Financing, Organizing, and Managing the Agricultural Research Portfolio[1] 6

Agricultural productivity has increased rapidly in the United States—more rapidly than productivity in the general economy. Many attribute a good portion of this growth to public-sector agricultural research which is conducted primarily through land-grant colleges and USDA research agencies. In recent years, the agricultural sciences have increasingly been asked to do more with less. Questions have been raised about whether the old research institutions are still needed, and about how they should adapt to accommodate changes in science, in scientific institutions, in society and social attitudes, in government, in agriculture itself, and in the general economy.

The post-war years have been characterized by a general growth in congressional interest in agricultural research, and political involvement in allocating research resources. Funds earmarked for particular purposes, or to be spent in particular locations, have increased markedly, while other types of funds have increased at a slower rate or declined. Recently, as a reflection of concerns about the size of the government budget, research investments have been scrutinized more carefully and demands for accountability have intensified.

In the discussions leading up to the 1995 farm bill, agricultural science policy has been put, along with other agricultural policies, on the negotiating table. Given recent moves toward freer global trade, competitiveness has assumed ever greater importance. And as components of competitiveness, environmentally supportable improvements in agricultural productivity, and in product safety and quality, driven by research, are critical. There is not yet a clear consensus on what role government should play, but there is no doubt that it will be involved in some way.

The purpose of this chapter is to provide a basis for policymakers to approach agricultural research policy questions—questions concerning the financing, organization, and management of public-sector agricultural research programs, including accountability provisions—in an objective and consistent fashion. The chapter reviews the U.S. government's agricultural research policies and related arrangements for administration and accountability. It draws on relevant economic principles to review and evaluate the past and present policies as a basis for considering policy directions for the future.

[1] Material in this chapter was drawn from the OTA contractor report, "Agricultural Research in the Public Interest," by Julian M. Alston and Philip G. Pardey, May 1995.

The primary focus of the chapter is on how public sector research can compensate for the private sector's relative lack of investment in agricultural research. Discussion is not restricted to whether the total amount of taxpayer funding is adequate. To achieve the greatest gains for society as a whole, a more fundamental rethinking of the basis for and approaches toward *financing, organizing,* and *managing* public-sector agricultural research is needed. Most previous commentators have, simplistically, called for more federal research dollars. Other public policy mechanisms can and should be used, along with taxpayer funds, to increase total private and public investment in agricultural research, and to promote a socially profitable mixture of research programs (from basic to applied research; across disciplinary areas; across commodity-oriented research programs; in terms of geographic relevance; among environmental and other natural resource issues). The policy analysis must include a consideration of different funding mechanisms—show how they affect the cost of research (including who bears the cost in relation to who benefits), and how they affect incentives for private research.

The benefits that public and private research provide to society are also affected by existing mechanisms for allocating public sector research resources, and for managing those resources to ensure that they are used to greatest effect. Since, ultimately, individual scientists make many of the critical decisions, the relevant issues extend beyond simply allocating resources to high-priority questions. Mechanisms to ensure that individual incentives are compatible with the public purpose, and some accountability arrangements, are also desirable. Such considerations lead to a questioning of the use of political criteria versus formula funding or competitive grants to allocate research resources—at least about how the decisions concerning those funding arrangements are made.

A rethinking of options extends beyond the boundaries implied by the current institutional structure (which is dominated by the State Agricultural Experiment Stations, or SAES, and the USDA intramural laboratories) to consider a greater use of in-between alternatives, such as regional research institutions, and to allow open competition among these different institutions, where appropriate, for available funds.

The economic rationale for government intervention in agricultural research is market failure—in this case, a socially undesirable situation that the free market will not correct on its own. This leads, logically, to the use of economic arguments to determine how government can best correct the market failure. The particular virtue of the economic approach is that it provides a coherent, consistent basis for developing, considering, and evaluating alternative approaches towards financing, organizing, and managing public-sector agricultural research.

Along with the use of economics, there has to be an integrated, rather than piecemeal, assessment of the full range of public policy issues related to agricultural research. Decisions must be made concerning the amount of resources (federal, state government, and other) to allocate to research, the way research is funded, the types of research undertaken, the institutional structures related to allocating resources and conducting research, and the mechanisms for communicating the research results. All of these factors are mutually dependent and should be thought through together. Linkages among these aspects are important. Making changes in one element (for instance, increasing or decreasing federal support for research) without thinking through the implications for other elements of the system (for instance, incentives and institutional mechanisms for industry-based research support) could have undesirable and unforeseen consequences.

BASIS FOR GOVERNMENT INTERVENTION IN RESEARCH

Principles for Government Intervention

Spillovers and Externalities

A basic tenet of economics is that the benefits society receives from production and consumption (in this case agricultural production and consumer consumption) will be maximized when the costs to society of that production or consumption are equal to the social benefits it provides. A "market failure" exists when private incentives lead to a different resource allocation, and a different product mix, than the socially optimal outcome. This will happen if private benefits and costs differ from social benefits and costs, so that private interests and national interests do not exactly coincide. For the purposes of this discussion, a market failure can be viewed as a socially undesirable situation that the free market will not correct on its own.

Market failures can be caused by externalities. Externalities, which can be positive or negative, result when the effects of certain production or consumption activities "spill over" to other parts of society. Groundwater that is polluted by agricultural chemicals is an example of a *negative* externality. Free-riding by others on an individual's research results is a *positive* externality.

Appropriability and Private Sector Underinvestment

Market failure in agricultural research seems to be widely taken for granted: left to its own devices, the private sector would invest too little in agricultural research. Some incentive problems arise from the economics of the research enterprise as it relates to the size of farm firms. The nature of research activity, which is usually long-term, large-scale, and risky, means that the typical firm in agriculture is not able to carry out effective research (although it can help to fund it), and institutions may have to be set up on a collective basis.[2] The main reason for private-sector underinvestment in research, however, is inappropriability of research benefits: that is, the firm responsible for developing a technology may not be able to appropriate all of the benefits accruing to the innovation. The reason for such an "appropriability" problem is often that fully effective patenting or secrecy is not possible, or that some research benefits (or costs) accrue to people other than those who use the results.[3]

Appropriability problems give rise to an asymmetry between the incidence of benefits and the costs of research. For certain types of research, the rights to the results are fully and effectively protected by patents, so that the inventor, by using the results from the research or selling the rights to use them, can appropriate the benefits.[4] Often, however, those who invest in research cannot capture all of the benefits—others can "free-ride" on an investment in research, using the results and sharing in the benefits without sharing in the costs.[5] Hence, private benefits to an investor (or group of investors) are less than the social benefits of the investment and, as a result, some socially profitable investment opportunities remain unexploited. In the absence of government intervention, the investment in agricultural research is likely to be too little.

