basis. Nevertheless, currently there is more risk on a global basis in intellectual property right protection of transgenic animals.

4. The Calgene Tomato: A Case Example

Enhanced vertical marketing ties appear inevitable for some new biotechnologically-based food products. The Calgene Corporation, a U.S.-based DBC, in 1993 is expected to commercially market the first genetically-engineered tomato for the fresh market. The tomato has an extended shelf-life of 7 to 10 days compared to conventional tomatoes. It will be marketed under the brand name FLAVR SAVR and the company anticipates tight vertical control over the entire production and distribution of the tomato. The company has no previous experience in distributing or marketing food products.

Calgene intends on contracting with producers to have the tomato grown under rigid cultural practice specifications. Growers will not be "producers" in the traditional sense since they will never own the crop they cultivate. The company will provide for the national distribution of the tomatoes into retail food stores. Longer-term plans call for transnational licensing of the technology. The Calgene tomato is an early indication of the tighter vertical relationships that are likely to accompany new bioengineered food products. The dilemma is to understand the economic factors which lead to these anticipated tighter vertical ties and understand their consequences.

5. Alternative Vertical Linkages

Viewed broadly as a continuum, alternative vertical linkages in agricultural commodity marketing channels range from no explicit vertical tie, i.e. sale of products or procurement of inputs with simple open or spot market transactions, through contractual arrangements of various forms, and ultimately to vertical ownership integration. Understanding the motivations for managerial choice among these alternative exchange arrangements is challenging.

Using transaction cost logic, Sporleder has argued that asset specificity may be viewed as a necessary but not sufficient condition for vertical integration (Sporleder, 1992). Cost control typically is effective when relying on open market product sale or input procurement. Managerial choice of contracts as a vertical linkage is constrained by bounded rationality. Ownership integration is discouraged as a vertical linkage through relatively high idiosyncratic investment from ubiquitous asset specificity. However, lessened holdup possibilities exist when firms rely on ownership integration. In essence, managerial choice may be motivated by a desire to balance between the weaker cost control of ownership integration with diminished quasirent exploitation potential. Strategic alliances, or *extente cordiale*, as a relatively new vertical linkage, may be viewed as the choice of managers when attempting to vertically optimize among control, bounded rationality, and idiosyncratic investment. The role of intangible assets and the motivation for firms to engage in vertical FDI is not explained by these notions however.

Several types of horizontal and/or vertical contractual linkages are prevalent among biotechnology firms. A recent Ernst & Young survey identified equity-based agreements, agreements to further manufacturing, research agreements, marketing agreements, and technology licensing agreements (Burrill, 1990, pp. 66-67). The equity-based agreements usually provide for a minority equity position in a biotechnology company to a major corporation. The major corporation then becomes a collaborator in R&D to develop one or more of the biotechnology firm's products or processes. An agreement for further processing extends the manufacturing capability of the biotechnology firm, either in-house or on a customized manufacturing basis by a collaborator firm, in return for a share of the profits to the collaborating firm. The research agreement is to facilitate continued R&D of a process or product where the collaborating firm supplies funds in exchange for a share of the profits. Agreements involving marketing augment the biotechnology firm's capacity in marketing a commercial product, where the collaborating firm provides expertise, a marketing network and/or distributors to market the product or process in exchange for a share of profits. Licensing agreements transfer the rights to use a technology to a collaborating firm interested in commercialization of the product or process. Licensing agreements do not necessarily indicate a continuing interaction between the biotechnology firm and the licensee but such continuity is common.

6. Some Evidence on Intangible Assets

Intangible assets are a vital portion of total assets of many large firms, including those engaged in biotechnology. Intangible assets as a percent of total assets tends to be highly variable among major firms. For example, Monsanto and Eli Lilly, two major U.S.-based corporations, reported 1991 intangible assets at 20.7 percent and 15.7 percent of total assets, respectively, Table 1. Calgene, a U.S. DBC, reported intangible assets at 17.7 percent of total assets for the same year. However, Celltech of the U.K. and Hoechst Ag of Germany reported intangible assets at zero percent and 0.4 percent of total assets, respectively, for 1989. Because of the lack of international accountancy standards for intangible assets, however, these comparisons may be data artifacts and thus of little analytical insight.

