For Want of a Nail

The Case for Increased Agricultural R&D Spending

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Introduction

Federal and state investments in agricultural research have consistently generated very high social rates of return. Surveys of the hundreds of studies quantifying the returns from agricultural research suggest rates of return in the range of 40–60 percent per year.1 The most recent, comprehensive work by Alston et al. reconfirms that US public investment in agricultural research and development (R&D) has paid off handsomely, with benefit-cost ratios of 20:1 and higher.2 Nevertheless, for many reasons, including a redirection of federal agricultural research funds

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away from productivity-oriented R&D, funding for research targeted at agricultural productivity has stagnated since the early 1980s. Although public investments in agricultural research have long-lasting economic-growth consequences, these effects took considerable time to appear because of the nature of the research (for example, developing new crop varieties typically takes ten years or more). However, while US agricultural productivity growth was rapid between 1949 and 1990, running at an average of about 2 percent per year, since the early 1990s growth has slowed to a crawl, averaging less than 1.2 percent per year between 1990 and 2007 (see table 1). The link between the slowdown in public funding and the slowdown in agricultural productivity growth is apparent.

A failure to revitalize federal funding for agricultural productivity-oriented research will have adverse effects on all US households, especially the poorest ones. Effective investments in agricultural R&D lead to innovations on farms that in turn enable reduced costs of production for American farmers, allowing a more abundant supply of farm commodities to be produced at a lower cost and sold at a lower price. The poorest households particularly benefit from lower food prices because they spend the largest shares of their income on food.

At a time when food prices are soaring, it is especially misguided to continue to undermine agricultural productivity growth by limiting federal investments in agricultural research in general and productivity-oriented research in particular (in favor of agricultural research dealing with environment, nutrition, health, and a host of other issues). To tackle the growing hunger and food-security problems confronting the United States and the world,
what is sorely needed is an increase in federal and other public funds focused squarely on research that will improve agricultural productivity.

Building on the pioneering study by Zvi Griliches, economists have compiled compelling evidence about the key role of agricultural research in increasing agricultural productivity. Over the past century and more, R&D has contributed to a transformation of US agriculture. R&D has fueled productivity growth, enabling US farmers to do more with less and thus helping them remain competitive in increasingly integrated global commodity markets. The resulting growth in US production of global food and feed staples, such as corn, wheat, and soybeans, has also played a significant role in growing food supplies worldwide. In aggregate terms, US agricultural output in 2007 was more than five times greater than output in 1910. The 1.74 percent annual increase in output over 1910–2007 was achieved with only a 0.15 percent annual increase in the total quantity of inputs.

Notwithstanding these considerable achievements over the past century, US agricultural R&D is at a crossroads. The close of the twentieth century marked changes in policy contexts, as well as fundamental shifts in the scientific basis for US agricultural R&D—shifts that will enable entirely new areas of agricultural innovation spurred by developments in informatics, genetics and genomics, and remote sensing—and shifting patterns of research investments and emphasis in the rest of the world. Even though rates of return to agricultural research are demonstrably very high, we have seen a slowdown in spending growth in the United States and a diversion of funds away from R&D targeted at agricultural productivity. Together these trends spell a slowdown in US farm productivity growth at a time when the market has begun to signal the beginning of the end of more than a half century of global agricultural abundance. It is a crucial time to rethink national agricultural R&D and innovation policies and reposition the US agricultural research and innovation system to address the changing scientific and market realities in the century ahead.

**R&D and Innovation Policy Principles**

The economic arguments in favor of government intervention in science and agricultural research center on issues of market failure. The main reason for private-sector underinvestment in R&D is that the firms or individual investors responsible for developing a technology may not be able to capture all, or even any, of the benefits accruing from the investment.

For some types of research, the rights to the results can be effectively protected by patents or other forms of intellectual property, allowing the inventor to capture benefits by using the results from the research or selling the rights to use them. Agriculture offers only a few examples of this type; for example, under current intellectual property rules, seed companies like Pioneer-DuPont and Monsanto can patent and obtain royalties from genetically modified crops. But many companies draw on the more basic agricultural research conducted by public agencies and universities, much of which is not patentable. These public-private linkages in agricultural R&D are directly comparable to those in the biosciences more generally and the health sciences in particular—where, for example, many of the new drugs, medical devices, and other health-related innovations developed by the private sector stand squarely on the shoulders of the extensive public research undertaken by the National Institutes of Health and US universities.

When the firms and individuals who invest in and invent new technologies through R&D cannot capture all the benefits, others can “free ride” on their research, using and benefiting from the results without sharing in the costs. This is exactly the case for a substantial share of agricultural research, such that absent government intervention, investment in certain types of agricultural research will be too little—especially given that most crop and livestock products are produced by hundreds of thousands of “atomistic” farms, and the complex biological nature of agricultural production means that R&D lag times can be extra long.
Another distinctive feature of agriculture is that many agricultural production processes are intrinsically site-specific, such that the performance of many agricultural technologies varies markedly across the agricultural landscape. Agricultural production requires targeted technological solutions to address geographic differences in agronomic and climate conditions—for instance, the great variations in soil and climate from California to Texas to the Midwest. This site-specific aspect means that agricultural R&D differs fundamentally from most other areas of science. For example, innovations stemming from the information sciences or many health technologies work equally well wherever they are deployed. The US public policy response has been to develop a joint national and state structure for conducting and funding agricultural R&D.

