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Wallace Huffman

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Developments in the Organization and Finance of Public Agricultural Research in the United States, 1988-1999

by Wallace E. Huffman*

Abstract: This paper describes major external changes to the U.S. public agricultural research system over 1988-1999; describes the reactions of the public agricultural research system to the external changes, specifying the innovations that have occurred over the last decade; and draws conclusions about the present and future performance of the U.S. research system. The decade of the 1990s brought slow growth to public agricultural research funding. CSREES tried to stimulate greater interests in competitive grant programs. The states have generally resisted this move. A major asymmetry exists in the sharing of transactions costs associated with external peer-reviewed competitive grant programs. This is especially true when the average grant size is small and the average award rate is low.

* C.F. Curtiss Distinguished Professor of Agriculture and Professor of Economics and Agricultural Economics, Iowa State University, Ames, IA 50011. The preparation of the paper was stimulated by a conversation with Willem Janssen at ISNAR in The Hague, The Netherlands, May, 1999.

Developments in the Organization and Finance of Public Agricultural Research in the United States, 1988-1999

In the United States, the R&D system for agriculture is one of shared financing and conducting research. Both types of activities occur in the public and private sectors. Within the public sector, financing is also shared between the federal government and 50 state governments, but in 1988, the state governments accounted for about twice as many resources as the federal government. Public agricultural research is conducted primarily in the Agricultural Research Service (ARS) and Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA) and in the state agricultural experiment stations of the state land-grant university system. In financing agricultural research, there are net transfers of resources from the federal government and private industry and commodity groups to the state agricultural experiment station (SAES) system. There is very little public sector financing of agricultural research in the private sector. In 1988, approximately 50 percent more resources were allocated to conducting agricultural research in the private than public sector, and within the public sector, about 50 percent more resources were allocated to agricultural research in the SAES system than in the USDA's research agencies (Huffman and Evenson 1993).

A complex set of forces that affect the finance and organization of public agricultural research were operating in the United States during the past decade, and they have brought changes. The political environment at the national level was unusual during 1988 to 1998. It followed the Reagan Presidential term (1980-1988) where federal tax rates were cut and tax policy streamlined to reduce government revenue in an attempt to squeeze down the size of federal government operations. When government expenditure reduction proved more difficult than tax reductions to achieve, a rapidly growing federal government deficit occurred. The

deficit grew to the mid-1990s when it became apparent that a national economic disaster was approaching. In 1995, the U.S. Congress set out to balance the federal budget, and new legislation was finally passed in 1996 which has as its goal achieving a balance federal budget by 2002. This meant cutting federal government expenditures in real terms significantly. However, due to some unusual federal program changes (e.g., dramatically restructuring the national welfare program) and fortuitous economic events, the federal budget balance occurred much earlier than anticipated--in 1998 rather than 2002 (Clinton 1999). Thus, many of the unusual adjustments that were occurring over the reference period seem to be completed.

The objectives of this paper are: (i) to describe major external changes to the public agricultural research system, (ii) to describe the reactions of the public agricultural research system to the external changes, specifying the innovations that have occurred over the last decade, and (iii) to draw conclusions about the present and future performance of the U.S. research system. The paper draws heavily upon Huffman and Just (1999a,b,c) and Huffman and Evenson (1993). A recent report on the colleges of agriculture (Committee on the Future of the Colleges of Agriculture et al. 1995) and a book by Alston and Pardey (1996) also provide important information about the organization of agricultural research in the United States. The story unfolds in the following sections.

Key Developments that have affected the Agricultural Research System

***Changing demands for public agricultural research*.** Income and price changes have been a major force for changing the demand for public agricultural research, resource and environmental quality, and food safety. Khanna, Huffman, and Sandler (1994) have shown that the demand for public agricultural research is income and price responsive. They tested pure and

impure models of public good demand and concluded that an impure public goods model of the demand for public agricultural research by state governments fits well and better than a pure public goods model. They showed that the demand is price elastic but income inelastic. Furthermore, it seems reasonable to extend these results to federal government behavior. With real federal government revenues (net of trust fund revenues) declining 21 percent over 1988 to 1997 and real state government revenues (net of intergovernmental transfers) growing about 27 percent, there were major economic forces for restructuring public sector support of agricultural research.

