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Evaluating Returns to Social Science Research: Issues and Possible Methods

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Several approaches have been employed over the past 25 years to evaluate returns to agricultural research (see Schuh and Tollini and Norton and Davis for recent reviews of the literature). Many studies have provided estimates of returns to aggregate agricultural research, to agricultural commodity groups, and to individual agricultural commodities. Those that have provided estimates of returns to specific technologies, research projects, and research programs have concentrated for the most part on applied production oriented research such as plant breeding (Griliches, Kislev and Hoffman). Few studies, however, have attempted to quantitatively evaluate the returns to non-production oriented research such as social science research. The purpose of this paper is to explore possible methods for conducting such an evaluation. We begin by presenting data which highlight the importance of social science and related research relative to total agricultural, forestry, and home economics research. We then briefly discuss the problems inherent in its evaluation and suggest a conceptual framework for measuring its value. Empirical means of estimating economic returns to social science research are examined followed by an application of decision theory to agricultural economics research evaluation.

The Magnitude of Social Science Research

Social science research commands a significant share of total research dollars spent on agricultural and related research. The Current Research Information System (CRIS) provides research expenditure data categorized by Research Problem Areas (RPAs). Out of the total 100 RPAs in this classification system, we have identified 34 which pertain primarily to social science research (see Table 1). In 1977 out of a total of $1,032 million spent on research by the state agricultural experiment stations, USDA, forestry schools, and other cooperating institutions, approximately $98 million was spent on social science-related research or about 9.5% 1/. Many of the RPAs are related to agricultural economics. Agricultural economists have spent a good deal of effort evaluating returns to agricultural research but little of this effort has been directed toward evaluating agricultural economics research. RPAs 108, 114, 316, 501, 503-511, 601-604, 807, and 808 all appear to involve agricultural economic research components and total over $54 million, about 5% of total agricultural and related research. 2/

There are also several research problem areas which are primarily nonproduction and nonsocial science oriented but may contain small amounts of social science research (See Table 2). Expenditures on these research categories of which watershed protection and management and human nutrition are the largest totaled $98.4 million in 1977 or about 9.6% of total agricultural and related research.

Problems Inherent in Social Science Research Evaluation

The lists of research problem areas in Tables 1 and 2 suggest the first problem inherent in social science research evaluation. There are many different types of research with a variety of hard-to-measure outputs. Some of the research projects are not directed toward increasing agricultural output or farmers' and consumers' incomes. They are concerned with improving nutrition, preserving the environment, reducing hazards to the population, or affecting other societal goals. Those RPAs that are concerned partly with economic growth or income distribution usually generate research output which impacts very differently than production-oriented research. Production oriented research such as plant breeding, plant pathology, animal breeding, etc. for the most part result in increases in bushels or pounds of production due to improved quality of inputs. Social science research, on

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Table 1. Expenditures on Major Social Science Research Categories in 1977 Classified by Research Problem Area (RPA). Total USDA-SAES-Forestry Schools-Other Coop Institutions

RPA	Title	No. of Projects	Scientist Years	Funds
108	Econ and Legal Prob. of Water Mgt	47	18.4	$ 1,276,131
114	Rsch on Mgt of Research	27	10.8	747,865
303	Econ of Timber Prod.	55	29.1	1,957,993
316	Farm Business Mgt	139	49.4	2,808,506
501	Improvement of Grades and Stands	97	45.0	4,230,424
502	Marketing of Timber Products	39	41.9	2,791,382
503	Marketing EFF of Agr Prod & Inputs	315	118.5	7,933,989
506	Supply, Demand, Price Analysis	209	130.0	7,886,333
507	Competitive Interrelationships in Ag	66	20.6	1,035,489
508	Domestic Market Development	66	22.4	1,312,333
509	Performance of Marketing Systems	202	113.3	6,665,945
510	Group Action and Market Power	69	26.7	1,405,424
511	Improve. in Agr. Stats	31	11.9	986,643
512	Improve. in Grades & Stands of Forest Products	20	13.6	874,151
513	Price Anal. Forest Products	20	13.5	923,537
601	Foreign Market Development	79	93.9	4,887,684
602	Eval. of Foreign Food Aid P.	3	.3	22,251
603	Tech. Assist to Dev Countries	61	29.6	1,730,844
604	Prod Devel & Mkts, Foreign Mkts	27	27.7	2,009,764
703	Food Consumption Habits	214	112.4	9,600,767
705	Select and Care, Clothing and Tex.	65	21.8	1,064,590
801	Rural Housing	62	29.0	2,130,263
802	Indiv. & Family Dec. Making	169	35.1	2,386,525
803	Rural Poverty	44	9.4	596,787
804	Improve Econ Pot. of Rural People	119	32.0	2,157,872
805	Commn. & Ed. Processes, Rur. People	139	29.6	2,762,300
806	Ind. & Fam Adjust to Change	185	59.0	4,298,096
807	Struct Change in Agr	138	77.3	7,142,478
808	Gov't Prog to Bal Farm Output & Demand	51	32.4	1,939,024
902	Outdoor Recreation	184	63.1	4,786,814
903	Multi-use, Forest Prod.	85	31.7	2,563,113
907	Improve Income Opp. in Rural Com.	193	57.2	3,550,863
908	Rural Institutional Improvement	317	97.5	6,495,301
	Subtotal, Social Science and Related Categories			98,212,481
	Total, All Research Problem Areas			$1,031,711,787

the other hand, seldom affects quality of inputs directly.

Furthermore, it is difficult to determine the causality of changes which occur following social science research. It is easier to link yield effects to plant breeding research than it is to ascertain that changes in farmer behavior or in institutions are due to research which suggested those changes. Related to this is the fact that information is available to farmers from sources other than public research and extension. Farmers rely on their experience and private sources of information as well. (Eisgruber, 1973, summarizes sources of information for Indiana and Illinois farmers).

In addition, there is a certain degree of complementarity between some types of social science research and biological and physical research which is difficult to quantify. Many of the problems of social science research evaluation relate to the measurement of output. In the next section, we suggest conceptual bases for making such measurements.

