# What Can be Done to Reinvigorate U.S. Agricultural Research?

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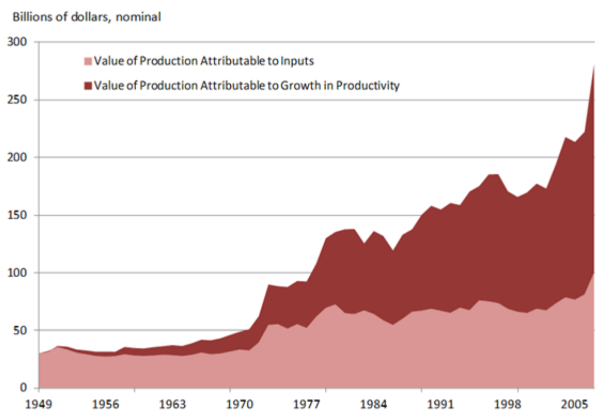
Over the past century and more, research and development (R&D) has contributed to a transformation of the U.S. food and agricultural sectors. R&D has fueled productivity growth, enabling U.S. farmers to do more with less. It has helped U.S. farmers to remain competitive in increasingly integrated global commodity markets and better achieve an environmentally sustainable supply of biofuels, fiber, and feed, as well as safe, nutritious, and affordable food. But support for U.S. public agricultural R&D has waned at a time when U.S. farm productivity growth is slowing. In what follows we describe the evolving patterns of support for public agricultural and food R&D, the shifting emphasis of spending within the broad portfolio, and some potential policy approaches to revitalize U.S. agricultural research.

## THE VALUE OF AGRICULTURAL R&D AND PRODUCTIVITY

In 2007, U.S. agriculture produced more than five times the quantity of agricultural output (as measured by an index aggregating the quantities of all crop and livestock products) produced in 1910 (Alston et al. 2010). The 1.74 percent per year increase in output over 1910–2007 was achieved with only a 0.15 percent per year increase in inputs (as measured by an index aggregating quantities of labor, capital, land, and purchased inputs such as energy, agricultural chemicals and seeds).

This productivity growth is valuable. The upper line in Figure 1 plots the total value of U.S. agricultural output from 1949 to 2007. If U.S. agriculture had employed the same inputs but agricultural productivity had remained constant from 1949 forward, then the value of agricultural production would have followed the lower line, instead. Thus the (lower) dark shaded area represents the output attributable to inputs given constant 1949 technology and productivity, and the (upper) lighter shaded area represents the output attributable to productivity growth since 1949.

*Figure 1. U.S. Agricultural Output Value Attributed to Productivity Growth, 1949–2007*




*Source:* Pardey, Alston and Chan-Kang (2013b)

By 2007, when the value of U.S. agricultural output was $281.5 billion, 78 percent of the output in that year (i.e., $219.6 billion) was attributable to productivity growth since 1949. Equivalently, absent that productivity growth it would have taken 78 percent more inputs to achieve the same output as actually produced, so productivity growth since 1949 saved $219.6 billion worth of inputs in 2007 alone. In more concrete terms, it would take an additional 729.5 million acres combined with an additional farm labor force of 1.76 million full-time annual equivalents, as well as much more other inputs, to produce the 2007 output using 1949 technology.

Much of this growth in U.S. agricultural productivity and production was attributable to innovations enabled by investments in agricultural R&D. The public part of these investments yields benefit-cost ratios in the range of 20:1 to 30:1—proof not only of a remarkably profitable undertaking for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the nation but also of persistent underinvestment (Alston et al. 2011).

## THE POLICY CHALLENGE

U.S. farm productivity growth has slowed appreciably since 1990. Even though rates of return for productivity-enhancing research are demonstrably very high, we have seen a slowdown in both public and private spending on agricultural R&D in the United States and a diversion of public research funds away from farm productivity enhancement. Together these trends spell a further slowdown in U.S. farm productivity growth at a time when the market has begun to signal the beginning of the end of a half-century and more of global agricultural abundance.