The composite balance sheet for all U.S.-based biotechnology firms, published by the Ernst & Young High Technology Group, reveals intangible assets of about 11 percent of total assets for 1989 (Burrill, 1990, pp. 120-121). Only about 1 percent of total assets of firms represented by the composite balance sheet were reported in patents, an additional 1 percent in investments in partnerships, with another 4 percent in goodwill and other intangibles. The composite balance sheet is compiled by the Ernst & Young Group for all biotechnology firms, not just those engaged in agricultural or food biotechnology.

7. Intangible Assets and Foreign Direct Investment (FDI)

There are three leading hypotheses concerning the determinants of FDI although only one tends to be supported by existing empirical evidence (Grubaugh, 1987a). One hypothesis is that firms become international and engage in FDI as a matter of capital arbitrage. A second hypothesis is that oligopolist firms simply chose to compete with their rivals by producing in various countries. The third hypothesis is that vertical integration is encouraged when firms possess intangible assets.

Connor captures the essence of firm-specific intangibles by representing them to include "...patents, trademarks, consumer loyalty to its brands, a positive enterprise image, research and development (R&D) resources yielding technological leadership, effective data gathering and information systems, special relationships with sources of financial capital, and so on" (Connor, 1983, p. 398). Clearly, several of these characteristics are associated with biotechnology, e.g. R&D that yields technological leadership, patents, and/or trademarks.

The role of such intangible assets is at the core of most of the empirical evidence regarding incentives for firms to invest in foreign operations; the larger a firm's intangibles, the greater its foreign investment (Casson, 1987; Caves, 1974; Connor, 1983; Grimwade, 1989; Grubaugh 1987a and 1987b; Gruber, Mehta and Vernon, 1967; Handy and Henderson, 1992; Helpman, 1984; Meredith, 1984). Most of the empirical investigations of the relationship between intangible assets and FDI, however, do not distinguish between horizontal and vertical investments. Thus, they offer scant insight into whether international investments by biotechnology firms will be vertical. Therefore, industrial organization and the theory of vertical markets is invoked here to identify the motivations that leads biotechnology firms specifically to transnational vertical investment and other vertical tie-in strategies.

Industrial organization theory is sufficiently developed to identify economic incentives for a firm to vertically integrate under specified competitive, technological, and institutional conditions. It provides a somewhat less definitive understanding regarding the motivation for contractual vertical ties, but can generate insight into conditions under which these may be viable strategies.

Theoretically, the most definitive motivations for a firm to engage vertical ties are evident in the presence of some degree of monopolistic market power, i.e. when firms can influence price through decisions regarding quantity sold. Firm-specific intangible assets convey a degree of such power in that they distinguish the firm's product and differentiate it from those of others. Biotechnology, i.e. the production of products using a unique bio-engineered system, if patented, treated as a trade secret, strongly associated with a specific brand name or trademark, or otherwise uniquely tied to a firm, is thus a basis for the presumption of market power.

Given such conditions, the economic motivation for vertical investments or tie-ins can be traced out under assumptions of either fixed proportion or variable proportions production functions (based on Carlton and Perloff, 1989). The case for fixed proportions is presented first since this is a reasonable representation of a biotechnology process, e.g. the production of one genetically-engineered tomato requires the input of one genetically altered seed.

Assume that the biotechnology firm is the upstream producer of a unique genetically-altered tomato seed; the downstream enterprise is an overseas tomato grower that produces the genetically-engineered product for a specific and differentiated end-user market, e.g. a 15-day "flavor-fresh" tomato. Both firms, as sole suppliers of "flavor-fresh" seed and tomatoes, have a degree of downstream market power. Also assume that the upstream firm, as the originator of this specific biotechnology, seeks to maximize profits from the sale of the bioengineered product in the end-use market.