Table 2. Expenditures Classified by RPA on Non-Production Oriented Research Categories in 1977 which contained Small Components of Social Science Research

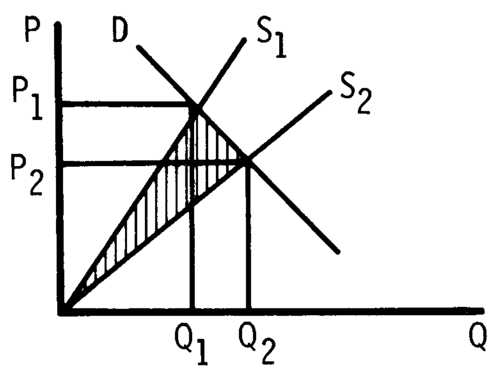
RPA	Title	No. of Projects	Scientist Years	Funds
107	Watershed Protect. and Mgt	287	245.2	$ 27,467,000
306	Prod. Mgt Sys. for Fruits and Veg.	86	22.0	1,694,113
309	Prod. Mgt Sys. for Field Crops	204	52.3	4,796,797
313	Prod. Mgt Sys. for Animals	288	67.2	10,045,385
701	Toxic Res. in Food	224	102.2	8,994,496
702	Food Prot. from Toxins	251	147.5	11,363,865
704	Home and Commercial Food Service	58	17.9	1,259,364
706	Control of Insects Affecting Man	136	71.3	6,781,747
707	Prev. Trans. of Diseases and Par. to Man	32	8.1	745,755
708	Human Nutrition	469	217.0	19,716,663
709	Reduce Hazard to Health and Safety	115	90.0	6,567,490
	Total			$ 99,432,675

Conceptual Framework for Measuring the Value of Social Science Research

It would appear that a common thread running through most types of social science research is that the output is information rather than a new or improved product. In some cases, the information may lead to someone producing a better product but the research itself does not produce the product. For purposes of classification, the types of information provided by projects in the research problem areas listed in Tables 1 and 2 can be grouped into seven basic categories: (1) management information, (2) price information, (3) institutional information, (4) product and environmental quality information, (5) human nutritional information, (6) information to aid in adjusting to disequilibria, and (7) information to aid in reduction of rural poverty. Much of the information generated by research in these areas is directed toward goals of increasing economic growth due to greater economic efficiency, improving the relative position of rural poor, and furthering personal health and safety. Some projects are aimed at more than one goal and perhaps a few contribute little to any of these goals. Many of the projects, even those directed primarily at the second and third goals, would appear to have some effects which could be measured or at least conceptualized in terms of having an economic value. Therefore, we turn now to each of the seven information categories listed above and explore how the economic value of the information from the related research projects might arise.

(1) Management Information. Many social science RPAs are concerned with improving management to facilitate attainment of technical or allocative efficiency. The value of information on technical efficiency results from its potential to provide producers with improved knowledge of the true parameters of the existing or new technology for a particular commodity. The value of information on allocative efficiency results from its potential to provide producers with improved knowledge of the most profitable or utility maximizing combination of inputs and outputs given the technology and expected prices. In Figure 1, we illustrate the effects of improved technical efficiency on the market for a particular commodity.

Figure 1.

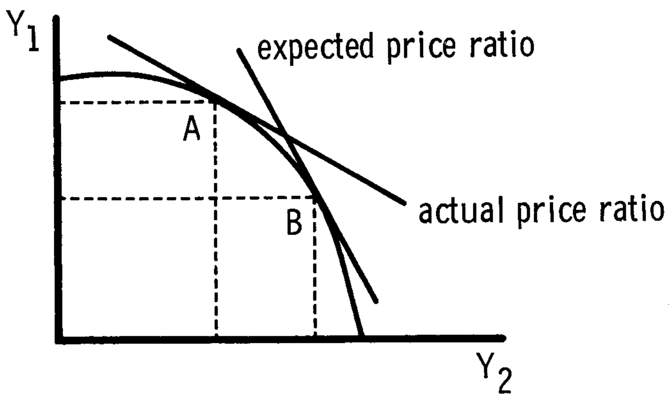


If producers combine inputs in such a manner that they attain improved technical efficiency, then there should be a shift in the production function for that commodity resulting from the improved timing of input usage, fuller exploitation of the complementary relationships among inputs, etc. This would result in a downward shift in the supply curve since it represents increased output from the same amount of inputs. This is a phenomenon similar to Finis Welch's "worker effect" of education and results in some benefits equal to the shaded area in Figure 1.

Figure 1 also illustrates the effect of improved allocative efficiency in use of inputs for a particular commodity. If management research enables producers to discover a lower cost combination of inputs to produce the same quantity, this should shift the supply curve down.

Figure 2 illustrates the effect of improved allocative efficiency in the choice of commodities to produce. If management research causes a movement from A to B, then benefits can be estimated as the increased profit resulting from this more efficient allocation of resources.

Figure 2.



(2) Price Information. The benefits to improved price information are illustrated in Figures 3 and 4. Assume producers estimate the price of the commodity to be P_1 which is above the equilibrium price P_e. In this case, they will produce a quantity of Q_1 which is larger than the equilibrium quantity Q_e. The resulting price will be P_1' and the resulting change in net social benefit will be A + B + C - (A + B + C + D) = D.

If economic research such as econometric modeling efforts lead to price forecasts which are closer to P_e, then this net social loss will be reduced. A similar argument could be made for the case where producers underestimate price (Figure 4). The change in net social surplus is - (A+B) + (A-D) = - (B+D).

(3) Institutional Information. Many types of social science research provide information on how certain institutions might be changed to function more efficiently or improve social welfare. The effects of this research depends on the type of institution being analyzed. The term "institution" can be defined as the set of

Figure 3.