**US agricultural productivity growth has slowed to a crawl, averaging less than 1.2 percent per year between 1990 and 2007.**

These conventional reasons for inadequate private-sector investment in agricultural R&D (from the point of view of society as a whole) explain the major result from the empirical literature across different commodities and different countries: public and other investments in agricultural R&D have been—in aggregate, on average, and at the margin—highly profitable from society’s point of view. The stagnation in federal and other public funding for agricultural productivity-oriented research is therefore of considerable concern.6

**R&D and Innovation Policy in Practice**

The history of agricultural R&D and related government policy in the United States is one of jointly evolving state and federal, public- and private-sector roles. However, it should be recognized from the outset that, especially over the past fifty years, much of what counts as private agricultural research has been targeted at food processing, and private investments targeted at farm productivity are only a relatively modest part of what is measured as private-sector agricultural R&D spending.

**Enhancing Innovation Incentives.** To find it attractive to make risky investments in R&D, private investors must expect sufficient returns. The introduction of intellectual property rights, beginning in the United States with patents, trademarks, and copyrights in the eighteenth century, rates among the more prominent public policy measures intended to stimulate the creation and dissemination of US inventions. The effective scope of intellectual property protection in the United States for 150 years after the ratification of the Constitution offered little protection for biological inventions such as new crop varieties, but it did apply to product and process inventions such as chemical, mechanical, storage, transport, and food-processing inventions, among others. The first steps toward explicitly broadening the scope of intellectual property protection to include inventions involving living things began with the Plant Patent Act of 1930, which provided for the protection of asexually reproduced plants.7 The 1970 Plant Variety Protection Act strengthened intellectual property protection for sexually propagated varieties. In 1980, a sea change in the intellectual property protection of agriculture was heralded in the United States by three events: a key Supreme Court decision held that the class of patentable subject matter included living organisms; an act of Congress (the Bayh-Dole Act) established the general right of grant recipients such as universities to apply for patents on most federally funded research,8 and in that same year Cooperative Research and Development Agreements, designed specifically to speed up the commercialization of federally developed technology, were introduced;9 and, finally, Stanley Cohen and Herbert
Boyer were awarded US patent number 4,237,224 on their fundamental recombinant DNA technology, which ushered in a new era of genetic modification of plants for agriculture.

**Forms of Federal Funding.** A federal role is justified because new technologies are not strictly local in scope and may often be usefully applied in more than one state, and because the nature of demand for US agricultural commodities (such that in most cases, all else equal, an increase in US supply results in a lower price) implies that significant benefits from agricultural research accrue to consumers who are often outside the producing state or region. Joint federal and state funding is a natural outcome where the appropriate jurisdiction is neither individual states acting alone nor the federal government alone. A significant part of the federal role in agricultural R&D is to fund research undertaken by State Agricultural Experiment Stations (SAESs) and, in the process, encourage particular kinds of research investments.

**Formula and Other Block Funding Instruments.** The core (and, many argue, the strength) of the Hatch Act funding of the SAESs, both in its original 1887 form and following the 1955 amendments, has been the distribution of block funds with little or no programmatic direction by the federal government. The federal legislation authorizing funding generally requires that states match federal funds. In fact, this arrangement has been part of the formula funding legislation since the Research and Marketing Act of 1946, which required that federal funds provided through the states to the SAESs be matched on a one-for-one basis by state governments. This requirement is consistent with the observation that the benefits from agricultural research are shared between (local) producers and (nationwide) consumers and with an equity-based argument that those who benefit should pay. In many cases, the matching requirement is not a binding constraint. When states spend more than is required to receive federal funds, a reduction in federal funding may not necessarily induce a further reduction in state funding, and vice versa.

No formula funds approach is perfect. Other matching rules could be applied, not least because the best organization to perform the research could be in a different location than where commodities are produced. Nevertheless, funding decisions are largely made by Congress and, realistically, federal funds for agricultural R&D are to an important extent allocated in ways that satisfy the political and other concerns of House and Senate members.

**Competitive Grants.** Another funding mechanism is the investigator-initiated grant, generally awarded following a merit-based competition, typically with substantial input from a peer-review procedure. As Alston and Pardey note, the advantages of competitive grants include, in principle, responsiveness and flexibility, potential to attract the best talent through open competition, potential to ensure through professional and peer review that research resources flow in the directions with the greatest expected payoff, and capability to balance and complement other research resources and programs. Possible disadvantages include that competing for grants can be time-consuming and expensive, and can add an element of uncertainty compared with other types of funding arrangements; peer review can easily lead to cronyism; competitive grants can be directed in uneconomic directions for political or other reasons (just like other types of grants); and it may be inappropriate to have the “tail” of competitive grants “wagging the dog” of SAES research that is substantially supported by core formula and state funding.

