

## **PUBLIC SCIENCE, BIOTECHNOLOGY, AND THE INDUSTRIAL ORGANIZATION OF AGROFOOD SYSTEMS**

Steven Wolf & David Zilberman<sup>1</sup>

Concentration in the agricultural biotechnology sector and general patterns of restructuring raise important policy questions regarding public investments in research and extension. We argue that the most valuable contributions public sector organizations can make to development lie in: 1) fostering a decentralized system of innovation; 2) constructing capacity for the differentiation of technologies, organizational forms, and consumer products; and 3) maintaining the potential for radical innovation through leadership in fundamental research.

*Key words:* public research; agricultural extension; Land Grant university; privatization; differentiation; radical innovation

The most important agricultural biotechnology innovations originated in universities, were transferred to start-up companies, and were then absorbed by global corporations (Kenney, 1986). Monsanto, DuPont and others have developed their bio-engineered products through a combination of in-house research and acquisition of intellectual property. Joint ventures and buy-outs have been commonplace, and the emergence of the lifescience industry has occurred rapidly. Now that Pioneer Hybrid has been purchased outright by DuPont, there is rising concern over non-competitive structure in input markets (Wright, in press; “In The Mill,” 1999). Emerging patterns of integration between input manufacturers and agrifood processors -- linkages designed to coordinate and capture value in biotechnology-based, identity preserved commodity chains -- have heightened concerns over industrial structure. These developments raise questions about the fate and orientation of public research and extension.

### **Shifting Public-Private Relations In Agricultural Research And Extension**

Private sector investment in research is expanding rapidly and universities have become desirable places to spend some of this money, if agribusiness firms can capture value produced in the research process. Universities are targeted because faculty and graduate students have shown themselves to be highly creative and productive, and because investments in university research are

---

<sup>1</sup>Steven Wolf is a Post-Doctoral Fellow at the Department of Agricultural and Resource Economics, University of California, Berkeley and Unité d'Économie et Sociologie Rurales, Institut National de la Recherche Agronomique - Toulouse, France. David Zilberman is a Professor and the Chair of the Department of Agricultural and Resource Economics, University of California, Berkeley. © 1999 AgBioForum.

cost effective, despite overhead charges. The logic of outsourcing to create flexibility, lower debt and indirect costs, and to deflect liability applies to the expensive and rapidly changing field of genetic research. We are now at the stage where a major company like Novartis has formed an exclusive relationship with a university partner. Under a recent agreement, Novartis will fund molecular biological research at the University of California, Berkeley and provide access to proprietary data and technology in return for a preferential position in the process of commercialization of resulting products.

Because faculty researchers and universities are competing for limited public funds to support expensive research, making alliances with leading commercial firms is an attractive strategy. Public support for research has been stagnant (Kloppenborg & Buttel, 1987), and the future of public research and extension in an industrializing agriculture is uncertain as there is a perception in some quarters that the globalizing agrifood industry is capable of servicing its own research and information needs. The role of the state in agricultural development is further clouded by the contemporary political economic context in which all public investments must meet increasingly stringent tests of legitimacy. This shift toward private sector dominance should be interpreted in connection with the integration of global markets and the related trend of disengagement of the state. The United Kingdom and New Zealand are perhaps the most striking examples of privatization in agriculture. There, over the course of this decade, the federal research and extension establishments have been sold off to private bidders (Bunney, 1998).

In the United States (U.S.), public funding for agricultural research has remained roughly constant in the 1990s while private agricultural research expenditures tripled between 1960 and 1992 (Fuglie *et al.*, 1996). In 1992, at \$3.7 billion, private sector expenditures on agricultural research were almost 50% more than the public sector's \$2.5 billion. Given rapid and large increases in private investment, the two principle policy questions are: (1) what will be the balance between public and private sector funding in Land Grant universities; and (2) what will be the targets of such public investments.

### **The Basis Of Public-Private Complementarity In Agricultural Research?**

Some have suggested that universities can increase revenues and keep pace with rising private investment by more aggressively marketing their research products. That is, by patenting and licensing intellectual property produced in the university, substantial funds can be realized and plowed back into research. Regardless of economic feasibility, this strategy is an indication of the emerging orientation of public science. Historical, economic, and ideological forces have given rise to the American entrepreneurial university (Etzkowitz, in press), fueling concerns as to the extent to which science will be proprietary and knowledge will be commodified.