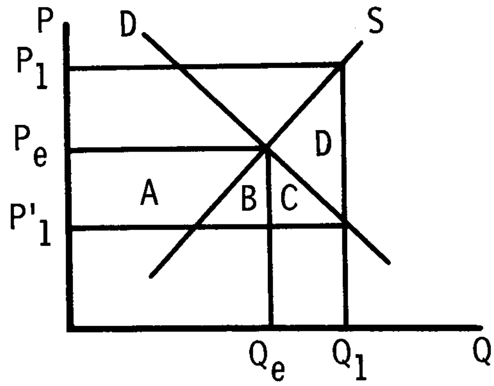
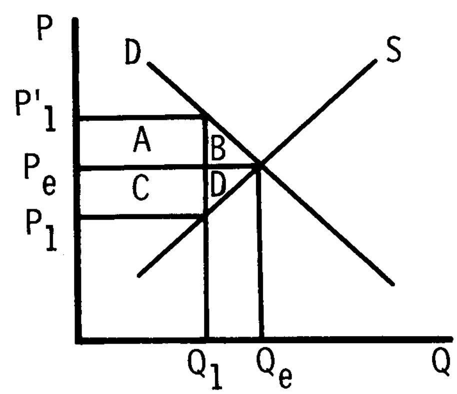


Figure 4.



behavioral rules that govern a particular pattern of action and relationships (Ruttan). If farm programs are changed as a result of agricultural policy research, this can be thought of as institutional change. Timing plays an important role in the resulting benefits to such research. In many cases with economic research, the welfare impacts of proposed institutional changes are estimated. Evaluation of that research then requires judgment as to the impact of the research on the subsequent institutional change.

(4) Product and Environmental Quality Information. For those goods for which quality can only be determined upon use, research on product quality and dissemination of the information can save the consumer costs that would have been incurred following purchase of a lower quality good. Whether these are actual cost savings or not, the end result will be that consumers obtain more utility from the bundle of goods they consume. They more correctly perceive the true shape of their utility functions resulting from consumption of the particular good for which information was provided. Since the consumer's

demand for the good is derived from his utility function, this will result in a shift out in demand for some goods and a shift in for others in the bundle of goods consumed. This will result in an increase in net social benefits which then need to be weighed off against the cost of the research. In some cases, the research leads to government standards which eliminate the lower quality and sometimes hazardous good from the market. Direct benefits may be realized as lower medical costs if a hazardous good is removed.

(5) Nutrition Information. Research which leads to improved nutrition may cause a shift down in the supply curves for many goods and services due to a reduction in medical costs and increased labor productivity. Different types and amounts of food might be consumed following realization of the importance of certain nutrients and upon acquisition of information on the nutrient content of certain foods. In other words, nutritional information can affect the utility that a consumer perceives will be obtained from certain foods. This will result in a shift out in demand for certain foods and a shift in for others. Nutritional information can perhaps be thought of as a special case of the product quality case. Changes in net social benefits will result from the supply and demand shifts.

(6) Information to Aid in Adjustments to Disequilibria. Information which leads to more rapid adjustments to disequilibria results in more efficient use of resources so a greater bundle of goods can be produced with the same set of resources. Conceptual frameworks used to describe the benefits of management and price information can be used here with the added factor that returns realized today are worth more than the same returns realized tomorrow.

(7) Information to Aid in the Reductions of Rural Poverty. The value of research to reduce rural poverty is dependent in part on the weight placed on the equity goal. Rural poverty may also be partly a manifestation of a disequilibrium situation. To the extent that research efforts to reduce rural poverty have resulted in identifying its causes and recommending possible solutions, the benefits may be measured conceptually in terms of improvements in real income of the poorest segments of the rural populations.

Empirical Means of Evaluating Social Science Research

Eisgruber (1978) points out three approaches that have been used empirically to evaluate the value of information: the net social benefits approach, the decision theoretic approach, and the scoring approach. The conceptual framework in the last section lends itself most readily to the net social benefits approach. Eisgruber points out that while the idea of measuring changes in net social benefits by what we now refer to as changes in consumers and producers surplus has existed since the writings of Depuit, Hayami and Peterson were the first to use the approach in an analysis of the value of information. They examined the value of outlook information in the United States. Since then, Freebairn has extended this analysis to the evaluation of net benefits from more accurate price information.

The decision theory approach explicitly considers that the value of information is an outgrowth of the economic theory of uncertainty. Hirscheiffer points out that uncertainty is summarized by the dispersion of individual's subjective probability distributions over possible states of the world. Information consists of events tending to change these probability distributions.

The decision theoretic approach can be summarized as follows: A variety of actions are presumed to be open to the decisionmaker a_1, a_2, ... a_m. Several states of nature, S_1, S_2, ... S_n, are also possible and the decisionmaker has some knowledge of the likelihood (prior probability) of such states occuring, $P(S_i)$. With a given amount of knowledge, the decisionmaker will choose the action a_i^* which maximizes his expected utility. The expected utility of j^{th} action is $\Sigma_i\, u(a_j|S_i)\, p(S_i)$. Now if additional information, Z_1, Z_2, ... Z_m, becomes available to the decisionmaker and he has knowledge of the probability of the information coming true, i.e., $P(Z_j|S_i)$, then Bayes Theorem can be used to derive posterior probabilities of states of nature occurring, $P(S_i|Z_j)$. By Bayes Theorem:

$$P(S_i|Z_j) = \frac{P(S_i)\ P(Z_j|S_i)}{\sum_i P(S_i)\ P(Z_j|S_i)}$$

The revised expected value of a_j is now $\sum_i U(a_j|S_i)\ P(S_i|Z_j)$. The value of the information is the difference between the maximum utility with and without the information and this can be compared with the cost of obtaining the information.

The major problem with using this approach is in the estimation of subjective probabilities in the prior and posterior situations. Because of difficulties in obtaining these probabilities the approach has been used primarily for microproblems. The appropriate utility function must also be determined unless a linear utility function is assumed so that maximizing expected profits is equivalent to maximizing expected utility (Eidman, Carter, and Dean).

With the scoring approach, scientists and/or administrators are called upon to weight alternative research projects or problem areas according to several weighted evaluation criteria. Scoring systems can require a good deal of data and are very expensive in terms of time required of very busy people. (See USDA, Paulsen and Kaldor; Mahlstede; Shumway and McCracken for examples of scoring models used in agricultural research evaluation).

