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THE VALUE OF ECONOMIC RESEARCH

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Little is known about the impact of social science research in general, and food policy research, in particular. In order to expand the scope of available academic research and to develop quantitative methods for estimating the impact of IFPRI's work, several papers were commissioned from social scientists. Furthermore, IFPRI held an essay contest to solicit research from a broader range of scientists. The resulting papers were discussed at a two-day symposium organized by IFPRI in 1997. This Discussion Paper is a revised version of a paper prepared for and discussed at the symposium. Other papers will be published in this Discussion Paper series over the next months.

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ABSTRACT

Economic research generates a wide array of benefits. These include information, technological change, and improved policy. There are few quantitative studies of the benefits of economic research, and some benefits may be misattributed to biological and physical research. To be productive, economic research must be transmitted and the user must be able to use it. Therefore, investment in extension outreach and economic literacy are important to improve its impact. Even casual observation suggests that economic research is valuable, but noneconomists must be convinced of this. Since benefits are likely to be concentrated in a small number of successful projects, a useful approach to the assessment of the benefits of research is to identify these projects and their results.

The analysis must recognize that the accuracy of any estimates of benefits is uncertain. In addition, the argument behind the estimates should be transparent, relying on documentation and testimony from users, policymakers, and noneconomists. Assessments of the benefits of economic research provide information that can be used both to justify support for economic research and to allocate monies among lines of research.

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INTRODUCTION

Economists have recently provided intriguing and useful information on the value of public research in natural science and agriculture (for examples, see Huffman and Evenson 1989 and Alston and Pardey 1996). But less is known about the value of economic research in agriculture. This paper provides a perspective for the study of this topic.

It begins by placing the products of economic research in three groups—new economic information, products contributing to technological change, and products contributing to policy—each of which has its own users, impacts, and benefits. The argument is made that the effects of research depend on the transmission of results and the capacity of users to take advantage of them. Thus, the productivity of economic research depends on the quality of extension and economic literacy.

A quantitative framework is then developed for assessing the benefits of an economic research program and key issues associated with implementation. This is followed by a presentation of alternative approaches to reduce the effort required to assess the impact of research. One way to do this would be to concentrate on a small number of successful programs that capture most of the benefits. Because estimates of the effects of research are shrouded with uncertainty, methodologies to communicate the magnitude of this uncertainty are suggested. The attribution of benefits to specific projects is especially difficult, so it is important to develop sound documentation and testimony to link economic research projects to the effects that they are alleged to have. Some examples based on case studies illustrate how to overcome the more problematic issues in the empirical evaluation of economic research benefits.

Research on the productivity of social science research in agriculture is in its infancy, so the emphasis in this paper is not on providing exact formulas or rigorous procedures. Instead, the paper identifies the most problematic methodological aspects of the evaluation of economic benefits, and suggests how to address them. Economists may use estimates of the productivity of economic research to affect decisions made about the allocation of resources to agricultural economics. But this information should also be used to assess the productivity of various lines of research within agricultural economics and to allocate resources among them. The productivity of research in the field depends strongly on how the research results are distributed. Efficient strategies for developing research programs may need to be interrelated and to depend on investment in education and the dissemination of results. Finally, this paper highlights the problematic nature of having economists quantify the effects of their own research. That creates problems of moral hazard and credibility. It is not enough to convince economists of the value of economic research; the results of that research must be effectively communicated to noneconomists. Credible analyses of the impact of research must rely on independent sources and objective documentation as well as rigorous methodology.

CLASSIFYING THE EFFECTS OF ECONOMIC RESEARCH

Studies on the productivity of research have emphasized the effects it has through embodied innovations, that is, through new products. But research also leads to disembodied innovations, such as new practices and management strategies. Both embodied and disembodied innovations have the "public goods" properties and are likely to be underprovided by the private sector. Thus, research supported by the public sector should lead to new knowledge and information and produce disembodied innovations.

Some of the disembodied innovations produced by economic research are institutional innovations that provide new organizational structures to address social, economic, and environmental problems. Some are managerial and decisionmaking innovations that improve the choices made by firms, consumers, and the public sector. The outputs of economic research are diverse; to avoid omission and to develop the appropriate arsenal of tools to assess their benefits, it is useful to classify them. In Table 1, the outputs of economic research are divided into three classes and nine categories. The first class, economic information, includes prices and quantities, institutions and policies, and aggregate information. The second class includes three categories of outputs that contribute to technological change: innovations in production and management, product introduction and marketing methods, and management tools for research and development. The third class includes three categories that affect public policies: policy paradigms and institutional innovations, policy analysis tools, and assessments of the impact of research on policy.

This classification scheme shows the diversity of the results of economic research. It suggests that an effort to estimate those benefits correctly must be ambitious. As Table 1 demonstrates, the categories of research output vary both in who uses that output and in the type of benefits generated. Many categories may require the development of specific analytical tools to quantify their benefits. Several points provide insight into an evaluation of the benefits from the output of research.

First, few quantitative studies of benefits of economic research exist. The only category of outputs of economic research for which such estimates have been made is data on prices and quantities. The Data Task Force of the American Agricultural Economics Association documented some of the benefits associated with price estimates provided by the U.S. Department of Agriculture and argued that the value of these benefits significantly exceeded the cost of generating this information (American

Agricultural Economics Association 1996). It is important to develop and apply methodologies to assess the benefits from the other eight categories.

Second, some economic research benefits may be misattributed to biological and physical research in agriculture. There are two possible sources for such misattribution of benefits. Economic research has facilitated the adoption of many innovations by improving the means for identifying niches for new technologies and contributing to the design of effective strategies for marketing and education. In addition, economic research results have been internalized in technologies that are promoted by members of other disciplines. For example, nutritionists promote feed-rationing formulas that may have originated in the optimal diet studies of Stigler, and research on farm and agribusiness management has resulted in software and other decision tools that have been used by resource and production managers to increase the efficiency of land allocation and food distribution. These contributions have been attributed to other categories.

