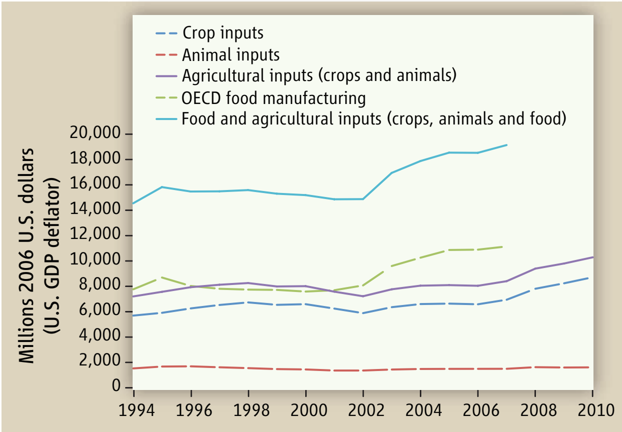
RESEARCH FUNDING

The Contribution of Private Industry to Agricultural Innovation

Led by seed biotechnology, private-sector spending in agricultural R&D grew 43% from 1994 to 2010.

Keith Fuglie,[1] Paul Heisey,[1] John King,[2] Carl E. Pray,[3] David Schimmelpfennig[1]*



Global private investment in food and agricultural input research. For 1994–2010; see (*6*) for data and methods.

Most of the increase in global agricultural production over the past half-century has come from raising crop and livestock yields rather than through area expansion. This growth in productivity is attributed largely to investments in research and innovation (*1*). Since around 1990, there has been a decline in the rate of growth in yield per area harvested for several important crops (*2*). In parallel, the rate of growth in public spending on agricultural research and development (R&D) has also fallen, which may account for declining crop yield growth and may be contributing to rising food prices (*3*).

Absent from this picture has been the role of the private sector in contributing innovations for food and agriculture. There is evidence that innovations in some manufacturing industries (machinery and chemicals, especially) have benefited agriculture (*4*) but little systematic evidence on the level and trend in private-sector R&D investments targeting applications to the agricultural sector (*5*). There is little quantitative evidence of private R&D's contribution to agricultural productivity. Our understanding of how different factors may induce or hinder incentives for private R&D—like government investments in public research and policies concerning intellectual property (IP), taxes, and regulations—is limited by the lack of data.

To fill in this data gap, we surveyed global agricultural R&D investment by industries supplying inputs to agriculture, as well as R&D in biofuel and food manufacturing (*6*). We present some results of this survey and preliminary analysis of causes and implications of the observed growth in private R&D.

Private R&D Growing Faster than Public

Between 1981 and 2000, the absolute increase in private-sector spending on food and agriculture research in the Organization for Economic Cooperation and Development (OECD) countries, where the majority of private research has taken place, was nearly three times as great as the increase in real public-sector research; by 2000, 54% of total food and agricultural R&D in OECD countries and 39% globally was private (*7*). These estimates do not break out food manufacturing from agriculturally related R&D, and the relevance of this for the agricultural sector is not clear. From more detailed information available for the United States, only about half appears to be agriculturally related, with food manufacturing research focused primarily on the development of new consumer food products (*8*).

Our survey provides 1994–2010 annual estimates of global private R&D in seven industries supplying agricultural inputs to farms, as well as the food manufacturing industry through 2007 and the biofuel industry for 2009 (*6*). World inflation-adjusted R&D spending in the seven agricultural input industries combined increased by 43% between 1994 and 2010 (*6*). All of this growth, however, occurred in industries supplying inputs for crop production, led by the seed-biotechnology and farm machinery industries, whereas R&D related to livestock remained essentially unchanged (see the first chart).

Global private investment in food manufacturing research was U.S. $11.5 billion in 2007 and in agricultural input research was $11.0 billion in 2010 (with $8.7 billion of this oriented to crops). Within the agricultural input industries, there have been striking changes in the composition of research investment. This is best illustrated for the United States, which accounts for a little over one-third of global private agricultural input research. In the 1960s and 1970s, agricultural chemicals and farm machinery dominated private agricultural R&D; as late as 1980, these two sectors accounted for more than three-fourths of the total (*6*). In the 1980s and 1990s, private investment in crop-related seed and biotechnology research began to grow rapidly and, by 1998, surpassed other industries' agricultural R&D spending (see the second chart) (*6*). For the United States and globally, private R&D spending on crop seed and biotechnology grew rapidly in the 1990s; leveled off in real terms from the late 1990s until about 2005; then accelerated again, reaching $3.7 billion by 2010.