Research that enhances farm productivity benefits domestic consumers when farm products are inputs to domestic food and fiber consumption and foreign consumers when farm products are exported. Consumers pay lower prices, receive better quality or more diverse products. U.S. families spent only 16 percent of personal consumption expenditures on food in 1988 and this share was down to 12 percent by 1998. As U.S. consumers' concerns for food costs have lessened, other consumer concerns have become more visible, e.g., food safety, fat content, processing, technology used to produce the product (Committee on the Future of the College of Agriculture et al. 1995, p. 22-24).

Households' demand for resource and environmental amenities, for food safety, and for food processing are income elastic but for unprocessed food and food at home it is income inelastic (Antle 1999a,b). During 1988-1998, U.S. per capita real income grew at an average rate of about 2 percent, but this was about one-half the rate for the previous decade (Clinton 1999). Thus, income growth was continuing to shift U.S. households' expenditure shares toward

income elastic goods and services, i.e., resource and environmental amenities, food safety, and food processing, and away from income inelastic goods and services, e.g., unprocessed food, food at home. Income driven changes in households' demand, however, were occurring at a slower pace during the 1988-98 period than during the preceding decade.

During 1988-98, the aggregate supply of U.S. domestic agricultural output grew at an average rate of about 3 percent, 1.9 percent for animal products and 3.5 percent for plant products (Ahearn et al 1996). Relative to the preceding decade, these should be compared to 1.3 percent, 1.6 percent, and 1.2 percent respectively. Thus, during the most recent decade, the domestic supply of agricultural output was growing relatively rapid. Furthermore, total factor productivity was growing at an average rate of about 2.9 percent during 1988-98, and this was slightly faster than during the preceding decade. Thus, rapid productivity change most likely was a drag on the demand for public agricultural research during both the current and past decade.

R&D leading to new technologies for farming has also raised public concern because of possible negative impacts of farm chemicals on human health, of tillage practices and chemicals on soil and water quality, and new farming practices generally on wildlife and the composition of the landscape. Research has shown that agricultural chemicals and soil sediments are impairing the quality of some surface and groundwater sources and imposing costs on water users (USDA 1997). This evidence has increased the demand for research on new production technologies that are cost effective and less degrading of the environment and human health (Committee on the Future of Agricultural Colleges et al. 1995).

Although the USDA's competitive research grants program was first established in 1977 to address high-priority research areas identified by an advisory committee to the secretary of agriculture and somewhat refocused in the mid-1980s on biotechnology, it was re-named the National Research Initiatives Competitive Grants program in the 1990 farm bill. The purpose of the NRI is to support high-priority fundamental and mission-oriented research of importance in the biological, environmental, physical, and social sciences relevant to agriculture, food, and the environment. The broad parameters of the NRI program, including the major program areas, were legislated in the 1990 Farm Bill. The legislation requires that stakeholders and others have input.

The 1995 farm bill debate was very much affected by the interests of Congress in balancing the federal budget by 2002. When the farm bill was actually passed in 1996, it removed all production restrictions on farmers' use of land except for the planting of fruits and vegetables and minimum conservation requirements, eliminated deficiency or income payments that were market-price based, and established a new research program called the Fund for Rural America. The main effects of the new legislation has been increased production of soybeans and corn (reduced production of small grains and cotton), somewhat greater uncertainty about output prices, and increased inter-regional competition. The addition of the Fund for Rural America seemed to be in anticipation of new research problems that would arise under increased market orientation of farmers' production decisions.

The fund for Rural America became part of the USDA's competitive grant's program. This program focuses on increasing international competitiveness, efficiency, farm profitability, environmental stewardship, and rural community enhancement. Its goal was to fund applied,

developmental, and adaptive research, technology transfer, extension, and related outreach activities and extension. Also, it emphasized multi-disciplinary and system approaches to research for large rural problems and the integration of research, education, and extension. Collaboration, partnerships, and cooperation across institutions and organizations were strongly encouraged. When applied research was commodity specific or locally focused, matching federal with other funds was required. For both the NRI and Fund for Rural America, the research agenda was set at the national level and scientists across a broad range of institutions were eligible to compete for the funds.

The Government Performance and Results Act (GIPRA) of 1993 has meant strategic planning and annual program performance reporting for every agency of the federal government, including the Cooperative Research, Education, Extension Service which oversees the federal formula funding of agricultural research and extension of the land-grant universities (U.S. Congress 1993). This legislation was stimulated by concerns in the U.S. Congress for greater accountability to taxpayers for the performance of programs and a need for better planning of federal programs.