The 2008 Farm Bill represented yet another congressional attempt to allocate more of the federal funds for agricultural R&D by peer-reviewed competitive means (versus formula funding, block grants, or earmarked means of disbursement). As part of an Agriculture and Food Research Initiative (AFRI), which combines authorities of the previous National Research Initiative and Initiative for Future Agriculture and Food Systems programs, the 2008 Farm Bill authorized (but did not fully fund) annual appropriations of $700 million in competitive grants for each of the fiscal years from 2008 to 2012. These
competitive grants are to be awarded on the basis of merit, quality, and relevance for a two-year period up to a maximum of ten years. The legislation dedicates 60 percent of AFRI funds to fundamental (or basic) research (30 percent of which must involve multidisciplinary teams), and the remaining 40 percent to applied research. It also requires that recipients provide matching funds for applied research that is commodity-specific and less than national in scope.

Many commentators seem to take agricultural growth rates for granted.

**Earmarked Funds.** Despite some indications of congressional intent to shift agricultural R&D funding toward a more competitive allocation model—at least by dint of increases in the amounts authorized for competitive funding over several decades—amounts spent through competitive grants did not increase much. Rather than cede funding-allocation decisions to competitive scientific peer-review processes, congressional earmarks in the federal funding of agricultural R&D have been persistent and pervasive. Earmarked funds are allocated by legislative mandate in congressional appropriations bills to provide funding for specific research projects at specific locations.14

**R&D Investment Trends**

Agricultural R&D spending is a critical policy instrument that governments can apply to influence the path of agricultural productivity. Research funded by the Farm Bill also has consequences for food processing, nutrition, and food safety, and it can help sustain and even enhance the value of ecosystem services linked to the land, water, climate, and biodiversity used in, produced by, and otherwise affected by agriculture. To make informed public policy choices regarding the agricultural R&D decisions in the 2012 Farm Bill requires a strategic understanding of the present patterns of investment in agricultural R&D in the United States and elsewhere. The long time lags between investing in agricultural R&D and realizing a social return on that investment dictate a very long-run perspective on these R&D spending trends.

Public research funds allocated in the Farm Bill are not the only source of federal R&D funds affecting agriculture. As the boundaries between scientific disciplines blur with changes in the underlying science, and as the technical problems confronting the food and agriculture sectors find some of their solutions in research conducted outside the conventional agricultural sciences, it is appropriate to begin by placing food and agricultural R&D spending in the broader context of science spending.

**Overall Pattern.** In 2008, the United States invested a total of $398 billion in R&D of all types. The private sector accounted for $289 billion (73 percent), with the federal government picking up $42 billion (10 percent) of the tab. Around $9.6 billion (just 2 percent) of the total was related directly to food and agriculture.15 The private sector conducts a smaller share of food and agricultural R&D (46 percent) than total R&D. In contrast, universities perform only 13 percent of total R&D in the United States but 39 percent of the food and agricultural R&D by way of land-grant colleges and other cooperating agencies. Almost 11 percent of total US R&D takes place in federal government labs, while 16 percent of US food and agricultural R&D is conducted in US Department of Agriculture (USDA) labs. These significant structural differences might reflect historical precedents in policy and the development of institutions, but they also likely reflect differences in the firm structure, appropriability conditions, and biological production that distinguish US agriculture from the industrial sector more generally.

In 1889, shortly after the Hatch Act was passed, federal and state spending appropriations totaled $1.12 million (see figure 1a). Over a century later, in 2009, the public agricultural R&D enterprise had grown to $5.15 billion (net of forestry), an annual rate
of growth of 6.9 percent in nominal terms and 3.7 percent in real (inflation-adjusted) terms. Intramural USDA and SAES research accounted for roughly equal shares of public research spending until the early 1940s, after which the SAES share grew to 67 percent of total public spending on agricultural R&D by 2009.

In 1915, federal funds were made available for cooperative extension between the USDA and various state extension agencies for the first time. In that year, almost $1.5 million of federal funds were combined with $2.1 million from various state and local government sources for a total of $3.6 million. This total grew by 6.8 percent per year to reach $1.76 billion by 2006 (see figure 1b). Extension spending grew hand in hand with public spending on agricultural R&D for much of the first half of the twentieth century. Then, during the period 1950–1980, inflation-adjusted growth in extension spending slowed to 2.25 percent per year, compared with 3.35 percent per year for agricultural R&D. Subsequently, during the period 1980–2006, extension spending shrank by 0.45 percent per year, compared with the slow growth of public agricultural R&D by 0.92 percent per year.16

### Figure 1: Long-Run Trends in Agricultural Research and Extension Spending

**a. SAES and USDA Intramural Research Spending, 1890–2009**

![Graph showing the trend of SAES and USDA intramural research spending from 1890 to 2009.]