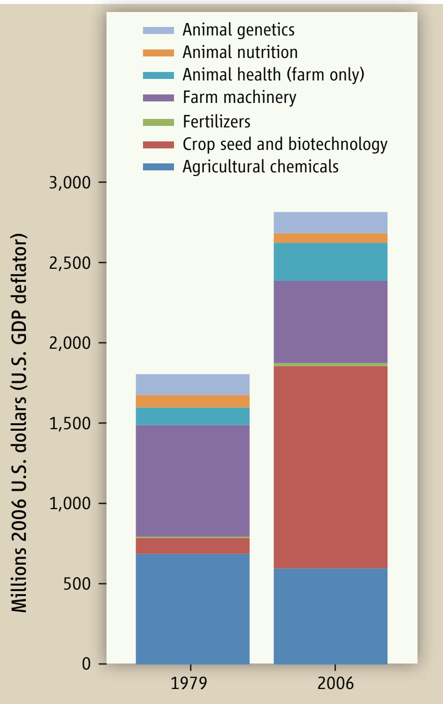
In recent years, research into biofuels, a new agriculturally related research area, has become increasingly important. In 2009, private companies spent ~$1.47 billion on biofuels-related research globally. More than 75% of these expenditures were in the energy sector, but about $340 million was spent by crop seed–biotechnology companies to improve biofuel feedstocks (*9*).

Drivers of Private R&D

Factors influencing returns to investment in R&D by private, for-profit firms include market size, technological opportunity, appropriability (the ability of firms to appropriate economic benefits of research), and costs of R&D inputs (*10*). Across agricultural input industries, market size does not appear to be a good predictor of the amount of R&D invested, as research intensity (research spending as a percentage of net sales) varies widely, from 10.5% in seeds to 0.25% in fertilizers. Research intensity within each industry, how-

[1]Economic Research Service, U.S. Department of Agriculture (USDA), Washington, DC 20472, USA. [2]Office of the Chief Scientist, USDA, Washington, DC 20250, USA. [3]Rutgers, The State University of New Jersey, New Brunswick, NJ 08901, USA.

*Author for correspondence. E-mail: des@ers.usda.gov.



Private agricultural input research in the United States. For 1979 and 2006; see (*6*) for data and methods.

ever, has remained fairly constant over time. Thus, for some industries in which sales have grown rapidly, e.g., the seed industry, R&D also has grown rapidly.

Advances in molecular genetics opened up new technological opportunities in biotechnology and, together with strengthened patent protection over biological inventions (one form of appropriability), stimulated growth in private-sector investment in crop improvement. The public sector, through research at universities, national laboratories, and international centers, contributed to this process by developing improved genetic resources, genomic information, and molecular tools (*11*, *12*). Universities have also contributed to private research through training the science and technology (S&T) workforce. A larger supply of S&T workers reduces R&D input costs for private firms, raising returns to their R&D investments.

Although, in most industrialized countries, patent protection has been available for mechanical, chemical, and pharmaceutical inventions for a century or more, patent protection for biological inventions has been more recent and gradual, beginning in the United States only in 1980 (*13*, *14*). Most countries now provide patent protection for novel biological organisms and plant breeder's rights for novel plant varieties—provisos for membership in the World Trade Organization. Plant breeder's rights offer considerably weaker IP protection than patents, and some countries have begun to offer patent protection for novel plant varieties as well. This strengthening of patent protection increased appropriability for private firms and likely induced more agricultural R&D.

More stringent environmental and safety regulations have also exerted influence on food and agricultural R&D. Regulations on new chemical and biotechnologies may have increased overall R&D spending by firms in order to meet these requirements but may have diminished rates of innovation, as a larger proportion of R&D funds was redirected from discovery research (*15*–*17*). In addition, regulations may create barriers to entry for new firms. In crop biotechnology, high fixed costs and long time lags in meeting regulatory requirements reduce incentives for private firms to develop new traits for small, heterogeneous markets, such as horticulture (*18*).

Implications

Growth of private R&D spending for agriculture in the face of slowing or stagnant public R&D resources raises the question of whether private R&D can substitute for public R&D. If so, long-term productivity growth in agriculture may be maintained or revived even as public R&D spending wanes. However, to the extent that technology opportunities created through basic research and the training of the S&T labor force are largely public-sector functions, reduced public-sector capacity may eventually reduce returns to private R&D as well and lead to lower aggregate investments in innovation (*19*–*21*). In addition, agricultural biotechnology may need public investment to achieve wide international dissemination, especially in poor countries with limited IP or regulatory capacity (*22*).

Another issue is whether the concentration in agricultural input industries may have adverse consequences for market performance. In several input industries, a few firms dominate global market sales, account for most of the industry R&D spending, and hold large patent portfolios. These factors may be creating possibly major barriers to entry of new firms and may be limiting market competition (*23*).

Not only is private agricultural input R&D concentrated among a few firms, it also appears to be focused on fewer commodities, technologies, and markets than public R&D (*24*). Areas that the private sector has avoided are generally those where profitable opportunities are perceived to be low. However, private R&D appears to be responsive to changing technological opportunities when market and regulatory conditions are favorable, as evidenced by the rapid growth in crop biotechnology and biofuel R&D. Policies to strengthen IP, streamline regulatory procedures, and offer favorable tax treatment for R&D investment can encourage private investment in agricultural innovation. However, lack of sufficient market competition or barriers to entry by new firms could constrain the potential contribution of industry to agriculture.

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