The 1998 Agricultural Research, Extension, and Education Reform Act (AREERA), however, has superseded GIPRA. The 1998 act applies to land grant institutions receiving Hatch (research) and Smith-Lever (extension) formula funds from the federal government (U.S. Congress 1998). As a part of accountability, every university must file a “plan of work” for use of authorized funds, integrate research and extension activities (for roughly 25 percent of the funds), implement a process for obtaining stakeholder input concerning the uses of research, extension, and education formula funds, and see that a merit review of programs are conducted at

least once every five years. Also, the requirements of regional research were extended to be multi-state, multi-institutional, and multi-disciplinary. In addition, multi-state extension programs are required for the first time, and the National Academy of Sciences was requested to study the role and mission of federally funded agricultural research, extension, and education. In particular, the Academy is to focus on the strength of science in the USDA's Agricultural Research Service programs; how ARS relates to capacity of the U.S. agricultural research, extension, and education system; examine appropriateness of the "formula" for allocating Hatch (research) and Smith-Lever (extension) funds to the states; and examine the system of competitive grants for agricultural research, extension, and education.

In carrying out the 1998 legislation, CSREES has established the following five goals for its next five-year plan and expects the supporting institutions to conform to the guidelines: (i) an agricultural system that is highly competitive in the global economy, (ii) a safe and secure food and fiber system, (iii) a health, well-nourished population, (iv) greater harmony between agriculture and the environment, and (iv) enhanced economic opportunity and quality of life for Americans.

The strengthening of intellectual property rights to biological innovations started in 1970 with creation of the plant-variety-protection system and continued during the 1980s with the U.S. Supreme Court decision in *Diamond vs. Chakrabarty* (1980) which extended patent protection to living organisms, the subsequent ruling by the Patent and Trademarks Office's Board of Appeals which extended this decision in *Ex parte Hibberd* (1985) to cover all plants, including open-pollinated seeds, and the Board's decision in 1987 in *Ex parte Allen* which extended patents to cover nonhuman animal genes, traits, and breeds. The recent changes in the

intellectual property rights system to accommodate the products from the applications of the 1980 Cohen-Boyer patent on the basic technique of gene-splicing (recombinant DNA) and the potential for transgenetic organisms, plants, and animals have opened many new opportunities for profits to the private sector. The advances in biological and information science and strengthening of IPRs have been major factors in the accelerated rate of growth of private agricultural R&D expenditures in the U.S. since 1977 relative to public agricultural research expenditures (Fuglie et al; Huffman and Evenson 1993). The restructuring in the U.S. of the chemical/life sciences and seed industries around Monsanto, Dow and Dupont (see figure 1) is raising new issues about public-private sector relations in the advance of science and technology for agriculture. In 1988, all of the current "satellites" of these companies were operating as independent businesses.

The USDA has expanded its research efforts to some extent through joint ventures. These include the use of cooperative agreements that are jointly funded and performed largely with SAES and veterinarian medicine schools and cooperative research and development agreements (CRADAs). Cooperative research agreements between the USDA and agricultural experiment stations have been in existence for a long time, but CRADAs resulted from the 1986 Technology Transfer Act. This legislation permits federal laboratories to enter into CRADAs with universities, private companies, non-federal government entities, etc. The principle goal of CRADA is to stimulate technology transfer activities by linking the pre-invention scientific research capacity of federal laboratories with commercial research and marketing expertise of the private sector. Under a CRADA, partners put up resources, and the nonfederal partner receives the right of first refusal to any joint discovery and may be given exclusive access to data

from a joint project. CRADA activity has increased rapidly, amounting to over 500 projects by 1995 (Fuglie, et al 1996, p.56), but private sector CRADA resources are less than 1 percent of the budget of the Agricultural Research Service (Cole 1998).

Changing Organization of Science and Research

New developments in the organization of agricultural research. Three major changes are highlighted. First, the U.S. Congress has reduced real funding for formula and program funding (traditional federal funding of public agricultural research) and increased centrally controlled competitive grant funding. Federal expenditure on biological research by the USDA's Agricultural Research service were $438 million in 1988 (real 1984 dol.) and decreased to $420 million in 1997, a 4.2 percent decline. The USDA's expenditures on social science research (ERS) decreased from $40 million in 1988 to $33 million in 1997 (real 1984 dol.), a 19.4 percent decline. For the state agricultural experiment station system (SAES), real grand total research expenditures increased slightly (2.2 percent) from 1988 to 1997, or from $1,145 million to 1,202 million (1984 dol.). The share of SAES system funding coming from federal-regular-formula funds declined by 1.2 percentage point which was a combination of a decline of 2.8 percentage points in the share coming from regular-federal-formula funding and a 1 percentage point increase in the USDA competitive grants programs, i.e., the NRI, and an 0.7 percentage point increase in the share from special grants programs. Second, public agricultural research scientists are being encouraged to pursue nontraditional sources of funding such as federal funds outside the USDA, private corporations, and producers (commodity) groups. The share of SAES system funds coming from contracts and grants with non-USDA federal agencies increased by 2.7 percentage points over 1988 to 1997. Also, the share of USDA contracts and cooperative