While there may be other means of evaluating returns to social science research, the three mentioned by Eisgruber (1978) appear to be among the most promising. In the next section, we provide an example in which the decision theory approach is used to evaluate returns to one type of agricultural economic research. This is followed by an illustration of how the net social benefits approach can be combined with the decision theory approach in research evaluation. An empirical example using the scoring approach is beyond the scope of this paper.

Application to Agricultural Economics Research

In this section we make use of decision theory to evaluate returns to price outlook information. Each fall agricultural economists at the University of Minnesota develop outlook statements for each of the major agricultural commodities in Minnesota. One part of the outlook projections is the expected price of each commodity over the coming marketing year. At the time the projections are made, the economists have a good idea of the size of current crops. They make price projections, therefore, based on the expected demand over the following months. They recognize that conditions change in unforeseen ways, but the outlook information provides a reference from which farmers can adjust their expectations. National and international factors are described in the outlook which might affect the price projections.

One of the crops for which outlook projections are made is soybeans. Each fall farmers must decide how to market their crop over the coming months. There are many different strategies open to them. Three common ones are: (1) to sell at harvest; (2) to store until spring, anticipating a seasonal price rise; and (3) to store at harvest, pricing the crop through the sale of futures. In this example, we illustrate how decision theory can be used to evaluate the return to soybean price outlook information developed to help farmers make this marketing decision.

The five components of a decision framework in which additional information is brought to bear on a problem are actions, states, calculation of a monetary payoff table, conversion to utility values, and estimation of prior and posterior probability distributions. In this example there are three possible actions:

a_1 = sell soybeans at harvest (October), a_2 = store soybeans and sell in the spring (May), and a_3 = store soybeans and sell in spring, but price them through the sale of July futures.

We will assume three possible states of nature: S_1 = the price in May more than covers storage costs (by \$.15/bu. or more); S_2 = the price in May just covers storage costs (\$.15/bu. less to \$.15 per bu. more); and S_3 = the price fails to cover storage costs (at least \$.15/bu. less than covers storage.)

A time series of cash and futures prices as well as storage costs are shown in Table 3. These data can be used to develop the payoff matrix of returns relative to sale at harvest (see Table 3a).

Optimally, one would like to convert the values in the payoff matrix to utility values. In our example, we will assume linear utility which enables us to use the payoff table directly. The prior probabilities of states of nature occurring should be the decisionmaker's subjective probabilities without knowledge of outlook projections. Farmers have a variety of information sources they draw upon such as farm magazines, their experiences and records, etc. These subjective probabilities can be elicited through a variety of means (Anderson, Dillon, and Hardaker) and should be obtained in conducting an evaluation of this sort. In our example, however, we will assume that farmers base their expectations on historical seasonal price movements. Prior probabilities, $P(S_i)$, are developed from the historical probabilities for the last 15 years and are shown in Table 3a. These can then can be combined with the payoff matrix to determine the expected value of each of the three outcomes. If no additional information were available, action two would be optimal and would have an expected value of \$.58 per bushel. This is found by multiplying each element in the payoff matrix by the appropriate $P(S_i)$ and then summing the values for each action.

Now, assume that farmers have access to the price outlook information. By looking at past outlook projections and actual states of nature which occurred, conditional probabilities can be developed $P(Z_j|S_i)$, *i.e.*, the probabilities of particular outlook projections given the states of nature which occurred in the past (see 3a). These conditional probabilities can then be used to calculate the posterior probabilities, $P(S_i|Z_j)$, *i.e.*, the probabilities of states of nature given the outlook by using Bayes formula

$P(S_i|Z_j) = \frac{P(S_i)P(Z_j|S_i)}{\sum_i P(S_i)P(Z_j|S_i)}$. The joint probability, $P(S_i)P(Z_j|S_i)$, is the product of the prior and conditional distributions and $_i\ P(S_i)\ P(Z_j|S_i)$ is obtained by summing the joint probabilities over all S_i for a particular Z_j (see Table 3c).

Applying the posterior probabilities to the original payoff matrix gives the expected value

Table 3: Price Data

Crop Year	Cash Price[a/] October	Cash Price[a/] May	Storage[b/] Cost	May Futures[c/] Oct 15	May Futures[c/] May 15	July Futures[c/] Oct 15	July Futures[c/] May 15	Outlook Predicted (May)	Gains and Losses: Cash[d/] Market	Gains and Losses: Futures Market (July)	Gains and Losses: Net
67-68	2.53	2.67	.17	2.73	2.73	2.74	2.73	2.50	- .03	+ .01	- .02
68-69	2.44	2.66	.16	2.62	2.67	2.62	2.71	2.50	+ .06	- .04	- .03
69-70	3.32	2.63	.16	2.58	2.68	2.59	2.70	2.35	+ .15	- .11	+ .04
70-71	2.83	2.92	.19	3.07	2.98	3.07	2.99	2.90	- .10	+ .08	- .02
71-72	3.09	3.49	.20	3.34	3.50	3.35	3.54	3.50	+ .20	- .19	+ .01
72-73	3.21	8.76	.21	3.44	9.07	3.46	8.37	3.00	+5.34	-4.91	+ .40
73-74	5.82	5.39	.38	6.18	5.45	6.19	5.52	5.50	- .81	+ .67	- .14
74-75	8.34	5.20	.55	9.04	5.22	9.05	5.09	6.50	-2.59	+3.96	+1.37
75-76	5.06	5.15	.33	5.57	5.22	5.62	5.27	5.00	- .24	+ .35	+ .11
76-77	6.19	9.41	.41	6.36	9.83	6.33	9.74	6.00	+2.81	-3.41	- .60
77-78	5.01	6.94	.33	5.35	7.37	5.42	7.22	6.25	+1.60	-1.80	- .20
78-79	6.56	6.99	.43	7.07	7.23	7.07	7.39	6.50	0	- .32	- .32

[a/] Mid month.