**b. Extension and Public Agricultural Research Spending, 1915–2006**

![Graph showing the trend of extension and public agricultural research spending from 1915 to 2006.]


**NOTES:** Public agricultural R&D is the sum of expenditures by the forty-eight SAESs and intramural USDA agricultural R&D. Public agricultural R&D includes SAES and USDA intramural spending, exclusive of forestry research. Nominal extension and research spending were deflated to 2005 prices using an agricultural R&D deflator from P. G. Pardey, M. A. Andersen, and C. Chan-Kang, “A US Public Agricultural R&D Price Deflator, 1890–2009” (Department of Applied Economics staff paper, University of Minnesota, St. Paul, MN, forthcoming 2011).

**Pace and Productivity Orientation of Public Agricultural R&D Spending.** The substantial growth in public agricultural R&D since the late 1800s masks important details: notably, a marked slowdown in the growth of spending in recent decades and a shift in the focus of research away from increasing productivity in the production of food and feed, and toward other policy priorities. The pace of growth in real (inflation-adjusted) investment slowed considerably over the past several decades: from 3.63 percent per year during the 1950s and 1960s, to 1.79 percent per year during the 1970s and 1980s, to just 0.94 percent per year during the 1990s and 2000s (see figure 2). As Alston et al. showed, the real rate of spending growth for total US science has also progressively slowed in recent decades, but the slowdown in growth in public and private spending on agricultural R&D has been much more pronounced. Agricultural R&D, as a share of total US science spending, gradually slipped from 4 percent in 1953 to 2 percent in 2009.17

Enhanced productivity as a result of agricultural R&D means that consumers have access to a more abundant, cheaper, safer, higher quality, and more...
diverse and convenient food supply, produced with lower stress on natural resources and the environment. But the relevant comparison is not against a counterfactual scenario in which productivity would be sustained even without any R&D. In fact, a substantial share of privately and socially profitable agricultural R&D is necessary simply to maintain productivity (for example, by developing new methods for combating new or evolving pests and diseases that have become resistant to existing treatments). If R&D ceased altogether, the typical scenario would be declining agricultural productivity or crop yields and rising costs, not simply a continuation of current (or baseline) yields and costs. Significant investments in so-called maintenance research, between 35 and 70 percent of all agricultural R&D by available estimates, are required just to prevent productivity from falling.

The consequences of the slowdown in spending growth for the future path of productivity may be exacerbated by the reduction in the share of total agricultural R&D investment spent on agricultural productivity-oriented R&D. In 1976, around 64.6 percent ($1,272 million, 2005 prices) of all SAES research was so oriented (see figure 3). By 2009, only 56.3 percent ($1,769 million, 2005 prices) of SAES research sought to raise or maintain farm productivity. The productivity orientation of SAES research varies markedly among US states, with the smaller Northeastern states spending an average of only 46 percent on farm-productivity research in 2009, compared with 67 and 64 percent in the Mountain and Northern Plains states, respectively.

Private versus Public Trends. A common perception is that private-sector spending has grown dramatically over recent decades, more than offsetting the slower growth in public spending. In fact, according to Dehmer and Pardey, over the past half century, the growth in private agricultural R&D spending only slightly out-paced the growth in public spending, such that the private share of total agricultural R&D inched up over time (see figure 4a).18 In 2006, the private share of total agricultural R&D was 49.7 percent,
compared with 44.3 percent in 1953—still well below the private sector’s 73 percent share of total R&D overall, that is, across all US science. Moreover, a large share of the private research relates to food processing: around 59 percent of the $4.6 billion of total food and agricultural R&D in the United States in 2006 (see figure 4b).

Sources and Forms of Public Funding. Of the $3.7 billion spent on agricultural R&D by the SAESs and related institutions (including schools of veterinary medicine or forestry, and the 1890 land-grant institutions) in 2009, 38.1 percent came from federal sources, 38.4 percent from state government, 8.0 percent from industry grants and contracts, and 15.4 percent from income earned from sales, royalties, and other sources. Research conducted by USDA labs was almost entirely reliant on federal government funding; $1.4 billion (91 percent) of that research in 2009 was so funded.

Putting aside the years of the Great Depression and World War II, the state-government share of total SAES funding grew fairly steadily from 1890 to a peak of 69.3 percent in 1970. Since then, the state-government share of SAES funding has declined dramatically, down to 38.3 percent in 2009. Beginning in 1975, funding from industry and self-generated funds was on the rise, accounting for 23.7 percent of total SAES funding in 2009 (and 61.7 percent of total funding when combined with funding from various federal government agencies).

