

UC Berkeley

CUDARE Working Papers

Title

Public research in agriculture: an alternative institutional framework

Permalink

<https://escholarship.org/uc/item/1b73b3jj>

Authors

Rausser, Gordon C.
Zilberman, David D.

Publication Date

1981-04-01

Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

Working Paper No. 136

PUBLIC RESEARCH IN AGRICULTURE:
AN ALTERNATIVE INSTITUTIONAL FRAMEWORK

Gordon C. Rausser and David Zilberman

GIANNINI FOUNDATION OF
AGRICULTURAL ECONOMICS
LIBRARY

APR 1981

California Agricultural Experiment Station
Giannini Foundation of Agricultural Economics
April 1981

24

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18



Gordon C. Rausser and David Zilberman--Public Research in Agriculture:
An Alternative Institutional Framework

Gordon C. Rausser is Chairman and professor and David Zilberman is an assistant professor, both of agricultural and resource economics at the University of California, Berkeley.

10

PUBLIC RESEARCH IN AGRICULTURE: AN ALTERNATIVE INSTITUTIONAL FRAMEWORK*

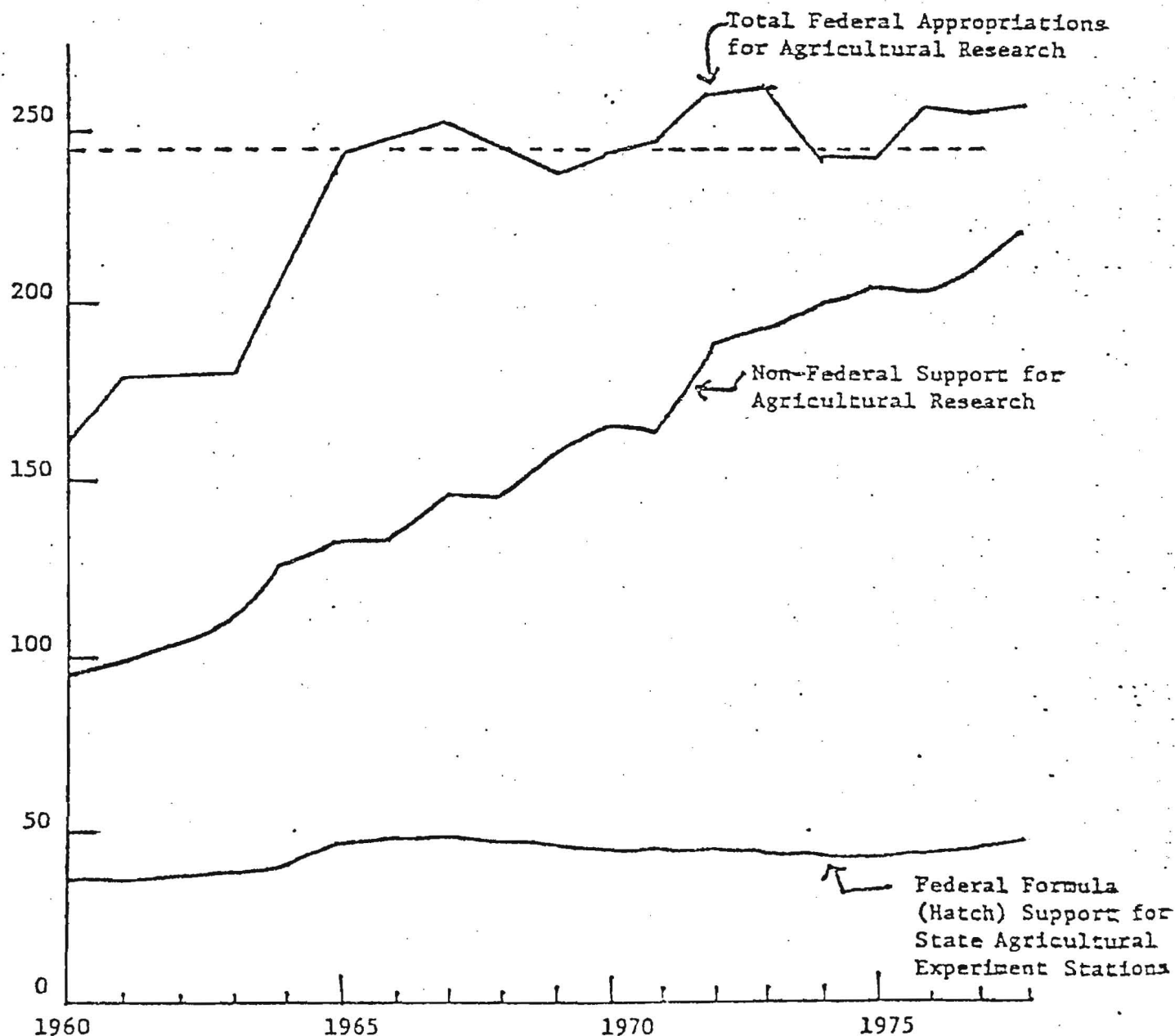
1. Introduction

The stagnation in federal support for agricultural research and extension over the last 15 years has become the cause for serious concern (figure 1). As R. J. Hildreth notes in a recent AAEA newsletter, the emphasis has shifted from support for expanded budgets to finding the necessary support for maintaining existing budgets. Similar observations have been advanced by McCorkle who has argued that the entire agricultural research structure is under serious challenge. On numerous occasions, Ruttan has eloquently shown that the challenge cannot be based on the agricultural research establishment's "efficiency" performance. However, as McCorkle notes, for any public investment in agricultural research, there are numerous conflicting goals which extend beyond efficiency.

In the popular media, there is a growing disenchantment with public research which is thought, in the short run, to benefit the large wealthy landowners, a few selected input manufacturers, or some of the major processors of agricultural products. Much of the fire directed toward public research in agriculture comes from organized groups such as farm labor unions, small farmers, and consumer interest organizations. They claim that agricultural research activities tend to serve agribusiness interests and that public funds are employed to distort income distribution toward those with large endowments and to enhance concentration. They often argue--and in some instances, correctly--that much of the research undertaken by the public

Figure 1
 Purchasing Power of Federal Appropriations and Non-federal Support of
 Agricultural Research Programs in the U.S. for 1960-1978
 (Liska, 1979)

Millions of Dollars
 (1967 dollars)



Source: Ruttan, Vernon W., "Agricultural Research and the Future of American Agriculture," presented at a conference on The Future of American Agriculture as a Strategic Resource, The Conservation Foundation, Washington, D.C., July 14, 1980.

sector should instead be made by the private sector. The agricultural research establishment is viewed as simply subsidizing those who would otherwise undertake this research themselves--an instance of redistribution from the poor to the rich.