agreements with the SAES system increased by 1.2 percentage points. The share of funding for the SAES system from private sector sources (e.g., private industry, commodity groups, foundations) increased by 2.2 percentage points. Therefore, the largest increase in SAES system funding over 1988 to 1997 has been from non-USDA federal and private sector sources and the primary decline has been in the relative importance of regular federal formula funding.

The funding of the USDA's own research operations is almost exclusively by the federal government, but the CRADAs have provided a new and still relatively small source of research funds, largely for ARS research. Third, public universities are increasingly entertaining and entering into exclusive joint ventures with a particular large ag-chemical/life science company. The University of California-Berkeley has entered into an unusual joint venture with Novartis and other institutions are evaluating alternatives. Novartis has agreed to provide $25 million for funding over 5 years of research projects largely in the Department of Plant and Microbial Biology, University of California-Berkeley, and to provide access to unusual plant germ plasm to their scientists. The research funds for projects are to be channeled through a faculty controlled committee that will evaluate research proposals and give out the awards. Novartis is given first right of refusal to negotiate a licensing agreement on all advances from research funded by Novartis money and those funded by federal money.[i] The Berkeley-Novartis arrangement is unusual in that other companies are excluded from working with faculty who are covered by the Novartis venture. Departments frequently have had faculty contracting with competitors at the same time.

Some other changes in the relative emphasis of the public and private sector have also occurred. Within plant breeding, the public sector has largely withdrawn from hybrid corn,

cotton, and soybean varietal development and the private sector has taken a full role. This trend has been in progress for at least 30 years, but accelerated after 1970. In particular, the public sector is no longer a significant source of inbred lines for hybrid corn variety development (Huffman and Evenson 1993). Thirty years ago, the public sector was also the dominant source of new varieties for soybeans and cotton, but this has all changed. The private sector has become the dominant source in new vegetable variety development, too.

In small grains, which are open pollinated, e.g., oats, wheat, barley, the private sector has found limited profitability in developing new varieties, and during the past decade, the private sector has largely pulled out of this seed market. The public sector is the major source of new varieties for these crops.

Over 1988 to 1998 the combination of building on advances in biology and information sciences and strengthening of IPRs has resulted in the private sector taking over a larger share of applied agricultural research where expected private sector profitability has been good. In some other areas of applied research, the expected payoff rates has been negative or low, e.g., small grain varietal development, resource and environmental quality research, policy research, and work remains for the public sector to undertake. Although the private sector finances a little research in the basic/general sciences and pre-technology science areas, discoveries in these areas are largely pure public goods and are difficult for the private sector to capture returns without patent or breeders' rights protection. Overall the public sector has withdrawn from applied research that is in direct competition with the private sector and shifted its emphasis to research in the basic-general and pre-technology sciences.

Changing responsibilities of the public vis-a-vis private sector research. Overall the rate of growth of private agricultural research funding has been growing faster than public agricultural research funds (Huffman and Evenson 1993; Fuglie, et al 1996). The research of the private sector is heavily focused on applied agricultural production--new technologies for crop and livestock production. The private sector, however, engages in relatively little research on natural resource management, regulation, policy and consumer protection. It, however, invests a large amount in food and agro-industrial research (Huffman and Evenson 1993).

In the U.S., the public sector, especially the public universities, have taken a larger role in basic and pre-technology scientific discoveries. Since 1950, the USDA's own agricultural research operation has been about one-half the size of the SAES system (Huffman and Evenson 1993) . During 1988 to 1997, the rate of growth of funds for the SAES system was significantly larger than for the USDA's research agencies, so the relative importance of the SAES system has increased. The private sector has taken on a larger share of applied research as advances in science and strengthening of intellectual property rights have made private R&D profitable in more areas. The private sector, however, continues to find applied research in some areas unprofitable and it has withdrawn during the 1990s from some areas of research. For example, Pioneer Hibred gave up on wheat variety development and gave its wheat germ-plasm to Kansas State University.

