Why Scientists Should Talk To Economists—and Vice Versa

by John M. Antle and Robert J. Wagenet

Today the public demands that agricultural research be accountable not only in economic terms—that is, that economic benefits justify the costs of research investments—but also in terms of potential environmental and public health impacts. In the past, agricultural economists have been involved primarily in economic research assessments conducted *ex post,* or after the fact. But economists in collaboration with other scientists can also provide public research institutions with the tools they need to set research priorities consistent with public objectives, and to assess tradeoffs among economic, environmental, and health outcomes associated with agricultural technologies. Knowledge of these tradeoffs is necessary to evaluate research for social accountability.

Setting research priorities

Increasingly, the public's traditional concerns about food availability are being replaced with concerns about the quality and safety of food, and with the impact of food production on the environment. As a result, researchers face an increasingly complex task: to balance environment and health concerns while continuing to enhance productivity. The growing complexity of the task facing research institutions puts greater demands on their human and financial resources. These new demands make it all the more important for public research organizations to set priorities consistent with the public's needs and with the institution's personnel and resources.

We propose that publicly funded research institutions use a systematic, easily understood method in setting research priorities precisely because of the increasing responsibilities they face. The approach—illustrated in figure 1—is based on the economist's tools of benefit-cost analysis. In this figure, all of the relevant disciplinary sciences play a role in the decision-making process for setting research priorities and generating the data needed for evaluation of the economic, environmental, and public health impacts of research. We emphasize the need for collaboration across the full spectrum of biological, physical, and social sciences to address the impacts of agricultural technology.

A priority-setting process, beginning with input from public interest groups, policy makers and others, is the first step in formulating research objectives and research strategies to meet those objectives (figure 1). A research strategy is a research

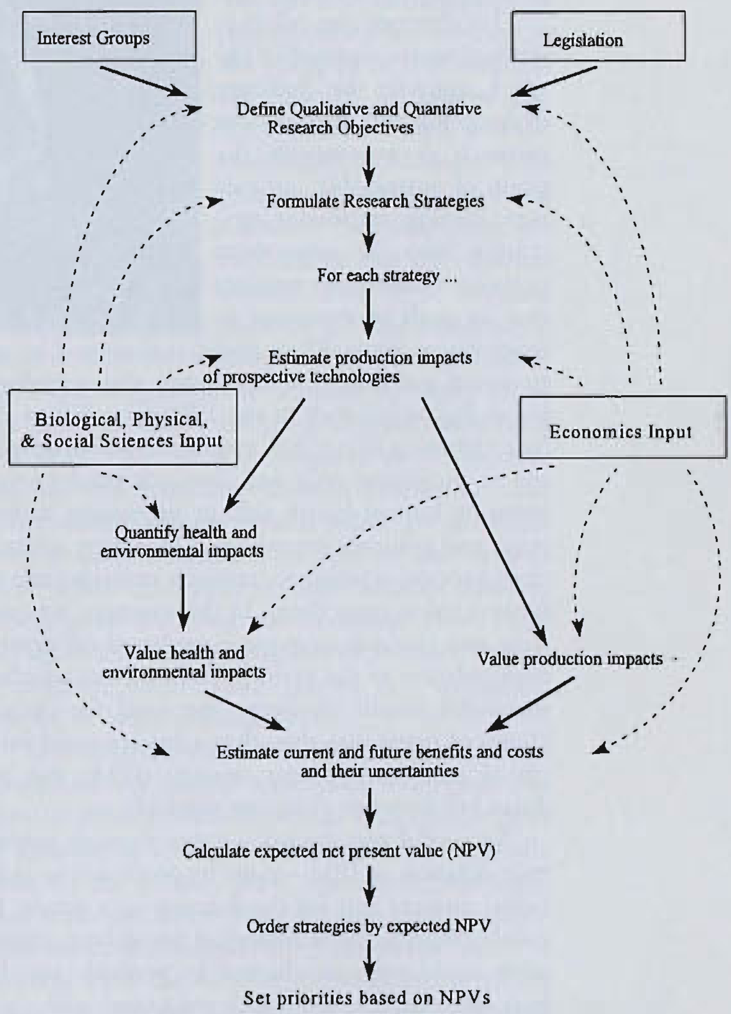
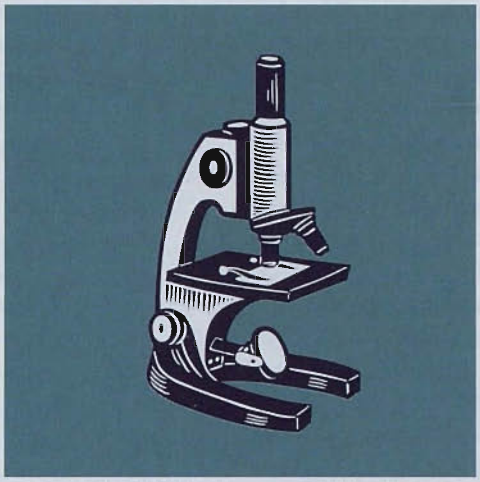