[b/] Storage costs based on 9% interest and 1.4% storage loss which = .066% for seven months.

[c/] 15th or closest date when market was open.

[d/] After subtracting storage costs.

of each action. The optimal action where each Z is predicted is circled in this last matrix. The expected value of the optimal strategy is (2.49).4 + (.02).33 + (.15).27 = \$1.046 per bushel. The value of outlook prediction compared to the situation where only the prior probabilities are used is \$1.046 - \$.584 = \$.462 per bushel. It should be emphasized that this value of \$.46 per bushel would be smaller if the average farmer's subjective prior probability distribution was more accurate than the distribution based on historical seasonal price movements which was used as a proxy.

One reason that the value of outlook information is so high is that the price of soybeans was extremely variable during the 1970s. During times of more stable prices, the value of outlook information would be less because the payoffs in the payoff matrix would be smaller. It is also necessary to predict states 1 and 3 correctly at least part of the time for the additional information to be valuable. To illustrate this point we can compare the value of the outlook predictions with that of the May soybean futures price in October. Conditional probabilities, joint probabilities, posterior probabilities, and expected values of using the posterior probabilities were developed for the May soybean futures for the same 12-year period. The resulting value of information was -\$.15 per bushel. Table 2 shows why there was no return. In 10 of 12 years, the futures market predicted (as one would expect) that state 2 would occur, *i.e.*, the price in May would just cover storage. In the other two years, it predicted that the price would more than cover storage (S_1) and, in fact, just the opposite (S_3) occurred. If decision-makers used both futures and outlook information, this would reduce the value of outlook information. It is also interesting to compare the value of a perfect predictor with the value of the outlook projections. If a perfect predictor was available, the posterior probability

Table 3.

a. **Payoff Matrix**

Actions

States of Nature (S_i)	a_1	a_2	a_3	Prior Prob. 1/ $P(S_i)$
S_1	0	2.49	-.10	.4
S_2	0	.02	-.07	.33
S_3	0	-1.55	.45	.27
Expected value of a_i using $P(S_i)$.	0	.584	.0936	

b. **Conditional Probability Matrix P(Z/S)**

Observations

(S_i)	Z_1	Z_2	Z_3
S_1	.5	0	.5
S_2	0	.6	.4
S_3	0	0	1

c. **Joint Probability Matrix P(S)P(Z/S)**

Observations

Prior Probabilities $P(S_i)$	Z1	Z2	Z3
.4	.2	0	.2
.33	0	.198	.132
.27	0	0	.27
P(Z)	.2	.198	.602

d. **Posterior Probability Matrix**

$$P(S/Z) = \frac{P(S)P(Z/S)}{P(Z)}$$

Observations

(S_i)	Z_1	Z_2	Z_3
S_1	1	0	.332
S_2	0	1	.219
S_3	0	0	.449

e. **Expected Value of Action Using Posterior Probabilities**

Posterior Prob's	Actions a_1	a_2	a_3	P(Si)	
					.996
$P(S_i/Z_1)$	0	2.49	-.10	.4	.01
$P(S_i/Z_2)$	0	.02	-.07	.33	.04
$P(S_i/Z_3)$	0	.13	.15	.27	1.046

Value of Outlook = 1.046-.584 = .46/bu

1/ Prior probabilities based on farmer looking at data for last 15 years.

Table 4. Payoff Matrix

Actions*

S_i	a_1	a_2	$P(S_i)$
S_1	-11.4648	2.0375	.25
S_2	-1.8614	.1372	.5
S_3	7.8733	-3.1754	.25
Expected value of A_i using $P(S_i)$	-1.8286	-.2159	

* Payoff values are in millions of 1978-79 dollars.

Table 5. Expected Value of Actions Using Posterior Probabilities

Actions

Posterior Probabilities	a_1	a_2	$P(S_i)$
$P(S_i/Z_1)$	-6.634	1.08164	.25
$P(S_i/Z_2)$	-1.8397	-.09584	.5
$P(S_i/Z_3)$	.65524	-1.0565	.25

distribution $P(S|Z)$ would show values of 1.0 down the diagonal (with zero elsewhere) and lead to an optimal strategy bundle of (a_2, a_2, a_3) with an expected value of (2.49).4 + (.02).33 + (.45).27 = 1.124. This value of information of the perfect predictor is 1.124 - .584 = .54.

Some words of caution are in order. First, a linear utility function was assumed. If farmers are concerned about risk as well as expected income, then this would affect the payoff matrix and the resulting value of information. Second, this analysis assumed that a correct prediction of state 1 is worth the same whether it occurs in a year when prices exceed storage by several dollars or by only 16¢. The expected value is the same but clearly the actual historical value was dependent on which years the outlook was correct.

For purposes of determining the aggregate value of this outlook information, it is necessary to determine total soybean sales affected by the outlook predictions. In an average year from 1969 to 1978 soybean production was 93.7 million bushels. It is very difficult to determine what percentage of farmers actually used outlook information. Eisgruber (1973) provides an estimate that 11% of farmers in Indiana and Illinois make use of the extension service for price outlook information. At the same time, very few farmers who use price outlook information from the university use only that information when making a soybean storage decision in October. However, other sources of information for farmers such as radio, newspapers, and farm magazines often base their price outlook on university projections. Therefore, for purposes of illustration assume that 10% of Minnesota soybean farmers use the university outlook projections exclusively and that these farmers also produce 10% of the Minnesota soybean production. This results in a value of soybean outlook information of 93.7 million x .46 x .10 = $4.3 million per year. One can compare this with the cost of doing the outlook research and extension. It appears that under any plausible cost assumption the return is extremely high.