Economics is also a beneficiary of the results of research in other disciplines (mathematics, statistics, computers, sociology). This has to be recognized in any assessment of the contributions of economics. However, the presumption here is that agricultural economics has been a net exporter of methods.

Third, an assessment of research benefits is useful in determining research incentives and allocating resources within disciplines, including economics. The work of economists demystified the process of scientific discovery, showed that it is affected by incentives, and led to the introduction of more formal mechanisms for managing research (Binswanger and Ruttan 1978). There is a growing tendency among the organizations that sponsor research (CGIAR, BARD, NSF) to emphasize incentive-based programs, to target research areas with the highest return, and to evaluate research performance periodically using economic criteria.

Furthermore, it can be useful to assess the productivity of different lines of research within disciplines in order to improve research management. In particular, it is important to assess the comparative benefits of various research lines in economics and agricultural economics. We economists have to practice what we preach.

Fourth, rigorous economic modeling has led to many institutional innovations and policy paradigms. Economics is a young discipline, only about 300 years old. For much of its life, the aim of theoretical research was to refine and generalize the basic insights of Adam Smith (on the social desirability of free markets) and David Ricardo (on the gains from trade) using more advanced machinery. Indeed, Arrow and Debreu received the Nobel Prize for identifying conditions under which a competitive equilibrium exists and is socially optimal. But the added rigor and advanced machinery expanded the capabilities of economic research and led to a multitude of policy paradigms and institutions. For example, over the last 40 years formal economic analysis has advanced the notions of externalities, public good, market failure, incentive-compatible policies, trading in pollution permits, intellectual property rights, and so forth.

Fifth, assessments of the impact of research are preventive and corrective. They are generally routine exercises, but they can require original research on methodology or empirical estimation. Such assessments can be especially valuable if they lead to the selection of superior outcomes. The most important contribution of this research may be preventive: it screens wasteful proposals. For example, the use of formal cost-benefit analysis to assess water projects in the United States has led to a significant reduction in new water projects and has prevented many pork barrel projects (Zilberman, Griffin et al. 1994). Assessment research can also identify the unintended consequences of proposed policies, and this may lead to changes in policy. Finally, it provides extra benefits by introducing alternatives for policy that would not have been considered. For example, Sunding and his colleagues were asked to evaluate the cost of transferring water away from California agriculture to the environment. They recognized that the cost depended on whether it was permissible to trade in water. That helped to establish water trading as a key ingredient of water reform.

Sixth, timing is everything. Implementation may lag behind economic research and the publication of its results. As Rausser and Zusman (1991) suggest, the timing of policy reforms may depend on random events. In particular, policies and institutions may be changed during and after periods of crisis. A body of economic research that could provide an intellectual foundation for new institutions and arrangements might have no observable impact until after a crisis. The major reforms in California's water law after the 1987–92 drought were based on concepts and ideas that had long been promoted by economists (Zilberman, Sunding et al. 1994).

Seventh, there is a difference between recommending a policy and implementing it. The benefits of economic research may not be fully realized because a policymaker either may act against the advice of economists or ignore it. Even if policymakers do not act in accord with the recommendations of economists, they may claim that they follow economists' advice or behave according to an economic principle out of a concern for public relations. In some political situations, the results of potentially valuable policy research may be wasted.

Eighth, economists make mistakes. Incorporating the recommendations of economic research into policy does not necessarily ensure that the policy will succeed or that human well-being will improve. Economists have a track record of giving wrong advice. After all, many consider Marx to be an economist. Based on what at the time were considered sound economic principles, South American economists followed development strategies that emphasized import substitution and led them nowhere (Prebish 1950). In other cases, ignoring or even acting against the recommendations of economists have produced successful outcomes. These cases cannot be ignored in an assessment of the value of economic research. Economists must attempt to identify those situations where economic research has failed so that they can learn from these failures.

TRANSMITTING THE RESULTS OF ECONOMIC RESEARCH

The value of economic research that provides new knowledge to economic agents in either the private or public sectors has to be based on the transmission and interpretation of the research results to final users and the capacity of users to use that information. The availability and accessibility of research results to potential users depend on the effort made to transmit the information through extension and the communications media (including books for popular consumption, radio, television, and the printed press).

Suppose research results have N identical potential users. Assume that the gains users receive from research depend on the amount of the research, the extension effort, and the education of the user. Let H be the amount of research (measured by research expenditure), and let X denote expenditures on the transmission of information through extension (and other means, which will not be described in order to simplify the discussion). Let the education of the user be denoted by D. It is reasonable to assume that, in most cases, the more education users have, the more they benefit from the given information. If G denotes the gain for an individual receiving research results, it can be presented as $G = g(D, H, X)$, where g is the functional relationship between the gains from research, research and extension expenditures, and user education. The percentage of the population that receives the results of research is denoted by P, and it is a function of expenditures on extension, $P = p(X)$, where p is the functional relationship between the percentage of the population that receives research information and extension expenditures.

The gross benefit from research in this simple model is denoted by GB, and is

$$GB = N \text{ x } P \text{ x } G = N \text{ x } g(D, H, X) \text{ x } p(X). \tag{1}$$

Equation (1) suggests that society's gains from research increase as the number of potential users of the information expands, the information transmission system becomes more effective, and potential users become more educated and better able to use the information. The formulation in equation (1) implies that the information generated by economic research is a public good that can be used by many individuals simultaneously. This assumption is valid in many situations and suggests that the benefits of economic research depend on the size of the affected industry or economy. The same research effort, *ceteris paribus,* may generate a greater benefit if it addresses problems of the United States as a whole rather than just one state.

The net benefits from research, *NB*, is equal to gross benefits minus the cost of research and extension:

$$NB = N \text{ x } g(D, H, X) \text{ x } p(X) - R - X. \qquad (2)$$

Expenditures on research and extension (and, within a wider context, education) are public policy choices. Strategies that maximize benefits from research and extension allocate resources so that the marginal benefit of research is equal to the marginal benefit of extension. Thus, there are situations in which investments in extension and education are essential if society is to gain from research. In other words, the returns to research are likely to be meager if there are no effective mechanisms for transmitting results to the final users or if these users do not have the education to take advantage of the information generated. Thus, when a research program is established that generates economic information, it should have effective mechanisms for disseminating its results and for producing results that are useful to its designated clientele.