Figure 1. A multidisciplinary approach to setting research priorities

program or project, such as the pest management projects we discuss below, designed to achieve research objectives such as reducing the adverse effects of pesticide use. For each research strategy, the relevant disciplinary scientists collaborate with economists to quantify the production impacts of prospective technologies, then quantify the environmental and public health impacts of the technologies, value these impacts, and combine these findings in the form of net present values of each research strategy to aid in priority setting. We emphasize that essentially the same procedures, from quantification of production impacts through calculation of net present values, are followed in *ex post* assessment of research. The key difference is that at the priority-setting stage, prospective estimates of the impacts of technologies must be made, whereas in *ex post* assessments these impacts are quantified from observations of the current farming technology. The priority-setting job is greatly simplified once this process is followed because previously collected impact assessment data provide a foundation for subsequent priority-setting exercises.



To illustrate the priority-setting process outlined in figure 1, consider the challenge of designing pest management research to accomplish the goals of sustainable agriculture. Putting sustainable agriculture into the investment decision framework requires that its goals be expressed in quantitative terms. These goals, as expressed by agricultural and other interest groups and as embodied in legislation such as the 1990 farm bill or the Safe Drinking Water Act, might include maintaining or increasing crop and livestock productivity, reducing human health risk, or improving surface water and groundwater quality. Once these research objectives are established, research strategies can be formulated to meet them. In this example, we consider two research strategies: one based on genetic manipulation of the plant to resist a pest, which if successful would eliminate the need for certain classes of pesticides; the other a conventional integrated pest management strategy (IPM) that reduces but does not eliminate pesticide use.

Successful pest control—either through genetic manipulation or IPM—must be profitable to individual farmers and for the industry as a whole. In collaboration with the biological researchers, economists could estimate changes in pesticide use, labor, other inputs, and yields associated with each research strategy, as indicated in the central part of figure 1. The extent of adoption of the technology by the industry and its economic impact at the farm and industry level could then be estimated.

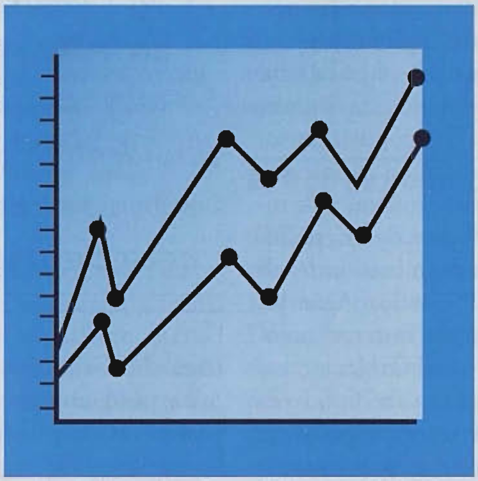
Based on production impacts of the technologies, biological researchers can also estimate the human health and environmental impacts of a change in pest management technology. Despite the public perception that integrated pest management techniques reduce or eliminate pesticide use, many IPM techniques use "economic thresholds," guidelines to trigger pesticide applications. These guidelines are based on criteria intended to efficiently control pest damage in relation to farm profitability and do not explicitly consider either environmental or human health impacts. The agricultural science community often assumes that only inefficient use of a technology causes environmental and health problems. While inefficient use may indeed be one source of health and environmental problems, it is also important to note that environmental and health effects of pesticides are "external costs" not counted in farm profitability. Consequently, even the use of pesticides according to an "economic threshold" can result in excessive off-farm environmental or health effects. These "external costs" are particularly important in setting research priorities because they are not borne by farmers, and the market does not provide an economic incentive for farmers to take corrective actions.

Teams of economists, occupational health specialists, and environmental scientists can assemble data on human toxicity of the pesticides, their transport, and fate in the environment. These data can be used to estimate changes in human health risk, water quality, and other key dimensions of health and the environment associated with the IPM technologies and the use of genetically engineered pest-resistant varieties. As indicated in figure 1, the economic, environmental, and health impacts need to be valued in comparable units of measurement—an issue we will discuss in more detail. Combining the data on the economic, health, and environmental benefits, and accounting for uncertainties in these estimates, the expected net present value (NPV) of each technology can be estimated and used to assess research priorities.