Historically, the USDA was the primary federal government agency channeling funds to the SAESs, mostly through the Cooperative State Research Education and Extension Service (CSREES), now the National Institute of Food and Agriculture (NIFA), but that has changed. In 1975, the USDA disbursed about 74 percent of the federal funds flowing to the SAESs through a combination of formula funds, grants, and contracts, but by 2009 its share had declined to about 50 percent. The other half of federal funds is now being disbursed by a wide range of federal agencies, including the National Science Foundation, the National Institutes of Health, the Department of Energy, the Department of Defense, the US Agency for International Development, and others (see figure 5). The CSREES-cum-NIFA share of federal funding for SAES research also declined (from 66 percent in 1975 to 39 percent in 2009), such that the NIFA now provides just 15 percent of total SAES funding.
Formula funding as a share of total USDA support to the states also shrank from 86.6 percent in 1970 to 35.2 percent in 2009. Thus, less than 20 percent of the total federal support to the SAESs in 2009 was in the form of formula funds, given the substantial decline in the USDA share of support to the SAESs over this same period. In contrast, earmarked or special grants funding also increased in absolute and relative terms. Federal funds allocated by means of congressional earmarks are now as high as those allocated by competitive peer-review processes. Funds allocated by way of formula or as grants and contracts to collaborating institutions still account for 81 percent of USDA funding for SAES research, but only 41.5 percent of all federal funding for SAES research.

Behind these overall national trends lies a good deal of variation among states in their sources of funding and the pattern of change in those sources over time. On average, between 2005 and 2009, federal funding accounted for 39 percent of all SAES funding, and state governments contributed another 39 percent, such that $1.01 of state funding flowed to the SAESs for every dollar of federal funding in 2009 (see table 2). This is well below the $2.81 of state funding for every dollar of federal support in the 1920s. In 2009, the Plains and Southeastern regions averaged more than $1.40 from state sources for every dollar of federal support, and the Pacific and central regions received almost equal shares of federal and state funding, whereas the Mountain and Northeast regions each received less than one dollar of state funding for each dollar from federal government coffers.

**Global Context**

In 2000, the latest year for which relevant data are available, the developed countries as a group (including the United States) accounted for the lion’s share of total spending on food and agricultural R&D, 71 percent, with 38 percent conducted by public agencies and 33 percent by private firms. The public-private split among developing countries is much different, with only a small slice (2 percent) of the world’s food and agricultural research conducted by private firms located in developing countries.

This global division of labor in agricultural R&D continues to change. The growth rate of public agricultural R&D spending worldwide has slowed, but the slowdown is much more pronounced in high-income countries, including the United States. The developing world is increasing its investments in agricultural research at a much faster pace, albeit more slowly in recent years than in earlier decades. If these disparities between high- and low-income-country growth rates persist for several decades, the balance of global agricultural R&D will shift away from the United States and other rich countries. Notably, just three developing countries—China, Brazil, and India—accounted for almost 43 percent of the entire developing world’s public agricultural R&D spending in 2000. Moreover, countries such as China are aggressively ramping up their investments in R&D in general, and in agricultural R&D in
particular. These growing R&D investment disparities between the United States and the rapidly growing countries in the developing world will have largely predictable and increasingly unfavorable consequences for the international competitiveness of US agriculture unless policy changes are put in place to revitalize investments in US agricultural research.

Policy Options and Implications. As explained above, correcting for market failures is the primary justification for government action. Past efforts to correct for the pervasive tendency of private markets to underinvest in agricultural R&D have had high social payoffs—high enough to suggest that the correction has been too small and an expanded investment is

Table 2: Ratio of State to Federal Government Support for SAES Research, 1920s to 2000s

<table>
<thead>
<tr>
<th></th>
<th>1920s</th>
<th>1950s</th>
<th>1980s</th>
<th>2000s</th>
<th>2009</th>
</tr>
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<tbody>
<tr>
<td>Total US</td>
<td>2.81</td>
<td>2.95</td>
<td>1.80</td>
<td>1.08</td>
<td>1.01</td>
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<td>Forty-Eight States</td>
<td></td>
<td></td>
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<tr>
<td>Average</td>
<td>2.81</td>
<td>2.95</td>
<td>1.80</td>
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<tr>
<td>Minimum</td>
<td>0.04</td>
<td>0.47</td>
<td>0.41</td>
<td>0.21</td>
<td>0.17</td>
</tr>
<tr>
<td>Maximum</td>
<td>11.04</td>
<td>13.40</td>
<td>4.05</td>
<td>3.24</td>
<td>2.99</td>
</tr>
<tr>
<td>Selected States</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>California</td>
<td>10.15</td>
<td>13.40</td>
<td>2.55</td>
<td>1.05</td>
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</tr>
<tr>
<td>Minnesota</td>
<td>7.49</td>
<td>4.10</td>
<td>2.96</td>
<td>1.62</td>
<td>1.44</td>
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<td>Wyoming</td>
<td>0.59</td>
<td>1.66</td>
<td>1.46</td>
<td>2.10</td>
<td>2.51</td>
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<td>Regions</td>
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<td></td>
</tr>
<tr>
<td>Pacific</td>
<td>5.04</td>
<td>8.50</td>
<td>2.03</td>
<td>1.04</td>
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<tr>
<td>Mountain</td>
<td>1.28</td>
<td>1.92</td>
<td>1.20</td>
<td>0.63</td>
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<tr>
<td>Northern Plains</td>
<td>2.32</td>
<td>2.34</td>
<td>2.11</td>
<td>1.55</td>
<td>1.76</td>
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<tr>
<td>Southern Plains</td>
<td>2.45</td>
<td>2.38</td>
<td>2.40</td>
<td>1.58</td>
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<td>Central</td>
<td>5.95</td>
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<td>2.84</td>
<td>1.26</td>
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</table>