Equation (2) also emphasizes the importance of economic literacy. When the potential users of economic research have strong backgrounds in economics, they can use more powerful and refined economic concepts, which may improve the quality of the results. Analysis of the optimal allocation of resources between research and extension further suggests that increased economic literacy is likely to reduce the need for extension and interpretation. Thus, improved economic literacy increases the net benefits from research by both increasing the gross benefits from research and reducing the cost of extension. In spite of the importance of basic economic concepts in everyday life (such as discounting, trade-offs, and efficiency), most people do not get a decent economic education in their primary and secondary schooling. The lack of economic literacy may be the biggest obstacle to the productivity of economic research. Furthermore, most economics courses in universities are designed to produce economists rather than to provide individuals with a basic knowledge of economics. Economists are challenged to develop academic programs that will appeal to individuals in other disciplines.

Equations (1) and (2) emphasize the links among the creation, transmission, and use of information and illustrate the interdependency among research, education, and extension. But the model fails to capture the complexities that affect the productivity of research. Individuals and organizations are heterogeneous, and even within one sector economic agents vary drastically in the potential they have to gain from information, their access to it, and their capacity to use it. Given the heterogeneity in economic literacy in the population at large and among policymakers, it may be worthwhile to use several mechanisms to communicate the results of the same research. To obtain the optimal impact, not only the effort to transmit research, but the formulation of research and the type of answer it provides should be adjusted to the capabilities and needs of the users. The message must be tailored to the client, not the messenger. Thus, broad and sophisticated research efforts may need to be sacrificed if the main objective is to maximize the immediate contribution of research to a real-world situation.

Economic agents use many types of economic information that they obtain from many sources. To assess the benefit of a specific research program, one has to consider it in that context. There are likely to be several providers of economic information, and the products of economic research may be either complements or substitutes. There are externalities between research projects, and the results of one may borrow from the processes and outcome of another. Thus, it may be difficult to pinpoint the impact of a particular research project. In some cases, it would be advisable to assess the benefits of lines of research that may consist of several interdependent studies rather than to attempt to estimate the benefits of each individual research project.

When several projects address the same problem independently, the one with the most significant impact might not be the one with the highest quality results. Instead, it may have the better program for outreach and transmission. The selection of channels for transmitting results depends on the potential users of information, their skills and backgrounds, and specific technological and institutional circumstances. There are several major mechanisms through which research results can be transmitted to final users:

Print Media: This includes books and magazines for the general reader, scholars, or professionals and practitioners.

Electronic Media: These are radio, television, and the Internet. These media tend to be updated frequently. They may even be interactive.

Education: This includes basic as well as college education, and professional degrees and training.

Extension: This consists of tailor-made outreach programs such as demonstrations and short courses that are targeted and specific. In many cases, extension can include participation in the use of economic information.

Consulting: Consultants are paid to conduct research and give advice on its implementation.

Table 2 shows how the classes of economic research results described in Table 1 can be transmitted to final users. Table 2 presents hypotheses that need to be tested empirically, but it can be used as an instrument to think about the problem. Several points about transmitting the results of research that the table suggests should be emphasized.

First, the effectiveness of the channels of communication in transmitting research results varies by category. Formal economic education, for example, is probably most effective in communicating new policy paradigms and institutional innovations. In the printed media, books and magazines can effectively convey information about new policy paradigms, while technical and statistical bulletins are a major channel for communicating information on prices. The electronic media are becoming a major tool for transferring information on prices and quantities. They may become an important means for disseminating policy impact studies.

Second, economists can popularize economic concepts and paradigms in the print media. Milton Friedman's articles in *Newsweek* have done an excellent job of educating the public about the ideas of Adam Smith and David Ricardo. Bestsellers written by distinguished economists such as John Kenneth Galbraith and Paul Krugman have familiarized policymakers with economic thinking. Increased economic literacy will improve the effectiveness of economic research, but effective popular communication by economists can achieve the same end.

Third, the economics profession should encourage a wide array of publications addressing economic issues with different degrees of sophistication. It is most prestigious to publish in technical journals that are accessible only to the most highly trained economists. But to have optimal impact, the results of economic research should be published in less technical and more policy-oriented journals that are accessible to economists in industry and even to educated laymen. *Choices* and the *Journal of Economic Perspectives* fill an important gap, and the introduction of other outlets that appeal to a broader audience will increase the productivity of economic research.

Fourth, the policymaking process determines the best way of communicating the results of policy impact studies. If decisions are made through popular ballots (the proposition to ban chemicals in California, for example), then the electronic media become important. If policy decisions are made in a legislature, where a modest number of decisionmakers interact, then in-depth reporting through print media may become more important. When there is a single decisionmaker, then a consultant may be the most effective way to transmit knowledge.

Fifth, there are both wholesalers and retailers of knowledge and information. Universities and organizations like the Economic Research Service of the U.S. Department of Agriculture (USDA) can generally be viewed as wholesalers of information, as they address a wide variety of topics from many perspectives. Organizations like consulting firms and specialized newspapers are information retailers; they sort and modify the results generated by wholesalers to fit the needs of specific clients, who are often individual decisionmakers with particular needs, willing to pay for a tailor-made product.

Sixth, the earnings of information retailers capture benefits that actually belong to the wholesalers. Since retailers rely on the information produced by wholesalers and in many cases pay too little for it because such information is a public good, their net earnings capture the benefits of publicly funded research. Thus, one indicator of the value of economic research is implicit in the income of economic consulting firms (American Agricultural Economics Association 1996). Further research should be devoted to developing a mechanism to quantify this relationship.

Seventh, consulting provides public benefits. Consulting work can increase the productivity of economic researchers, both because it is an effective way to transmit knowledge and because it can add an element of realism to economic research.