Institutional commitment and "paralysis by analysis"

Since the early 1980s, the executive branch of the federal government has required that new regulations undergo a regulatory impact assessment similar to the process described in figure 1. More recently, Congress passed the Government Performance Review Act that requires federal programs—including agricultural research—to document their performance. The international agricultural research system has also begun to systematize both its priority setting and impact assessments. However, these procedures have not generally been used to assess agricultural research priorities in the United States. Some state experiment station directors utilize multidisciplinary advisory committees for strategic planning and have begun to recognize broader impacts of research. Until recently, however, most state agricultural experiment stations and the U.S. Department of Agriculture have not used a formal priority-setting framework that explicitly accounts for food supply, environment, and health impacts of research.

Many factors may have delayed adoption of formal impact assessment methods. Many scientists and administrators believe it is too costly and time consuming to implement these methods with the data and expertise on hand. Public interest groups who are advocates of new government policies and programs argue that it would take years to compile data and rigorously analyze policy options. According to them, the problems are too urgent to risk "paralysis by analysis." The taxpaying public or a member of Congress making funding decisions might reasonably ask why institutions that generate considerable scientific data at public expense cannot utilize the data to assess the impact of their research. Indeed, data are the foundation of the scientific method. But unless researchers know what kinds of data are needed to conduct impact assessments, little substantive progress toward effective impact assessment will occur.



The solution to "paralysis by analysis" is not to abandon informed decision making; rather, the solution is to encourage scientists to collaborate with economists to provide timely assessments of their research. Assessments will take time and effort. Quantitative analyses of complex research options cannot be constructed on short notice. But assessments can be constructed in a timely manner, and at reasonable cost, if research institutions make the commitment to invest in the requisite data, methods, and expertise. The data needs of impact assessment must be communicated to researchers at the time they design research. When such data generation involves additional costs, institutional support must be provided.

Designing collaborative research

We fully believe that research can be designed to meet the standards of good science while also satisfying the standards of accountability and policy relevance. To meet these two objectives, the first step is to communicate to scientists how their research can contribute to the mission of publicly funded research by involving them in the priority-setting process described in figure 1. Researchers must then coordinate their research designs so that data and models can be integrated across disciplines as appropriate to support research planning and impact assessment. As users of disciplinary data for priority setting and impact assessment, economists need to communicate with scientists to ensure that data generated in disciplinary research are compatible with the needs of priority setting and impact assessment.

To illustrate, consider further the environmental benefits of reducing pesticide use through the development of pest-resistant plant varieties or the adoption of IPM. Following figure 1, we assume that the production impacts of the prospective technologies have been quantified by agricultural scientists. Soil and crop science tell us that the environmental benefits of reduced pesticide use vary according to climatic and soil conditions. The pesticide-reducing technologies will be adopted by many farms operating in widely differing climatic conditions and soils. Thus pesticide impacts vary across the physical and economic units in production. But policy makers and the general public are not interested in environmental conditions on one farmer's field; rather, they want to know whether environmental goals are being met generally. How, then, can agricultural scientists quantify the total impact of pesticide use on water quality in a watershed, aquifer, or larger political unit?

This question raises a basic issue in the design of research for impact assessment. Biological and physical science research, which underpin analysis of agricultural and environmental issues, typically focus on the cellular, plant, animal, or field scale. This scale is different than the one used to determine which technologies affect the public, and it is different than the scale of measurement at which public policies are directed. For example, federal policies to protect drinking water quality strive to ensure the water quality for recognized watersheds or aquifers.

To resolve this issue we propose a general principle for coordinating the design of multidisciplinary research: researchers from all concerned disciplines must agree upon a unit of analysis—defined in both spatial and temporal terms—useful in quantifying the impacts of production technologies. In the water quality example, soil scientists and economists can define a spatial unit of measurement, such as a farmer's field, with which both the economic and environmental impacts of the technologies can be reliably assessed. They also can define a temporal unit of analysis—such as a day, week, or month—over which activities such as input use and their impacts can be measured. The physical impacts in the population of farm fields can be described by probability distributions of solute leaching below the root zone and runoff into surface water. Economists can also estimate in probabilistic terms how farmers change pesticide use as they adopt the new technologies that reduce pesticide applications.

By combining these data for the physical and economic populations, it is possible to estimate the mean environmental impacts in the population, or to assess the probability that leaching or runoff will exceed a critical level. This environmental risk information can then be related directly to policy objectives, such as maximum contamination levels set by the U.S. Environmental Protection Agency.

Identifying the impacts of production technologies on human health and the environment takes us a significant step closer to making the link from science to policy. But in both research planning and impact assessment, it is rare that one research strategy or technology dominates all others in all relevant dimensions. One technology may be more productive but also riskier for human health than another. Thus, the alternative types of agricultural research imply tradeoffs among economic, environmental, and public health goals. Public acceptance of these tradeoffs is, of course, another matter. The scientific community has a long way to go in convincing the public that zero risk is unattainable and that tradeoffs are unavoidable.