This critical view of public research in agriculture has translated into political and legal action. An example of such action is the case of the University of California tomato harvester research. Over a period of more than 20 years, the University of California, through a combination of engineering and horticulture research, was able to develop jointly both the machine harvester and the tomato plant that made this machine feasible. A class-action suit by the California Agrarian Action Project, Inc., against the University of California seeks to enjoin the University of California from expending public resources to engage in commercial mechanization research. This case also seeks an order requiring the University of California to establish a fund for the retraining and relief of farm workers displaced by commercial mechanization projects of the University.¹ The political pressure surrounding this suit motivated Secretary of Agriculture Bergland, in early 1980, to publicly pronounce that the U. S. Department of Agriculture would no longer support labor-displacing mechanization research.

The above phenomenon is symptomatic of an underlying trend that has been lamented by distinguished public servants and economists. John Gardner has characterized current U. S. public policy as "a war of the parts against the whole." This system is faced with potential destruction as a result of numerous internal conflicts taking place between various interest groups. J. B. Kendrick has argued that Gardner's characterization holds for American agriculture. He states, "these internal struggles portend disaster for

American agriculture if they continue on their present course." Thurow has articulated the above views in terms of a zero-sum society. As he notes:

"The problem with zero-sum games is that the essence of problem solving is lost allocation. But this is precisely what our political process is least capable of doing. When there are economic gains to be allocated, our political process can allocate them. When there are large economic losses to be allocated, our political process is paralyzed. As with political paralysis comes economic paralysis."

To solve this dilemma, Thurow argues that,:

"Our society has reached a point where it must start to make explicit equity decisions if it is to advance. The implicit undefended unanalyzed equity decision that have been built into our tax, expenditures, and regulatory policies of the past simply won't carry us into the future. To implement public policies in the future we are going to have to be able to decide when losers should suffer income losses and when losers should be compensated. We have to be able to decide when society should take actions to raise the income to some group and when it should not take such actions. If we cannot learn to make, impose, and defend equity decisions, we are not going to solve any of our economic problems."

This paper suggests an institutional framework to manage public research in agriculture. This framework should resolve numerous internal conflicts and allow effective decision making. The logical basis for this alternative institutional framework requires an examination of a number of issues. First,

what characteristics of research must be considered in determining the "best" mix of private and public investment in agriculture research? Does this evaluation base differ across research categories? What alternative criteria and decision rules are appropriate for evaluations of public research? How do we operationally evaluate alternative research activities in the public sector and provide incentives for effective coalitions to be formed in support of socially valueable public research?

Prior to introducing the alternative institutional framework, the above questions are addressed in Sections 2 and 3. Public versus private research in agriculture is investigated in Section 2, and research evaluation and compensation are treated in Section 3. Section 4 outlines the alternative institutions needed to implement an ex ante evaluation framework incorporating actual compensation rules. Finally, a concluding section ends the paper.

2. Public Versus Private Research in Agriculture

In agricultural research evaluation, most analysts treat research as an aggregate without distinguishing the types that should be supported by the public sector from those types that should be supported by the private sector. In our analysis, we will find it useful to draw a distinction between three major types of research: basic-core, semibasic, and applied research. These categories represent stages of the research process. Basic-core research is the search for general knowledge without regard to its ultimate usefulness. Semibasic research is also a process of search for principles, but it is targeted toward potentially applied areas. Here the basic-core stock of knowledge is taken as given; and attempts are made to alter its appropriateness, quality dimensions, and other characteristics. Applied research is explicitly designed to improve production possibilities and to improve

information sources for economic decision making. The results of applied research have the unique feature of entering actual production processes. Applied research can have two effects: technological, through the improvement of production functions, and pecuniary wealth redistributions due to price reevaluations that may occur from the release of the new technology.

In each of the above research categories, the basic justification for public support of research is related to the notion of information as a public good. A wealth of literature on the economics of research and invention argues that there tends to be underinvestment in the private sector for such activities due mainly to the imperfect appropriability of knowledge. As Hirshleifer notes, the pecuniary effects may offset this tendency and serve as incentives for private investment in research since the innovator who arrives first with the information is able, through speculation or resale of information, to capture the pecuniary effects. Other justifications for public investment in research and inventive activities include, inter alia, the distinction between public versus private risk preferences (Arrow and Lind), the distinction between public and private discount rates (Marglin, Rawls), and the magnitude of uncertainty and the economic life of generated knowledge. Other reasons for public support that are generally not recognized by analysts relate to the public sector's desire to foster and maintain a competitive structure within the agriculture and food sector. This basis for public investment in research requires evaluations of the structure, conduct, and performance of the private sector; market distortions resulting from technological change; returns to the scale of knowledge accumulation; and the kind of incentives that exist for coalitions or group actions formed to support research in the private sector.

Each of the areas of agricultural research, viz., biological, chemical, mechanical, economical, informational, and managerial can be distinguished in terms of their patent enforceability, economic life, technological versus pecuniary effects, and the ability of rivals to imitate the research and development processes. These characteristics will determine, in large part, whether the net benefits of research and development activities can be captured by the private sector. To the extent that such benefits can be captured, the public sector should not be involved in such research and development activities. Obviously, given the definition and associated distinguishable areas of research for the core-basic stage, only the public sector can be expected to make investments during this stage. However, in the case of semibasic and applied research, the optimal mix of public versus private research investments for each area of agricultural research becomes an important issue.

In the case of chemical research activities, a mix of public and private sector research can be justified during the stage of semibasic research. However, in the case of applied research, the private sector can and does assume much of the responsibility for research and development activities. This is due in large part to the short economic life of such activities in the chemical industry over which much, if not all, of the benefits accrue to the innovator. Moreover, there is a fair amount of concentration in the chemical industry; as Kamien and Schwartz observe (p. 24), intermediate concentration ratios seem the most conducive to research effort and success, while extreme concentration ratios provide less incentive for private investments in research and development activities. Moreover, they note that, in the case of the commonly tested hypothesis that research and development activity increases

more than proportionately with firm size (p. 32), "the bulk of empirical findings do not support it, with the notable exception of the chemical industry."

In the case of mechanical research activities, once again much of applied research can be undertaken by the private sector. This result occurs simply because of the characteristics of economic life and technological and pecuniary effects. Such research activities are often patentable, enforceable, and thus cannot be easily imitated.