These conventional reasons for private-sector "underinvestment" in agricultural research explain the major result from the empirical literature concerning different commodities and different countries: agricultural research has been, on average, a highly profitable investment from society's point of view. In turn, this suggests that research has been underfunded, and that current government intervention may be inadequate. This is not to say that the amount of government spending necessarily should increase. Changes in

[2] There are exceptions to the *typical* situation, but even when firms are large enough to find it profitable to carry out some research, there is still likely to be too little research for the other reasons (appropriability and externalities).

[3] This appropriability problem extends beyond relations among single individuals to relations among collectives, such as one producer cooperative or industry group versus another, and among states and even countries.

[4] For instance, the benefits from most mechanical inventions and developing new hybrid plant varieties, such as hybrid corn, are mostly appropriable.

[5] For instance, an agronomist or farmer who developed an improved wheat variety would have difficulty appropriating the benefits: the inventor could not get the potential social benefits simply by using the new variety himself; but if he sold the (fertile) seed in one year, the buyers could keep some of the grain produced from that seed to use as seed thereafter.

government intervention can take many forms. Some see it only in terms of increased government (that is, taxpayer) funding of research, but that is only a part of the problem. The federal government can also act to change the incentives for the private sector or state governments to increase their investments in private or public research. That government intervention is inadequate implies simply that the nature of the intervention should change so as to bring forth either more private investment or more public investment. In addition to efficiency gains from increasing the total research investment, the government can also intervene with a view to improving the efficiency with which those resources are used within the research system.

Environmental Externalities

Spillovers and externalities may be relevant not only in relation to the products from research, but also through problems in the markets for agricultural outputs and inputs, leading to indirect problems in research. Agriculture often involves environmental externalities arising from spillover effects of agricultural production on other agricultural producers (for example, through effects on incidence of pests) or others through impacts on groundwater or air pollution that are not compensated through markets. Even in the absence of market failures associated with the atomistic nature of agricultural production, and appropriability, there will be problems with incentives, so that the direction of research will be biased against technologies that help alleviate the effects of environmental externalities and in favor of technologies that make the effects of environmental externalities worse. In the absence of government intervention, commercial decisions will tend to produce too much pollution and preserve too little pristine wilderness.

Agricultural research can generate technologies that are environmentally friendly, relative to the current technology; but it is not sufficient to invent the technology. The very nature of (negative) externalities is that it doesn't pay private investors to make an effort to reduce them, either in the choice of production practices with given technology, or in the choice of the direction for technology to evolve through research, development, and adoption decisions. If agricultural research is to be effective in reducing environmental externalities, the resulting new technologies must be adopted, and if they are to be adopted, they must be viewed as privately profitable. This could happen in one of two ways: either a new (environmentally friendly) technology is privately more profitable than the current technology, under the current incentives, or the government acts to change the adoption incentives as well. Similar arguments apply to the development and adoption of technologies that consume stocks of unpriced or underpriced natural resources. Private incentives are liable to lead in the direction of developing and adopting technologies that consume too many natural resources, unless government acts to modify the incentives and "internalize" the externalities.

Research Beyond the Farm Gate

The farm input suppliers, and other components of the agribusiness industry that transport, processes, and markets farm products, tend to be relatively large firms, large enough to exploit economies of size in research. The technologies they use tend to be mechanical, of a type that can be protected by patents, or process innovations that can be protected by secrecy. The technology used by agribusiness is often not specialized to agribusiness, and can be adapted from broader industry (for example, refrigeration or transportation technology). For these reasons, appropriability problems tend to be less important in the agribusiness industry than in the farming industry. Thus, the potential role for the government (by inference, the chance of market failure) is *generally* greater in research pertaining to farming than in research pertaining to agribusiness.

There are exceptions, however. Some parts of the farming industry are involved in vertically integrated structures where research benefits can be internalized (for instance, the broiler chicken industry); certain types of technology applicable to farming are effectively protected by patents (for instance, machinery, hybrid lines of plant varieties). Research incentive problems are important in some parts of agribusiness. In plant breeding, for example, there is “natural” appropriability for hybrid lines, since the crop does not reproduce itself, but for open-pollinated varieties it is necessary to legislate and enforce property rights to ensure appropriability.

It is important to exercise discretion in judging specifically where the market failures in research are important and where they are not, since government investment in research in a particular area is likely to crowd out some private-sector research. In cases where private-sector underinvestment in research is not otherwise a problem, public-sector research can *cause* a private-sector underinvestment.

Rates of Return to Research

The payoff to research can be summarized in terms of the private rate of return (comparing private costs and benefits to the investors in the research) and the social rate of return (comparing benefits and costs to society as a whole). Alston and Pardey (1) have documented the results of a large number of studies of social and private rates of return to agricultural research. The overwhelming conclusion from that collection of results is that estimated rates of return to agricultural research have been very high, typically well in excess of 20 percent per year. The relevant comparison is with the rate at which the government borrows money, typically 3–5 percent per year. Since the rate of return to research is much greater than the borrowing rate, there appears, in general, to have been a gross underinvestment in agricultural research.

It is less clear from this type of evidence whether there has been an underinvestment in agricultural research relative to other industrial research. For instance, a number of studies that were recently documented by the Industry Commission (IC) (13) in Australia showed rates of return to industrial research that are comparable to rates of return to agricultural research: typically well in excess of 20 percent, and often ranging around 100 percent per year.[6] Hence, the rate of return evidence does not support a diversion of resources from industrial research to agricultural research. Rather, taken at face value, the evidence on rates of return to both the industrial research and agricultural research supports the view that resources should be diverted from other economic activities to both.[7]

Some reservations can be raised about the evidence on rates of return. Most of those studies have not adjusted for the effects of price-distorting policies (such as commodity price support programs) on the measures of research benefits, an omission that might lead to over- or understatement of the benefits and the rate of return (2). Most have not adjusted for the effects of the excess burden of taxation on the measures of costs, an omission that will lead to a systematic understatement of the social costs and an overstatement of the social rate of return (9).

On the other hand, a number of factors could lead to *underestimated* rates of return to agricultural research, including the omission of spillovers from agricultural research into nonagricultural applications and the consequences of such things as environmental, food safety, and social science research that are not reflected in conventional productivity or rate-of-return measures. Allowing for all these potential sources of error, on balance it seems likely that the rates of return to both public and private agri-

[6] The IC documented 20 rates of return to industrial R&D (reported in 10 studies of the United States and 4 studies of Japan) to the industry and, where available, to firms in other industries as well as to the nation as a whole. The unweighted means of the annual rates of return were 26 percent to the industry (standard deviation of 13 percent), 75 percent to firms in other industries (standard deviation of 27 percent), and 85 percent to the nation (standard deviation of 22 percent). The IC also reported similar evidence on rates of return to industrial R&D in Belgium, Canada, France, Germany, and the United Kingdom.