While there is no doubt that university research is a source of great value, capturing this value has proven difficult. In spite of 20 years of intensive technology transfer activity, university revenues in the U.S. from licensing and patenting are in the order of magnitude of \$600 million per year. This revenue stream is about 6% of university research costs (\$10 billion) and less than one percent of university budgets (which exceed \$100 billion). While this revenue stream is growing rapidly, marketing university technology cannot be regarded as an alternative to public funding (Zilberman *et al.*, 1999).

We contend that public investment in universities, particularly Federal funding, is vitally important to maintenance of a healthy system of innovation. In addition to the traditional economic logic that

universities produce public goods, we argue that public research contributes to the maintenance of competitive economic structure, specifically, retention of the capacity for differentiation of technologies, organizational forms, and consumer products. Public investment also holds the potential for radical innovations that will not emerge from more narrowly focused private research. By creating open access to knowledge and tools and supporting people's ability to use them effectively, universities promote a more democratic and economically robust structure.

The nature of relations between the U.S. Department of Agriculture (USDA), Land Grant universities, and commercial investors in input technology is inextricably linked to a second undecided question, that is, the future industrial organization of commodity chains. Public funding of research and extension will affect the structure of the farm and agribusiness sectors, the diversity of agricultural technologies and consumer products, the extent to which farmers retain autonomy, and economic development of agriculturally dependent communities. A strong commitment to public funding will allow universities to maintain their independence from any specific commercial interest, which is essential for retention of open access to science and technology. Facilitating broad access to technology and knowledge will insure dynamism and a more heterogeneous structure in systems of innovation (Callon, 1994).

A vibrant and independent university system will continue to produce fundamental knowledge, which is different from the strategic, pre-technology projects that large private organizations are increasingly willing to undertake. The commitment to fundamental science will provide support for the applied research and technology development efforts of existing private sector firms and make discoveries that industrial laboratories (and perhaps privately funded public facilities) may never pursue.<sup>1</sup> Beyond basic research, public funds should be targeted toward applied projects, particularly socially desirable outputs that private investors would not undertake because the results are not appropriable. Public research should shift its focus away from reducing production costs of commodities; the largest category of public research spending (Fuglie *et al.*, 1996, p.19). Instead, development of specialized products and production processes that take advantage of site-specific resources must be emphasized. This strategy will lead to more agro-ecologically oriented production systems, and more value being created and retained by a wider range of actors.

By maintaining access to information and technology, publicly funded universities can facilitate entry of new entrepreneurs into a wide variety of niches in agricultural and, more generally, rural production systems. Niches include input services, production, processing, and the marketing of rural products. The objective of public universities should not be to fill existing niches but rather to create an environment in which people can develop new productive activities. Universities are social technologies which are well positioned to support a decentralized system of innovation. By providing infrastructure, education, and access to knowledge and technology, public research and extension can serve as a catalyst and facilitator of an increasingly diverse set of projects.

Capacity for radical innovation -- scientific advance that is qualitatively different from what came before -- is a critical justification for continued public engagement in an agricultural knowledge system. By retaining a parallel mechanism for innovation, -- that is, an infrastructure separate from but linked to the commercial infrastructure -- we remain open to create and exploit new opportunities. Of course, maintenance of such capability comes at a cost, but one we think is justified. Investments to sustain diversity of technical and organizational forms serve to avoid the complacency and potential suppression of innovation that can accompany concentration. While some have argued that innovation is enhanced rather than retarded by concentration, we believe this outcome is based on an analytic framework that focuses narrowly on the rate of exploitation of

existing technologies and knowledge. In certain settings, monopoly-like conditions may well lead to more rapid incremental advancement along the existing trajectory. But there is a high likelihood that the realization of existing alternatives that have been theorized, but not yet developed, and the identification of new lines of inquiry capable of reorienting or displacing industrial sectors, will be slower or more incomplete within a highly concentrated environment.<sup>2</sup>

Lastly, sustaining multiple trajectories leverages private research investment. In response to the risk of being left in the dust of a rapidly advancing technological frontier, firms are more likely to act like “learning organizations” seeking continually to reinvent their products rather than wait to be “leap frogged.” At the very least, firms will make investments in human capital to position themselves to follow quickly behind the leaders of projects that threaten their position.