For biological research activities, not subject to the Plant Variety Protection Act, it is likely that an underinvested, stagnant equilibrium will arise in the private sector due to the ease of imitation and the lack of patent enforceability. Thus, much of the socially desirable biological research undertaken during the semibasic and applied stages should be supported by the public sector. For economical, informational, and managerial research and development activities, again difficulties arise in individual innovators' attempts to capture the net benefit of any particular innovation. Thus, one may expect underinvestment in these types of research from the private sector. Note, however, that there are some incentives for the formation of coalitions or groups in the private sector (e.g., commodity associations, research and development marketing organizations, and the like) to take advantage of the pecuniary externalities and returns-to-scale dimensions that arise from such research and development activities. As Hirshleifer notes (p. 573), a group of such individuals might willingly cooperate in making expenditures far in excess of the social value of the information to be acquired. Of course, when this type of collusion exists, public sector R&D may be unnecessary.

In the above discussion, the key determinant of the desirability of public research is based on whether the private sector can capture sufficient benefits from the result of its research activities. Quite simply, if such benefits can be captured, then incentives exist for the private sector to make the appropriate levels of investment in R&D activities. Note, however, that this analysis ignores the possibility that public R&D research may be justified on still other grounds. Specifically, for those situations in which private research might have a detrimental effect on the structure of the industry, making a competitive structure noncompetitive, or a noncompetitive structure still more imperfect, a mix of public and private research may serve to preserve competition and/or reduce the amount of concentration.²

3. Evaluation and Compensation in Agricultural Public Research

As the previous discussion suggests, a particular research program can be evaluated in terms of (a) patent enforceability, (b) economic life, (c) technological versus pecuniary effects, and (d) the relationship between public and private risk preferences and between public and private discount rates. Research programs within the semibasic and applied stages can be classified by (a)-(d) in accordance with whether the research should be undertaken by the private sector, the public sector, or some mix of activities on the part of both the public and private sectors. For those research programs that are allocated to the public or public/private categories, we have a set of eligible research programs that must be evaluated. In other words, which of these programs should be supported?

There are a number of alternative criteria and methodologies that can be employed to select from the set of eligible research programs. These

alternatives are outlined in the excellent survey studies of Schuh and Tollini and Norton and Davis. A distinction is drawn between ex post and ex ante evaluations of agricultural research. In ex post evaluations, historical data are utilized along with either measures of consumers and producers surplus or empirically estimated production functions (with research as an input variable) to compute commodity specific rates of return or an aggregate rate of return.³

Ex ante evaluation frameworks range from simple scoring models to more complex mathematical programming models (Schuh and Tollini). The uncertainty, probabilistic, and dynamic features of these evaluation frameworks vary widely. In some cases, the evaluation frameworks are static and deterministic while in other cases dynamic programming and probabilistic sampling procedures are utilized (Atkinson and Bobis).

With few exceptions (Scobie, 1979; Pinstруп-Andersen and Franklin; Ramalho de Castro and Schuh), all of the approaches to ex post and ex ante evaluation emphasize efficiency to the neglect of equity measurements. In the evaluation of public research in agriculture, however, equity considerations can no longer take a back seat to efficiency. In fact, not only must the uncertain equity and efficiency effects of various research programs be evaluated but, in addition, the effects of compensating those who lose from the introduction of new technology must be considered. As Thurow has argued, actions undertaken by the public sector require the determination of ". . . when losers should suffer income losses and when losers should be compensated."

To be sure, the actual implementation of compensation is no simple matter; it requires explicit value judgments. In a very thoughtful analysis, Pasour has examined the issue of compensation and found it infeasible. Some of his

justifications include measurement problems along with risk and moral hazard. He also states that ". . . individuals who are disadvantaged by any of the enumerable changes of a dynamic economy would appear to have an equal claim to compensation" (Pasour, p. 615). This implies a value judgment that weights each member of society equally. However, he invokes the public choice literature to argue that the "government inevitably serves to promote the interest of particular individuals or groups at the expense of other individuals or groups" (p. 616). Thus, a "system of general compensation to offset the direct and indirect losses associated with acts of government affecting economic progress would be inconsistent with this role of government" (p. 616). Hence, in Pasour's view the public sector cannot implement compensation schemes under the "right" (equal) welfare weights.

In any event, the difficulty of implementing compensation schemes has led to the concept of "potential" compensation. This concept originated with Kaldor and Hicks as a solution for the interpersonal comparison problem in welfare economics. Following the corrections to the original Kaldor/Hicks potential compensation principle, offered by Scitovsky and Samuelson, a number of agricultural economists have used this concept to determine whether it is possible for the gainers of a particular public policy to compensate the losers.⁴

In a society described by Thurow as well as Gardner, the concept of potential compensation is of little value. In Thurow's world of a zero-sum game or a constant pie size, it is not possible for gainers to compensate losers such that everyone can be made better off. Even if we do not accept the zero-sum society view of Thurow, the views expressed by Gardner have similar implications. Potential losers of public research policies which

might well increase the size of the pie are able to form effective coalitions that block and/or diminish support in the public sector for such research activities. The awareness of such groups and their degree of influence have seriously diminished the role of government in enhancing one interest group at the expense of another. Moreover, political reality dictates the assignment of alternative weights to the benefits and costs that accrue to various interest groups. Taking these weights into account in the evaluation process results in different outcomes than the potential compensation rule dictates.

In essence, we are left with the conclusion that actual compensation must be seriously considered. The challenge is to design the institutions and mechanisms that will make a policy of compensation feasible. To achieve feasibility, it is desirable that the compensation be the outcome of a mutual agreement among the affected parties. Of course, the implementation of voluntary compensation is fraught with problems of truthful preference revelation on the part of losers and gainers. As game theory formulations reveal, there are incentives for some groups to be free riders. Contrary to many claims in the literature, from an operational standpoint, such free-rider problems resulting from the provision of public goods have never been solved nor does a solution seem likely (Green and Laffont). When a voluntary solution is not attainable, a compensation arrangement must be imposed, taking into account the social weights attached to welfare of affected groups. The institutional design must facilitate support for socially valuable research programs while holding in check the free-rider problems.

4. Institutional Design for the Evaluation of Public Research

The proposed institutional design involves four principal groups. They are: (1) research initiators, (2) research administrators, (3) the Public Research

Commission, and (4) interest-group representatives. The research initiators formulate programs, prepare budgets, and submit their proposals to research administrators. Any member of society or group of citizens may suggest a public research program; however, the expectation is that most research programs would be initiated by members of the research community.

The second group, the research administrators, will operate at either the federal or state level and must be armed with an evaluative support staff. Their range of responsibilities includes: (a) initial qualitative screening of research program proposals to determine whether they are entitled to public support; (b) for those programs that are entitled to public support, estimating the benefits and costs across various groups in the general population; (c) determining an initial incidence of burden to finance each research program and to compensate losers; (d) attempting to form an effective coalition in the public and private sectors to support the proposed research program; and (e) if, after negotiation, effective support cannot be captured, submitting the research program along with the incidence of burden to the Public Research Commission.