[7] The rates of return may not be fully comparable between agricultural and industrial R&D (or even within those classes), since different studies make different types of assumptions, use different concepts, and hold different things constant. Such details can have substantial effects on the estimates and thus are important for making relevant or meaningful comparisons.

cultural research have been high and that there has been underinvestment.

Forms of Government Intervention

It is one thing to establish a case of market failure. It is another to determine the best action for the government to take to reduce the costs that society must pay for the market failure. Indeed, taking *no* action may be the optimal policy. Many interventions are used in relation to agricultural research. They include improvements in private property rights (such as recent changes in intellectual property rights involving plant variety protection or "utility patents" for plants), enhanced incentives for private research (through the provision of tax breaks, direct subsidies, or other incentives, for instance), the provision of public funds for publicly or privately executed research through competitive grants, or the creation of new public or private sector research institutions (as an example, legal arrangements under which an industry funds research cooperatively). Another way to finance public sector agricultural research is to sell the scientific results (even public sector organizations such as universities now often patent their research results whenever possible, and sell the product).

These alternatives may all differ in terms of their incentive effects and the total cost to society of financing research. An intervention is justified only if it improves the situation by reducing social costs of market failure—the benefits of the intervention must be greater than the costs. Different interventions will be more or less effective at correcting different types of market failures; they will also have different distributional (or equity) consequences.

The dominant U.S. strategy has been to use state and federal government revenues to finance public or private sector research. This includes the provision of tax breaks and other financial incentives for private research, which involves a loss of government revenues, as well as the direct use of government funds both to finance private research, through grants and contracts, and to finance the production of knowledge in a variety of publicly administered research organizations.

Public Sector Research Expenditures

Public sector research in the United States is big business by most measures. In 1994 the federal government spent a little more than $64 billion on research, compared with only $178 million in 1949.[8] About $38.8 billion, or 57.1 percent, was spent on defense-related research and development, down from its 69.7 percent share of total research spending in 1987. In 1994, about $29.1 billion was earmarked for nondefense research and development, of which federally funded agricultural research accounted for just $1,142 million, or 1.7 percent of the total. Table 6-1 gives a more detailed, longer-run perspective on agricultural research spending in the United States. In 1889, shortly after the Hatch Act was passed, federal and state spending totaled $859.3 million. A century later the public sector agricultural research enterprise had grown to more than $2.6 billion, an annual rate of growth of 8.0 percent in nominal terms. The national system in 1889 was dominated by intramural research by USDA. By 1993 SAES accounted for 74 percent of total public spending on agricultural research, with federal laboratories operated by USDA making up almost all of the remaining 26 percent.

The sources of funds for SAES research have also changed markedly. During their early formative years, SAES received a relatively small but growing share of their funds from state sources. The proportion of funds received from state sources peaked at 69 percent in 1970 and has fallen steadily since to average only 48 percent in 1993. Funding from miscellaneous fees and sales (including funds from grants and industry checkoffs) has grown steadily as a share of

[8] These are in term of nominal or current purchasing power (i.e., undeflated figures) rather than real or constant purchasing power (i.e., which would be obtained by using a price index to deflate the nominal figures).

TABLE 6-1: Long-Run Perspective on Funds for Public-Sector Agricultural Research, 1889–1993.

	SAESs[a]					
Year or decade average	State	Federal	Miscellaneous fees & sales	Total	USDA[b]	U.S. total
			(millions of current dollars)			
1889	0.08	0.59	0.06	0.72	0.14	0.86
1890–99	0.22	0.70	0.11	1.04	0.21	1.25
1900–09	0.65	0.87	0.31	1.84	1.04	2.88
1910–19	2.24	1.43	1.09	4.76	4.48	9.24
1920–29	6.01	2.11	2.09	10.21	18.44	28.65
1930–39	8.25	4.88	2.60	15.72	30.68	46.40
1940–49	15.81	7.42	5.44	28.67	40.97	69.64
1950–59	56.17	19.10	14.27	89.55	46.08	135.63
1960–69	132.10	42.87	25.20	200.18	109.32	309.50
1970–79	289.13	131.14	63.41	483.68	258.58	742.26
1980–89	646.44	359.41	207.04	1,212.89	500.37	1,713.25
1990	927.15	500.86	338.07	1,766.07	614.08	2,380.15
1991	961.73	532.15	358.72	1,852.59	650.62	2,503.22
1992	956.29	582.06	376.52	1,914.87	689.97	2,604.84
1993	960.41	632.39	387.54	1,980.33	692.29	2,672.63
			Annual growth rates (%)			
1889–93	9.52	6.95	8.93	7.96	8.50	8.04
1980–89	7.87	6.87	9.57	7.86	5.06	7.04
1990–93	1.18	8.08	4.66	3.89	4.08	3.94

SOURCE: Office of Technology Assessment, 1995. Compiled from various USDA sources, including U.S. Department of Agriculture *Inventory of Agricultural Research* data for years after 1980.

[a] Data includes experiment stations and cooperating institutions for U.S. contiguous states.

[b] Series approximates intramural research by USDA and consists of total appropriations to the Agricultural Research Service, the Economic Research Service, and the Agricultural Cooperative Service less appropriations to contracts, grants, and cooperative agreements with the SAESs made by these USDA agencies.

the total since the early 1970s and now accounts for nearly 20 percent of SAES funds.

Between 1972 and 1993, total support for SAES grew by 8.5 percent per year in nominal, or current purchasing power, terms (as shown in table 6-2) and only 2.8 percent in real or constant purchasing power terms. About 51 percent of the federally sourced resources have come from Cooperative State Research, Education, and Extension Service (CSREES) administered funds, which include funds dispersed on a formula basis, some earmarked funds, and funds made available to the states as part of the competitive grants program.[9] The remainder (about 49 percent) of the federal funds going to the states comes from other earmarked funds, funds

[9] In October 1994, USDA initiated a major reorganization which, among other changes, merged Cooperative State Research Service and the Cooperative Extension Service into a newly created Cooperative State Research, Education, and Extension Service (CSREES). This action draws the cooperative extension and research functions together into a single agency for the first time in USDA history.

