Rates of Return to Public Investment in Agricultural Research and Education

by Peter J. Barry, University of Illinois, with contributing authors Julian Alson, University of California, Davis; Bruce Gardner, University of Maryland; Tracy Irwin Hewitt, C-FARE; Wallace Huffman, Iowa State University; George Norton, Virginia Tech University; and Michael Phillips, National Research Council.

Both federal and state legislative bodies provide substantial funds for agricultural research and education. In part, at least, their funding decisions rest upon the expected payoffs to society of these expenditures of public funds. Economists have for decades estimated the social rates of return from these investments and found them to be quite high. Naturally enough, the complexity of making these estimates raises questions about their validity and applicability to government funding decisions. As Congress began to debate the research and education part of the latest farm bill, C-FARE, the Council on Food, Agricultural, and Resource Economics, a non-profit organization, sent a letter to House and Senate agricultural and appropriations committees, explaining rates of return to public investment in agricultural research and education, and answering concerns about the validity and applicability of these estimates. The C-FARE assessment will be of interest not only for the current policy debate but also for those that arise year after year at both the federal and state levels.

—The Editor

Since the late 1950s, more than three dozen studies have estimated social rates of return on public investments in agricultural research and education in the United States. These studies have, for the most part, found high real social rates of return for most categories of applied and basic research—estimated rates of return to research typically range from 40 to 60 percent per year, or even higher. These high payoffs from the past help to justify continued support for agricultural research and development in the future.

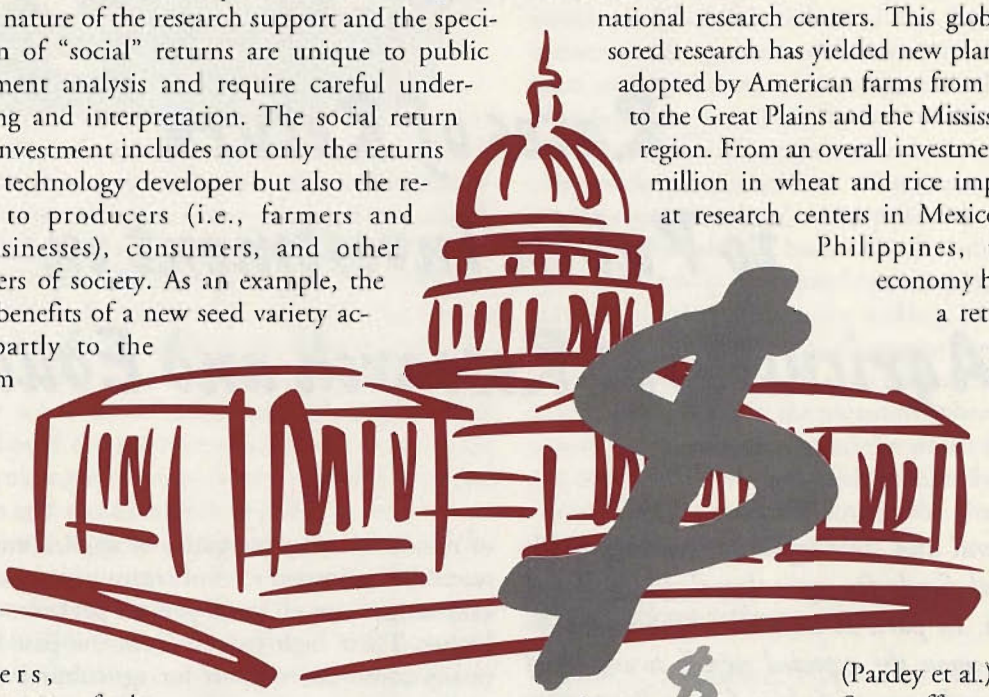
From a social perspective, farmers and agribusinesses have profit incentives to overinvest in technologies that result in negative environmental externalities, the costs of which are neither directly identified nor borne by the parties in question.