The motivation for vertical integration stems from the successive stages of market power. This is most easily illustrated by the case of non-integrated successive monopolies, or double marginalization. The marginal revenue curve for a downstream monopolist becomes the inverse demand function for its upstream supplier. Thus, the downstream monopoly rotates the demand function faced by the upstream supplier downward from its point of axis in the vertical dimension, i.e. the downstream firm's demand function for the genetically-engineered tomato seed is half what it would be if the downstream industry were perfectly competitive. Because the upstream supplier also is a monopolist, it determines profit maximizing output on the basis of the revenue function that is marginal to this downward-rotated demand function. Thus, total output in the end-use market is progressively reduced by monopoly at both vertical stages, i.e. marginalization is doubled, reducing output at each stage by half from its perfectly competitive level.

Vertical integration preserves the final market monopoly but eliminates the successive upstream monopoly, thus eliminating the double marginalization. This increases both total output and total profits.

Now suppose the assumption of fixed proportions is relaxed. Assume that the genetically-altered tomato seed can be combined in varying proportions with fertilizer to produce a varying number of genetically-engineered tomatoes, i.e. tomato production can be increased by increasing the use of either seed or fertilizer. Fertilizer is supplied by a perfectly competitive industry; "flavor-fresh" seed by the monopolist.

In this case, the motivation for the biotechnology firm to vertically integrate rests with potential gains in profits from elimination of monopoly price distortion in factor use. The basic intuition is straight forward. Because of the monopoly price for seed, the grower uses relatively more of the competitively priced fertilizer than dictated by efficient factor use if both inputs were competitively priced at marginal cost. Quantity sold and total profits are both lower than if the inputs were used in their most efficient ratio, due to the production-reducing impact of the lower quantity and higher priced seed on the downstream grower.

Given this situation, the case for downstream integration by the monopolist supplier is apparent. By acquiring the grower enterprise, seed can be supplied at marginal cost and combined with fertilizer in the most efficient proportions, thus eliminating the factor use inefficiency. The integrated monopolist captures the efficiency gain in the form of profits generated in the downstream market. The supplier's profits increase by the extent to which efficiency gains exceed the cost of integration.

Three types of vertical restraints or contracts have been shown theoretically to induce the same results as vertical integration in the successive monopoly case. These are contracts between the upstream and downstream enterprises that (1) set a maximum resale price, (2) impose minimum resale quantity quotas, and (3) provide for franchise fees. The first is used by the upstream monopolist to force the downstream firm to set a competitive resale price; the second is used to force a competitive quantity into the end-use market; the third is used to transfer, at least partially, the downstream monopoly profits to the upstream firm in return for pricing the upstream transaction at marginal cost.

8. Conclusions and Implications

Biotechnology will be an expanding influence on global food and agricultural production in the future. International intellectual property rights protection is quite well-developed, although transgenic animal property rights protection is not at this time. An economic feature of many biotechnology advances is that they are intangible assets specific to the firm holding the intellectual property rights to the products or processes.

Tighter vertical coordination in agricultural commodity marketing channels and in food processing/distribution channels is anticipated as a consequence of commercializing biotechnological advances. Cognizance of the economic determinants of enhanced horizontal or vertical ties is important for understanding the complex transnational patterns likely to develop around the commercialization of biotechnology. The analysis here focuses on the relationships among firm-specific intangible assets, market power, and transnational vertical integration.

Much empirical evidence supports the hypothesis that as a firm's intangible assets increase so will its foreign investment. However, the empirical evidence does not discriminate between the horizontal or vertical nature of the amplified FDI. Nevertheless, industrial organization theory may be invoked to generate insight into conditions under which vertical integration may be encouraged. Firm-specific intangible assets are synonymous with some degree of monopoly power by a firm. Integration or other vertical restraints between upstream and downstream firms are motivated through double marginalization. Downstream integration by a monopolist supplier permits supplying the input at marginal cost and eliminating otherwise inefficient factor use. The implication of this analysis is that biotechnological advances can be expected to lead to tighter vertical coordination in marketing and enhanced vertical FDI.