U.S. agriculture is closely connected to international markets, and so domestic agricultural R&D policies must take into account developments elsewhere in the world. Middle-income countries such as Brazil and China have been gaining ground relative to the United States and the high-income countries generally in both their shares of global investments in agricultural R&D and in their shares of global agricultural production (Pardey, Alston, and Chan-Kang 2013a). And in those large agricultural countries, agricultural productivity growth rates have not slowed as they have in the United States (Alston and Pardey 2013). One implication, if this pattern continues, is that the United States can expect to continue to become less competitive in international markets, and will continue to lose market share to today's middle-income countries (Pardey and Beddow 2013).

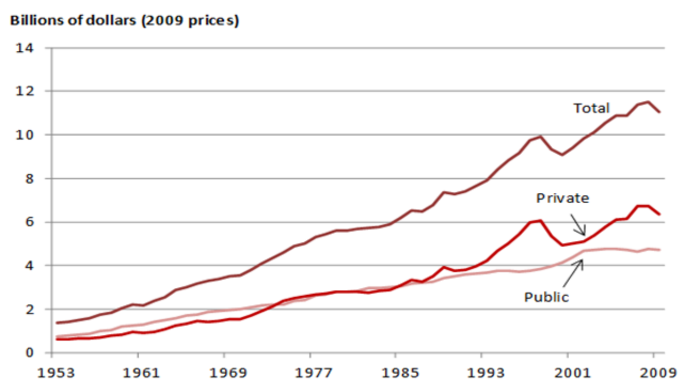
Agricultural R&D policy in the United States is at a critical juncture. In early May 2013, both the Senate Committee on Agriculture, Nutrition, and Forestry and the House Committee on Agriculture finalized proposals for a new U.S. Farm Bill. Both Committees propose to eliminate "direct payments" and thereby reduce commodity supports by more than $4 billion per year. But neither of the Committees proposes to redirect any substantial amount of these budget savings to growth-promoting investments in public agricultural R&D. Instead, both propose only very modest increases in funding for agricultural R&D that will imply a further decline in the real quantity of R&D once inflation is taken into account.

An economic approach to U.S. agricultural R&D policy suggests the federal government need not necessarily foot the entire bill; coupling increased federal investments with policy innovations to incentivize additional investments from state governments and industry participants should be part of the policy package. The Senate Committee has proposed a new "Foundation for Food and Agricultural Research" that would combine public and private research funds, but the amount of proposed federal funding is modest and the implementation details are not altogether clear. Pardey, Alston, and Chan-Kang (2013b) present arguments for approaches in this genre, for reinvigorating U.S. agricultural R&D, involving public-private partnerships funded in part by coupling commodity "check-off" arrangements with matching public funding.

## SHIFTING INVESTMENT PATTERNS

Agricultural R&D is funded and conducted more in the public sector, compared with general R&D. In 2009, the United States invested a total of $400.5 billion in R&D of all types. The business sector accounted for $289 billion of this total, with the federal government picking up $31 billion (8 percent) of the tab. An estimated $11.1 billion (just 2.8 percent) of the total spent on science in the United States in 2009 was related directly to food and agriculture (Figure 2). The business sector conducted a larger share of total R&D (72 percent of the total in 2009) than food and agricultural R&D (57 percent), though the private share of agricultural R&D has been growing. Food processing research accounted for around 38 percent of the $6.3 billion of total private food and agricultural R&D in the United States in 2009.