Members of the Public Research Commission would be appointed by elected officials at either the state or federal levels. The appointment procedure of commissioned members should be designed to insure that the policies and decisions of the Commission reflect societal value judgments on equity across groups affected by the proposed research. The Commission would be empowered with the authority to determine whether the program should be supported by the public sector and, if it should, to impose the final incidence of burden to support the research program. This latter authority is viewed as an incentive for effective coalitions to be formed prior to the submission of the research

program and initial incidence of burden by the research administrator to the Public Research Commission.

Individual interest groups from both the public and private sector will be represented by participants who articulate the interest of potentially affected groups and negotiate on their behalf. Each interest group organization will be responsible for the management of a "reserved" fund. This fund will be composed of beneficiary group members' dues to finance the research program or the amount of compensation for a losing group that must be distributed among group members who suffer from the outcomes of the research program. In this framework, many existing organizations can serve as interest group representatives. For example, labor unions, producer cooperatives, grower associations, and commodity associations have the machinery to represent their constituencies and manage such reserved funds. Similarly, governmental agencies exist, e.g., Environmental Protection Agency, which can effectively represent more diffused interest groups, e.g., consumers. In some situations, governmental intervention may be required to form entities to protect the interest of groups that have not developed representative organizations. If the transaction costs of forming such entities are prohibitive, then the government would maintain the reserved fund for, and negotiate on behalf of, such groups. In any event, the existence of interest group representative organizations is essential to make the proposed framework operational. Such organizations significantly reduce the number of parties involved in the "incidence of burden" negotiation and the transaction costs of implementing the proposed institutional design.⁵

Stages of Research Evaluation

The institutional design is motivated by the need to accommodate a research selection process which is depicted in figure 2. This process consists of three major stages of evaluation. In the first stage, a decision must be made on whether the "public sector" should participate in and support the proposed research program. In this stage, it must be determined by the research administrator and his support staff whether there are incentives for the research program to be undertaken by the private sector. This will involve determining whether (1) the potential outcomes of the suggested project are patentable, (2) the patent is enforceable, (3) the outcomes have short economic life, (4) they are not easily imitated, and (5) the pecuniary effects of the research are desirable to the innovator. If the answer to all these questions is positive, the public decision-making body has to consider whether the undertaking of such a project by the private sector may have undesirable effects on the structure of the relevant industries. If this is not the case, the first-stage qualitative screening evaluations of the project terminates here, and its support is left to the private sector.

It should be noted that public research is not advocated in every instance in which private research may result in increased concentration. In some situations, the nature of the new technology, particularly its return to scale properties, along with the nature of the relevant output markets (degree of demand elasticity), may give rise to larger plants and a reduced number of firms. Under these circumstances, undertaking such research in the public sector and ultimately releasing the successful completion of such research to the private sector will not effectively alter the tendency towards such concentration. This, of course, suggests that research need not be undertaken

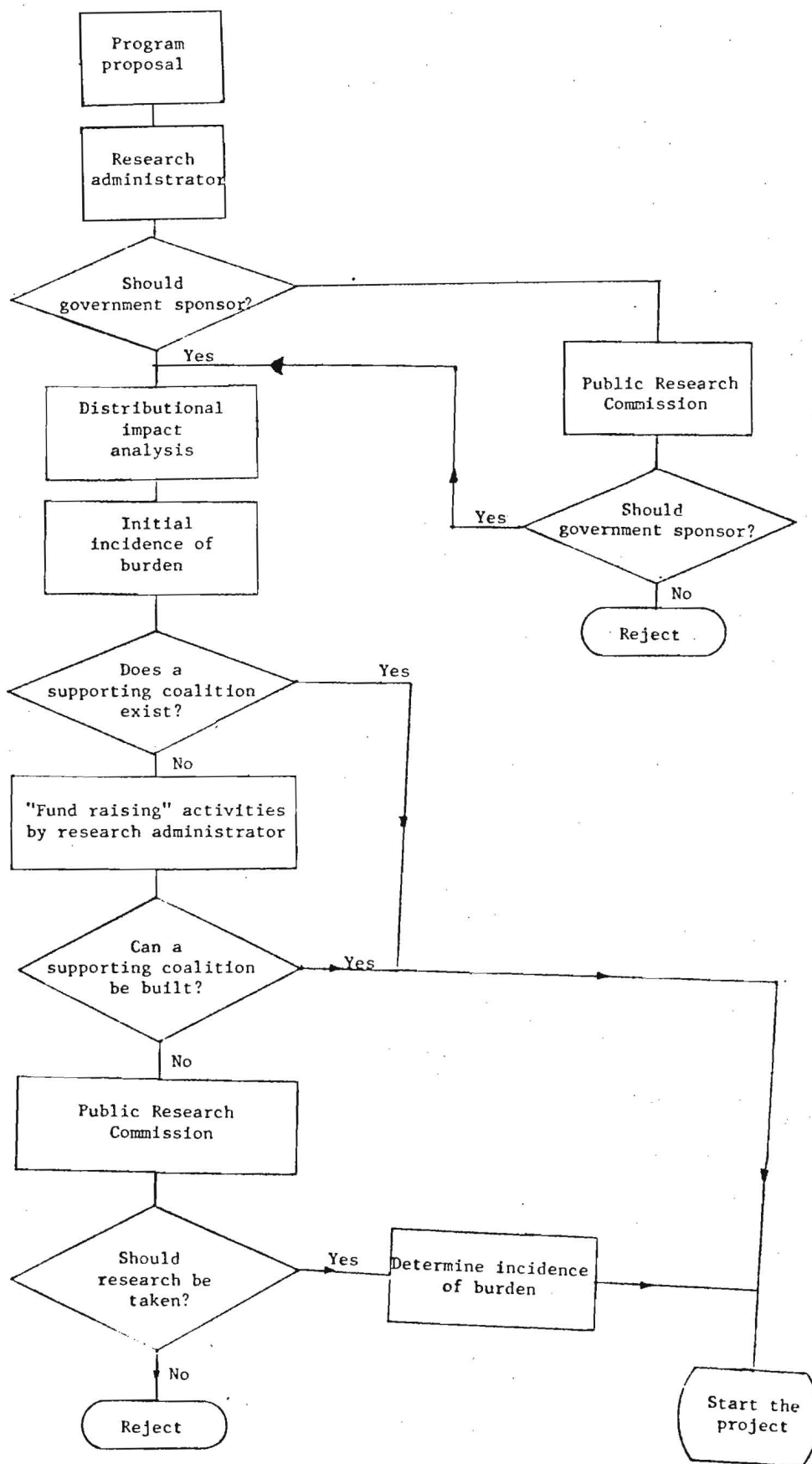


Figure 2. The Public Research Evaluation Design

by the public sector. Thus, under the noncompetitive criterion, only if specific circumstances strongly suggest that public research can actually improve the industry structure should it be pursued.