Table 1. *Intangible assets as a proportion of total assets, selected firms involved with agricultural and food biotechnology*

Country/Firm	Percent	(Year)
United States		
American Cyanamid	8.2	(1990)
Calgene	17.7	(1991)
Cetus Corporation	8.0	(1991)
DeKalb Genetics	17.3	(1991)
DuPont	8.5	(1991)
Eli Lilly	15.7	(1991)
Monsanto	20.7	(1991)
Pioneer	1.9	(1991)
Upjohn	9.5	(1991)
Vega Biotechnologies	8.3	(1991)
Netherlands		
AKZO	0.0	(1990)
DSM	1.0	(1990)
Unilever	0.0	(1990)
United Kingdom		
Celltech	0.0	(1990)
Sweden		
Hoffman-LaRoche	4.9	(1990)
Germany		
Bayer	3.3	(1990)
BASF	3.0	(1991)
Boehringer Ingelheim	1.9	(1990)
Boehringer Mannheim	0.3	(1989)
Hoechst Ag	0.4	(1989)

Source: CIFAR

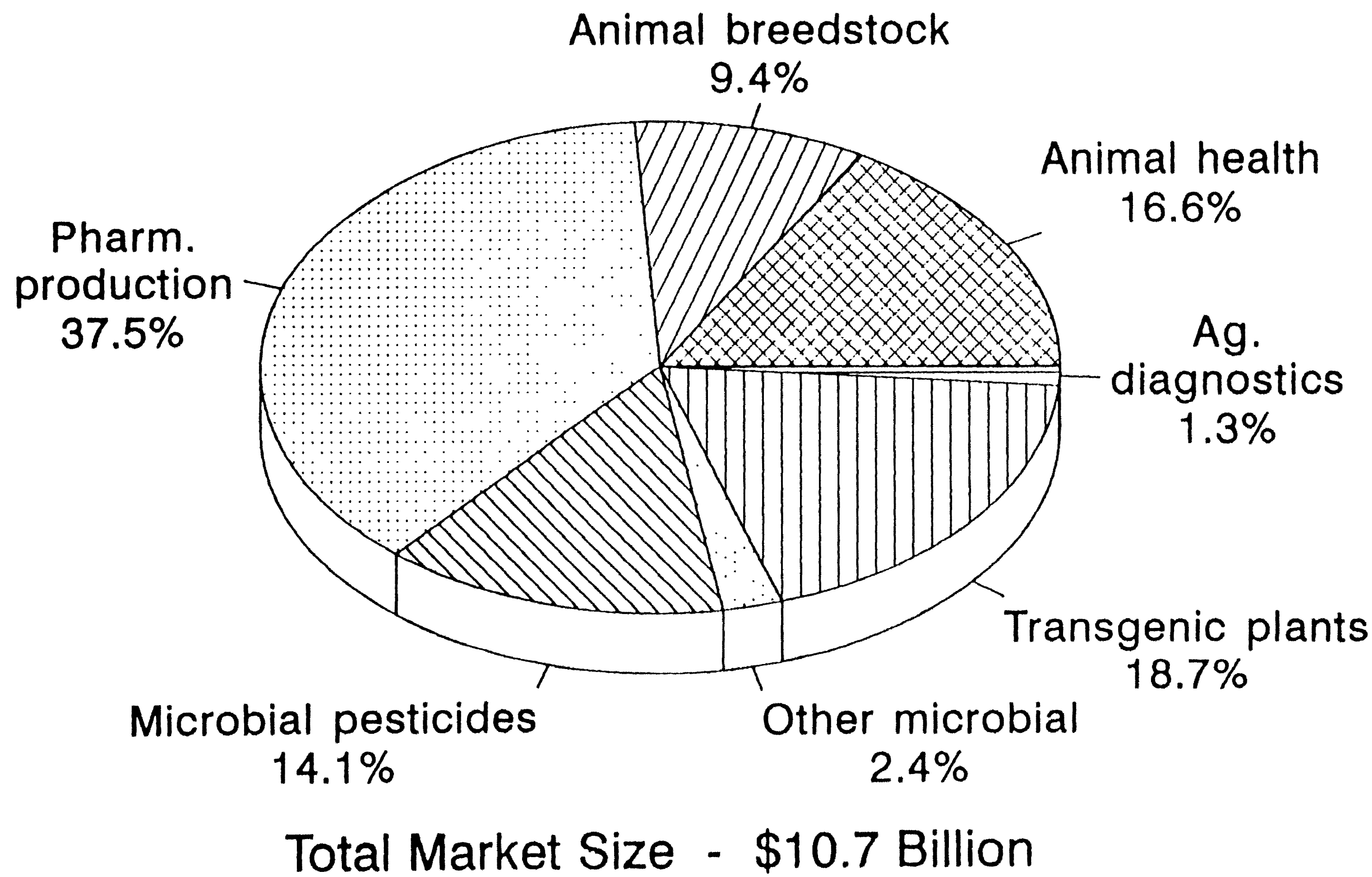
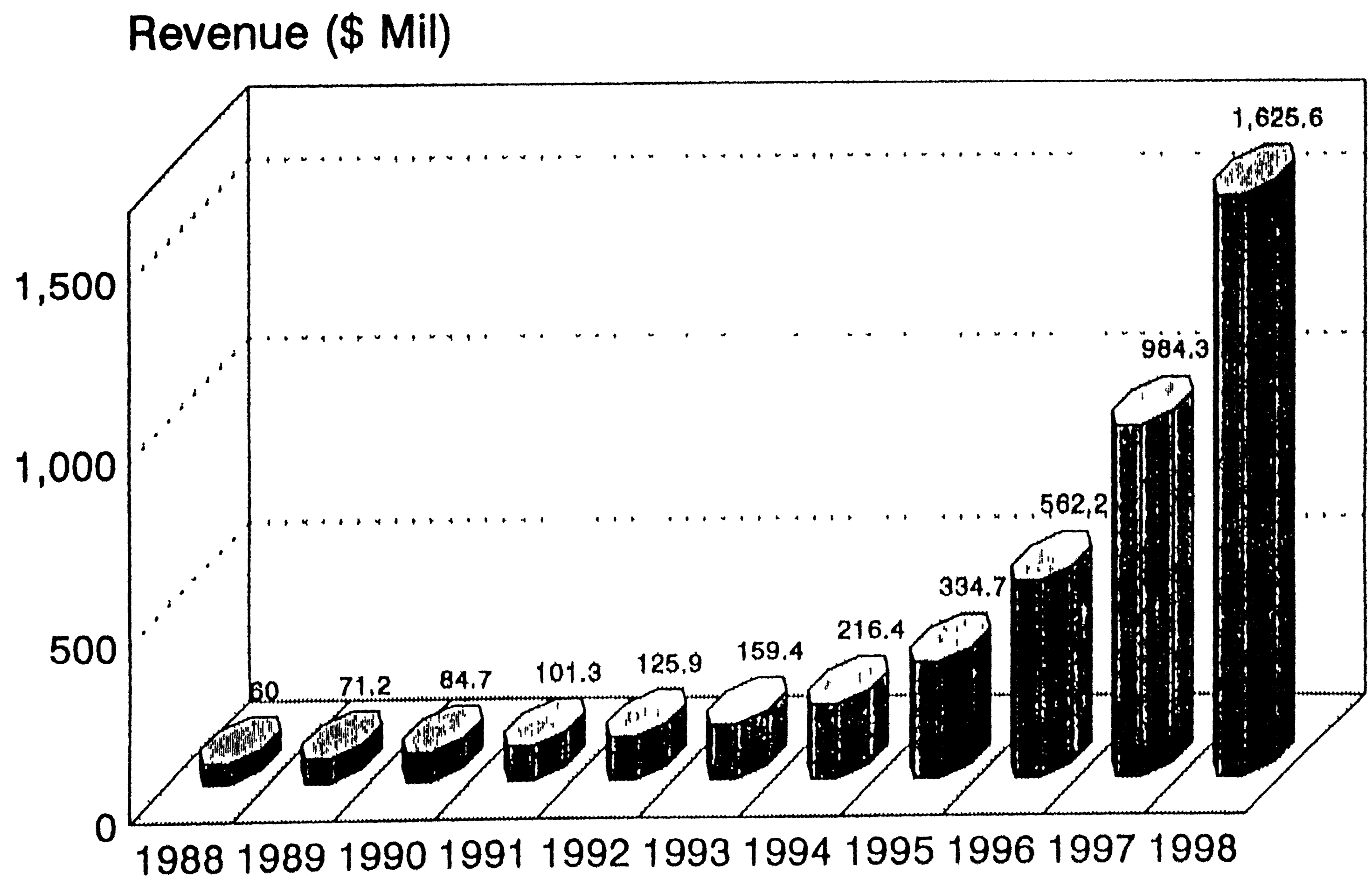