### **Strategic Targets Of Public Research**

The public sector can complement the private sector by serving as an engine of differentiation and radical innovation. Toward this objective, we identify four sets of activities for public research and extension to pursue. These sets of activities are as follows:

- Produce basic knowledge and make it available to a wide range of private sector agents.
- Develop site-specific technologies and services that the private sector will not adequately supply to audiences the private sector will not target.
- Upgrade competencies of farmers and other potential entrepreneurs to allow them to participate actively in innovation, not just adoption.
- Catalyze innovation by facilitating collective action and providing an infrastructure in which a wide range of people and organizations can capture value from public research products.

Public investments in research and extension contribute to material well-being by addressing market failures and by insuring “creative destruction” in the economy. By supporting the creation of new firms and new sectors, public science enhances competition and raises performance requirements on private firms. This important feature of our national system of innovation is endangered as knowledge becomes increasingly proprietary and universities and their faculties seek corporate sponsors. Clearly, connectivity between public researchers and commercial firms is valuable in terms of both putting research products to work and in stimulating new research questions. Our interest lies in strengthening this two-way flow while retaining a commitment to fundamental research and maintaining open access to knowledge (Foray, 1998).

In the case of agricultural biotechnology, current levels of commercial concentration, fragmentation of intellectual property rights, and the complexity and cost of the research limit who can participate in product development (Ransom *et al.*, 1998). As a result, we are on a trajectory that is increasingly narrow in terms of access to and control of the technology. Biotechnology has the potential to be a source of differentiation of production systems and organizational forms. However, such differentiation will not be realized if there no institutional mechanism is in place outside of the product development and marketing structures of the heavily concentrated commercial sector. To promote differentiation, public investment in agricultural science should be increased and public scientific capability and the extension system should be oriented toward

increasing the potential number of firms and collectives engaged in biotechnology innovation. Through a policy of open science and training in entrepreneurship, more people in more settings will have access to the power of knowledge.

## **Endnotes**

<sup>1</sup> We agree with critics of the linear model of innovation that basic research is not the only pathway to discovery. Clearly, applied research and insights of practitioners can lead to theoretical questions that support fundamental discoveries. Regardless of recent recognition of multiple pathways to fundamental insights, basic research remains an important strategy for development.

<sup>2</sup> We are aware that this argument again invokes the now highly unfashionable linear model of innovation. See Endnote 1 for our reasoning.

## **References**

- Callon, M. (1994). Is science a public good? Science, Technology and Human Values, 19(4), 395-424.
- Etzkowitz, H. (in press). Beyond the endless frontier: From the Land Grant to the entrepreneurial university. In S. Wolf & D. Zilberman (Eds.), Knowledge generation and transfer: Implications for agriculture.
- Foray, D. (1998). The economics of knowledge openness: Emergence, persistence, and change of conventions in the knowledge systems. In N. Lazareic & E. Lorenz (Eds.), Trust and economic learning. Northampton, MA: Edward Elgar.
- Fuglie, K., Ballenger, N., Day, K., Klotz, C., Ollinger, M., Reilly, J., Vasavada, U., & Yee, J. (1996). Agricultural research and development: Public and private investments under alternative markets and institutions (U.S. Department of Agriculture [USDA], Economic Research Service [ERS], Agricultural Economics Rep. No. 735). Washington, DC: USDA/ERS.
- In the mill. (1999, March 20). The Economist, pp. 64-65.
- Kenney, M. (1986). Biotechnology: the university-industrial complex. New Haven: Yale University Press.
- Kloppenburg, J. & Buttel, F. (1987). Two blades of grass: The contradictions of agricultural research and state intervention. Research in Political Sociology, 3, 111-135.
- Ransom, E., Busch, L. & Middendorf, G. (1998). Can cooperatives survive the privatization of biotechnology? In S. Wolf (Ed.), Privatization of information and agricultural industrialization (pp. 79-94). Boca Raton, FL: CRC Press.
- Wright, B. (in press). Challenges for agricultural research and extension in a world of proprietary science and technology. In S. Wolf & D. Zilberman (Eds.), Knowledge generation and transfer: Implications for agriculture.

Zilberman, D., Castillo, F., & Parker, D. (1999, March). Performance of university offices of technology transfer. Paper presented at the meeting “Innovation and technology transfer in the 20<sup>th</sup> Century”, University of California, Berkeley, California.