NOTES: The figure for the United States represents the forty-eight-state total. The 1920s figure is the simple average of observations for 1920–29, and similarly for remaining decades. No state appropriations data were reported in the USDA Current Research Information System unpublished annual data files for Rhode Island after 2006. We used the 2006 observation as our best estimate of the corresponding 2007, 2008, and 2009 estimates.
warranted. Paradoxically, recent developments in the amount and orientation of agricultural R&D are likely to exacerbate the slowdown in agricultural productivity growth, weaken US international competitiveness, put upward pressure on the prices of farm commodities and food, and add to environmental stresses and food-security concerns in the decades ahead. Several options for changes in US policies and institutional arrangements for providing agricultural R&D are briefly canvassed here, with an eye to the shifting domestic and global landscape within which they will play out.\textsuperscript{21}

**Reinvesting in Agricultural R&D.** While it may be hard to unequivocally attribute a slowdown in productivity to a previous slowdown in research spending, it is not hard to make a case that an increase in spending on farm productivity–oriented research is warranted if we want a return to the rates of productivity improvement enjoyed during the 1970s and 1980s. Certainly, recent rates of growth in US public-sector agricultural R&D spending of less than 1 percent per year (from 1990 to 2009) are well below the rates that prevailed over the preceding four decades (an average of 2.7 percent per year over 1950–1990, with agricultural R&D spending growing more than 3.6 percent per year during the 1950s and 1960s). If the pace of agricultural R&D spending does not increase, productivity growth will be difficult to sustain at the rates required to meet the expected future growth in demand for food and biofuels. The possibility of a return to the rates of productivity growth of the 1970s and 1980s seems unlikely, even with a massive increase in research spending, but many commentators seem to take such growth rates for granted.

US federal budget projections are dire, and it is undoubtedly a hard sell to rehabilitate commitments to agricultural R&D from the federal public purse. Unlike some other areas of the economy, where state governments have stepped in to fill gaps created by the withdrawal of federal funds, the weakening of federal support for agricultural R&D has been accompanied by a weakening of support from state governments. Those making these public funding choices should be cognizant of the implications. In this case, a failure to revitalize US agricultural R&D spending will likely have enduring consequences for the sustainability of US agriculture in a competitive global environment and for the natural resources on which it depends. Some political constituents are farmers, but all Americans consume food, fiber, and fuel. If US and global agricultural productivity growth continue to slide, the inevitable consequence will be an increase in the price of food (which disproportionately affects poor people) and increased pressure on national and global natural resources.

Redirecting some federal tax revenues to agricultural R&D is one option, and it is relevant to consider the federal spending priorities within which that commitment would have to be made. In 2009, agricultural R&D accounted for just 2 percent of the federal budget spending on all areas of science. Agricultural R&D represents only 2–3 percent of total USDA expenditures (which totaled $115 billion in 2009), in the range of one-tenth of the amount spent annually on farm commodity program subsidies in typical years, and a tiny fraction of the amount spent annually on food and nutrition programs (almost two-thirds of the USDA budget in 2009). Agricultural R&D could have been doubled in 2009 in exchange for a 20 percent reduction in farm subsidy payments (which have been recently low because of commodity price booms) or a very modest reduction (3.3 percent) in food subsidies for consumers. In the long run, such an increase in agricultural R&D might well have a bigger favorable effect on both farmer incomes and nutrition of the poor compared with the subsidy programs that are better funded and increasingly so.

**Cofinancing Arrangements.** Paying for more of the public support for agricultural R&D using general tax revenues is one option, and it is certainly consistent with the notion that the general public ultimately benefits from this investment through lower food prices and access to a broader array of agricultural products with higher quality and other desirable attributes, as well as enhanced or
rehabilitated environmental services associated with new agricultural production practices. But farmers who adopt the new technologies arising from R&D also gain in improved productivity, lower costs of production, and enhanced competitiveness in global food and feed markets. Thus, another option is for farmers and other agribusiness interests to cofinance certain types of public research investments undertaken on their behalf.