*Figure 2. Public, Private and Total U.S. Agricultural R&D, 1950–2009*



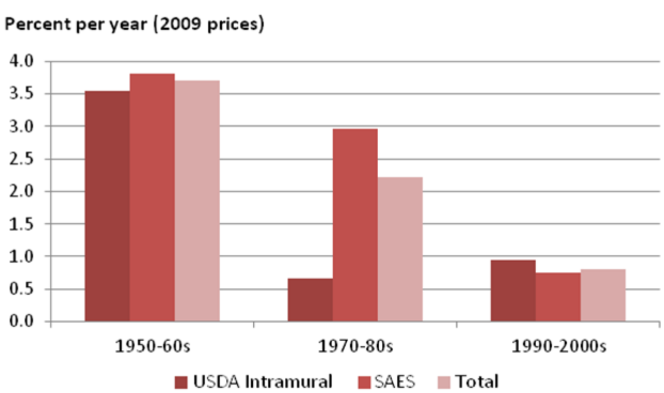

*Source*: Pardey, Alston and Chan-Kang (2013b)

Public food and agricultural R&D spending (net of forestry) grew from 1889 at an average annual rate of 7.7 percent in nominal terms and 3.9 percent in real (i.e., inflation-adjusted, 2009 base-year prices) terms to a total of $4.7 billion in 2009. Inflation-adjusted growth in spending averaged only 3.4 percent per year for the period 1950–1980, and slowed to 0.71 percent per year for the period 1980–2009. In more recent years, aggregate real spending on public agricultural R&D has been on the decline. Real spending in 2009 was 7 percent below the corresponding amount in 2004.

Research conducted by the United States Department of Agriculture (USDA) and the state agricultural experiment stations (SAESs) accounted for roughly equal shares of public food and agricultural research spending until the early 1940s, after which the SAES share grew to 73 percent by 2009. Spending on cooperative extension grew from 1915 at an average rate of 6.7 percent per year, but during the period 1950–1980 inflation-adjusted growth in extension spending slowed to 2.39 percent per year, and during the period 1980–2006, real extension spending shrank by 0.25 percent per year, to reach $1.76 billion in 2006 (the latest year of available data).

The real rate of growth of U.S. science spending has also progressively slowed in recent decades (Figure 3). However, the slowdown in U.S. public and private agricultural R&D spending has been much more pronounced, such that total spending on agricultural R&D, as a share of total U.S. science spending, gradually slipped from 4 percent in 1953 to under 3 percent in 2009. But unlike most other industrial sectors, agriculture requires significant investments in "maintenance" research—it takes between 35 and 70 percent of all food and agricultural R&D by available estimates just to maintain farm productivity and prevent it from falling given changing environmental circumstances, most notably the inevitable co-evolution of pests and diseases to overcome technologies presently in use. As other agendas such as research on health, nutrition, the environment and biofuels have gained ground, the share of SAES research directed to enhancing the productivity of U.S. farmers has declined from an estimated 65 percent of the total in 1976 to only 56 percent in 2009.

*Figure 3. Agricultural Research Spending Slowdown*




*Source*: Pardey, Alston and Chan-Kang (2013b)

## SOURCES AND FORMS OF PUBLIC FUNDING

Of the $3.6 billion spent on food and agricultural R&D by the SAESs and related institutions in 2009, 38.0 percent came from federal sources, 38.3 percent from state government, 8.2 percent from industry grants and contracts, and 15.5 percent from income earned from sales, royalties, and various other sources. Research conducted by USDA labs was almost entirely reliant on federal government funding; 96 percent of the total of $1.53 billion of that research in 2009 was so funded.

The state-government share of total SAES funding has fallen dramatically from 69.3 percent in 1970 to just 38.3 percent in 2009. Since 1975, funding from industry, self-generated and miscellaneous funds has risen, and it accounted for 23.7 percent of total SAES funding in 2009. In the 1920s, on average, states provided $2.68 for every dollar of federal support to the SAESs. By 2009 only $1.01 of state funding flowed to the SAESs for every dollar of federal funding support.

Historically the USDA was the dominant federal government agency channeling funds to the SAESs, 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 that share had declined to around 50 percent and the USDA's National Institute for Food and Agriculture (NIFA) now provides just 16 percent of total SAES funding. The other half of federal funds is disbursed by a wide range of federal agencies.