QUANTIFYING THE BENEFITS OF AN ECONOMIC RESEARCH PROGRAM

As economics has penetrated to the everyday life of research funding organizations, there has come to be a growing need to develop quantitative estimates of the benefits of agricultural economic research, especially research that is policy-related. This section develops a simple formula for quantifying the benefits of research and discusses how to address some of the thorny issues in applying it.

Policy generally affects economic systems by influencing a key variable or parameter (such as demand, supply, or the equilibrium of the market). Methodologies to assess the impact of policy change are well-documented elsewhere and so will not be presented here.[1] The emphasis here will be on issues associated with evaluating a research program comprising many projects that may affect several policies over a long period of time. There are uncertainties about policy choices in general and the exact contribution of economic research to any change in policy in particular. The analysis and discussion below address these problems of dimensionality and uncertainty.

Assume that the research program of a group—be it USDA, IFPRI, or a department in a university—consists of N identifiable research projects. Let i be an indicator of research projects that can assume values from 1 to N. This program is assumed to affect M policy issues. Let j be the indicator of policy problems, so that j assumes a value from 1 to M. The research project affects a decision about policy by generating information and knowledge that contribute to the selection of the policy chosen over other options. Suppose that in the case of a particular policy, j, the number of policy options considered is $K_j + 1$. For a particular policy problem, j, let k assume values from 0 to K_j, where $k = 0$ for the option chosen. It assumes values from 1 to K_j for the other policies considered in addressing policy problem j.

It is unclear which policy option should be adopted to address policy issue j in the absence of the chosen policy ($k = 0$). Since a policy is likely to last for several years, let P_{kjt} denote the probability that policy option $k > 0$ would have been implemented to address problem j if the option $k = 0$ was not available. Let the difference of social welfare resulting from the use of policy option 0 instead of k at year t be denoted by)*Bkjt*. This difference in welfare is the aggregated change in the economic surplus associated with switching from policy option k to 0 at period t.

Let the year 0 be the benchmark period for discounting benefits. In most cases, this will be when the evaluation is being conducted. The assessment of the benefits of research may be restricted only to those benefits that could be seen ex post, partly as a result of the policy research program. In this case the time horizon for an assessment of benefits will be from $t = \quad T_p$ to $t = 0$ (T_p denotes the number of past years considered in the analysis). However, the life of the policy option does not end with the assessment of benefits. Thus, it also is useful to consider the future benefits (ex ante) of selecting a policy option. In this case, the time horizon for the assessment may be from $t = T_p$ to $t = T_f$ (T_f denotes the number of future years of the analysis). One major difference between assessing benefits from the selection of a research option ex post and ex ante is that policy option 0 was chosen precisely to address policy problem j. Thus,

$$\sum_{k=1}^{K_j} P_{kjt} = 1 \text{ for } t \leq 0 \text{ and } \sum_{k=1}^{K_j} P_{kjt} = 1 \text{ for } t > 0.$$

The probability that policy 0 will not be chosen in the future is

$$1 - \sum_{k=1}^{K_j} P_{njt} \text{ for } t > 0.$$

Let G_j denote the expected discounted net benefit of selecting policy option $k = 0$ to address policy issue j. Then

$$G_j = \sum_{t=-T_p}^{T_f} \left(\frac{1}{1 + r} \right)^t \sum_{k=1}^{K} \Delta B_{kjt} P_{kjt} \ .$$

It is unreasonable to attribute the selection and enactment of a policy option entirely to a research project. Economists may conduct brilliant research and communicate it effectively to policymakers, yet other players in the political system may influence the selection of a recommended policy. Let $0 \leq S_{ij} < 1$ be the independent share of project *i* in the solution to policy problem *j*.[2] The economic benefits attributed to project *i* will then be

$$\sum_{k=1}^{N} S_{ij} G_{ij}.$$

These are the expected net benefits of the project to all the policies it influences. The net economics of the research program are

$$\sum_{j=1}^{M} \sum_{i=1}^{N} S_{ij} G_{ij}.$$

The formula for the net benefits of a research program seems straightforward, but obtaining actual estimates is an empirical challenge, for several reasons. Some of these obstacles and suggestions to overcome them are presented below. They include the dimensions of the research program, uncertainties about the economic impact of individual projects, and difficulties in crediting the benefits of research.

DIMENSIONALITY

The number of projects (*N*) in a research program may be in the tens or even hundreds, and the number of policies it affects (*M*) may be in the tens or hundreds as well. These effects may occur in several countries over different time periods. Therefore, quantitative estimates of G_{ij}, the economic impact of one project on one policy, may be both time consuming and prohibitively expensive.

Fortunately, studies on the distribution of benefits and the effects of research programs suggest that these distributions are skewed. A small number of projects may account for most of the effects of a research program. Parker, Zilberman, and Castillo (1998) found that out of several hundred royalty-generating research projects at the University of California, the top two generated 70 percent of the technology transferred in 1994. This suggests that an assessment of the economic impact of a research program should concentrate on identifying the most effective research projects and assessing their benefits. The aggregate benefit of these projects provides a lower bound for the benefits of the program. Thus, let $*_{ij}$ be an indicator when $*_{ij} = 1$, if the effect of a project on policy issue *j* is assessed, and 0 otherwise. A lower bound on the net expected benefits of a research program is

$$\sum_{j=1}^{M} \sum_{n=1}^{N} \delta_{ij} G_{ij} S_{ij}$$

A "cherry picking" approach to estimating research benefits is to identify a small number of projects and policies that a priori seem to have the highest $G_{ij}S_{ij}$ and estimate only their benefits. Three possible approaches to identifying productive research projects are presented here.