TABLE 6-2: Source of Funds to SAES and Other Cooperating Institutions, 1972–1993

	Federal				Non-Federal					
Year	CSREES admin[a]	USDA[b]	Other[c]	Total	State	Sales	Industry[d]	Other	Total	Grand total
	(millions of current dollars)									
1972	71.5	7.0	28.2	106.7	205.5	23.2	16.6	11.0	256.3	363.0
1973	78.2	7.7	29.6	115.4	222.1	28.1	17.7	11.7	279.6	395.1
1974	83.2	8.8	32.0	124.0	247.5	32.4	21.0	12.2	313.0	437.0
1975	92.0	11.1	35.3	138.4	284.7	37.3	24.0	15.0	361.1	499.4
1976	104.8	10.5	40.8	156.1	309.7	30.7	28.3	16.4	385.2	541.3
1976[e]	26.2	2.6	10.2	39.0	77.4	7.7	7.1	4.1	96.3	135.3
1977	118.9	12.6	55.6	187.0	321.2	39.1	32.7	21.9	414.8	601.8
1978	134.5	16.5	57.9	208.8	374.9	40.1	34.7	22.4	472.1	680.9
1979	156.3	21.1	64.6	242.1	413.5	46.7	37.1	27.2	524.6	766.6
1980	162.8	27.5	71.6	261.9	456.4	55.9	48.4	30.5	591.3	853.1
1981	174.3	33.3	83.0	290.6	501.2	59.1	53.5	38.2	652.1	942.7
1982	199.2	36.2	107.6	343.0	545.2	62.5	61.3	45.5	714.6	1057.6
1983	204.9	38.9	95.2	339.0	576.5	65.4	66.7	49.1	757.7	1096.7
1984	210.5	38.5	103.2	352.3	621.8	66.3	71.0	54.4	813.5	1165.7
1985	221.0	35.9	112.4	369.4	678.3	70.5	79.1	61.5	889.3	1258.7
1986	222.7	35.8	140.6	399.1	741.7	69.4	85.1	70.2	966.5	1365.6
1987	230.8	36.8	148.1	415.7	778.9	75.4	93.8	85.1	1033.1	1448.8
1988	247.8	42.2	153.5	443.5	823.4	84.8	99.1	91.1	1098.3	1541.8
1989	261.0	48.9	169.7	479.6	894.4	92.4	111.3	102.1	1200.2	1679.8
1990	272.8	54.1	188.6	515.5	950.1	102.4	126.6	112.4	1291.5	1807.0
1991	290.8	57.8	199.4	548.0	985.9	113.6	134.0	114.9	1348.4	1896.3
1992	316.6	60.7	221.3	598.7	981.5	116.1	143.4	121.0	1362.1	1960.7
1993	331.0	68.6	249.0	648.5	985.4	110.0	146.1	134.8	1376.3	2024.8
	Annual Growth Rates (%)									
1972–93	7.6	11.5	10.9	9.0	7.7	7.7	10.9	12.7	8.3	8.5
1989–93	6.1	8.8	10.1	7.8	2.5	4.5	7.0	7.2	3.5	4.8

SOURCE: Office of Technology Assessment, 1995. Compiled from U.S. Department of Agriculture, *Inventory of Agricultural Research,* various annual issues, table IV-E.

NOTE: Includes all state agricultural experiment stations, forestry schools, 1890/Tuskegee institutions, veterinary schools, and other cooperating institutions.

[a] Includes formula funds, special grants, and competitive grants.

[b] Includes monies received from USDA grants, contracts, and cooperative agreements.

[c] Includes contract, grant, etc., monies received from agencies such as the National Science Foundation, Energy Research and Development Administration, Department of Defense, National Institutes of Health, Public Health Service, National Aeronautics and Space Administration, Tennessee Valley Authority, and so on.

[d] Includes monies received through industry grants and agreements.

[e] Includes appropriations for the transition quarter which covers the period from July 1, 1976 to September 30, 1976.

derived from USDA grants, contracts, and cooperative agreements, funding received from agencies such as the National Science Foundation, the National Institutes of Health, the Department of Defense, and so on. These have accounted for a rising share of the SAES total, well up from their 33 percent share of federal funds just two decades ago.[10] Revenues from the sale of services and products (including royalties from patents) account for only 5.4 percent of total funds. Industry funds from grants, checkoffs, and the like still account for only 7.2 percent of the total, although this was one of the faster-growing components of funds received over the past two decades.

The differential growth rates imply a changing mixture of sources of funds, with a rising share of funds from industry sources and, of the government funds, a shrinking share of funds from state governments. Of the federal funding, competitive grants have been rising relatively quickly and have grown, along with earmarked funds, partly at the expense of formula funding. Some of these changes are in directions that should enhance economic efficiency, such as more industry funding, increased competitive grants and less formula funding—but the rate of change may be too slow, and competitive grants may still have too small a share. Other trends, such as declining state government support and the rise of earmarked funds, will not enhance economic efficiency in agricultural research.

USDA both disperses and relies on federal research funds. Table 6-3 details the deployment of federal appropriations to USDA. Since 1970 an increasing share of USDA resources earmarked for research and education has gone to research, with a corresponding contraction in the share going to education and extension services. Such services now account for a quarter of total funds, whereas in 1970 they took one-third of the available resources. ARS accounts for about one-third of all USDA expenditures on research and education, a share that has remained fairly constant over recent years. Slightly more than one-fifth of USDA expenditures on research and education are administered by CSREES, mostly earmarked to go to SAES and other cooperating institutions, although some of the competitive grant funds that CSREES oversees are spent by agencies within USDA.

Private Sector Research Expenditures

The private sector committed $3.3 billion to in-house agricultural research in 1992, about 27 percent more than the amount spent on agricultural research conducted by the public sector (table 6-4).[11] The amount of privately conducted research increased nearly 19 fold in the past three decades, a substantially faster rate of growth than occurred in the public sector. As a result, for every dollar of publicly conducted research in 1992, the private sector spent $1.27, compared with just 94 cents in the early 1960s. But, like the public sector, the growth in private spending on agricultural research slowed considerably in recent years. From a rate of growth in real spending on private agricultural research in excess of 4.5 percent per year throughout the 1960s and 1970s, the rate dropped to only 1.7 percent for the post-1980 period. The focus of this private research also changed considerably. In 1960, agricultural machinery and postharvest and food-processing research accounted for more than 88 percent of total private agricultural research. By 1992 these areas of research collectively accounted for only 44 percent of the total, with

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[10] As a share of the total, not just federal, funds going to SAES, these sources of funds collectively accounted for 9.7 percent of the total in 1972 and 15.7 percent in 1993.

