Background

Forces Driving Changes in the Agricultural Input Industries

Plant Breeding and Biotechnology

Issue

Understanding the forces that have been driving changes in the agricultural input industries is key to understanding how public policies might affect structure and performance in the industries.

Context

Many different forces are driving the changes in agricultural input industries. The most significant changes have been in agricultural research, particularly plant breeding. At least four major factors are believed to increase private-sector investment in agricultural research and plant breeding—scientific advances, changes in intellectual property rights (IPR) regimes, new institutional structures for public- and private-sector research and development (R&D) collaboration and technology transfer, and increasing globalization of agricultural input markets.

Specific Factors

Advances in Science

Advances in science have created technological opportunities, which in some areas, have translated into the ability for agricultural input companies to create additional value, part of which they capture. Biotechnology methods, such as tissue cell culture, genetic engineering, and molecular mapping, have made it possible for researchers to reduce the time to develop new plant varieties and to increase their precision in modifying plant traits. As a result, developing new crop varieties with production- or quality-enhancing traits appears to be increasingly profitable for the agricultural input industry. Many of the developments in crop varieties have capitalized on linkages between seed and chemical inputs. New herbicide-resistant crops complement established herbicide product lines and boost sales by expanding the number of crops resistant to herbicides. The development of insect-resistant crops enables seed and chemical companies to offer new crop protection technologies.

Changes in IPR Regimes

Intellectual property protection is expected to stimulate private R&D because it allows companies to recoup major investments in developing new technology and to appropriate a greater proportion of the returns to these investments. Expanded IPR's for biological inventions have led to greater private-sector plant breeding efforts over the past 30 years.

In 1970, the U.S. Congress instituted the Plant Variety Protection Act (PVPA), which awarded plant breeders' rights for new crop varieties produced from seed, particularly field crops. Since then, the PVPA has been revised to expand coverage to vegetables and tubers, to restrict farmers' rights to resell protected seed, and to disallow protection for new varieties that simply involve superficial changes in appearance.

The Patent and Trademark Office first granted utility patents for biological inventions in 1980, when the Supreme Court authorized the use of standard utility patents for microorganisms. Utility patents were authorized for plants and animals in 1985 and 1987.

Evidence suggests that these decisions, particularly the utility patent extensions, have promoted private-sector plant breeding activities. Private-sector R&D efforts in plant breeding, measured in scientist years, have intensified and are now slightly more than twice the plant breeding effort in the public sector (Frey). Moreover, the private sector owns the majority of plant variety protection certificates (PVPC's) and utility patents awarded for multicellular living organisms (Fuglie et al.).

Expanded Public- and Private-Sector Research Collaboration

Collaboration between the public and private sectors has been enhanced by legislation that promotes greater collaboration and exchange between Federal laboratories and the private sector. In most cases, this legislation has reversed earlier policy.

The Government Patent Policy of 1980 (Bayh-Dole Act) granted all institutions "certainty of title" for inventions from federally funded research. The Bayh-Dole Act also allowed Federal laboratories to issue exclusive licenses for patents of their inventions, which are more attractive than the nonexclusive or open licenses previously granted to firms.

The 1980 Stevenson-Wydler Technology Innovation Act mandated that each Federal research agency develop specific mechanisms for disseminating government innovations.

The 1986 Technology Transfer Act gave government agencies additional means to foster technology transfer by authorizing Cooperative Research and Development Agreements (CRADA's). CRADA's allow direct research collaboration, which was not authorized before the passage of the Act, between Federal researchers and the private sector. USDA's collaborations with the private sector have significantly increased over the last decade (Day-Rubenstein and Fuglie).

Globalization of Agricultural Input Markets

Globalization of agricultural input markets resulting from increased global demand for agricultural products and falling barriers to trade has provided opportunities for private industry to expand sales and increase research efforts in other countries. An indicator of this expansion is the 2.2-percent increase in real annual U.S. exports of agricultural inputs since 1983 (Pray and Fuglie). Foreign market and investment opportunities have also been broadened by trade agreements, such as the General Agreements on Tariffs and Trade, the World Trade Organization, and the North American Free Trade Agreement. The number of foreign-owned patents for agricultural technologies and research investments by multinational firms has been expanding in many countries (Pray and Fuglie).

Research Issue

Quantitative measures of various causes and an appropriate economic model relating them to private-sector investment would be useful in explaining the importance of the issues just discussed (and possibly others) in driving the increase in private-sector investment in agricultural biotechnology and plant breeding. Current analyses, however, are based largely on theoretical arguments, plausibility, or anecdotal evidence. As Jaffe argues concerning patent policy in general, "despite the significance of the policy changes and the wide availability of detailed data relating to patenting, robust conclusions regarding the empirical consequences for technological innovation of changes in patent policy are few." Similarly, though the empirical importance of changes in science, technology transfer, and globalization is likely to be great, precise empirical studies of these phenomena are relatively sparse.