The need for multidisciplinary collaboration in valuation research

Economics can help assign appropriate monetary values to physical measures of environmental quality and public health. The use of monetary values is appealing because environmental and health effects can be aggregated with the economic effects of agricultural technologies for priority setting and impact assessment. However, unlike economic effects, the monetary valuation of changes in environmental quality and human health usually cannot be measured directly because they are nonmarket goods. The valuation of nonmarket goods has been a major research objective in environmental economics over the past thirty years. An established, although still somewhat controversial, set of techniques now exists to obtain values for nonmarket goods that are comparable to those for market goods.

As with the priority-setting and design stages of research, valuation is another area for collaboration between economists and other scientists. To see why, consider the valuation of plant improvement research. One of the most successful cases of agricultural research was the development of hybrid corn. The classic 1957 study by Zvi Griliches estimated the returns to investment in hybrid corn research. Griliches used production data to estimate yield improvements associated with the improved varieties. Using economic concepts, he translated these yield improvements into economic benefits to both producers and consumers of corn. Finally, Griliches computed the present value of benefits to the present value of the costs of developing the improved varieties to obtain the net present value of the research effort.

The taxpaying public or a member of Congress making funding decisions might reasonably ask why institutions that generate considerable scientific data at public expense cannot utilize the data to assess the impact of their research.

We now know that the use of fertilizers and pesticides in U.S. corn production has caused contamination of surface water and groundwater. Agricultural scientists have developed an extensive array of methods for testing for water contamination at specific sites, and predicting water contamination under varying physical and climatic conditions. Yet, policy makers have not made full use of these scientific advances to better meet public goals for water quality.

To make better use of the knowledge available on water science, measured changes in water quality must be expressed in ways that affect peoples' well-being. Scientists think of water quality changes in terms of water chemistry, but people value groundwater or surface water quality in relation to their needs, such as for drinking or for recreational uses. Collaboration between water scientists and economists can develop the science and data needed to translate changes in water chemistry into terms that people associate with their uses of water, such as costs of water treatment or wastewater disposal. Other disciplines may help identify the consequences of changes in water quality, such as impacts on fish and wildlife populations, or human health impacts. With the critical link made between science and valuation, the appropriate valuation technique can be determined, the research conducted, and physical changes translated into monetary values to complete the evaluation process outlined in figure 1.

The economics of research on research

Since Griliches's seminal study of hybrid corn, economists have conducted numerous studies of the economic returns from investments in agricultural research. This literature generally concludes that public sector investments in agricultural research have yielded relatively high rates of return, typically higher than returns to private sector investment. But these studies fall short of satisfying the growing demand for agricultural research to account for its economic, environmental, and public health impacts.

Most studies of research impacts consider only the economic benefits of higher productivity from new technologies. The research evaluation literature has developed increasingly refined models and estimates of economic impacts, but has virtually ignored all other social, environmental, or health impacts. It appears that agricultural economics has suffered from its own disciplinary isolation and has failed to apply economic principles in designing its own research. Indeed, an "economically optimal" allocation of research effort would devote suitable effort to all potentially important impacts rather than ignoring environmental and health impacts while progressively refining economic measurements. Broadening the scope of impact assessments would greatly enhance their value as a tool to support informed decision making by the public.

Impact assessment is an essential part of doing research

We conclude by reiterating two messages. First, the only way to set priorities that are consistent with public goals, and to demonstrate that those goals are being met, is by making impact assessment an integral part of the public research enterprise. Scientists and economists must collaborate to define problems and identify appropriate research programs to address public goals and concerns. Second, economics is the discipline uniquely suited to integrate data and bridge the gap between science and policy. Economists in collaboration with other scientists can help society understand and evaluate the tradeoffs between economic, environmental, and health outcomes associated with the use of agricultural technologies. The growing demand for science to be accountable and relevant to policy means that economists have a valuable contribution to make to research priority setting, design, and evaluation of publicly funded research. ■

■ For more information

This article is based on a report commissioned by the American Agricultural Economics Association and the Economic Research Service of the U.S. Department of Agriculture entitled "Why Scientists Should Talk to Economists: The Role of Economics in Enhancing the Value of Publicly Funded Agricultural Research." The purpose of the report was to communicate to the agricultural science community the role of economic research in support of agricultural research. Copies are available from the AAEA Business Office, 1110 Buckeve Ave., Ames, IA 50010. The report was also published in the November/December 1995 issue of the *Agronomy Journal* under the title, "Why Scientists Should Talk to Economists."

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