[11] The private R&D estimates are documented in detail by Alston and Pardey (1). They explain that measuring privately conducted agricultural R&D in ways that can be meaningfully compared with the public sector figures is problematic. Invariably, changes and inconsistencies are found in the underlying survey methods used to compile the private sector series. Also, it is often difficult to distinguish in-house R&D from other activities such as product promotion, or to distinguish agriculture-related R&D from other types of R&D, and the public and private series currently available are not always strictly comparable in terms of their coverages regarding the pre-, on-, and post-farm research orientation.

	CSREES Administered					Economics & Statistics						Education		
Year	Competitive	Others	Total CSREES	Agricultural research service	Forest service	Economic research service	Statistical service	Total	Total research	National ag. library	Extension service	Other	Total	Total research & education
						(millions of current dollars)								
1970	—	62.7	62.7	160.1	45.6	—	—	17.0	285.4	—	146.2	4.8	151.0	436.4
1971	—	69.6	69.6	178.6	48.8	—	—	18.4	315.4	—	165.6	5.5	171.1	486.5
1972	—	83.0	83.0	191.7	54.4	—	—	18.8	347.9	—	182.2	6.1	188.3	536.2
1973	—	91.5	91.5	208.1	57.8	—	—	20.6	378.0	—	197.9	6.5	204.4	582.4
1974	—	90.1	90.1	205.0	64.7	—	—	22.0	381.8	—	206.7	6.8	213.5	595.3
1975	—	101.8	101.8	224.4	77.6	—	—	24.9	428.7	—	217.2	7.9	225.1	653.8
1976	—	114.5	114.5	282.8	82.3	—	—	28.9	508.0	—	230.2	8.3	238.5	746.5
1976[a]	—	28.6	28.6	64.4	22.3	—	—	7.4	122.4	—	56.0	2.1	58.1	180.5
1977	—	129.0	129.0	282.9	89.8	24.5	4.7	29.2	530.9	—	232.7	9.2	241.9	772.8
1978	15.0	142.9	157.9	313.9	90.6	26.0	5.0	31.0	593.4	6.6	257.5	20.8	284.9	878.3
1979	15.0	159.3	174.3	328.0	95.0	28.2	5.4	33.6	630.9	7.0	263.8	21.2	292.0	922.9
1980	15.5	170.4	185.9	358.0	95.9	26.1	5.0	31.1	670.9	7.3	274.0	21.5	302.8	973.7
1981	16.0	184.7	200.7	404.1	108.4	39.5	7.5	47.0	760.2	8.2	292.2	22.4	322.8	1,083.0
1982	16.3	204.3	220.6	423.2	112.1	39.4	7.0	46.4	802.3	8.2	315.7	11.0	334.9	1,137.2
1983	17.0	215.3	232.3	451.9	107.7	38.8	7.6	46.4	838.3	9.1	328.6	11.9	349.6	1,187.9
1984	17.0	220.7	237.7	471.1	108.7	44.3	8.2	52.5	870.0	10.4	334.3	18.2	362.9	1,232.9
1985	46.0	230.6	276.6	491.0	113.8	46.6	8.4	55.0	936.4	11.5	341.2	21.3	374.0	1,310.4
1986	42.3	227.3	269.6	483.2	113.6	44.1	8.0	52.1	918.5	10.8	328.0	18.4	357.2	1,275.7
1987	40.7	253.0	293.7	511.4	126.7	44.9	3.4	48.3	980.1	11.1	339.0	18.7	368.8	1,348.9
1988	42.4	260.7	303.1	544.1	132.5	48.3	3.6	51.9	1,031.6	12.2	358.0	19.8	390.0	1,421.6
1989	39.7	270.9	310.6	569.4	138.3	49.6	2.9	52.5	1,070.8	14.3	361.4	21.9	397.6	1,468.4
1990	38.6	288.0	326.6	593.3	150.9	51.0	2.8	53.8	1,124.6	14.7	369.3	28.6	412.6	1,537.2
1991	73.0	300.3	373.3	631.0	167.6	54.4	3.2	57.6	1,229.5	16.8	398.5	34.8	450.1	1,679.6
1992	97.5	316.9	414.4	670.6	180.5	59.0	3.6	62.6	1,328.1	17.8	419.3	35.8	472.9	1,801.0
1993	97.5	317.5	415.0	671.7	182.7	58.9	3.9	62.8	1,332.2	17.7	428.4	35.7	481.8	1,814.0
1994	103.1	325.2	437.3	679.2	193.1	55.2	3.5	58.7	1,359.3	18.2	434.6	37.5	490.3	1,849.6
1995[b]	130.0	272.1	402.1	712.7	204.0	53.7	3.5	57.2	1,376.0	19.6	432.4	38.9	490.9	1,866.9

TABLE 6-3: U.S. Department of Agriculture Appropriations for Research and Education, 1970–1992 (Cont'd.)

	CSREES Administered					Economics & Statistics					Education			
Year	Competitive	Others	Total CSREES	Agricultural research service	Forest service	Economic research service	Statistical service	Total	Total research	National ag. library	Extension service	Other	Total	Total research & education
						Annual growth rates (%)								
1970–80	1.7[c]	10.5	11.5	8.4	7.7	2.1[d]	2.3[d]	6.2	9.0	5.2[c]	6.5	16.1	6.9	8.3
1980–90	9.6	5.4	5.8	5.2	4.6	6.9	-5.6	5.6	5.3	7.3	3.0	2.9	3.0	4.7
1970–94	13.4	7.1	8.4	6.2	6.2	4.9	-1.7	5.3	6.8	6.5	4.6	8.9	4.8	6.2

SOURCE: Compiled from various USDA sources, including U.S. Department of Agriculture, *Inventory of Agricultural Research*, various annual issues.

[a] Includes appropriations for the transition quarter which covers the period from July 1, 1976 to September 30, 1976.

[b] Estimate only.

[c] Growth rate is for the 1978–90 period.

[d] Growth rate is for the 1977–90 period.

