Privatization and Innovation in Agricultural Biotechnology

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Agricultural biotechnology as a science exists thanks to publicly funded research, but it exists as an industry thanks to privately funded product development. How compatible are these two?

Over the last 150 years, agriculture has seen several waves of innovation based on scientific developments in machinery, chemistry and biology. Each wave has increased productivity, altered input use and modified industrial structure. The latest wave, agricultural biotechnology, has reshaping agriculture just as profoundly as the earlier ones. In particular, this wave has been marked by a massive privatization of agriculture's genetic inputs. Understanding this privatization is important in formulating government and university policies.

Privatization and Technology Transfer

"Biotechnology" usually refers to the application of biological tools and techniques that identify genes, turn them on or off, and move them between organisms. Applications of biotechnology have been developed from a score of basic research breakthroughs, many of which occurred in universities and were then transferred to the private sector to be used in commercial research and development (R&D). Because of long product development lead times, uncertainties, and large downstream investments, private commitments to develop university-spawned technologies rest upon prospects for sufficient returns, something greatly enhanced by intellectual property protection. With this understanding, the Bayh-Dole Act, passed in 1980, gave universities the right to patent discoveries resulting from federally funded research. Most universities have established Offices of Technology Transfer (OTTs) to identify patentable inventions and license the rights to those inventions to private companies.

U.S. universities have seen an increase in the utilization of academic inventions by business and have received significant licensing royalties, amounting to over $1.2 billion in 2000. Typically, much of the benefits captured by universities are created by a small number of big technology hits, such as the broad international protection and licensing of strawberry varieties, which have generated over $85 million for the University of California since 1982.

Startups and Takeovers

While the Bayh-Dole Act addressed some of the legal impediments to the commercialization of inventions made by academic scientists, two factors continued to limit private interest in investing in promising academic inventions: the high uncertainty associated with the new technologies and the resistance of some corporate R&D departments to go outside for new ways of doing things. University technology transfer efforts have thus, in many instances, focused on starting up new firms, teaming up university scientists with promising inventions with interested venture capital investors. U.S. university technologies have helped spawn over 3,300 new companies in the last 20 years. Major biotechnology companies like Genentech (South San Francisco, CA) and Chiron (Emeryville, CA) and agricultural biotechnology companies such as Calgene (Davis, CA) and DNA Plant Technologies (Oakland, CA) all started with technologies that originated in university labs. Once a startup's technology is sufficiently developed and demonstrates commercial viability, major corporations may then invest, sometimes to the extent of acquiring that startup. Monsanto, for example, acquired Calgene, and Savia, a vegetable seed giant, acquired DNA Plant Technologies through its U.S. subsidiaries Seminis and Bionova.

Gains from Privatization of Knowledge and Private Investment in R&D

Universities are still a major source of new biotechnology innovations in spite of the increased privatization of biotechnology (see Figure 1). Universities contribute to industry's productivity both by transferring technologies directly to existing companies and by spawning new companies that drive new competition with existing companies. Consumers benefit from the introduction of new

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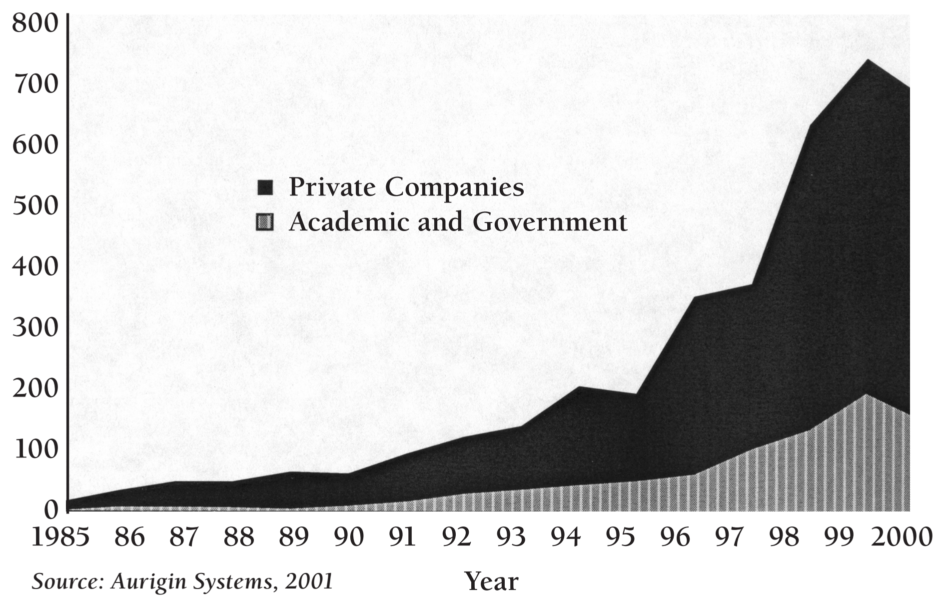

Source: Aurigin Systems, 2001

products, higher quality and lower prices. Even when an industry is stagnant and not very innovative, universities can be a source of technological change and competitiveness. Investment by venture capitalists or multinational companies in university-spawned biotechnology startups depends fundamentally on expected profitability, but it is also important for risk management, strategic positioning and firm learning. In addition, the takeover of start-up companies at healthy prices provides an exit strategy that serves as an economic stimulus to encourage other inventors and venture-minded investors to shoulder the risk of starting up new biotechnology firms.

