TX

AFPC staff rept 88-7

WHO WINS AND WHO LOSES FROM AGRICULTURE AND FOOD BIOTECHNOLOGY: SOME POLICY IMPLICATIONS

Department of Agricultural Economics
Texas Agricultural Experiment Station
Texas Agricultural Extension Service
Texas A&M University system.

AFPC
AGRICULTURAL & FOOD POLICY CENTER

WHO WINS AND WHO LOSES FROM AGRICULTURE AND FOOD BIOTECHNOLOGY: SOME POLICY IMPLICATIONS

Ronald D. Knutson

Agricultural and Food Policy Center
Department of Agricultural Economics
Texas Agricultural Experiment Station
Texas Agricultural Extension Service
Texas A&M University

May 1988

AFPC Staff Report 88-7

Who Wins and Who Loses from Agriculture and Food Biotechnology: Some Policy Implications

Ronald D. Knutson[1]

A basic tenet of technological change is that it inevitably precipitates structural change. The magnitude of the change is roughly proportional to the size of the technological advance and the velocity with which the advance is adopted. Biotechnology foretells a quantum leap in the ability to change the genetic make-up of plants or animals and to design new products or inputs used in production. Its effects currently center in industries such as agriculture and medicine where there has been a history of rapid technology adoption. As a result, major, relatively rapid, economic and structural impacts can be anticipated.

In any technological change there are winners and losers. Since technological change has been a key to economic progress (an improved standard of living), the winners outnumber the losers. If the economic system is reasonably competitive, net benefits exist to society as a whole. Yet there are individuals who are adversely affected by technological change.

Public and private market institutions affect the distribution of benefits from technological change. In addition, one of the roles of government has been to create a smoother transition for change in industries such as agriculture.

The purpose of this paper is to indicate the prospective economic impacts of biotechnology on the participants in the agricultural and food industries--from the farmer through the consumer. In the process, the winners and losers from this process of technological change will be identified. For only a few specific technological innovations where the magnitude of impacts on prices and costs is known, some indications of quantitative magnitude of benefits are indicated. In these cases, heavy reliance is placed on the

---

[1]Presented at the conference on Biotechnology, Science and Society, Interdisciplinary Center for Cell Products and Technology, Indiana State University, Terre Haute, April 22, 1988. The author is a professor and extension economist, Agricultural and Food Policy Center, Department of Agricultural Economics, Texas A&M University System, College Station.

research of my colleague James Richardson, The Office of Technology Assessment, and Bob Kalter at Cornell University. Greater detail of the implications of biotechnology for agriculture and food policy is contained in Knutson and Richardson.

The Winners and Losers

The winners and losers from technological change can be identified by sequentially indicating the major steps in the discovery and adoption process.

Discovery: Public-Private Sector Interaction

Historically, most of the basic research leading to major technological breakthroughs in agriculture has been done either in the laboratories of USDA or in the land grant university agriculture experiment stations. The resulting discoveries were made relatively freely available to private sector firms for adoption in their research and development activities. While unique farm machinery and chemical discoveries were patented, the genetic stock of varieties relied upon by even the private hybrid seed companies was not patented. An exception existed in asexually reproduced plants, such as roses, which enjoyed specially enacted patent protection.

This policy of "free" access to the discoveries of agricultural research was part of the social contract (Rousseau) between the agriculture component of the land grant universities and the public. An extension of that social contract has involved objective evaluation of alternative agricultural technologies with the result of information being made freely available to farmers and other interested clientele. This evaluation process has been a joint undertaking of USDA, experiment stations, and the extension service.

An economic effect of this social contract was to result in rapid diffusion of the benefits of technology to the public all the way to the consumer. Farmer production decision errors were minimized by freely available objective research results. The absence of patents on forms of genetic progress, combined with public information, meant that profits were rapidly competed away.