TABLE 6-4: Private-Sector Agricultural Research Expenditures, 1960–1992

	Input oriented					Total	
Year	Agricultural chemicals	Machinery	Veterinary & pharmaceutical	Plant breeding	Postharvest & food processing	Current	Real
			(millions of current dollars)			(millions 1980 dollars)	
1960	9.7	75.9	6.0	5.6	80.0	177.2	511.9
1965	63.0	86.9	23.0	8.8	123.1	304.8	700.1
1970	126.0	89.1	45.0	26.3	206.1	492.5	839.0
1975	176.0	138.0	79.0	50.0	273.1	716.0	917.6
1980	390.0	287.0	111.0	96.7	456.1	1,340.8	1,340.8
1985	758.0	304.5	159.0	179.3	801.1	2,201.9	1,574.4
1990	1,031.0	360.5	245.0	314.4	926.9	2,877.8	1,544.6
1991	1,077.0	381.9	276.0	342.0	962.7	3,039.7	1,557.1
1992	1,123.0	394.0	306.0	399.7	1,088.0	3,310.7	1,648.0
			Annual growth rates (percent)				
1960–92	16.0	5.3	13.1	14.3	8.5	9.6	3.7
1960–70	29.3	1.6	22.3	16.7	9.9	10.8	5.1
1970–80	12.0	12.4	9.4	13.9	8.3	10.5	4.8
1980–92	9.2	2.7	8.8	12.6	7.5	7.8	1.7

SOURCE: Alston, J.M. and Pardey, P.G., *Making Science Pay: The Economics of Agricultural R&D Policy*, American Enterprise Institute Press, Washington, DC, 1995 (forthcoming).

the share of total private sector research directed toward agricultural machinery dropping from 43 percent in 1960 to less than 12 percent just three decades later. Two of the more significant growth areas were plant breeding and veterinary and pharmaceutical research. Spending on agricultural chemicals research grew the fastest and now accounts for about one-third of total private agricultural research.

Overview of Funding Patterns

These data point to a dramatic shift in the pattern of publicly and privately conducted agricultural research in the United States over the past two or three decades. In summary, both the private and public sectors have expanded their annual investments in agricultural research, but private sector agricultural research has expanded more quickly. Within those broad categories the mixture of activities has changed: not every element has grown at the same rate. Among the changes in support for agricultural research, perhaps the most significant is the declining share provided by state governments. State government support for SAES has been stagnant during the 1990s, a change which has been offset by rapid growth in fees and sales, and industry support, combined with some growth in federal government support. At the same time, the nature of federal government support has changed, with an increasing emphasis on competitive grants and a dwindling role for formula funds. A persistence of such patterns of change seems likely, and would have major implications for the structure, conduct, and content of public research at both the state and federal levels. Of course, the rate, as well as the direction, of change, is critical.

GOVERNMENT ROLE IN AGRICULTURAL RESEARCH

Government action is warranted if it is believed that the benefits of agricultural research will exceed the costs. The best kind of intervention is the one with the greatest net national benefit. In the case of agricultural research, the unfettered workings of the free market produce too little research and not enough agricultural scientists. What should the government do? Government production is only one of several options. Government research funded by general government revenues is not obviously the best policy in all cases, but it is by far the dominant element of U.S. government response to a private sector underinvestment in agricultural research. High rates of return to this investment justify the government intervention and testify to a substantial persistent underinvestment.

The mix of agricultural research (in terms of the types of research being undertaken), and the way funds are obtained, disbursed, and managed, are also questionable. Questions can reasonably be raised about the distribution of the total between the intra- and extramural alternatives, and about the incentives within USDA's administration of the two programs. Questions can also be raised about the processes and procedures used to allocate research resources within the two broad programs. Of the extramural funding through CSREES, very little is allocated according to economic, or even scientific, criteria. Only one-quarter of the total extramural funding goes to competitive grants. More than half of the extramural funds are distributed among states by formulas based on their values of agricultural production and rural and farm populations, essentially political criteria that are unlikely to yield the maximum social payoff to the investment. Other extramural funds are allocated according to other political criteria, through the Special (earmarked) Grants program.

Financing arrangements, as well as spending patterns, can be improved. The contributions by state governments have been declining as a share of the total. And while private sector research and industry contributions to public sector research have been rising, the general taxpayer still bears the brunt of the burden.

Principles for Intervention

The optimal intervention by the government, aiming to reduce the distortions arising from inadequate private sector incentives for agricultural research, would seek to:

1. optimize the total investment in public sector agricultural research, and the mix of research, while minimizing the attendant problems of "crowding out" private research;
2. minimize the cost of raising the revenues to finance public sector research by using the least-cost sources of funds;
3. organize public sector research institutions so that they can conduct research in the least-cost way, with a minimum of wasteful replication of facilities and programs;
4. allocate and use research resources efficiently among programs and projects (that is, according to economic criteria, not political criteria), minimize transactions costs and administrative and bureaucratic overhead, and allow decentralized decision-making where effective incentive mechanisms are possible.

Respectively, these four principles relate to economic efficiency of research in terms of (a) the total funding, (b) the sources of funds, (c) institutional organization, and (d) resource allocation and management. This section considers these four elements of research policy with a view toward identifying possible changes that would lead to greater economic efficiency.

Total Funding for Agricultural Research

Agricultural research institutions and policies have evolved considerably since their inception. The public sector U.S. agricultural research enterprise is now big business—worth more than $2.6 billion per year. Correspondingly, private sector investment in agriculturally related research grew to total $3.3 billion per year by 1992. In spite of the government's efforts, there is still too little agricultural research being produced. A significant increase in federal funding, or federal government action to stimulate increased funding by either state government or industry, seems to be warranted. Unlike other agricultural programs in the farm bill, which involve a net drain on the economy, agricultural research is a socially profitable thing for the government to do. Concerns about the budget should not crowd out agricultural research.

In relation to total funding, prospects for expanding total federal funding for agricultural research seem gloomy, and it might not be the most economic way to address the sustained underinvestment. Hence, alternatives are discussed for using federal resources to mobilize greater supplementary funding from other private and government sources.

Financing Strategies

Under the present policy, a mix of federal and state government funding is used to support agricultural research conducted by SAES. In addition, federal and state governments conduct separately administered programs of research. The primary source of funding for these expenditures is the general tax revenues of the federal and state governments—an expensive source of revenues[12] (10). Industry funds garnered through tax incentives, matching grants, or from checkoffs may be less expensive, fairer, and politically more sustainable when used to finance certain types of research in order to achieve an expanded total public sector research budget[13].

Agricultural research may be a public good, accessible and potentially beneficial to all, but this does not mean that everyone in the nation benefits and it does not mean that everyone in the nation should pay. Both fairness and efficiency are promoted by funding research so that, as

[12] Recent studies have shown that it costs society more than a dollar to provide a dollar of general taxpayer revenues to finance public expenditures. The U.S. evidence indicates that a dollar of government spending on agricultural research may cost society between $1.07 and $1.25 when the market problems induced by taxation are taken into account (10).

[13] There are two basic types of checkoff programs: voluntary and legislated. Voluntary checkoffs involve industry members funding certain activities by agreeing to contribute funding for a common purpose. Legislative checkoffs involve the passage of legislation by a government entity (state or federal) requiring certain persons (such as farmers) to pay assessments on marketing or some other act of a particular product or service.

much as possible, the costs are borne in proportion to the benefits.[14] This can be encouraged by choosing funding arrangements that reflect the geographic focus and the commodity orientation of the research. Thus, different agricultural research programs and projects call for different funding arrangements. In particular, a greater use of private sector funding through such vehicles as commodity checkoffs and a greater use of multistate (but subnational) regional or commodity research programs is suggested. The federal role in both instances may be to develop the institutional arrangements, to provide incentives such as matching grants, or both.