The above example illustrates how the decision theory approach might be used to evaluate returns to social science research. It is oversimplified however, for a number of reasons. First, we have assumed that the farmers who use the outlook to decide whether to store receive either the price in October or the price in May for their soybeans. Second, it is likely that a smaller percentage of Minnesota soybean farmers use the outlook to make a hedging decision as compared to those who use it to make a storage decision. Third, and perhaps most important, we have assumed that the amount of soybean sales affected by the Minnesota outlook projections is small relative to total sales in the country. This allowed us to assume that the actions of those farmers who made use of the price projections did not affect the price in either period. In other words, we assumed that the affected farmers faced perfectly elastic demand for their soybeans. In the remainder of this paper, we alter these assumptions and recalculate the value of outlook information.

When one extends this analysis to the more general case and assumes that price is affected by sales activities of the farmers, he should then calculate the payoff in terms of changes in net social surplus. This must be done for each action-state combination in the payoff matrix.3/ How this would be done can be conceptualized with the aid of Figures 5, 6, and 7.

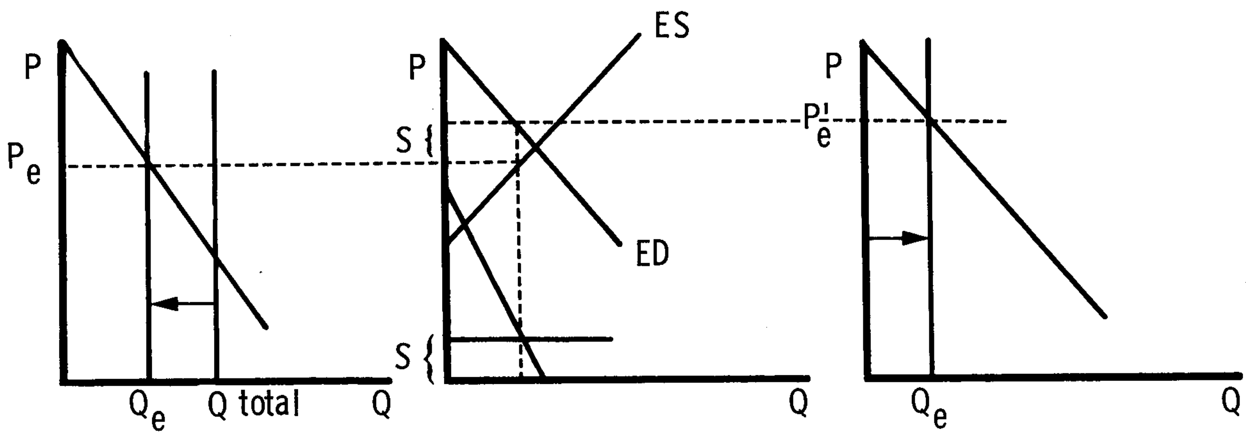
State 2 can be represented by Figure 5. The total supply of the commodity (Q_{Total}) would be allocated so that Q_e were sold in the fall and Q_e' in the spring. The eqilibrium price in the spring (P_e') would be higher than the price in the fall (P_e) by an amount equal to the storage cost (S).

State 1 represents a situation when too much is sold in the fall (Figure 6). The observed price (P_2) would be below the optimum price (P_e) in the fall and above the optimum price (P_e') in the spring. Consumers would gain A + B in the fall and lose C + D in the spring. The change in producer surplus would be E - A in the fall and -F + C in the spring.

In the situation where state 3 occurs, too little is sold in the fall (Figure 7). The observed price (P_2) would be above the optimum price (P_e) in the fall and below the optimum price (P_e') in the spring. Consumers lose A + B in the fall and gain C + D in the spring. The change in producer surplus is A - E in the fall and F - C in the spring.

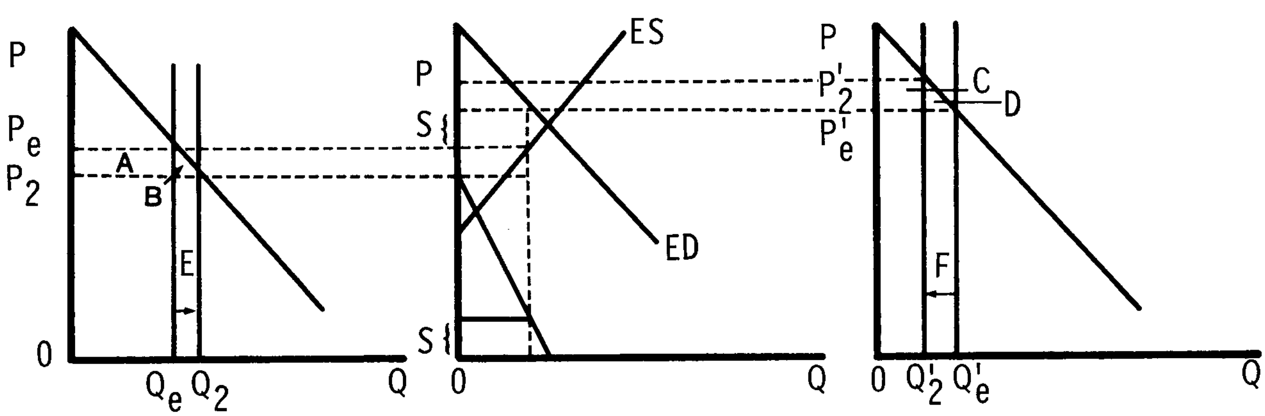
Suppose farmers who use price outlook information sell 10% of the total production of the commodity. If they take action 1, i.e., sell all their grain in the fall, this would move the projected supply curve in the fall to the right by 10% of the projected spring sales. The effect on consumers and producer surplus can be calculated by comparing the old projected position of the fall supply curve to one 10% to the right for each state of nature, and the new projected position of the spring supply curve to one 10% to the left of the old projection. If farmers using outlook information took action 2, a similar analysis could be made with the curve shifting in the opposite direction. The projected original positions of the curves can be based on the observed location when each state of nature occurred over the past few years. One extension of this analysis would be to simulate the effect on benefits of varying the percentage of farmers

Figure 5.