The relative inability of firms to capture profits from agricultural research led to the charge that the absence of patent rights on forms of genetic progress meant that new technologies would "sit on the shelf" of agricultural scientists--a charge which goes largely unsubstantiated. A more likely occurrence is that the policy resulted in a disproportionate allocation of resources toward the types of research that would lead to patents. This may be one of the factors resulting in heavy reliance on chemicals, as opposed to genetic resistance, as a means of controlling diseases and pests. Identically the same reasoning may be applied to the emphasis in medical research. The absence of patenting genetic progress also meant that barriers to entry into the seed and plant breeding business were relatively low, resulting in many small seed companies.[2]

The social contract between the agriculture component of the land grant universities and society began to change in 1970 with the enactment of the Plant Variety Protection Act. The subsequent *Diamond v. Chakrabarty* Supreme Court decision extended patent right protection to new life forms. This opened the door for patenting virtually all products of biotechnology including animals and their offspring. This change in policy has resulted in increased use of lawyers by agricultural experiment stations and other biomedical research facilities to provide assurance that patents are intact and the employment of staff having business experience to sell the patent rights.

The social contract between the agricultural research arm of the land grant system and society has clearly changed--although it is not clear that society (or its policymakers) perceives the significance of this change. Whether the social contract between the extension arm of the land grant system and society has changed remains to be determined. If extension fails to progressively pursue its mission of objectively evaluating this patented

---

[2]It should be noted that genetic progress was not completely without institutions designed to capture above normal profits. Brand names, such as Pioneer and Dekalb were developed by intense advertising with copyright protection. More subtle, but perhaps equally effective, foundation seed stock sources were set up under university auspices to protect the integrity of the seed.

private sector controlled technology, its social contract will also have significantly changed. This patented technology will comprise an ever increasing share of the new products available.

This conclusion has significant meaning for universities that have not enjoyed land grant status. As a result of patenting, the land grant universities are less unique--more like the universities that do not enjoy land grant status. In addition, USDA's competitive grants for biotechnology research became available to all universities. Interestingly, the research in biotechnology is also less unique. There is less of a distinction between biochemistry and chemistry or between medicine and veterinary medicine.

From an economic perspective, patenting the products of biotechnology means a redistribution of the costs and the benefits of research between the public and private sector. This is seen in the sharply increased private sectors investment in biotechnology research (OTA), in the increased patent activity that results therefrom (Evenson), and in the increased concentration of economic activity resulting from acquisitions, consolidations, and mergers of biotechnology related firms. Whereas previously the public sector was paying for a large share of the research costs through its tax dollars, now the private sector is paying a larger share of the costs through its investments, production input costs, and consumption expenditures. If in the process of a readjustment of the social contract, public expenditures on agricultural research do not decline, the pace of technological change should materially accelerate.

Market Effects of Biotechnology

Firms actively involved in the production, marketing, and utilization of the products of biotechnology *or their substitutes* are all directly affected by these new products.

Development Costs

The magnitude of private sector commitment required to develop, secure regulatory clearance, and market a product of biotechnology is generally unappreciated. For example, while bovine somatotropin (bST) was first synthesized from E. Coli bacteria in the early

1980s and its impact upon milk production was demonstrated as early as 1985; it is not likely to be approved for commercial use until 1990 (Baile, et al.). This delay in introduction has occurred despite overwhelming evidence that bST is produced naturally by cows, occurs naturally in milk in trace quantities, has no effect on humans, and, in fact, is a protein that is digested upon entering the digestive track (Smith). Each of the four companies holding patents on bST has spent millions of dollars proving its safety and efficacy.

The development and regulatory approval costs associated with bST, pST, or any other product of agricultural biotechnology are initially borne by the patent holding company and subsequently by the farmer-adopters. These companies and farmers are the initial beneficiaries. The companies attempt to recover huge development and regulatory approval costs while the initially adopting farmers take the risk of adjusting their management and feeding practices to a yet unproven technology.[3]

Pricing

One of the key issues facing the company marketing a newly approved technology involves setting a price on a new input in an environment where the potential payoff is influenced by the quality of farmer management in adopting the technology. In the case of bST, *experimental* farm increases in output per cow range from 5 percent to almost 40 percent (Smith). In a nonexperimental setting, the range in results may be even wider. While models can be developed that assist in this price determination process, the true distribution of payoffs is seldom known.

Even less is known about the psychology involved in the adoption of a new technology, (in the case of bST, periodic animal injections are required), the potential for significant required changes in management practices, and the probability of major changes in government

---

[3]In reality the biggest farmer risk may be taken by those involved in applied field tests of technology prior to their approval. These farmers may also experience the largest potential rewards because the innovation is a free good, product prices are unaffected, and a head start is gained in applying the technology over adopters who wait until the product is available on the market.

policy regarding the price of milk (Smith). Complicating the pricing equation is the reality that, after a long and costly development process, there is substantial pressure by parent company managers to turn a substantial profit on the new product. The prices for new agricultural inputs, therefore, may appear to be astronomical--particularly in comparison with the period when the public was paying for a larger share of the research costs.