The first is to screen projects sequentially based on their assessed productivity. This procedure was applied by Just et al. in their study on the economic benefits of the United States-Israel Binational Agricultural Research and Development Fund (BARD) for the United States (Just et al. 1988). This binational fund supported 208 projects at the time of the review. Just and his colleagues used a two-step procedure to obtain a lower-bound estimate of the economic benefits of the fund. First, they asked fund directors and senior staff to identify the projects with commercial potential. They identified 55. Then research proposals and final reports from each project were reviewed. The principal investigators were asked to provide basic information about the economic impact of innovations resulting from their research (which crops were affected and where, estimated yield increases, cost reductions per acre, and so forth) and the names of those who had adopted or were likely to adopt the innovations. This screening identified projects with the highest potential for generating benefits. The expected discounted economic benefits of these projects were estimated to have a value of $521 million, much more than the $90 million the fund distributed at the time of the review. The distribution of benefits was highly skewed even among the top 10 projects: the top two provided 60 percent of the expected benefits.

A second approach is to have individual researchers select a subset of successful projects. A research team would then screen these projects to identify the most productive. Their benefits would then be quantified. This procedure was used by Goldman, Shah, and Zilberman (1990) and McWilliams and Zilberman (1996) to evaluate the productivity of extension in two California counties. They asked the project leaders (farm advisers) to provide basic information on two of their projects with the greatest economic impact. This information included descriptions of the projects and their results, quantitative information on regions and populations that would benefit from the discovery, quantitative estimates of per-unit benefits (per acre, animal), and the names of individuals who could verify these claims. After the initial screening, the research team for each study identified less than 10 projects with significant economic effects, and they quantified the benefits from these.

A third approach would be to make the initial selection based on the volume of service use. Where the amount of time allotted to each project or number of contacts with each client is documented, projects that require the most effort or service can be selected to have their benefits quantified further. This approach can be useful in assessing projects that generate economic information and predictions, as Parker et al. (1996) demonstrated in their study of the benefits of the California Irrigation Management Information System (CIMIS). The CIMIS directors provided a list of extensive users, and the research team interviewed these users to assess both the reductions in costs and the increases in revenue from the weather information provided by the system. Parker et al. estimated that the annual benefits to the subset of interviewed users were up to 26 times higher than the annual costs of running the CIMIS program. Furthermore, they discovered that the system generated unexpected benefits. CIMIS was designed to provide information to help farmers make decisions about irrigation, but some of the biggest users also used this information to make choices about pesticides, manage golf courses, and manage the water supply in urban areas.

A key feature these three approaches share is the collection of evidence from users of the system. Estimates of benefits provided by project leaders should be used only for the initial screening of projects and when corroborated by testimony from users or objective experts. In some cases more than seven people were contacted to assess the benefit of a particular project. One common finding is that researchers were often unaware of the effects of their research. By relying on networks of informants, program assessors will get evaluations that are more complete and consistent.

These three selection procedures underscore how important it is to document research projects, their benefits, and their users. The cost, speed, and accuracy of research evaluation are significantly improved if documentation procedures are established and followed as part of the research effort. Outreach programs can make it possible to document the benefits from research projects after the research has been completed.

UNCERTAINTY ABOUT THE ECONOMIC IMPACT OF INDIVIDUAL PROJECTS

The net benefit of a research program is a weighted sum of the expected net benefits of the individual research projects that make it up. These expected net benefits are not known with certainty. They have to be estimated, and the accuracy of their estimators is highly uncertain. The credibility of the assessment of a research program's expected net benefits is likely to increase if the analysis provides some measurement of the randomness of the G_{ij}'s estimates. In other words, it may be more useful to provide a confidence interval than a point estimate of the economic benefit. This approach was used to assess a proposed ban of pesticides in California.

In 1989, Californians voted on a proposition (Big Green) to ban the use of most chemical pesticides in the state. The results of research by agricultural economists from Berkeley were used in portraying the proposition in a bad light, which may have contributed to its defeat. Zilberman et al. (1991) assessed the economic impact of the proposition on five major California crops—almonds, grapes, lettuce, oranges, and strawberries. Several groups of scientists estimated the proposition's impact on the yield and output of different crops. Zilberman et al. (1991) used these numbers to estimate each crop's shift in supply as a result of the proposition. They found that the estimates of the demand and supply elasticities of the five commodities varied widely. They simulated the outcome of the proposition and several hundred likely scenarios. Had the proposition passed, the annual expected reduction in the consumer and producer surpluses of the five commodities was estimated to have been about $509 million. There was a 5 percent probability that the loss in consumer and producer surplus in the five markets would have been greater than $1,750,000,000 and a 5 percent probability that the losses in the surpluses would have been smaller than $390,000,000. The variability of the estimates on the impact for each of the crops was significant. This demonstrates the value of providing more than one number to represent the estimated impact of a policy change.

Sunding and his colleagues (1997) used a different approach to present the uncertainty of estimates of the effects of policies. Because modelers often disagree about the exact specifications of an economic system, they used three different models to assess the effects of reducing the supply of water to California agriculture. These reductions were associated with versions of the Central Valley Improvement Act of 1992 and water quality regulations for the San Francisco Bay and Delta. One of the three models was a large and detailed quadratic programming model of the water system in the San Joaquin Valley. Another assumed putty-clay technology (where input-output coefficients are fixed in the short run [clay] but may vary in the long run [putty]) and allowed little substitution between crops in adjusting to reductions in the water supply. This model was especially appropriate for assessing short-term income. A third model was less intensive but allowed more flexibility in adopting technology and in using ground water in response to water supply cuts. In most cases the putty-clay model provided a higher estimate of the reduction in water supply costs than the other two models. Overall, however, the results were consistent. For example, all the models indicated that the cost of aggregate cuts in the water supply depended on how the cuts were made rather than on their exact volume. So if the cost of supply reductions were shared only among a small group of growers who had junior rights to water, the cost of implementation might be two or three times higher than if the costs were shared among a major group of growers (for example, all the contractors in the Central Valley Project). Providing several estimates of economic effects based on different but plausible models is particularly useful in an ex ante impact assessment where final outcomes depend on contingencies likely to be determined or observed in the future. This holds true as well for estimates of the effects of economic research, where economists combat credibility issues when testifying about the value of their own product.