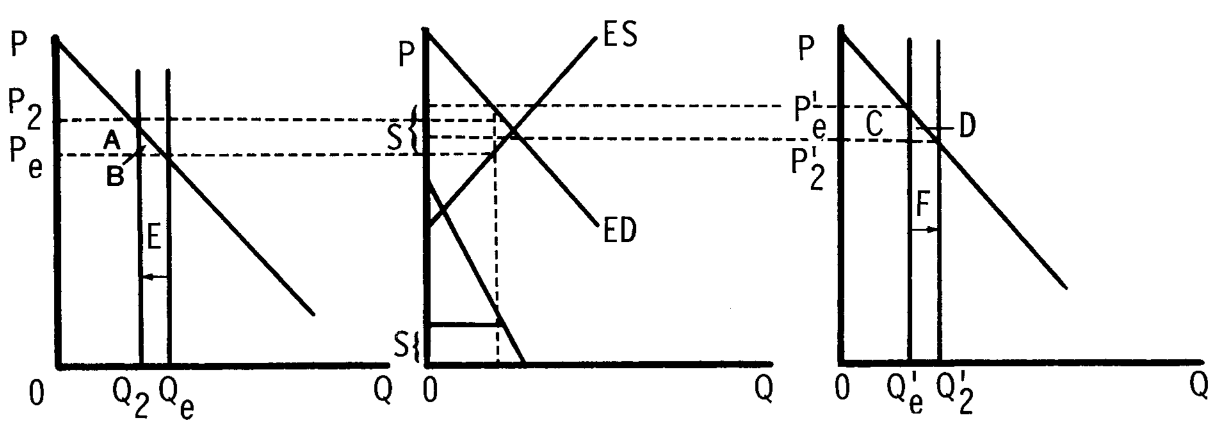
Supply & Demand, Fall | Excess Supply & Demand | Supply & Demand, Spring

Figure 6.



Supply & Demand, Fall | Excess Supply & Demand | Supply & Demand, Spring

Figure 7.



Supply & Demand, Fall | Excess Supply & Demand | Supply & Demand, Spring (production affected) using the outlook information. An example is provided below.

A Minneapolis October-June average soybean price is projected each fall at the University of Minnesota. Assume that farmers face the same states of nature described earlier in the paper 4/ and that they have the option of taking actions (1) selling all their beans at harvest in period t-1 (October), (2) storing beans and selling them during period t (November-June), (3) storing beans and selling them from July-September. Furthermore, assume that the outlook projections do not affect the quantities of beans sold in July to September. Assume linear demand curves for soybeans as represented in Figures 5, 6, and 7 and in Equations (1) and (2) below:

(1) $Q_t = a - bP_t$ or in inverse form

$$P_t = \frac{a}{b} - \frac{Q_t}{b}$$

(2) $Q_{t-1} = \gamma - \beta P_{t-1}$ or in inverse form

$$P_{t-1} = \frac{\gamma}{\beta} - \frac{Q_{t-1}}{\beta}$$

The Q_t, Q_{t-1}, P_t, and P_{t-1} are national quantities and prices. A fixed supply of soybeans is to be allocated between two periods, October (period t-1) and November-June (period t). The elasticity of demand for soybeans (e) is approximately -.3 (Houck, Ryan and Subotnik). Therefore,

$$e = b\frac{P_t}{Q_t} = -.3 \qquad e = \frac{\beta P_{t-1}}{Q_{t-1}} = -.3$$

$$b = -.3\left(\frac{Q_t}{P_t}\right), \qquad \beta = -.3\left(\frac{Q_{t-1}}{P_{t-1}}\right)$$

$$a = Q_t + b\,P_t \qquad \gamma = Q_{t-1} + \beta P_{t-1}$$

The consumer surpluses in the two periods are $CS_{t-1} = \int_0^{Q_{t-1}} P(Q)\,\partial Q$ and $CS_t = \int_0^{Q_t} P(Q)\,\partial Q$.

Total consumers surplus is $CS_t + CS_{t-1} = Z$.

$$(3)\quad Z = \frac{a}{b}Q_t - .5\frac{1}{b}Q_t^2 + \frac{\gamma}{\beta}Q_{t-1} - .5\frac{1}{\beta}Q_{t-1}^2 - S_tQ_t$$

where S is the storage cost.

By maximizing (3) one gets the maximum net social surplus (A^{max}) as represented in Figure 5. Each year there is an observed net social surplus (Z^{obs}) represented in (4):

$$(4)\quad Z^{obs} = \frac{a}{b}Q_t^{obs} - .5\frac{1}{b}(Q_t^2)^{obs} + \frac{\gamma}{\beta}Q_{t-1}^{obs} - .5(Q_{t-1}^2)^{obs} - S_tQ_t^{obs}$$

$$(5)\quad Z^{max} - Z^{obs} \geq 0$$

The Q_t, Q_{t-1}, P_t, and P_{t-1} are national quantities and prices. Now, assume that soybean price outlook information is used by 10% of the Minnesota farmers (affects 10% of Minnesota soybeans).

Let Minnesota quantities be represented by $\hat{Q}_t$ and $\hat{Q}_{t-1}$. If farmers take action 1 and state 1 occurs, the following net social surplus results:

$$(6)\quad Z_{s_1}^{action\ 1} = \frac{a}{b}(\hat{Q}_t - .1\hat{Q}_t) - .5\frac{1}{b}(\hat{Q}_t - .1\hat{Q}_t)^2 + \frac{\gamma}{\beta}(Q_{t-1} + .1\hat{Q}_t) - .5\frac{1}{\beta}(Q_{t-1} + .1\hat{Q}_t)^2 - S_t(Q_t - .1\hat{Q}_t).$$

The payoff from this action 1, state 1 combination is $Z_{s1}^{action\ 1} - Z_{s1}^{obs}$ when the Q's and P's are historical values for the years when state 1 occurred. An equation similar to (5) must be set up for each action-state pair.

National and state soybean data for 1967-68 and 1978-79 were used to calculate the necessary quantities, prices, coefficients, Z's, etc. (See Appendix Table 1). A payoff matrix was assembled from the subsequent calculations (see Table 4).