Adoption Process

Once the product is approved for commercial sale, the initial successful adopters realize the greatest benefits. This occurs because the initial adopters realize the efficiency gains of a new technology with very little effect on output prices. However, over time the market--and eventually even the government--respond to the increased production that inevitably results from an innovation with the result being a lower market price.

With the lower market price, the technology effectively changes from a carrot to a whip. That is, for the initial adopters the innovation was an attractive carrot from which they could benefit. However, once the technology is adopted by a sufficient number of farmers so that the price falls, the technology becomes a whip that must be adopted; or the farmer will run the risk of being put out of business due to the erosion of profits.[4]

Cochrane referred to this forced adoption process as the "treadmill effect." In other words, firms, in any industry where technology is changing rapidly, find themselves on a treadmill where they must continuously adopt new technology in order to keep pace with change.

It is the treadmill effect that causes some farmers to raise questions regarding the desirability of technological strategy. Yet, most dairy farmers are expected to adopt bST within three years (Kalter). Economics suggests that they will adopt or be out of the

---

[4]In the case of some products of biotechnology, it is possible that there may be a market niche for some farmers who effectively exploit a consumer segment that is willing to continue to pay a higher price for products produced without the aid of biotechnology. For example, after bST is introduced, it is anticipated that milk from cows not injected with bST will continue to be marketed as an "organic" product.

industry unless consumers change and employ a "stop the world; I want to get off" decline to consume the new bST milk. History demonstrates that consumers seldom turn down the benefits of a new technology.

History also suggests that larger farms tend to be more aggressive in adopting new technologies than either smaller or moderate size (family) farms. Stanton found a positive relationship between dairy herd size and milk output per cow. Carley and Fletcher found that herd size was one of the factors related to higher output per cow. In addition, size of herd was positively related to the use of management practices such as dairy herd improvement testing, artificial insemination, forage quality testing, and ration balancing.

Such studies lead to the conclusion that biotechnology may be *biased against* moderate size (family) farms. This conclusion is fortified by the studies indicating large economies of size in agriculture (Knutson, Richardson and Phillips; Knutson et al.) and by studies indicating that biotechnologies can be anticipated to be complex to apply. In other words, among farm sizes the greatest beneficiaries of biotechnology can be anticipated to be large farms in both absolute and relative terms. Moderate size farms are going to find survival *more difficult* in the age of biotechnology.

Consumer Benefits

The economic phenomena of new technology lowering the cost of goods and services that are the product of technological change mean that consumers are the greatest beneficiaries of change. Under competitive conditions, consumers are the only long-term beneficiaries of technological change. The more competitive the industry and the faster the rate of discovery, development, and adoption, the more rapidly consumer benefits are realized. Past studies have indicated rates of return associated with public investment in agricultural research and extension to be in the range of 45 percent to 130 percent (Ruttan, p. 248).

Consumer returns are not only realized in terms of lower prices but in more difficult to quantify improvements in product quality. While biotechnology holds the potential to reduce costs of production, and thus lower food prices, it has at least as great a potential to improve food quality. Not only are changes in the balance of nutrients possible, but problems such as the cholesterol content of animal fat could potentially be overcome.

The inelastic nature of the demand for farm products and the past availability of research results to firms, combined with relatively large public investments in extension of research results has resulted in a rapid transfer of the benefits of technological change to consumers. While the conference of patent rights may mean the discoverers and developers may capture a larger share of the benefits of change, this could be offset by a more rapid pace of technological discovery associated with increased private sector investment in research--given commensurately increased investment in extension.

Policy Implications

The agricultural and food policy implications of biotechnology have previously been discussed by Knutson and Richardson and by OTA. Those results will only be summarized here in terms of research and extension policy, structure policy, international trade policy, and domestic farm policy.

Research and Extension Policy

There is no turning back now on the issue of patent rights and the change in the social contract of the agricultural research component of the land grant university. Questions continue to exist regarding the social contract of extension.

Increased private sector involvement in agricultural research makes extension relatively more important. The increased flow of complex new inputs into agriculture places increased evaluation responsibility on extension. Some agribusiness suppliers may not desire objective evaluation of new inputs. Extension may resist evaluating products of the private sector for fear of the consequences of findings of poor performance. Objectivity of evaluation may be difficult to maintain on a product where the university holds patent rights. While the need for extension is greater, the challenges, likewise, are greater.