Industry contributes very little directly to U.S. public sector agricultural research; it is mostly funded by the general revenues of federal and state governments.[15] This situation should change for three reasons. First, industry funding is a potential complement to other sources of funds which, as a practical matter, are likely to continue to leave total funding inadequate from the viewpoint of both the industry and the nation. Second, from the point of view of raising funds in the least-cost way, mechanisms such as commodity checkoffs are likely to provide a relatively efficient (and fair) tax base. Third, in relation to allocating the funds efficiently, industry funding arrangements can be organized to provide incentives for efficient use of checkoff funds and other research resources.

Checkoff programs, as a major form of agricultural research funding, can be a practical reality. In 1985, the Australian federal government introduced legislation that provides for groups of commodity producers to establish research funds based on a checkoff (industry levy), which the government will match up to 0.5 percent of the gross value of production (GVP) of the commodity. These arrangements (revised in 1989) have been very effective in increasing total resources available for agricultural research. Indeed, for several commodities the 0.5 percent constraint on matching funds is binding; the research institutions are spending 1 percent or more of GVP (13).

Checkoff funding is clearly applicable to research on a particular commodity. By definition, this is not basic research. Similarly, checkoff schemes tend to be less applicable to research that affects multiple commodities and research that applies to particular factors of production or that has an environmental focus, but they need not be. However, these issues notwithstanding, commodity checkoffs could be used more extensively to support the significant proportion of research that can be identified with a well-defined commodity (or other) interest group. Some of these mechanisms are already in place in the United States but are relatively underused in the sense that only a small fraction of total research resources are generated in this fashion, and the checkoff funds are directed mainly toward market promotion.

The federal government could encourage a greater use of such funds for agricultural research by providing matching (or more than matching) support for programs funded using industry checkoffs. When a combination of industry levy funds and general revenues is used to finance public or privately executed research, there is a clear case for government involvement in the administration, management, and allocation of those funds to ensure that the public interest is adequately considered. It is important to understand that industry checkoff funding is not to be regarded solely as a producer "self-help" arrangement, that is, producers collectively funding research on their own behalf and to serve their own ends. Consumers and taxpayers are affected by, have an interest in, and should be involved in such enterprises as much as produc-

[14] Incentive problems in agricultural research arise from inappropriability of benefits and free-riding, and may be serious unless some way can be found to ensure that beneficiaries share appropriately in research costs. Hence, a criterion for efficiency, as well as fairness, is to whom the benefits accrue.

[15] The comments here pertain more to the farm production sector than to the input supply and post-farm agribusiness sectors which do fund and execute significant amounts of research.

ers. Producer-dominated boards allocating such funds are likely to direct research resources toward work that benefits a narrower set of interests than may be socially optimal. In addition, there still may be incentive problems if, within the group of producers and consumers of a commodity, there are different distributions of benefits from different research programs (for instance, producers from a particular region prefer research specific to their own situation, which may not benefit certain other producers).

What seems to be equally or more important, to secure industry support for this type of program, is an assurance that funds raised through checkoffs would not crowd out other federal or state research funding. If the use of commodity checkoffs would not yield an increase in total research funding, there might be some efficiency gains in terms of lower social costs of funding and greater efficiency of research resource allocation—but much diminished gains compared with a situation where the checkoff funds were additional. This is particularly so since checkoff funds are liable to be spent on relatively applied work, where the social returns may be relatively low. If the checkoff funds were not additional, some loss of efficiency might be associated with the effective diversion of funds from more basic to more applied research.

Research Organization

The appropriate regional and institutional structure for organizing research programs ought to vary according to the nature of the research. Some issues are clearly national issues and are appropriately addressed by federal programs. But the federal government can choose whether to address an issue using federal funds in federal research institutions, or in state organizations (or, for that matter, in private organizations), or by using incentives to encourage state organizations to take joint action.

Institutional Structure

In the land-grant system, SAES are substantially and physically integrated with colleges of agriculture (and, in many cases, extension agencies). This institutional structure was initially justified on the grounds of "complementarity" between research and teaching and extension. Although it is still a widely cited rationale for the continued support of the land-grant system, the precise nature and magnitude of these complementary effects is not always as clear as may be desirable. In any event, it is an open question whether the current number and structure of land-grant colleges, which has changed little over the years, is optimal for today. If we were designing the land-grant system today, from the ground up, for conditions in the twenty-first century, the results might be very different.

Serious study is warranted into whether economic efficiency criteria justify a land-grant college for each and every state (from a federal, if not a state perspective). It may be economic, for instance, to consolidate some college programs and, perhaps, some research programs among states, given that students are much more mobile and communications are much better these days than they were when the land-grant colleges were first formed. Similar questions can be raised about the organization of extension. Sources of supply for agricultural extension services are expanding rapidly. This factor, coupled with accelerating improvements in communication and information technologies, and better-educated farmers, raises similar questions about the cost-effectiveness of investments in agricultural extension services in the current organizational structures. These issues are well beyond the scope of this present study. The Board on Agriculture is currently conducting a study of the Land Grant University System, considering both research and teaching functions and their interactions. That study is expected to document in detail the nature of the interactions between the different functions and the evolution.

To facilitate some investigation of the potential roles for institutional alternatives, work is also under way to review the institutional structures in other countries, including Australia, the Netherlands, and the United Kingdom. In each of these countries there have been important recent changes in the administration of agricultural research, including issues of financing, organization, and management. Although none of those countries has ever had an arrangement like the U.S. land-grant system, combining research, teaching, and extension, their experiences of change may provide some lessons for the United States.

Regional Issues

Research spillovers, where results from one state's research are adopted in another state or overseas, are important. Individual states may not be able to capture economies of size and scope in research programs that pertain to larger jurisdictions. As a consequence, state-level arrangements are often inadequate. The intramural work of the USDA laboratories can often be seen as an effort to find solutions to problems that touched several states, but were beyond the research capabilities of individual states. At the same time, federal funding of *national* programs is not always the right policy for addressing underinvestment in research issues that involve multiple states.

Congress and USDA have also adopted a variety of approaches to encourage multistate cooperation in agricultural research. Support for regional research in SAES has been provided both on a formula basis, as earmarked funds, and more recently (as in the regional centers supervised by the Alternative Agricultural Research and Commercialization Board, created in the 1990 farm bill) on a competitive basis. The most concrete development was the institution of the nine regional research laboratories under the Bankhead-Jones Act in 1935 to study specific crops, livestock, and resources issues, and the four regional research laboratories introduced in 1938 to study new industrial uses for agricultural products. To many those developments might appear to have been driven as much by political and, perhaps, scientific factors as economic ones.