THE ATTRIBUTION OF BENEFITS TO ECONOMIC RESEARCH

The issue of credibility is especially important when S_{ij}, the coefficient of benefits attributed to economic research, is determined. In many cases economic research is essential in the policymaking process, but the final outcome depends on other actors in the system. Difficulties in determining how the credit for benefits should be shared is not unique to economic research. For example, it is a crucial element in the debate over how to share the profits of a new technology or how to establish royalty rights for that technology. The working hypothesis for technology transfer negotiations at the University of California is that the net surplus generated by innovations should be distributed equally among innovators, developers, marketers, and producers (Parker, Zilberman, and Castillo 1998). Of course, the share of each contributor is adjusted as part of the negotiation. Universities, for example, will demand higher royalties for the right to use university-patented innovations that are further along in their development. A similar logic should apply in establishing coefficients that attribute benefits to economic research.

Developing quantitative theories and tools to determine the shares of contributors in the establishment of a particular policy is an important challenge faced by political economists and applied political scientists. Unfortunately, “guesstimates” and ad hoc rules are often used to determine these shares. Because economists face an apparent conflict of interest in determining the value of economic research, it is essential to obtain testimony and evidence from noneconomists about the contributions of their research to policymaking. This may be done through interviews, media coverage, and so forth. To be credible, it is important to use a conservative number. Interviews with individuals involved in policymaking may provide one set of numbers for the contributions of economic research to policy. It would be useful to ask a sample of decisionmakers to rate (on a scale from 0 to 10) how economic research (or, if possible, even research provided by specific projects) contributes to a particular outcome of policy. Obtaining such numbers is desirable but not always feasible, and alternative approaches may have to be pursued.

As argued earlier, new policies may be viewed in the same way as technological innovations. Credit for their establishment should be divided among conceptual and applied economic programs and the political players that contributed to this process. For example, applied researchers, extension specialists, and communicators might describe the basic idea to policymakers and shape it to fit the particular circumstances. Politicians and other actors in the political arena might then vote or lobby for policies and take the credit or blame for their choices. Borrowing from offices that engage in technology transfer, a generic approach for attributing the credit for policy innovations would assign 25 percent credit to the economic research that identifies the policy and provides the basic idea. Economists would get some of the 25 percent credit for “development,” while the actors in the political process would get 50 percent for “marketing and production.” This formulation is obviously only a starting point. Because the circumstances that lead to new policies vary significantly, as do the roles of economists and policymakers, the share of the benefits assigned to economic research should also vary. This may be best illustrated by some examples based on the authors’ experience.

Big Green

Both proponents and opponents of this ballot proposition campaigned actively for it. Economists at the University of California became involved and may have affected the final outcome. Agricultural economists in Berkeley held a conference and wrote a report stating that the proposition was flawed because pesticides provide benefits, and some use could be justified because the benefits exceeded the costs. A number of politicians pressed university administrators to suppress this report and punish the scientists. The media picked up the story, and articles about the research made the front page of some major newspapers.[3] Based on this report, the opponents of Big Green adopted the argument that the proposition was bad for economic reasons. The public, which had favored the proposition in earlier polls, rejected it by a two-to-one margin. The proposition might have passed had it not been for the involvement of University of California researchers. To assess the benefits from this use of economic research, conservative assumptions should be adopted. The first is to attribute only 5 percent of the benefits to economic research rather than 25 percent. The second assumption would be to calculate the benefits of the use of pesticides on only the 5 crops mentioned earlier, out of more than 100 on which pesticides are used. This figure is conservatively estimated to be $300 million annually. If 5 percent of that figure can be attributed to the economic research benefits, the net benefit would be $15 million. This is greater than the expenditures on agricultural economists in the University of California.

Water Banks

Water in California and other western states has been allocated by water rights regimes that queue water users and their rights to water. This allows water trading, but it is not a water market system. For 40 years a large body of literature in economics and agricultural economics has advocated specific proposals to transform this system into a market-oriented one. For years economists testified at regulatory agency hearings in favor of this transition, but nothing changed until 1991. California was then in its fifth year of drought, and officials at the Department of Water Resources created a water bank.

The water bank bought the rights for water at $125 per acre-foot. This water was moved to the Delta, and farmers south of the Delta were able to buy it for $175 per acre-foot from the water bank. This mechanism facilitated trade between water-rich farmers in the north and water-starved farmers in the south. Some water was left to revitalize the ecosystem of the San Francisco Bay and Delta. A quantitative assessment of the 1992 benefits from this water bank, estimated to be $60 million, is presented in the appendix.

It seems reasonable to attribute 25 percent of the credit for the water bank to research in agricultural economics. Economists have argued in favor of water markets for years, in both professional journals and the popular press. Some senior decisionmakers in the Department of Water Resources are educated in economics and were familiar with the argument in favor of water markets. Economists and staff members in the university and the Water Resources Department have maintained constant contact. While it is difficult to identify the specific research projects that may have contributed to the establishment of the water bank, the long history of advocacy of the water bank system by economists justifies a 25 percent share of the $60 million benefit. This $15 million represents a significant benefit from economic research.

Other Water Stories

In recent years economists have been important in fostering a number of changes in water policy. Examining a few of these cases highlights the difficulties associated with quantifying the contributions of economists to the policy process.

During 1992 the U.S. Congress held a debate about the volume of water that could be diverted for environmental purposes from federal water projects in California. One of these proposals, the defeated Johnston Bill, called for diversion of 2.5 million acre-feet from the 8.0 million acre-feet of the Central Valley Project. The results of agricultural economic research were used to help defeat this bill and support the Bradley-Miller Bill that required that only 800,000 acre-feet to be diverted. Had the Johnston Bill passed, it could have increased the costs to society by $100 million (Zilberman, Sunding et al. 1994). But it seems unrealistic to assign any benefit to the economic research that helped to defeat this bill. Even if Congress had passed it, the President would have vetoed it. The important contribution of economic research to the Bradley-Miller Bill was that, in addition to the diversion of water to environmental purposes, it made it possible to trade in water. Even though this legislation passed in 1992, it is in the early stages of implementation and the direct benefits are thus far difficult to trace.