Table 4. Payoff Matrix

Actions*

S_i	a_1	a_2	$P(S_i)$
S_1	-11.4648	2.0375	.25
S_2	-1.8614	.1372	.5
S_3	7.8733	-3.1754	.25
Expected value of A_i using $P(S_i)$	-1.8286	-.2159	

*Payoff values are in millions of 1978-79 dollars.

A new set of prior and posterior probabilities were calculated and the value of outlook information was calculated (see Appendix Table 2). The expected values of actions using posterior probabilities are shown in Table 5.

The resulting net social value of the outlook information is $602,200 (1978-79 dollars). This figure can be compared with the cost of providing the outlook information and a rate of return estimated. Assuming soybean research required two weeks of researcher's time and that a scientist man-year is valued at approximately $100,000, the annual research cost would be $4,000. Additional costs are incurred for printing and extension activities, but the total annual cost would likely be under $10,000. There are also some costs associated with past research that provided a background for this analysis. The annual return is very high indeed.

Table 5. Expected Value of Actions Using Posterior Probabilities

	Actions		
Posterior Probs.	a_1	a_2	$P(S_i)$
$P(S_i \mid Z_1)$	-6.634	1.08164	.25
$P(S_i \mid Z_2)$	-1.8397	-.09584	.5
$P(S_i \mid Z_3)$	.65524	-1.0565	.25

The above example assumed that 10% of Minnesota soybeans are affected by the outlook information. The payoff was recalculated assuming the percentage was only 1%. The resulting value of information was $116,640 (1978-79 dollars), still a very high return to the outlook research and extension.

The decision theory and net social benefits approach could potentially be employed to evaluate other types of social science research. For example, it may be possible to evaluate certain types of policy research using a similar framework. It would be very important in such evaluations to specify the goals of the policy. A price support program and a particular support level suggested by research, for example, might be aimed at (1) maintaining farmers' income at a certain level, (2) maintaining low food prices, (3) minimizing the cost to the government (taxpayers), or some other goal. It is necessary to know the weights placed on these goals before one can measure the deviations from an optimum situation. Another problem with policy research evaluation is the difficulty in tying the causality of government action to research. There may be cases where research indicates a certain action would be optional from an economic standpoint but something else is done for political reasons.

Conclusion

There are a number of problems such as defining goals, measuring outputs, and determining causality between social science research and subsequent human actions which make social science research evaluation difficult. There is potential, however, to use decision theory and/or net social benefits approaches to provide quantitative estimates of economic benefits to certain types of social science research.

Footnotes

1/RPAs 705, 801, and 907 undoubtedly contain large non-social science-components as well.

2/It is difficult to know how much agricultural economics research is included in these RPAs without looking at specific projects. This 5% figure is most likely an upper bound since much of RPAs 108, 501, and 603 are probably not agricultural economics research.

3/In this case it is necessary to assume at the start of the analysis the amount of the commodity affected by the outlook information as this influences the level and distribution of gains and losses between producers and consumers. In the earlier example with perfectly elastic demand we worked with the per bushel payoffs and waited until the end to make the assumption about the amount of the commodity affected.

4/We assume however, that a deviation of $.10 from covering storage cost rather than $.15 defines these states.

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APPENDIX TABLE 1 - DATA

Crop Year	Mpls Price (Oct)	Mpls Price (Oct-June)	Mpls Price (Oct-June) Predicted	Average[1/] Storage Cost (Nov-June)	US Price (Oct)	US Price (Nov-June)	US Quantity (Oct) (1000 bu)	US Quantity (Nov-June) (1000 bu)	MN Quantity (Oct) (1000 bu)	MN Quantity (Nov-June) (1000 bu)	Cost[2/] Index
67-68	2.52	2.59	2.50	.11	2.44	2.50	272,416	573,147	18,206	37,113	2.17
68-69	2.44	2.53	2.50	.10	2.32	2.46	211,067	661,986	11,377	45,506	2.17
69-70	2.30	2.45	2.35	.10	2.23	2.39	320,573	685,670	16,722	45,605	2.08
70-71	2.83	2.90	2.90	.12	2.77	2.89	262,614	737,123	16,544	46,480	2.01
71-72	3.06	3.20	3.40	.13	2.96	3.03	291,673	756,233	11,509	42,840	1.92
72-73	3.21	4.81	3.25	.13	3.13	4.71	292,240	902,132	17,157	66,822	1.79
73-74	5.82	5.71	5.50	.24	5.63	5.24	294,003	1,055,424	22,394	80,867	1.48
74-75	8.34	6.46	6.50	.35	8.17	6.26	291,909	739,502	15,286	50,952	1.31
75-76	5.06	4.96	5.25	.21	4.92	4.65	311,024	999,609	17,739	61,101	1.19
76-77	6.19	7.64	5.70	.26	5.90	7.12	288,413	854,873	10,630	47,172	1.13
77-78	5.01	5.88	6.00	.21	5.28	6.02	324,163	1,226,181	21,414	95,023	1.08
78-79	6.48	6.68	6.50	.27	6.26	6.83	462,504	1,118,487	29,841	90,944	1.00

1/ Storage cost based on 9% annual rate of interest for an average of 4 months plus 1% loss and damage + .05 percent per month = 4.2% of the October price.

2/ Based on USDA cost of production index. Prices in this table are multiplied by this index before calculating payoffs.

Appendix Table 2. PROBABILITIES

Conditional Probabilities P(Z/S)			
	Observations		
(S_i)	Z_1	Z_2	Z_3
S_1	.33	.33	.33
S_2	.167	.67	.167
S_3	0	.33	.67

Joint Probabilities P(S) P(Z/S)			
	Observations		
$P(S_i)$ 1/	Z_1	Z_2	Z_3
.25	.0825	.0825	.0825
.5	.835	.3350	.0835
.25	0	.0825	.1675
P(Z)	.166	.5	.3335

Posterior Probabilities P(S/Z)			
	Observations		
S_i	Z_1	Z_2	Z_3
S_1	.497	.165	.247
S_2	.503	.67	.25
S_3	0	.165	.502

1/ Prior probabilities based on frequency of (S_i) from 1967-68 to 1978-79