Fig. 1 U.S. Agricultural Biotechnology Revenue Forecast, 1988 - 1998



Source: Market Intelligence Research Corp.

Fig. 2 Global Agricultural Biotechnology Market Size, Year 2000, By Application

References

Burrill, G.S. (1989). *Biotech 90: Into the Next Decade.* New York: Mary Ann Liebert.

Carlton, Dennis W. and Perloff, Jeffrey M. (1989). *Modern Industrial Organization.* Glenview, Illinois: Scott, Foresman.

Casson, Mark. (1987). "Multinational Firms," *The Economics of the Firm*, R. Clark and T. McGuinnes (eds). Oxford: Basil Blackwell.

Caves, Richard E. (1974). "International Trade, International Investment, and Imperfect Markets." Special Papers in International Economics No. 10. Princeton University, Department of Economics.

Center for International Financial Analysis and Research, Inc. (1993). *CIFAR.* Princeton, New Jersey.

Connor, John M. (1983). "Foreign Investment in the U.S. Food Marketing System." *American Journal of Agricultural Economics.* 65: 395-404.

D. Glass Associates, Inc. and Linderman Consulting. (1992). *Biotechnology in Agriculture: The Next Decade.* Report No. R920202. Decision Resources, Inc.: Burlingham, Massachusetts. p. 12.

Grimwade, Nigel. (1989). *International Trade--New Patterns of Trade, Production and Investment.* London: Routledge.

Grubaugh, Stephen G. (1987a). "Determinants of Direct Foreign Investment." *Review of Economics and Statistics.* 69: 149-152.

Grubaugh, Stephen G. (1987b). "The Process of Direct Foreign Investment." *Southern Economic Journal.* 54: 351-360.

Gruber, William, Mehta, Dileep and Vernon, Raymond. (1967). "The R & D Factor in International Trade and International Investment of United States Industries." *Journal of Political Economy.* 75: 20-37.

Handy, Charles R. and Henderson, Dennis R. (1992). "Foreign Direct Investment in Food Manufacturing Industries." Paper presented at the International Agricultural Trade Research Consortium symposium, *Competitiveness in International Food Markets*, Annapolis, Maryland, August 7-8.

Helpman, Elhanan. (1984). "A Simple Theory of International Trade with Multinational Corporations." *Journal of Political Economy.* 92: 451-472.

Market Intelligence. (1992). *Agricultural Biotechnology: Total Market.* Market Intelligence Research Company, Inc.: San Francisco, California. p. III, 8.

Meredith, Lindsay. (1984). "U.S. Multinational Investment in Canadian Manufacturing Industries." *Review of Economics and Statistics.* 66: 111-119.

Office of Technology Assessment. (1990). *New Developments in Biotechnology: Patenting Life.* New York: Marcel Dekker, Inc.

Office of Technology Assessment. (1988). *New Developments in Biotechnology: U.S. Investment in Biotechnology - Special Report.* OTA-BA-360. Washington, DC: U.S. Government Printing Office.

Office of Technology Assessment. (1991). *Biotechnology in a Global Economy.* OTA-BA-494. Washington, DC: U.S. Government Printing Office.

Sporleder, Thomas L. (1992). "Managerial Economics of Vertically Coordinated Agricultural Firms." *American Journal of Agricultural Economics.* 74: 1226-1231.