Economists have helped to establish institutions for trading water in California. For example, Olmstead and colleagues (1997) found an electronic water market in the Westlands water district had increased annual water trading by 150,000 acre-feet above recorded historical patterns. This water market was established as a cooperative effort between the water district, the university, environmental groups, and the Bureau of Reclamation, and it is expanding to include other water districts. Since environmentalists are involved in the project, their political objections to the construction of conveyance facilities for interregional trading may well be reduced. It is likely that there will be large-scale trade in water in the Central Valley within 5 to 10 years. Such trade will reform the California water system. Shah and Zilberman (1994) ran simulations that showed that up to 25 percent of available water could be saved if the state made the transition from water rights to water markets. However, this estimate does not include the cost of making the transition to the new system, adopting technology, and so forth. Even using a conservative estimate, and assuming a 5 percent savings of surface water, the annual savings would be about 1.6 million acre-feet. Conservatively valuing each acre-foot at $60, the annual benefit from water markets would be about $100 million. At present, the benefit from the water market operating in Westlands and other marketing arrangements can be estimated to be between $2 to $10 million (see the third annual report to the National Heritage Institute 1997). It may well reach $100 million over the next 10 years.

In this case, economists are entitled to at least 25 percent of the credit (they researched the problem, designed market mechanisms, communicated the results to policymakers, and even contributed to implementation). The present annual benefits from economic research in this area are between $0.4 million and $2.5 million, but future benefits may reach $25 million. But it is almost impossible to assign probabilities to the likelihood of creating a water trading system. Another drought may accelerate the process, while several wet years will delay it. However, it is clear that the return to the effort of the handful of agricultural economists who have studied water resource problems has been substantial.

PRESENTATION AND DOCUMENTATION

Any analysis of the benefits of economic research is aimed at a particular audience. This dictates how the results should be presented. In most cases, benefits are assessed in order to justify support for economic research. The matter of presentation will be addressed here in this context.

First, one has to know the audience. For example, individuals who fund economic research may be economically illiterate. It may be appropriate to educate decisionmakers about what economists are doing: what types of questions they ask, what methods they use, and what results they provide. There are many social and biological scientists who still consider economics to be a glorified form of accounting. It is important to understand that the story behind the numbers may be as important as the numbers themselves.

Second, decisionmakers may have their own perspectives. Some may hold the view that economic research is a tool to enhance inequality and to support the rich. Others may wish to consider only its implications for government spending and unemployment. While many policymakers view economic research as an investment that provides a satisfactory rate of return, there are others who are interested in how it affects particular constituencies. It is important to provide such information.

Third, there is the problem of circularity. An old Hebrew adage says the baker should not testify about his bread. In assessing the benefits of economic research, noneconomists will pay less attention to the analysis and more attention to the credibility of the evidence. Therefore, documentation is important. To supplement a quantitative analysis, an appendix with supporting statements from people who have benefitted can be effective in establishing credibility. Media can be useful as well. For example, tape recordings or the video testimony of a satisfied client of economic research may provide the credibility that the numbers, often generated by economists about economists, lack.

CONCLUSION

Economic research generates a wide array of benefits, including information, technological change, and improved policy. There are few quantitative studies of the benefits of economic research, and some benefits may be misattributed to biological and physical research. The productivity of economic research is determined largely by its transmission and the ability of users to use it. Therefore, investment in extension outreach and economic literacy are important means of increasing the impact of research.

Even casual observation suggests that economic research is valuable, but noneconomists must be convinced of this. Since most benefits are likely to be concentrated in a small number of successful projects, a useful approach to an assessment of benefits would be to identify successful projects and analyze the benefits they provide. The analysis must recognize the uncertainty of such estimates. In addition, the argument behind the estimates should be transparent, relying on documentation and testimony from users, policymakers, and noneconomists. An assessment of the benefits from economic research provides information that can be used to justify support for economic research and for allocating monies among lines of research.

One of the most difficult obstacles in preparing an assessment of the benefits of economic research is a lack of evidence. Economists believe that the allocation of funds to disciplines and within them should be based on productivity. Some also advise that a key ingredient of effective management is accountability. As economists, we must practice what we preach and establish an effort to document performance and results. Reductions in the cost of data collection and documentation have lowered the cost of such efforts. One logical follow-up of this approach would be to develop procedures for documenting and accounting for the effects of economic research.

APPENDIX

The benefits of the California water bank in 1992 are approximated in Figure 1. For simplicity, the numbers are rounded. Farmers sold 600,000 acre-feet to the water bank at $125 per acre-foot. Water use varies in the Delta, so that the marginal benefit of water may be as low as $25 per acre-foot (low-value crops such as rice and pasture generate a marginal benefit of $25 per acre-foot or even less [Sunding, Zilberman, and MacDougall 1997]. In Figure 1 a linear supply curve for water is assumed. This intercepts the vertical axis at $25 per acre-foot, and 600,000 acre-feet of water would be supplied when the price is $125 per acre-foot. Farmers in the San Joaquin Valley bought 400,000 acre-feet from the water bank at $175 per acre-foot. Again, a linear demand curve is assumed. It is choked at the price of $325 per acre-foot (high-value crops such as peaches, tomatoes, and oranges have generated benefits of $325 per acre-foot or higher [Sunding, Zilberman, and MacDougall 1997]). The benefit from the water bank includes four elements. First, the benefit to the seller is equal to the area *ABC* in Figure 1, or ΔABC = (125 – 25)($600,000)/2 = $30,000,000. Second, the benefit to the buyers is represented by the area of the triangle *EDF*, or ΔEDF = (325 – 175)($400,000)/2 = $30,000,000. Third, the area *CDFG* represents revenues to the government, half of which may cover the cost of the program, or $\diamondsuit EDFG$ = (175 – 125)($400,000) = $20,000,000. The net benefit they generate is about $10,000,000. Finally, the triangle *FGB* approximates the value of water left in the Delta, or ΔFGB (175 – 125)($200,000)/2 = $5,000,000. Assuming a linear demand for water to be used for environmental purposes that corresponds to line *FB* in Figure 1, the net benefit this water generated would be $5,000,000.