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The most straightforward approach may be for the government to pass enabling legislation that empowers industry to impose a research levy on producers. To encourage producers to implement such a scheme, the government could provide dollar-for-dollar matching of levy funds up to some predetermined limit (say, 0.5 or 1.0 percent) of the gross value of production of the industry. Such a scheme was implemented to good effect in Australia in 1985, and now almost half of all the funding to agricultural R&D performed by public agencies in Australia is jointly financed by taxpayers and industry through this institutional instrument. Other countries have analogous research levy schemes in place, including the Netherlands and Uruguay, where there is also a public-private matching requirement. Expanding the range of potential levy payers beyond farmers to include farm input suppliers and the postfarm food processors, as well as bioenergy and other industries that draw directly on the fruits of agricultural R&D, could also help fund it.

The other cofinancing dimension of US public agricultural R&D concerns state versus federal government matching requirements. As mentioned above, through 1975, each federal dollar committed to SAES research was generally matched by more than $2.50 of state government funding.27 Now the state government contribution barely matches federal funds, with funds from all federal agencies accounting for 38.0 percent of SAES spending in 2009 (and only 38.3 percent of the 2009 SAES total coming from state government sources, compared with 69.3 percent in 1970). Of course, state-federal matching arrangements vary considerably among the states. In 2009, for each federal dollar directed to the SAES, twenty-seven state governments contributed less than $1, fourteen states contributed between $1 and $2, and only seven states provided more than $2.28 Increasing the amount of matching state funding required to secure federal funding for SAES research is one practical way of rebalancing state versus federal support for SAES research. It could also focus research in locations with higher agricultural production, which could yield increased efficiencies in and productiveness of R&D given the strong site-specific attributes that affect agriculture, while at the same time expanding the total amount of support for publicly performed R&D.

Governance and Oversight. Keeping a clear separation between the individuals and the agencies funding (public) research and those carrying it out has merit, but the benefits from transparent independence have to be balanced against the benefits from having decisions based on informed expertise and against the desire to engender support from producer constituencies that provide industry funds. For example, the 1985 reforms in financing Australian agricultural R&D developed commodity- or industry-focused statutory authorities called Research and Development Corporations (RDCs) that oversee the allocation of funds with input from farmers, consumers (taxpayers), governments, and scientists. Importantly, the Australian RDCs do not conduct any research, thus minimizing potential conflicts of interest that come with agencies such as the USDA that both conduct intramural research and disburse funds to the SAESs.
and others to conduct research of their own. The institutional independence of the RDCs enables industry engagement in R&D allocation decisions while seeking to maximize the prospects of research resources being spent in ways that maximize both net national benefits and benefits to producers. In contrast, in existing programs in the United States, funds from check-offs that may be used for R&D or promotion purposes are allocated at the sole discretion of the industry groups administering them. In such programs, whether in the United States or Australia, the emphasis of the spending is typically on promotion and demand enhancement that pays off immediately, with comparatively little support for R&D that takes much longer to take effect and benefits only those producers who are able to adopt the resulting innovations. It required a combination of matching support, some (albeit limited) government oversight, and a clear definition of the purpose of the funds for this type of mechanism to be as effective as it proved to be in Australia.

The differences in types of research projects, performers, and purposes imply that a mixture of fund allocation and oversight mechanisms would be optimal to maximize the social returns to public investments in agricultural R&D. Investing in more explicit technical and economic information on the likely payoffs of any proposed research could well improve these payoffs over time, particularly as new analytical tools and data become available and cost-effective to use in assessing the impacts of R&D (including geospatial approaches that can be applied to better assess the site-specific responses to new agricultural technologies).

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Notes


5. Absent this growth in productivity, stemming largely from the technical changes attributable to investments in R&D, US agricultural output in 2007 from the same inputs would have been 78 percent ($219.6 billion) less than the $281.5 billion that was actually produced. As Nobel laureate Norman Borlaug observed, “Put another way, thanks to the agricultural productivity increases made possible through research and new technology development since 1990, an area greater than all the land in the 26 states east of the Mississippi River, has been spared for other uses. Imagine the environmental disaster that would have occurred if hundreds of millions of environmentally fragile acres, not suited to farming, had been ploughed up and brought into production. Think of the soil erosion, loss of forests and grasslands, and biodiversity, and extinction of wildlife species that would have ensued!” (N. E. Borlaug, foreword to Persistence Pays: US Agricultural Productivity Growth and the Benefits from Public R&D Spending).


10. In a recent econometric reexamination of the returns to agricultural R&D investments in the United States, Alston et al. showed that, on average, an additional dollar of SAES R&D spending generated $21 of benefit to the state conducting the research and around $32 of national benefit, implying that about one-third of the benefits from state-performed R&D are generated through spillovers to other states (J. M. Alston, M. A. Andersen, J. S. James, and P. G. Pardey, Persistence Pays: US Agricultural Productivity Growth and the Benefits from Public R&D Spending).