Structure Policy

Biotechnology, almost naturally, fosters larger farms, more integrated farms, mergers, consolidations, and acquisitions of firms within and serving agriculture. Moderate size family farms are seriously jeopardized by biotechnology trends. OTA devotes a 374 page report to determining what can be done to preserve the family farm structure in an age of biotechnology. They conclude that farm program benefits would have to be almost completely denied large farms. Research and extension programs would have to be tilted in the direction of helping family farms survive.

International Trade Policy

Biotechnology, itself, has become a focal point of international competition (OTA). West Germany and Japan appear to be the most aggressive rivals in the science of biotechnology. Among the food exporting countries, biotechnology will make competition for farm product markets more keen. The increased production associated with the use of biotechnology inputs requires that markets for agricultural products remain open.

Maintaining competitiveness in international markets requires that biotechnology inputs be available to U.S. farmers as soon as they are available to the farmers of competitive exporting countries. In addition, new biotechnology inputs must be adopted as soon as the innovations become available. This requires an efficient and effective regulatory clearance process, an effective system of technology transfer, and a farm policy that does not price U.S. products out of world markets.

Domestic Farm Policy

An increasing divergence of costs between adopting and nonadopting farmers will create pressure to continue farm programs. Substantial excess capacity could develop in products where innovations result in large increases in output and/or efficiency. Target and support prices will need to be adjusted downward in response to changes in efficiency. Flexibility, therefore, becomes a key to avoiding serious problems. Temporary production controls and resource adjustment programs will surely be considered. The key becomes one of providing a means by which resources may flow out of agriculture into other productive enterprises.

Conclusions

The conference of patent rights means that a larger share of the benefits of biotechnology will be distributed to those who hold the patent rights and the initial adopters of the technology. How rapidly the benefits flow to consumers depends on policies toward technology transfer institutions such as the Extension Service. Also affected is the survival of institutions such as the family farm.

Because of these differential impacts, planning for the impacts of biotechnology will be difficult. It is critically important that policymakers anticipate change and not get locked into an inflexible position.

References

Baile, C. A., F. C. Buonomo, and G. G. Krivi, "Future Developments in bST Technology," National Invitational Workshop on Bovine Somatotropin, D. Smith, ed. (St. Louis: ES/USDA, 1987), pp.74-86.

Carley, D. H. and S. M. Fletcher, "An Evaluation of Management Practices Used by Southern Dairy Farmers," Dairy Science, (1986), pp. 2458-64.

Evenson, Robert E. "Intellectual Property Rights and Agricultural Research and Development," Amer. J. Agr. Econ., (1983) pp. 967-75.

Kalter, Robert J. et al., Biotechnology and the Dairy Industry: Production Costs and commercial Potential of Bovine Growth Hormone, (Ithaca: Department of Agricultural Economics, Cornell University, 1984).

Knutson, Ronald D., and James W. Richardson, Implications of Biotechnology for Agricultural and Food Policy, AFPC Staff Report 88#2 (College Station: Texas A&M University, 1988)

Knutson, Ronald D., James W. Richardson, and Micheal J. Phillips, "Technological Change and the Structure of Agriculture," Forum for Applied Research and Policy, (Summer 1987), pp. 66-76.

Knutson, R. D., et al. Economic Impact of Payment Limits, unpublished manuscript, (College Station: Department of Agricultural Economics, Texas A&M University, 1988).

Office of Technology Assessment, Technology, Public Policy, and the Changing Structure of Agriculture, (Washington, D.C.: U.S. Congress, 1986)

Rousseau, Jean-Jacques, " The Social Contract or Principle of Political Right," Social Contract, Essays by Locke, Hume and Rousseau, (London: Oxford University Press, 1958), pp. 237-440.

Ruttan, V. W., Agricultural Research Policy, (Minneapolis: University of Minnesota Press, 1982).

Smith, David R. ed., National Invitational Workshop on Bovine Somatotropin, (St. Louis: ES/USDA, 1987).

Stanton, B. F., Complexities of Northeast Milk Producers in the National Market, Cornell University Agr. Exp. Sta. N. 87-5, (Ithaca: Dept. of Agricultural Economics, 1987).