The Long-term Effects of Proprietary Control over Knowledge

The patenting and licensing efforts of universities appear to have enhanced the utilization of academic discoveries in the short run, but constrained access to proprietary knowledge may slow down biotechnological innovation in the longer run. The ability of researchers in universities and international agricultural research centers to develop and introduce new technologies can be hampered by the legal intellectual property (IP) constraints on the use of proprietary knowledge, particularly tools that are key to research as well as to product development—tools such as the gene gun and *Agrobacterium* genetic transformation or the genetic "on" switches called "promoters." Academic and nonprofit researchers are reportedly finding some research projects or plant variety rollouts held up or delayed until they can gain access to the rights. This sometimes means waiting until key patents expire. Furthermore, if they cannot gain access to the state-of-the-art technologies, academic researchers risk falling behind their commercial counterparts. In the long run, this may reduce the rate of advance in basic science and, in turn, in commercial applications, in effect killing the goose that laid the golden egg.

Biotechnology and Developing Countries

Private investment in agricultural biotechnology has emphasized major U.S. crops such as maize, soybeans, cotton, potatoes and tomatoes, as it seeks out large potential markets where expected returns are high and intellectual property protection is good. Significantly less research effort has been devoted to crops important in poorer regions of the developing world, even though agricultural biotechnology innovations—being embodied in the seed—are perhaps uniquely well suited to attack agronomic and environmental problems in economically and technologically less-developed areas. For these areas to benefit, it is necessary for the public sector to invest in the application of biotechnologies. This, however, requires access to those basic biotechnology tools that are largely controlled by private companies. Even when the companies are willing, transferring these tools entails high transaction costs for license negotiations, biosafety testing and product registration. Under the current situation, the productivity and income gap between farmers in developed and developing regions can be expected to increase, even though biotechnology has significant potential to improve the well-being of poor and subsistence farmers.

Managing Intellectual Property

Special arrangements for management of intellectual property and technology transfer could facilitate biotechnology-based agricultural development that addresses the needs of the poor in developing countries. One possible arrangement is an intellectual property clearinghouse for agricultural biotechnology that provides up-to-date patent information, helps execute licensing transactions and pools together key systems of patents to decrease transaction costs in the management of intellectual property permissions.

The Future of Agbiotechnology

While the commercial developments of agbiotech thus far primarily benefit producers, crop genetic research is also enhancing nutritional value and other output quality traits to benefit processors, food retailers and final food consumers while also enabling “bioprocess” production of biomaterials and chemicals inside crop plants. Introduction of such quality-enhanced innovations are likely to cause an increase in downstream vertical integration for two basic reasons. First, the companies that develop the genetics may need to mediate farmer adoption, to assure them of adequate returns, especially when consumer acceptance is unclear or costs of production are high. Firms will therefore likely engage in contractual arrangements—such as those already prevalent in livestock and vegetable production—designed to reduce grower risk and facilitate adoption. The second reason for more vertical integration is that firms creating the genetics for quality-enhanced varieties may move to capture the value created by increased product differentiation downstream in processing and retail markets. This will mean greater product differentiation at the farm gate as well. Growers currently producing major commodities, subject to oversupply and low prices, are already interested in augmenting their revenues by growing niche products that use similar growing processes but require separate handling and identity preservation. In the wake of the recent incident over leaked corn that contained a hog vaccine molecule, politicians from Iowa objected loudly to a proposal by the Biotechnology Industry Organization for voluntary guidelines to keep such pharmaceutically enhanced corn from being grown in the Corn Belt; Iowa farmers see this as potentially big new business.

Further in the future, change in the structure of the agricultural inputs industry also may arise in cooperation or integration between the new agbiotech companies and machinery suppliers, depending upon the degree of complementarity to emerge in the relationship between genetic inputs and precision agriculture. Precision farming offers possibilities to increase productivity through optimized planting and care of finely tailored genetics, which may generate an expanded market at the farm level for biotechnology products, especially in areas with high local variation in agroecological conditions.

Conclusion

The introduction of biotechnology to agriculture has happened concurrently with the increased patenting and transfer of biological knowledge from the public to the private sector. Often the vehicle for this transfer has been the startup company, created to bear the risk of commercial development of the public sector invention. Establishing proprietary rights over knowledge enhances the incentives for commercial development, but it may constrain future innovations in both the public and private sectors. The two likely outcomes are market differentiation in IP rights using market institutions like the IP clearinghouse and the increased privatization and integration of agricultural value chains as new kinds of products and technological complementarities emerge.

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