Presuming that public participation is desirable, the second stage is quantitative in nature. It begins with a determination of the initial incidence of burden vector. This requires the (i) estimation of the benefits and costs that might be incurred by various groups as a result of the successful completion of the research program; (ii) the cost of the research program; and (iii) the distribution of outcomes that are potentially possible from the research program. The need for the cost estimate on the research program is obvious. Once the distribution of possible states characterizing the uncertain research output have been determined, the probabilistic effects related to the streams of benefits and costs to all parties must be estimated. Based on this information, the research administrator can determine an initial incidence of burden. This incidence of burden will include not only the cost of the research project but, in addition, sufficient compensation to those groups who suffer losses.

An operational rule for determining the initial incidence of burden will be introduced and justified in detail below. In more general terms, the compensation payment that must be made is divided among the gainers in proportion to their individual rewards. Generally, the cost of the research program will be shared among the gainers in proportion to their expected net benefits. This method insures that research administrators will determine initial incidence of burden only for programs for which the expected net benefits are at least equal to the research costs. Of course, all other research program proposals will be rejected.

Once the initial incidence of burden is determined and a program is found to have positive expected net benefits, the research administrator must attempt to form a coalition to support the program. If such a coalition can be formed, funds are available to finance the research program and to cover the compensation to losing groups. If, initially, a coalition cannot be formed, the research administrator will revise the incidence of burden using a revealed willingness-to-pay mechanism; namely, the research administrator will allow groups that are interested in the project to assume any additional burden to cover the deficit caused by the lack of response from other groups.⁶ The program will then proceed if these additional attempts result in the necessary funds. In addition to other desirable properties of this program selection procedure, differences in subjective views and risk preferences among various groups can be reflected in the incidence of burden. Another advantage of this procedure is that it generates cooperative participation. All affected parties have a direct input into the project selection process.

Of course, one danger of the revealed willingness-to-pay process is the notion of free riders. For example, if one group stands to gain significantly from a research program while another group expects to gain only small amounts, the latter group has some incentive not to participate in the financing of the research program. The latter group attempts to assume the role of a free rider, hoping that the group that will benefit the most from the research program will finance all beneficiary group proportions of the research cost and compensation. Another possible example involves a losing group which requests a compensation level well beyond reasonable estimates of its losses, hoping that gainers will accept their exaggerated compensation

claims. While some free-rider behavior of these sorts may be unavoidable, this problem can be controlled by the following stage in the recommended research evaluation procedure.

If, based on the concept of willingness to pay, the research administrator is unable to reach a supporting coalition for a voluntary incidence of burden, we move to the third stage. In this stage, the Public Research Commission evaluates the program and determines whether it should be supported and under what financial arrangements. In its deliberations, the Commission will review the data analysis and incidence of burden recommended by the research administrator. The Commission may actively seek evidence from the interest group representatives and consult with independent experts. In its deliberations the Commission should be guided by insuring that socially desirable programs are undertaken, that "losers" are fairly compensated, and that the cost of the research program is fairly shared by the beneficiaries. The Commission's decision on the incidence of burden, including both compensation arrangements and the sharing of research costs, need not reflect the willingness-to-pay criteria. Instead, it could reflect the collective view of the Commission members' value judgments of the equity tradeoffs among various groups in society.⁷ Hence, in contrast to the approach employed by the research administrator, the Commission does not necessarily utilize an equal weighting across various groups.

Since the Commission is selected by elected officials, its equity weightings across various groups should approximate more closely the value society places on alternative distributions of income and wealth. Like Pasour,

we recognize the limitations of representative democracy, but the value of utilizing this imperfect system to allow compensation exceeds its associated costs.

We do not expect the third stage of the research evaluation design to be used frequently. Its existence alleviates in large part the free-rider problem associated with the cooperative solutions of the second stage. Given the existence of the Commission, a gainer who suspects that the small contribution of other gainers is motivated by free-rider incentives will be more likely to refuse to cover whatever gaps that might result from such behavior. Similarly, if a gainer suspects that he is being extorted by losers, he can refuse to support the project and force Commission arbitration. On the other hand, groups who attempt to become free riders do so at the risk of an unfavorable incidence of burden being imposed by the Commission. In all of these cases, the option of submitting the entire program to the Commission protects potential victims of free-rider behavior and reduces the extent and likelihood of such behavior.

The cost of implementing the above three-stage research evaluation design certainly compares favorably with the current use of the court system to resolve ex post conflicts. This we will argue is the case even if we allow an appeal process beyond the authority that is assigned to research administrators. As figure 2 indicates, the institutional design allows research program initiators to appeal decisions made by the research administrator to the Public Research Commission. Likewise, the authority exercised by the Public Research Commission should be contestable in the courts. In each case, the appeal process should be designed to prevent abuse or excessive use.⁸

Incidence of Burden and Compensation

A critical component in the above design is the incidence of burden and the form of compensation. To be sure, we cannot generalize a formulation for determining the actual incidence of burden since it is the result of a negotiation process among the affected groups or as a politically determined decision made by the Public Research Commission. Our orientation in this section will be to introduce the rules for deriving the initial incidence of burden which is determined by the research administrator. These rules will provide a basis for determining the initial incidence of burden which initiates the negotiation process among the affected groups.

As noted in the previous section, the initial incidence of burden is based on the willingness-to-pay criterion. Hence, initially, equal weights are given to monetary gains and losses to the various affected groups. Dollar gain to consumers is treated equally with the dollar gain to producers. This approach is advocated simply because of its desirable property of market-based valuations and the desire to preserve the impartiality of the research administrator and his evaluative staff. The impartiality is essential since the research administrator must conduct the "fund raising" negotiations once the initial incidence of burden is determined. A second criterion that governs the initial incidence of burden is risk neutrality. The distributions of costs and benefits that accrue to various groups will be evaluated by their expected values. This approach offers a simple and operational basis for determining the initial incidence of burden.

The incidence of burden must consist of a vector of cash outlays each of the beneficiaries must contribute to finance the research program as well as a set of compensatory rules that dictate the amounts transferred from gainers to

the losers under different contingencies. In many circumstances, the contingencies refer to the form and nature of the research output. To be sure, the actual research output is uncertain; attempts to develop the use of recombinant DNA for preservation of one type of food may lead to preservation for another type. In some situations, contingencies must be expanded to account for the possible influence of external events on the distribution and composition of research benefits and costs.⁹ Since the benefits and costs associated with the research program are most certainly random variables, any method of analysis leading to the determination of the incidence of burden requires a characterization of the states of nature associated with the possible outcomes.