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13. Congress authorized $604 million for the 2010 competitive grants program administered by NIFA by way of AFRI but only $261.8 million was obligated, albeit a very substantial increase over the $132.3 million committed to competitive grants in 2009. See USDA, FY 2011: Budget Summary and Annual Performance Plan (Washington, DC, 2010), 118, www.obpa.usda.gov/budsum/FY11budsum.pdf (accessed May 27, 2011).


16. The extension-related agencies within the USDA ceased compiling and reporting extension expenditures obtained from state or local government sources after 2006. Given that funds from these sources constitute a significant share of all extension expenditures, it is especially difficult to construct a credible estimate of total US extension expenditures for the years after 2006.


22. This arrangement was implicitly criticized to some extent by the Productivity Commission in its draft report, in which it recommended reducing the rate of matching support. At issue was (a) the extent to which the investments yielded benefits beyond the farming sector, and (b) the extent to which the government support was effectively additional rather than simply crowding out industry funding. See Commonwealth of Australia, Productivity Commission, Rural Research and Development Corporations (Canberra, Australia, 2010). These are difficult questions to resolve, because they are essentially empirical questions and the measurement problems are challenging. Similar questions will arise with any such scheme. The issue for the US government is what rate of matching support would be necessary to generate significant industry interest in such an approach to funding agricultural R&D, and to what extent that would be a more effective use of government funds than 100 percent federal funding of agricultural R&D by some other means, or some other investment.


25. “In 1999 more than 30 percent . . . [of the funding for INIA, the country’s national agricultural research agency] . . . came from a commodity tax of 0.4 percent on the value of farm sales of most commodities. The government provides funding on a matching basis with annual tax revenue through its contribution to INIA, allocated quarterly” (N. M. Beintema, G. G. Hareau, M. Bianco, and P. G. Pardey, Agricultural R&D in Uruguay: Policy, Investment, and Institutional Profile, 12). They also noted, “By law, government contributions must equal or be greater than the total funds obtained via the commodity tax. In practice, however, the government has matched the cess revenues dollar for dollar.”

26. The Specialty Crops Research Initiative, introduced in the 2008 Farm Bill and administered as an element of NIFA, requires matching support from nonfederal sources, such as industry or state government, for relatively large-scale federal competitive grants. This has some features in common with the Australian RDC model—though it is based on matching at the level of individual projects rather than, as in the RDCs, for the entire program of research with the allocation of the funds left separate—and some features in common with the Australian Cooperative Research Center model,
which provided for joint public- and private-sector funding of applied research on a specific issue for a particular time period.

27. The national average state-to-federal funding ratio fell short of the $2.50 threshold for all the years between 1927 and 1946, as well as 1957.

28. The seven states with 2009 state-federal funding ratios in excess of 2.0 were Arkansas, Georgia, Louisiana, Nebraska, North Dakota, Oklahoma, and Wyoming (with Louisiana having the maximum ratio of $2.99 of state funding for every federal dollar). The ratio of state funding to USDA-sourced funds averaged 2.01 in 2009, with a high of 4.71 (Louisiana) and a low of 0.32 (Rhode Island). A total of nine states failed to match USDA-sourced funds with funds from state sources, while fifteen (twenty-six) states were below a 1.5 (2.0) state-to-USDA funding threshold.
This paper examines the benefits of increased agricultural research and development (R&D) spending. In 2008, only 2 percent of total R&D spent on science was directly related to food and agriculture. US public investment in agricultural R&D has proved successful, with benefit-cost ratios around 20:1. A failure to increase publicly funded agricultural R&D will likely have long-term consequences for the sustainability of US agriculture in a competitive global environment and for the natural resources on which it depends.

1) **Growth in federal agricultural R&D spending has declined:** The pace of investment growth has slowed from 3.63 percent per year (after inflation) during 1950–69, to 1.79 percent during 1970–89, to 0.94 percent during 1990–2009.

2) **Agricultural productivity growth has also slowed over the past decade:** Since the early 1990s, agricultural productivity growth in the United States has slowed to an average of less than 1.2 percent per year. The growth rate of public agricultural R&D spending by the world as a whole has slowed, but the slowdown is much more pronounced in high-income countries. Just three developing countries—China, India, and Brazil—accounted for almost 43 percent of the entire developing world’s public agricultural R&D spending in 2000 and have experienced high levels of productivity growth.

3) **More private-sector agricultural R&D is going toward food processing:** In 2006, 59 percent of the total $4.6 billion in private-sector funding for food and agricultural R&D was related to food processing.

4) **R&D spending can be increased with a decrease in farm subsidies:** R&D spending could have doubled in 2009 with a 20 percent reduction in farm subsidies or a 3.3 percent reduction in food subsidies to consumers.

5) **A significant share of R&D is necessary just to maintain productivity:** In 1976, 64.6 percent of funding was spent on maintenance research compared with 56.3 percent in 2009. If R&D were to cease altogether, we would not see a continuation of current yields or costs; productivity would decline and food prices would rise.