In the U.S., the driving forces behind accountability in public agricultural research has come primarily from the Federal government. The concern has been (1) with what taxpayers are obtaining in the way of benefits from federal expenditures and (2) an attempt to undertake better planning of federal government programs. Starting in the mid-1990s, the main focus of national

policies was to cut the size of the federal government budget deficit and achieve balance by 2002. Although fortuitous economic events brought a balanced federal budget much earlier than anticipated, the federal government is expected to carefully scrutinize research expenditures for agriculture in the foreseeable future.

Institutional Changes Within the Agricultural Research System

Institutional innovation in the field of governance and oversight. Both GIPRA and the 1998 Research, Extension, and Education Reform Act have been attempts to introduce new and effective strategic planning and regular performance reporting into agricultural research and education. Although the intent of these policies is good, they contain a large amount of bureaucracy in their implementation. GIPRA, which was broad legislation, lacked procedures or the flexibility to accommodate unusual attributes of research, e.g., large amount of ex ante uncertainty of payoff, long lags between input and payoff, asymmetric information on scientists' effort and difficult to monitor inputs, quality as the key dimension of output, heterogeneous productivity across scientists, relative to other government activities. Hence GIPRA is a failure for public research. AREERA was written specifically for research, extension, and education, but it too has bureaucratized accountability and reporting while making slightly accommodating the unique attributes of the research activity. The legislation, however, seems likely to increase the amount of multi-state, multi-disciplinary, and multi-institutional research that is undertaken. It also is requiring extension to pursue a new multi-state focus and actively cooperate in agricultural research. Institutions receiving federal formula funds must actively pursue non-traditional stakeholders' input to agricultural research, extension, and education programs. The

exact method by which stakeholder input is to be pursued, however, is left to each of the institutions to define.

In the United States, there has not been any public policy to directly sell public agricultural research units (assets) to the private sector. The type of privatization that has occurred has been one whereby the private sector has been permitted to assume a larger role in the financing and performance of agricultural research with it own resources. The expected profitability of these activities has been enhanced by the creation of new intellectual property rights and the strengthening of existing IPRs. The new R&D thrust of the private sector in biotechnology and information science does build heavily on prior advances in basic/general scientific discoveries that were part of public sector research, e.g., discovery of the electronic digital computer at Iowa State University in the late 1930s and associated technologies, the discovery of the structure of DNA in 1953 and of recombinant DNA or gene splicing technology in the late 1970s. There has been a significant increase in private sector funding of the SAES system over the reference period and a few private resources are going into USDA CRADAs.

Institutional innovations in the field of finance. Several changes have occurred immediately before and during the reference period. First, the 1985 farm bill permitted agricultural commodity groups to vote (hold a referendum) for coverage by mandatory commodity check-off programs (levies) to finance commodity promotion and agricultural research. If a referendum passed then a commodity group was designated to manage the check-off funds, e.g., the National Pork Council for the pork check-off funds, the National Corn Growers Association for the corn check-off funds. This check-off or producer levy program has continued through 1999, although producers have raised issues about the payoff to them of

expenditures on the promotion and research programs. Second, the share of regular federal appropriations for agricultural research that is allocated through competitive grants programs has doubled over the 1988-98 period, from about 8 to 17 percent. Third, SAES scientists have been increasingly pursuing non-USDA federal sources of research funding over the period and these funds are allocated largely through competitive grant programs. Thus, theses three changes in financing of agricultural research have increased the role of the performing research institution and its scientists in raising money or pursuing research funds.

The federal formula funding of agricultural research and extension has a long history of a matching requirement for the 1862 land-grant institutions, but the 1998 Agricultural Research, Extension and Education Reform Act extended the matching requirement for federal research and extension funds to 1890 (previously all black) land-grant institutions and Tuskegee Institute (see Committee on the Future of the Colleges of Agriculture...1995 for location of these institutions).

There is undocumented evidence of an increase (from a very small base) of endowed chairs for agricultural research being established during the reference period in land-grant universities funded by private donors, e.g., private industry, wealthy alumni, etc. The USDA-ERS has increased slightly its emphasis on contract research through cooperative agreements with outside scientists after it downsized its research staff during the early 1990s.

Institutional innovations in the field of research implementation. During the reference period, many public agricultural research institutions have felt some scarcity of funds or “tighter budgets” and most have implemented new management strategies, e.g., more emphasis on reviewing project proposals, shortening the length of projects, eliminating research assistantship

funding, direct involvement in current expense allocation. The effectiveness of the more active management strategy has, however, been debated, e.g., see Huffman and Just (1999a,b), and might be counter productive.