In determining a rule for compensation, we must first deal with its exact timing. Should the compensation rule be executed on an ex ante basis; namely, should winners compensate losers according to expected losses (plus some risk premium) before the research program takes place or should compensation be ex post where the gainers compensate losers according to their actual losses? An obvious danger of using strict ex post compensation rules is that some groups may modify their behavior as information becomes available on the progress of the research program. There is some incentive for such groups to minimize the compensation payment. For example, suppose a research program is directed toward the development of a new mechanical harvester, and it is determined at the outset of the research program that farmers who adopt the new technology must compensate workers who are displaced. As the research effort progresses, more information about the likelihood, timing, and nature of the new innovation is accumulated. When the accumulated information indicates that the research program will be a success and is nearly completed, farmers

who intend to utilize this technology have some incentive to terminate employment of current workers to reduce their cost of compensation.

The above "moral hazard" can be partially overcome by specifying compensation levels for each contingency prior to the initiation of the research program. These compensation levels would be based on the best estimates of costs and benefits across various affected groups that can be feasibly determined during the second stage of the research evaluation. In what follows, a modified ex post rule will be examined. This rule will be determined at the beginning of the planning horizon for each possible state of nature but actually paid only after the state of nature is revealed.

While the moral hazard problem is the achilles' heel of ex post compensation rules, this approach nevertheless has three distinct advantages over ex ante compensation rules. First, it is far easier to specify an operational ex post compensation rule than an equivalent ex ante rule. The latter is computationally more demanding than the former. For an ex post rule, we must compute the losses for each possible state of nature. These losses are then fully compensated by the beneficiaries where each gainer's contribution to the compensation fund is proportional to its gain. For example, for a certain state of nature, suppose there are n beneficiary groups, and the benefit of the i th group is denoted by B_i . Let the sum of losses be given by L and for the state of nature in question; thus, the level of compensation imposed upon the i th beneficiary group is

$$(1) \quad C_i = L \frac{B_i}{\sum B_i}.$$

The computation of an ex ante compensation rule requires determining for each loser group a certainty monetary equivalent to the uncertain losses.

Since risk aversion parameters of the various parties are unknown and difficult to estimate, it is operationally impossible to design a simple compensation rule that reflects risk aversion. A workable but yet unsatisfactory solution to the risk aversion measurement problem is simply to pay losers their expected losses and require that gainers contribute to the compensation fund in proportion to their expected gains. The remaining two disadvantages of the ex ante compensation rule emanate from this plausible solution.

Given that potential compensation exists, there are two possibilities that must be recognized for both ex post and ex ante compensation rules. First, for all states of nature, total benefits from the research program may exceed total cost. The second possibility is that, for some states of natures but certainly not all, total benefits fall short of total costs. For the first possibility, the expected net benefits for all groups are identical under both ex ante and ex post compensation systems. Nevertheless, if the various groups are risk averse, the ex ante compensation rule will always be inferior from the losers' standpoint. In addition, in some instances, the ex ante compensation rule will prove inferior for the beneficiary groups. The reason is simply that, if losers are risk averse, the distribution of net benefits under the ex post compensation rule will stochastically dominate the distribution of net benefits under an ex ante compensation rule.¹⁰ The same result is obtained for the distribution of net benefits of beneficiary groups so long as there is positive correlation between gains and losses. For example, suppose we have the simple case of two groups—one which loses and another which gains from the adoption of a new technology. Let us suppose in addition that there are two possible states of nature with respect to this technology. Let the

probability of the first state of nature be α , the gain of the beneficiary group for state of nature j be B_j , and the loss to the losing group be L_j . Given this specification, the ex ante compensation will be

$$(2) \quad C = \alpha L_1 + (1 - \alpha) L_2.$$

The distribution of benefits and costs under the ex ante compensation rule is recorded in table 1 along with the distribution of benefits and costs under the ex post compensation rule.

As table 1 reveals, the loser under the ex post compensation rule faces no loss. However, under the ex ante compensation rule, for one state of nature, he has a gain and for the other he faces a loss with an average loss of zero under the ex ante rule. Obviously, risk-averse individuals will prefer the ex post compensation rule. Similarly, if large gains are correlated with large losses, $B_2 > B_1$, $L_2 > L_1$ and $B_2 - L_2 > B_1 - L_1$, then

$$(3) \quad B_2 - L_2 < B_2 - C$$

while

$$(4) \quad B_1 - L_1 > B_1 - C$$

and hence risk-averse beneficiaries will prefer, under these circumstances, the ex post to the ex ante compensation rule.

One of the most attractive features of the ex post compensation rule is that losers will always prefer it to an ex ante rule. This is the case since

Table 1. Losses and Gains Under Ex Post and Ex Ante Compensation Rules

State	Ex-ante rule		Probability	Ex-post rule	
	Gain	Loss		Gain	Loss
1	$B_1 - C$	$L_1 - C$	α	$B_1 - L_1$	0
2	$B_2 - C$	$L_2 - C$	$1 - \alpha$	$B_2 - L_2$	0

losers are expected to be the greatest obstacle to forming an effective coalition to support a proposed research program. The ex post compensation approach preserves the aggregate net expected benefit to society while simultaneously being preferred by those who suffer from the introduction of new technology.

In addition to the above advantages of the ex post role, an even more important advantage relates to the influence of these rules on the aggregate expected net benefits of a research program. Specifically, under very plausible circumstances, the aggregate expected net benefits are higher under an ex post compensation rule than an ex ante compensation rule. This will occur when, for some states of nature, the net benefits of adopting an innovation are negative. If an ex post compensation rule is employed, the new innovation will not be adopted and, under this circumstance, the aggregate actual net benefit for the research output of the project will be zero.¹¹ On the other hand, if--under the realized state of nature--there are gainers, the new innovation will be adopted under an ex ante rule and the net benefit associated with this outcome will be negative. This observation can be illustrated using the notation that appears in table 1. If the gain resulting from a realization of the first state is smaller than the loss, then the net expected benefit prior to the initiation of the research program and under the ex post rule will be $(1 - \alpha) (B_2 - L_2) - R$, where R denotes costs of the research program while, under the ex ante rule, the net benefit will be $\alpha (B_1 - L_1) + (1 - \alpha) (B_2 - L_2) - R$. Clearly,

$$(5) \quad \alpha (B_1 - L_1) + (1 - \alpha) (B_2 - L_2) < (1 - \alpha) (B_2 - L_2).$$

In addition to the above advantages for the ex post compensation rule, if it is determined a priori and depends only on the state of nature for the various research outputs, the moral hazard problem will not be a serious issue. Hence, it is the recommended method of compensation to be incorporated in the initial incidence of burden. This means that the research administrator must assign, for each state of nature, those levels of compensation that cover all losses and are divided among the beneficiary groups in accordance with (1). This rule of compensation will assure that research outcomes (states of nature) with negative aggregate net benefits will not be adopted. Given a viable research program, namely, the existence of potential compensation, each beneficiary group will initially provide funding to finance the costs of the research program in proportion to its net expected benefit from the project. Given the ex post compensation rule, this computation needs to be done only for states of nature with positive aggregate net benefits (relevant states). Hence, if G_i is a net expected benefit across the relevant states of nature, and R is the cost of project, the i th beneficiary group must contribute

$$(6) \quad s_i = \frac{G_i}{\sum_{i=1}^n G_i} R$$

to finance the research. In addition to this cost, each beneficiary group must also pay the level of compensation determined by (1) once the state of nature on the research output is realized.