Research Funding Decisions, Resource Allocation and Management

The current set of institutional arrangements apportions research funds among alternative research-executing agencies in ways that have little economic foundation. High measured rates of return notwithstanding, a sizable share of the potential benefits from the agricultural research enterprise may have been wasted in inefficient resource allocation.

Roles for Economizing

Some would say that the system has worked very well (high reported rates of return testify to that) and, by implication, that we should not spoil a good thing. There is some truth in that. The public sector agricultural research system has achieved a great deal, and it would be undesirable to change it in ways that would diminish its capacity to contribute to the economy into the future. By the same token, the fact that it has done well does not mean that it could not have done better. Moreover, having done well in the past might not guarantee continued future success, especially considering recent trends in the evolving structure and management of the system that, if allowed to continue, may threaten its future effectiveness.

These concerns include, in particular, the rising politicization of research, including the rise of earmarked funds and declining state-government support. The rapidly changing economic environment in which the research system finds itself is also relevant in this regard. Things that worked in the past may not work in the future. The public sector may need to reconsider and revamp the way it goes about its business.

Allocating scarce research resources is an economic problem. In the system as it stands, too little use is made of economic analysis, economic incentives, and the economic way of thinking about problems. The current system emphasizes processes and politics, the inputs side, and pays scant attention to actual performance, the outputs side. There is a notable lack of any systematic attempt to undertake economic evaluation studies on agricultural research investments as an integral part of the resource-allocation process. Resources are allocated according to ad hoc approaches that may simply serve to reinforce prior prejudice.

Economic Criteria

It is very important to institutionalize processes that establish and enforce an economic efficiency criterion as the primary (preferably sole) basis for allocating research resources and for evaluating research performance, so that research resources are freer to flow flexibly, according to economic criteria, to achieve the most good. A simple, singular, economic efficiency objective coincides with the rationale for public sector research.[16] Resolving a simple objective also allows the development of simple and clear criteria for making decisions about how to allocate resources, about how to evaluate the outcome from research and, perhaps, about how to reward effort.

Earmarked Funds

The current system of formula funding is uneconomic and it is not obviously fair. However, it may be superior to earmarked Special Grants. Special Grants have been rising relative to other components of the research pot. If these earmarked grants do not crowd out other uses of the funds, they may not be as bad as if they compete for funds with projects that are justified on merit. Indeed, if they are additional funds, Special Grants might even be a profitable use of society's resources—but that seems unlikely. On the negative side, much of what is done in the name of Special Grants is of questionable intrinsic merit, and it is visible "pork" that looks bad and taints an otherwise, at least potentially, "clean" portfolio. It is not clear what can be done to reduce the politicization of research. One possibility is to increase the emphasis on demanding demonstrated benefits assessment as a criterion for funding. Another is, through regular formalized system reviews, to systematically expose the costs (or their orders of magnitude) of the elements that cannot be justified on merit.

Competitive Grants

Competitive grants, discussed in chapter 3, have a great deal to recommend them as a way of allocating public sector research resources. However, competing for grants is hard work and expensive, and if competitive grants are to deliver the promised benefits of greater allocative efficiency, they have to be allocated according to efficiency criteria. The same arguments can be applied to USDA's intramural research efforts. There is no reason why non-SAES organizations should not be allowed to compete for extramural funds, as in the NRICGP. Likewise, there seems to be no good reason why such a large share of the USDA agricultural research budget should be quarantined from competition. ARS will clearly be superior to SAES in some research areas, and vice versa; in some other areas they should collaborate.

Such decisions could be based on economic considerations rather than precedence. In general there could be more open competition, greater public scrutiny, and greater accountability for the public sector research effort. This change could be conducted in terms of the economic impacts of the research. It is not obvious what implications this more open competition would have for the balance of funding between the intra- and extramural research programs, but it would be expected to enhance the total net benefits through more efficient use of the funds.

[16] Although research ought to be directed according to economic efficiency considerations at the strategic or programmatic level, different criteria may be more applicable at the level of individual projects or individual scientists. Research within broad programs may be best directed according to well-structured and well-executed peer review. At that level, the critical issues may be scientific merit and technical considerations, such as the probabilities of research success and the likely lags involved in the research, more than the other economic variables.

Alternative arrangements could be instituted to reduce reliance on politically based Formula Funds and Special Grants for SAES, and to open up the USDA intramural funds for competition, thereby strengthening funding for competitive grants. But this must be subject to some caveats. Proposals ought to be subject to review based on the sole criterion of the expected economic benefits. A poorly administered and corrupted system of competitive grants could easily be worse than the antiquated, inefficient, and inflexible system of formula funding.

Transactions Costs

Some have argued that the transactions costs involved in competitive grants programs—in terms of the costs to individual scientists of preparing proposals, and reporting to granting bodies, and the costs of evaluating the proposals and deciding which ones to support—are so high that the programs cannot be economic. That charge could be accurate, but relevant alternatives must be compared, and on a comparable footing.

Every method of allocating research resources is bound to involve four types of costs: (a) information costs (the costs of obtaining relevant information on the benefits from different types of research projects, on which to base decisions); (b) other transactions costs (the costs of applying for grants, managing them, and administering them); (c) opportunity costs of inefficient resource allocation, due to research resources not being used in the projects and programs with the highest social payoff; and (d) "rent-seeking" costs (costs of resources being spent wastefully attempting to cause a redistribution of grant resources).

Different research resource allocation processes will involve different amounts of particular types of costs. For instance, through the proposal process, competitive grants generate information about research alternatives for decision makers. Although they may lower the cost of certain types of information, they also involve relatively high transactions costs. They might also involve relatively high rent-seeking costs (say, of scientists lobbying for their programs to be supported). However, these additional costs may be justified if competitive grants lead to a lower overall social cost, because they reduce the cost of resource misallocation. On the other hand, formula funds involve relatively high resource misallocation costs, which get higher the longer a formula stays fixed (since circumstances change) and relatively low transactions costs. This is not to say the transactions costs are zero, or that the rent-seeking costs are zero with formula funds (there is a fair bit of bureaucracy associated with the administration of the funds; the formulas do or, at least, may change from time to time). Earmarked funds may involve the greatest rent-seeking and resource misallocation costs, but they may also involve relatively small transactions costs. In short, the full costs should be considered when comparing research resource allocation procedures. Competitive grants are *relatively* efficient, but that is based primarily on a perception that the alternatives have involved very significant opportunity costs arising from resource misallocation.