During the reference period, there has been an increase in USDA-private sector joint-venture research and a slight increase in SAES-private sector joint ventures. However, the spotlight for these public-private joint ventures has shifted from the chemical/pharmaceutical to the biotechnology/life science industries. For the most part, the large chemical companies of the 1980s, e.g., Monsanto, Dow, Dupont, have become the large life-science companies of the late 1990s as industrial restructuring has occurred (Rausser et al 1999).

The SAES system was established with the guarantee of federal formula funding, but the SAES system had few restrictions placed on other funding options. Over time the SAES system has developed a diversified portfolio of funding sources which has allowed it to grow faster during the study period than the research component of USDA agencies, which rely very heavily on federal government funding (Huffman and Evenson 1993). This means that within the public sector, the performance of agricultural research is shifting further toward the SAES/university system.

During the reference period, there is no documented evidence of increased importance of international research networks or multi-institutional research programs. This, however, does not mean that no increase has occurred because the dramatic reduction in the real cost of long distance communication through the use of steadily improving e-mail services, especially for international exchange, has made long distance interactions and collaborations possible.

Conclusion

The most dramatic forces for change in U.S. public agricultural research during 1988 to 1999 were the 21 percent decline of real federal government revenues and 27 percent increase in state government revenues. The realities of the federal budget changes were a 5.5 percent decline in real resources for the USDA's own agricultural research and a 22 percent decline in federal-formula funding of the state agricultural-experiment-station system and of state budget changes were a surprising decline by 4.8 percent in real resources for the SAES system. Because the SAES system had a diverse funding base coming into the period, real SAES resources for research actually increased by 2.2 percent over the period. Large SAES-system resource increases were obtained from the private sector, non-USDA federal government sources, and contract and cooperative agreement funding from USDA research agencies. Of potential long-term concern to the SAES system is the decline in real resources from state governments, given the large increase in state government revenues and approximately 50 percent share of state government funding of the SAES system.

The private sector allocates significantly more resources to agricultural research than the total of all resources allocated to agricultural research in the public sector, and over the study period, the rate of growth of private sector funding of its own research was growing faster than public sector agricultural research funds. Two main forces were operating: unusual opportunities for private R&D from applications of discoveries in biological and information sciences and strengthening intellectual property rights to scientific discoveries. The momentum of these events seem likely to carry well into the 21st century. The relative size of agricultural R&D of the private sector is expected to continue to grow in the United States, and the public

agricultural research is expected to place greater emphasis on research in basic/general and pre-technology sciences and in applied research that is not directly competitive with the private sector.

Although peer-review competitive grants programs for allocating funds among research projects and scientists have grown in popularity during the 1990s, only 16 percent of regular federal appropriations for agricultural research were allocated by competitive grants programs in 1997. The popularity of grants programs seems likely to wane during the 21st century. The primary reason is that competitive grants from external funding sources are a relatively inefficient allocation mechanism, especially where the number of research scientists working in a field is small or where a large amount of experience has been accumulated with more efficient allocation mechanisms. However, setting strong incentives for scientific discovery in public research institutions will continue to be an important management activity in the 21st century.

The bureaucratic approaches to accountability in government which have been applied in the U.S. to federally funded programs will prove ineffective for research. The policies have paid too little attention to the unusual attributes of research, e.g., the large amount of ex ante uncertainty in high quality research, long lags from input of resources to payoff. Furthermore, to the extent that these programs have an impact they most likely will cause state governments to ask what they are getting from their major share of SAES funding. Given that agricultural research in public institutions which is funded by contracts and federal grants has been shown by Huffman and Just (1994) to have a significantly smaller state-specific or local public goods component than federal formula and state government program funding, scientific discoveries from different major types of funding sources for public agricultural research are not perfect

substitutes. Over the next decade state legislatures seem likely to see generally that national or private sector re-direction of state funds for agricultural research to serve national or private sector interests is a poor investment to them. When SAES administrators and scientists overemphasize chasing outside funding from federal and private sources, they will seriously jeopardize the majority of the SAES system funding base which comes from state governments. This seems likely to become a major issue in the early 21st century.

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Endnotes

i. At least for the University of California-Berkeley, the Bayh-Dole Act of 1982, which effectively transferred intellectual property rights to discoveries financed at least partially by federal funds to the nonfederal partner, has been important in developing a future financing strategy for plant biology research (Rausser 1999; Busch et al. 2004).