The ex post compensation rule has direct implications for the measure of aggregate expected net benefits of research programs, on the set of programs that will be selected, and on the distribution of research cost among the beneficiary groups. This can be illustrated by the example that has been

constructed in table 2. This table assumes three groups, A, B, and C; two states of nature with equal likelihood; and various net benefits (losses) for each group and each state of nature. The total cost of the research program is assumed to be \$100.

Given the adoption of the new innovation resulting from the research output under state 1, the aggregate net benefit is negative. Hence, under the ex post compensation rule, the innovation will not be adopted under state 1. No damage is incurred under this rule if state 1 occurs, and the expected aggregate benefit from the research program is \$250. Since the cost of the research program is presumed to be \$100, the program is economically viable. Under the ex ante compensation rule, the output of the research program will be adopted regardless of the state of nature. Hence, the expected aggregate net benefit under the ex ante compensation rule will be \$150. Hence, if the cost of the research program were to exceed \$150, the program would not be economically viable under the ex ante rule but would be viable under the ex post rule.

The initial incidence of burden is obviously different under the two systems. Under the ex post rule, they are smaller since they need cover only the research cost. Moreover, the distribution of cost differs since the expected benefits under the two rules differ. Notice that in the example of table 2, on average, all parties will benefit if the ex post compensation rule is employed; and all must share in the burden of financing the research program.

5. Conclusions

Given the current institutional setting, funds for agricultural research have become increasingly difficult to obtain. This is the case even though much empirical evidence has been accumulated on the significant economic value of

Table 2. Incidence of Burden Under Ex Post and Ex Ante Compensation Rules

State \ Party	Party		
	A	B	C
State 1 (.5)	-400	100	100
State 2 (.5)	100	200	200
<u>Research costs</u>			
<u>Ex ante</u> rule	0	50	50
<u>Ex post</u> rule	20	40	40
<u>Compensation</u>			
<u>Ex ante</u> rule	150	- 75	- 75
<u>Ex post</u> rule			
State 1 ^a	400	200	200
State 2	0	0	0

^aUnder this outcome and the ex post rule, the research output will not be adopted.

resources allocated to agricultural research and development (Ruttan, Knutson and Tweeten). We have argued that this result is explained largely by Thurow's notion of a zero-sum society. This view is reflected by a recent Secretary of Agriculture statement that the U. S. Department of Agriculture would no longer support labor-displacing mechanization research.

In the public arena, internal struggles over agricultural research funding levels have direct implications for productivity growth and the well-being of the U. S. agricultural and food system. The current institutional design for public research and development does not efficiently resolve the conflict that arises among affected groups. In this environment, what is needed is a new institutional design which fosters cooperation and mitigates conflict. Such cooperation will strengthen the link between the economic value of agricultural research and the funds available for research in the public sector.

We have advocated an alternative institutional design which effectively incorporates the best of the existing institutions. Its key elements include the involvement of the private sector, incidence of burden, ex post compensation, and imposed solutions when cooperation fails due largely to free-rider behavior. The proposed institutional design requires the active participation of research initiators, research administrators, a Public Research Commission, and interest group representatives. This design keeps in tact the superb land grant system of research and extension. At least with respect to applied and semibasic research, it creates incentives for this system to play an even more important role in American agriculture. It should lead to a greater availability of resources for research and development within the land-grant system. Moreover, under the proposed institutional design, the system should be more responsive to the needs and perceive problems of the ultimate users of agricultural research and development.

Footnotes

*The authors wish to express their appreciation to R. E. Evenson, A. de Janvry, W. E. Huffman, R. E. Just, G. Norton, W. L. Peterson, V. W. Ruttan, L. Sammet, A. Schmitz, G. M. Scobie, and C. R. Shumway for valuable discussions on the ideas presented in this paper.

¹It is requested that this fund be equal to the total sum received by the University of California from the sale of licenses for patents resulting from the mechanization research.

²For an examination of these issues, see Hueth, Schmitz, and Cooper.

³There are other major studies which do not fall into one of these two general categories. One group has been categorized by Norton and Davis as the "change in national income approach." An example of this type of analysis is provided in Tweeten and Hines. Still another group of studies has been characterized by Norton and Davis as nutritional impact investigations, and here the example frequently cited is Pinstруп-Andersen, de Londono, and Hoover.

⁴For example, see Schmitz and Seckler.

⁵Note that the institutional framework is designed to evaluate only semibasic and applied research. As noted in Section 2, basic core research is a process of searching for general knowledge without regard to its ultimate usefulness. In the case of such research, the observation of Schuh and Tollini that, "an overemphasis on evaluating research and assessing and monitoring research can stifle activity and destroy research entrepreneurship" is particularly appropriate. At best, what can be suggested for the evaluation of core basic research is a framework based on Simon's notion of bounded rationality. In this setting, bounded rationality might assume the form of satisficing goals measured in terms of what a society weights favorably. In any event, the institutional framework advanced here applies only to semibasic

and applied research. Little difficulty should be confronted in implementing the suggested framework to evaluate applied research. Since the semibasic research is targeted toward potential applied areas, the proposed design also seems appropriate in this instance. However, it will become obvious that a fair degree of insight and wisdom will be required in implementing the proposed framework for the evaluation of semibasic research.

⁶It has been formally proved that this program selection procedure has some very desirable properties; namely, the selected program meets both the Kaldor-Hicks welfare criteria and the willingness-to-pay welfare criteria. These results have been formally proved by Dorfman.

⁷Such tradeoffs can be captured in a number of fashions. One operational procedure that has been widely applied is the so-called multiattribute utility approach (Keeney and Raiffa). This framework has been extended by Keeney to address equitable distributions of risk.