The net benefit to sellers and buyers of water totals $60,000,000. The rest of the analysis of benefits is speculative. If there is a $10,000,000 net benefit to the government and a $5,000,000 environment benefit, then the total benefit from the water bank would be $75,000,000. To be conservative, the $60,000,000 figure will be used as the estimated benefit from the water markets.

NOTES

1. For example, Lichtenberg, Parker, and Zilberman (1988) developed procedures to assess the impact of supply shifts because of policy changes, and Lichtenberg and Zilberman (1986) developed a framework for estimating the effects of supply shifts due to changes in supply in an agricultural industry subject to price supports. Alston and Pardey (1996) present many models and examples to assess the effects of different types of policy changes, so this aspect of the analysis can be taken for granted.

2. The contribution of several projects to a single policy solution may be dependent, but the constriction of the shares should aim to avoid "double counting," and the sum of the shares will be equal to the overall shares of the research program. Thus, individual shares can be treated as independent.

3. "U.C. Warned Over Research on Big Green," *San Francisco Chronicle*, October 31, 1990; and "Green Lobby's Dirty Tricks," *Wall Street Journal*, January 2, 1991.

Table 1—Outputs of economic research: Examples and implications

Category	Prices and quantities	Institutions and policies	Aggregate information
Group 1: Economic information			
Examples	Commodity price predictions, output focus	Overview of international agricultural policies	Sectoral productivity estimates, sectoral accounts
Users	Traders, farmers, agribusiness	Agribusiness, investors, exporters, developers	Policymakers, voters
Benefits	Uncertainty reduction, increased efficiency, higher average output, lower prices	Increased trade and investment, reduced transaction costs, increased efficiency	Timely policy adjustments, informed political choices

Category	Production and management innovations	Product introduction and marketing methods	Research and development management tools
Group 2: Contributions to technological change			
Examples	Feed rationing formulas, resource allocation methods, conjunctive use of water, economic pest thresholds, location and transportation management tools	S-shaped diffusion curves, demand estimates, statistical tools to identify market slices	Competitive grants, research incentives, research assessment tools
Users	Resource managers, agribusiness, farmers	Agribusiness, investors, developers, farmers	Policymakers, research managers
Benefits	Improved resource allocation, increased profitability	Increased trade and investment, reduced transactions costs, increased productivity	Improved research productivity, improved research accountability

(continued)

Table 1—Continued

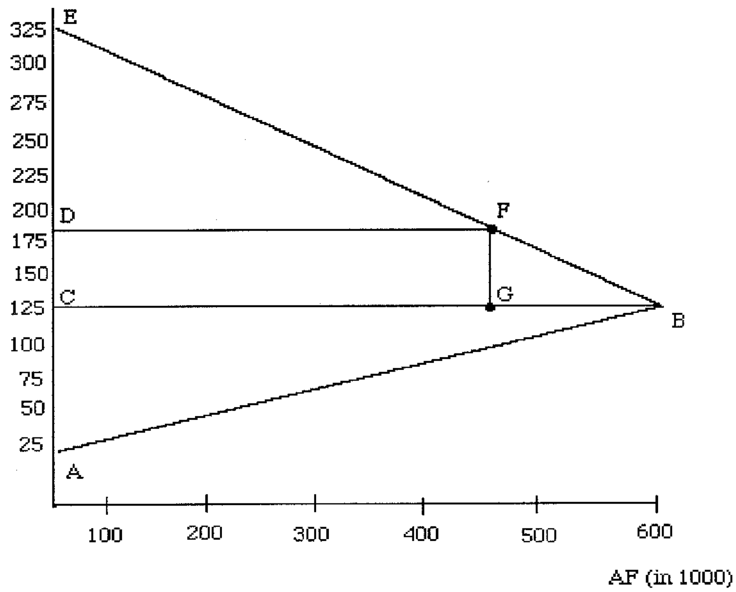
Category	Policy paradigms and institutional innovations	Policy analysis tools	Policy impact assessment
Group 3: Contributions to public policy			
Examples	Market efficiency, gains from trade, externalities, public goods, transferable pollution permits, incentive compatible policies, privatization, intellectual property rights	Cost-benefit analysis, input-output models, CGE models, impact assessment models	Analysis of alternative farm programs, prediction of economic impact of food stamp programs
Users	Government, policymakers, citizens, public organizations	Government agencies, policy analysts	Governments, policy analysts
Benefits	Improved resource allocation, equity, and quality of life	Improved policy efficiency	Screen out bad policies, improve policy designs, identify unexpected consequences

Table 2—The transmission of economic research results to final users

Classes of research outcomes	Transmission mechanisms				
	Print media	Electronic media	Education	Extension	Consulting
Economic information					
Prices and quantities	P	P			S
Institutional policies	P		P	S	
Aggregate information	P	S			S
Information for new technologies					
Management innovations	P		P	P	S
Adoption research	P			P	S
Research management	S				P
Policy research					
Policy paradigms and institutional innovations	P		P	S	S
Policy analysis tools	P		P	S	S
Policy impact studies	P	S	S	S	P

Notes: P = Primary impact.
S = Secondary impact.

Figure 1—Assessing the effects of the California water bank in 1992



Notes:

$$\Delta ABC = \frac{(125-25) * 600{,}000}{2} = 30{,}000{,}000$$

$$\Delta EDF = \frac{(325-175) * 400{,}000}{2} = 30{,}000{,}000$$

$$\Delta CDFG = \frac{(175-125) * 400{,}000}{2} = 20{,}000{,}000$$

$$\Delta FGB = \frac{(175-125) * 200{,}000}{2} = 5{,}000{,}000$$

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