Policy Issues

Strengthening intellectual property protection for biological inventions has encouraged private firms to pursue basic research previously addressed by the public sector. While the use of patents facilitates knowledge spillovers by broadening the dissemination of research findings, certain key questions arise for science policy.

- Should the goals of public research policy be reevaluated so that strategies that generate the greatest social return on R&D investments can be identified?

- Key to policy planning is determining when and how the public sector should interact with the private sector. When is an area of inquiry purely in the public domain, appropriate for public-private partnership, or most suitable for the public sector to pursue to prevent control by the private sector?

Some areas of research lack incentives for the private sector and remain distinctly in the public domain—for example, mitigating food safety risks, improving nutritional health, and enhancing environmental quality. Others areas of research in the public sector may depend on discoveries made and patented in the private sector. The potential for public-sector research to benefit from private-sector discoveries suggests a need to expand opportunities for partnerships. Despite many complementary research interests, public-private partnerships are not easy to forge, and disagreements over patent arrangements and licensing rights can be major barriers.

References

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Milestones in Molecular Biology and U.S. Agricultural Biotechnology

Scientific/Regulatory

1866—Mendel postulates rules to explain inheritance of biological characteristics

1908—First hybrid corn produced

1918—Economically feasible hybrid corn developed at the Connecticut Agricultural Experiment Station

1930's—Rapid diffusion of hybrid corn in Corn Belt

1952—First hybrid sorghum produced

1953—Watson and Crick discover double-helix structure of DNA

1960—Genetic code deciphered

1960's—Entire U.S. corn area planted to hybrid corn

1960's—Hybrid wheat developed, but not economically feasible

1973—First gene cloned (for insulin)

1974—Article in *Science* magazine on potential risks of genetic engineering research

1976—Founding of Genentech, Inc., first biotech company

1981—First transgenic animal (mouse) developed

1982—First transgenic plant produced

1986—Coordinated framework for regulation of biotechnology-derived products

1986—First transgenic livestock animals (pigs) developed at USDA's Agricultural Research Service (ARS)

1987—First U.S. field trials of transgenic plants (insect-resistant tomatoes) and microorganisms

1989—First recombinant DNA vaccine developed

1990—Food and Drug Administration (FDA) approves chymosin produced in genetically engineered (GE) bacteria for production of hard cheeses

1990—Human Genome Project initiated to map all genes in the human body

1991—USDA's Animal and Plant Health Inspection Service (APHIS) publishes guidelines for field trials of GE crops

1992—FDA announces policy on food derived from new plant varieties, including GE crops

1993—USDA/APHIS introduces simplified notification procedure for field trials of some GE plants

1993—FDA approves rBST for commercial use

1994—First deregulation of a GE plant (FlavrSavr tomato)

1994—Environmental Protection Agency proposes rules regulating plant pesticides. The rule was signed in 2000, although additional issues remain. The rule changes the name of these pesticides to plant-incorporated protectants (PIPS)

1996—First wide-scale planting of GE crops, including Bt corn, Bt cotton, and Roundup Ready soybeans

1997—First release of crop with stacked traits (Bt/Roundup Ready cotton)

1997—First animal cloned from adult cell (Dolly the sheep)

1997—USDA/APHIS expands simplified notification procedures for release of genetically modified organisms (GMO's) meeting certain criteria

1998—European Union requires labeling of GMO's

1998—USDA/APHIS introduces pilot program for comprehensive permitting for field tests of GMO crops

1999—FDA approves first nutraceuticals Take Charge and Benecol margarines

Intellectual Property

1790—U.S. Patent Act

1930—Plant Patent Act allows patenting of asexually reproduced plants

1970—Plant Variety Protection Act (PVPA) is an intellectual property rights system that protects only complete single varieties of plants. The PVPA is not a patenting system and does not protect genetic traits or plant transformation methods

1980—Patent granted on basic recombinant DNA technology to Cohen and Boyer, Stanford University

1980—U.S. Supreme Court rules that GE microorganisms can be patented under existing law

1985—U.S. Patent and Trademark Office rules that plants, including GMO's, can be patented under U.S. utility patent law

1980—Patent and Trademark Amendments passed that allow federally funded researchers to obtain patents (Bayh-Dole Act; Stevenson-Wydler Act)

1986—Federal Technology Transfer Act established Cooperative Research and Development Agreements (CRADA's) to facilitate technology transfer of publicly funded technologies

1988—First patent granted for a transgenic mammal (Harvard "onco-mouse," engineered for increased susceptibility to cancer)

1990—Patent granted for microprojectile accelerator ("gene gun") for delivery of DNA into plant cells

1993—Agracetus granted patent covering all transgenic cotton; canceled by U.S. Patent and Trademark Office on December 7, 1994; currently in appeal

1994—PVPA amended to protect breeders from cosmetic infringements, restrict farmers' rights to sell seed, and extend varietal protection from 17 to 20 years

1998—USDA/ARS and Delta and Pine Land patent "Technology Protection System" for production of plants with nonviable seeds