⁸This can be accomplished, for example, by imposing a high appeal fee that is waived only when the appeal is found to be "justifiable."

⁹For example, suppose a research program calls for the development of a new cotton variety but, before the research is completed, a new fiber might be developed which leads to significant decreases in the demand for cotton and the number of cotton producers. The distribution and composition of benefit and costs of a cotton variety will depend on whether the new fiber is developed. Hence, an appropriate compensation rule must take into account the possible introduction of the new fiber.

¹⁰In other words, the ex post compensation rule distribution of net benefits can be transformed to a distribution of net benefits under the ex ante compensation rule using a mean-preserving and a risk-increasing

transformation. For more details on such transformations, see Rothchild and Stiglitz.

¹¹Note that here we neglect the cost of the research program. This is justified since, given the sequential nature of when decisions are made, research costs are sunk when the adoption decision of a new innovation is under evaluation.

References

- Atkinson, A. C., and A. H. Bobis. "A Mathematical Basis for the Selection of Research Projects." IEEE Transactions on Engineering Management. EM-16, No. 1 (February, 1969), pp. 2-8.
- Arrow, K. J., and R. C. Lind. "Uncertainty and the Evaluation of Public Investment Decisions." Amer. Econ. Rev. 60(1970):364-378.
- California Agrarian Action Project, Inc., et al. vs. The Regents of the University of California et al. Superior Court of the State of California, Docket No. 516427-5.
- Dorfman, R. "Public Goods, Taxation, and a Modest Proposal." Harvard University, Department of Economics, 1980. Mimeographed.
- Gardner, J. "The War of the Parts Against the Whole." An acceptance speech at the 17th Cosmos Club Award Presentation, Washington, D. C., March, 1980.
- Green, J. R., and J. S. Laffont. Incentives in Public Decision Making. New York: North-Holland Publishing Company, 1979.
- Hicks, J. R. "The Foundations of Welfare Economics." Econ. J. 49(1939):696-712.
- Hildreth, R. J. "Public Funding of Agricultural Research and Extension: A Challenge to Economists." AAEA Newsletter, Vol. 2, No. 2, March, 1980.
- Hirshleifer, J. "The Private and Social Value of Information and the Reward to Inventive Activity." Amer. Econ. Rev. 61(1971):561-574.
- Hueth, D., A. Schmitz, and R. Cooper. "Social and Private Rates of Return to Investment in Research." Lawrence Livermore Laboratory, Paper No. ERPG-80-4-18, 1980.
- Kaldor N. "Welfare Propositions of Economics and Interpersonal Comparisons of Utility." Econ. J. 49(1939):549-552.

- Kamien, M. I., and N. L. Schwartz. "Market Structure and Innovation: A Survey." J. Econ. Lit. 13(1975):1-37.
- Keeney, R. L. "Utility Functions for Equity and Public Risk." Manage. Sci. 26(1980):345-353.
- Keeney, R. L., and H. Raiffa. Decisions With Multiple Objectives: Preferences and Value Trade-Offs. New York: John Wiley and Sons, Inc., 1976.
- Kendrick, J. B. "Grist for the Mill." California Agriculture, Vol. 34, Nos. 11-12 (November-December, 1980), p. 2.
- Knutson, M., and L. G. Tweeten. "Toward an Optimal Rate of Growth in Agricultural Production Research and Extension." Amer. J. Agri. Econ. 61(1979):70-76.
- Marglin, S. "The Social Rate of Discount and the Optimal Rate of Investment." Quart. J. Econ. 77(1963):95-111.
- McCorkle, C. O., Jr. "Agricultural Research: Where Are We and Where Are We Going?" University of California, Davis, Department of Agricultural Economics, 1978. Mimeographed.
- Norton, G., and J. Davis. "Review of Methods Used to Evaluate Returns to Agricultural Research." University of Minnesota, Department of Agricultural and Applied Economics, Staff Paper Series, 1979.
- Pasour, E. C., Sr. "Economic Growth and Agriculture: An Evaluation of the Compensation Principle." Amer. J. Agri. Econ. 55(1973):611-621.
- Pinstrup-Andersen, P., and D. Franklin. "A Systems Approach to Agricultural Research Resource Allocation in Developing Countries." Resource Allocation and Productivity in National and International Agricultural Research, ed. T. M. Arndt, D. G. Dalrymple, and V. W. Ruttan. Minneapolis: University of Minnesota Press, 1977.

- Pinstrup-Andersen, P., N. R. de Londono, and E. Hoover. "The Impact of Increasing Food Supply on Human Nutrition: Implications for Commodity Priorities in Agricultural Research and Policy." Amer. J. Agri. Econ. 58(1976):131-142.
- Ramalho de Castro, J. P., and G. E. Schuh. "An Empirical Test of an Economic Model for Establishing Research Priorities: A Brazil Case Study." Resource Allocation and Productivity in National and International Agricultural Research, ed. T. M. Arndt, D. G. Dalrymple, and V. W. Ruttan. Minneapolis: University of Minnesota Press, 1977.
- Rawls, J. Theory of Justice. Cambridge: Harvard University Press, 1971.
- Rothschild, M. and J. E. Stiglitz. "Increasing Risk: I. A Definition." J. Econ. Theory. 2(1970):225-243.
- Ruttan, V. W. "Agricultural Research and the Future of American Agriculture." University of Minnesota, Department of Agricultural and Applied Economics, Staff Paper Series No. P80-17, 1980.
- Samuelson, P. A. "Evaluation of Real National Income." Oxford Econ. Papers. 2(1950):1-29.
- Schmitz, A., and D. Seckler. "Mechanical Agriculture and Social Welfare: The Case of the Tomato Harvester." Amer. J. Agri. Econ. 52(1970):569-578.
- Schuh, Edward G., and Helio Tollini. "Costs and Benefits of Agricultural Research: State of the Art and Implications for the CGIAR." Consultative Group on International Agricultural Research, Purdue University, October, 1978.
- Scitovsky, T. "A Note on Welfare Proposition in Economics." Rev. Econ. Stud. 9(1941):77 and 78.

Scobie, G. M. "Variation in the Rates of Return to Agricultural Research:

Skeleton in Methodological Cupboard." Presented at a Ford Foundation Workshop, Seeking Explanations for Different Rates of Return to Agricultural Research, New York, February 2, 1979.

Simon, H. A. "Rational Decision Making in Business Organization." Amer. Econ. Rev. 69(1979):493-513.

Thurow, Lester C., Zero-Sum Society: Distribution and Possibilities for Economic Change. New York: Basic Books, Inc., 1980.

Tweeten, Luther G., and F. K. Hines. "Contribution of Agricultural Productivity to National Economic Growth." Agri. Sci. Rev. 3(1965):40-45.