## POLICY INNOVATIONS

It is a crucial time to rethink national food and agricultural R&D and innovation policies and reposition the U.S. food and agricultural research and innovation system to address the changing scientific and market realities in the century ahead. A chronic lack of funding lies at the heart of the problems and a doubling of total funding for public agricultural R&D could easily be justified. This could not be done usefully overnight, even if the funds were immediately available. But the total annual spending could be doubled over 5–10 years, with appropriate attention to the balance between investments in bricks and mortar and equipment, and to rebuilding the human capital capability.

Without question, it is hard to make a case for increasing public spending on anything—including agricultural R&D—in these tight fiscal times. However, given the long lags between investing in R&D and realizing the social payoffs to these investments, deferring decisions now could be "penny wise and pound foolish." Today's problems have been decades in the making and will take time to fix. Likewise, changes in investments in agricultural R&D beginning from today will have long-run consequences for the productivity and competitiveness of U.S. agriculture and the security of the nation's food supply.

An economic assessment of this problem (Pardey, Alston, and Chan-Kang 2013b) suggests four practical policy changes that would address the funding shortfalls over the decades ahead and make more efficient use of ever-scarcer research resources.

**Revitalize Federal R&D Support via the Farm Bill**. At least some of the savings envisaged in the Farm Bill from scaling back direct payments could be redirected toward additional federal support for R&D. As Pardey, Alston and Chan-Kang (2013, p. 36) observed "If even half of these funds could be diverted to agricultural R&D, rather than countercyclical payments or crop insurance, they could yield very large dividends for the nation and a greater benefit for farmers."

**Reengage State Government Support for SAES Research**. Over the past 40 years, state government funding as a share of total government (federal plus state) SAES support has declined precipitously. Expanding the scope of the state matching requirements to secure federal funding for SAES research is one practical way of rebalancing federal versus state support for SAES research. It could also serve to improve the spatial alignment of the performance of research with the location of agricultural production, with the potential for achieving increased efficiencies in the productiveness of R&D given the strong site-specific attributes that affect agriculture, while expanding the overall amount of support for publicly performed R&D.

**Reintroduce Policies to Increase Private Support for Publicly Performed Research**. Substantially enhanced support for public food and agricultural R&D could be engendered from primary producer and agri-business sources if the United States adopted a funding model in which a combination of government and industry funds is used to finance industry-oriented agricultural R&D, as done in some countries. The role for the federal government in this context is to take the lead in devising the institutional arrangements, and providing incentives for the industry to participate through the use of matching government grants.

**Increase Flexibility and Contestability**. Increases in total funding could come with changes in the way these funds are allocated. For example, incremental funds could be used to revive investments in farm-productivity-enhancing agricultural research and other high-payoff areas where markets fail to fund the economically justifiable amount of research. They could also be used to bid SAES researchers' effort away from existing sources of funds and applied in a contestable fashion; making the funds also available to non-SAES scientists on a competitive basis and thereby expanding the total research capacity available for agricultural research. They could also be used flexibly, shifting in application as priorities change among research areas and among researchers, unlike the existing core SAES funds that are tied up predominantly in salaries of tenured faculty. Contestability and flexibility could extend beyond individual scientists within the SAESs to the entire SAES system.

The issues are urgent. U.S. agricultural productivity growth is slow and slowing. The Experiment Station capacity is dwindling as the SAES human capability is shrinking and aging. Agricultural R&D is slow magic: the social payoffs are high, but even if we act immediately to remake and revive the Experiment Station and restore spending, the effects will not be felt for a long time. And this all presupposes the availability of funds, but institutional change to enable enhanced agricultural R&D spending takes time, too, even when we have support within the industry and in government. The situation is not yet desperate, and not hopeless, but a meaningful change will require a seismic shift in attitudes, expectations, and aspirations, and soon.

## FURTHER READING

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