Key questions arising from the estimated social rates of return involve their credibility, interpretation, and appropriate use. Our goal in this letter is to address these types of questions.

Social rates of return are calculated using the standard internal-rate-of-return approach to investment analysis. The estimates represent the compounded yield from an initial outlay of research funds that generate a multiyear series of research returns. The calculation procedures are similar to those employed in determining bond yields in which the investor pays the face or market value to purchase the bond, and then receives a series of inter-

est payments plus the return of the bond's principal at maturity. In the case of agricultural research, the research costs represent the initial investment, and the benefits arising from the research represent the resulting series of returns.

Beyond the calculation procedures, however, the public nature of the research support and the specification of "social" returns are unique to public investment analysis and require careful understanding and interpretation. The social return to an investment includes not only the returns to the technology developer but also the returns to producers (i.e., farmers and agribusinesses), consumers, and other members of society. As an example, the social benefits of a new seed variety accrue partly to the firm that produces the seed but also to farmers, purchasers of the farm products, and consumers.



In contrast, private internal rates of return for commercial private or public research investment have a broader scope and are usually larger than the private returns to a firm. While the broad scope gives a more complete accounting of gains, it is important to avoid counting the same gains twice.

The procedures for estimating research payoffs involve many key issues. Included among these issues are the following:

• Benefits from research occur only several years after the research is conducted. Lengthy time periods are involved because research may initially take a long time to affect production, and then the results of the research can affect production for a long time. The classic example of agricultural production research is the development of hybrid seed corn in the United States. The time from the initiation of the research leading to successful hybridization techniques until the widespread adoption and use of hybrid corn in the United States was in excess of forty years.

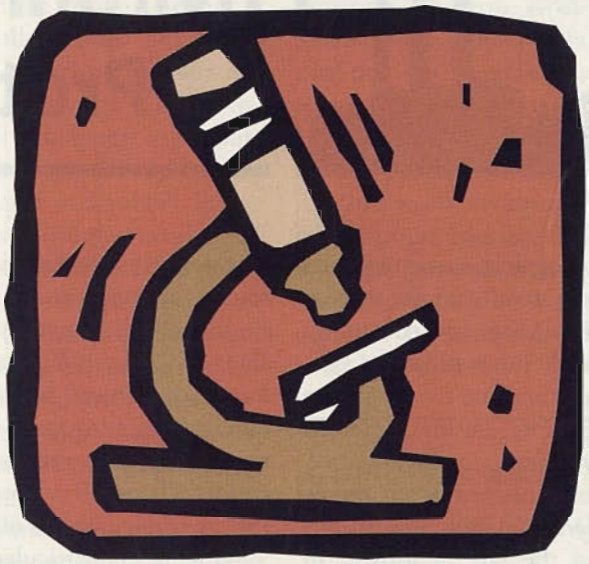
• Spillover effects are difficult to estimate. In measuring rates of return to research, it is difficult to account for research benefits and/or costs that spill into the United States (from other countries), out of the United States (to other countries), between states and regions of the U.S., between the agricultural and nonagricultural sectors, and those arising from private initiatives. Consider, for example, international crop improvement research funded in part by U.S. taxpayers through U.S. Agency for International Development (USAID) contributions to the Consultative Group on International Agricultural Research (CGIAR), a network of sixteen international research centers. This globally sponsored research has yielded new plant varieties adopted by American farms from California to the Great Plains and the Mississippi Delta region. From an overall investment of $134 million in wheat and rice improvement at research centers in Mexico and the Philippines, the U.S. economy has realized a return of up to $14.7 billion, reflecting benefit-to-cost ratios of 190 to 1 for wheat and 17 to 1 for rice (Pardey et al.).

• Some effects or "externalities" arising from research-induced technology often are difficult to identify and measure. In many instances, market prices may not fully reflect the benefits and costs of research. Examples include the nonpriced costs of environmental and resource degradation, the adjustment costs of labor and other inputs displaced by new technology, and adverse effects on human health, communities, and families. From a social perspective, farmers and agribusinesses have profit incentives to overinvest in technologies that result in negative environmental externalities, the costs of which are neither directly identified nor borne by the parties in question. For example, farmers' adoption of minimum tillage practices to reduce soil erosion may be accompanied by greater use of chemicals that create their own off-site costs. On the other hand, more intensive production practices may reduce the need to expand production onto new, environmentally fragile land. And, in fact, much agricultural research is aimed at mitigating environmental problems.

• New technology that increases productive capacity may increase surpluses and add to commodity program costs. Interrelationships between research policies and other agricultural policies warrant careful consideration in order to avoid conflicting effects. The decoupling of farmer production and marketing decisions from price and in-

come supports in the United States and the anticipated phase-out of government payments stipulated in the 1996 farm bill will reduce the domestic importance of these potential policy conflicts.

• Uncertainty and risks are associated with research outcomes. Research is a risky undertaking, with the high payoffs often concentrated in a few major breakthroughs. Evaluating the payoffs from selected or individual research projects will yield widely dispersed rates of return and introduce significant measurement problems. Focusing on the benefits and costs of aggregate research portfolios is a more realistic approach. The costs of public sector risk-bearing are also less than private risk-bearing costs because these costs are spread over numerous taxpayers and across diverse public sector investments. In addition, the benefits of research generally expand the realm of possibilities in the future and provide valuable elements of future flexibility for society.



• More emphasis is being given to *ex ante* measures. Most studies have considered rates of return on publicly supported agricultural research in the past. Extrapolating high past rates of return into the future assumes that the future provides opportunities generally similar to those of the past. In research planning and prioritization, greater emphasis is now being placed on estimating *ex ante* rates of return and research impacts. The forward-looking approach is consistent with the widespread application of capital budgeting and investment analysis procedures by private firms to new investment opportunities. *Ex ante* analysis is the primary use of these analytical techniques by private firms; it transfers naturally to *ex ante* analysis of public research investments.

The methods for evaluating research payoffs have been significantly refined over time. Generally, these refinements have yielded lower social rates of return. A 1996 study by Alston, Craig, and Pardey, for example, considered how more realistic specifications of time lags in research and development would affect output growth. Their revised estimates show annual rates of return in the 17 percent to 31 percent range for agricultural research.

Recent work at the Economic Research Service of USDA also re-evaluated the returns to agricultural research in light of potential biases attributed to questionable handling of the issues discussed above. This analysis considered the full economic cost of public expenditures, costs incurred by the private sector in technology development, and used conservative assumptions about the research lag. These factors reduced the estimated rate of return from 60 percent to 35 percent. In general, although these revised estimates are lower than previous estimates, they are still high relative to the government's costs of funds, the returns from alternative investments, and relative to private sector rates of return.

A neglected area in research evaluation is the contribution by social science research. Decision support and forecasting information, policy analyses, institutional innovations, and new organizational structures in agriculture contribute importantly to social welfare. Measuring these contributions of social science research, however, is difficult. The benefits often involve intangible, nonmarket goods with large spillover effects, including provision of information that serves to avoid adverse outcomes. Nonetheless, considerable headway is being made in developing appropriate measures of the benefits of social science research, and early indications are that the social rates of returns are high and comparable to those of technology-based research in the physical and biological sciences in agriculture.

In closing, we can conclude that the estimates of social rates of return to agricultural research now have high credibility and, with appropriate understanding, are meaningful to use in making decisions about future support for agricultural research. Moreover, the greater emphasis on *ex ante* measures of research payoffs is adding flexibility to the research evaluation process, and is contributing effectively to new strategic initiatives in research planning, prioritization, and accountability. ■

Peter J. Barry is chair of the C-FARE board of directors and professor of agricultural economics at the University of Illinois.