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ASSESSING RETURNS TO AGRICULTURAL EXTENSION

by Wallace E. Huffman

In a technically and economically dynamic environment, extension has the potential for enhancing the efficiency of production. Although extension was formalized and given federal financial support by the passage of the Smith-Lever Act in 1914, the literature reporting on reasonably rigorous attempts at ex post evaluations of agricultural extension has begun only recently to emerge. In earlier studies (e.g., Griliches (1964) and Evenson (1968)), expenditures on research and extension were aggregated together, and the total was used as one of the variables for explaining the growth in agricultural output (or productivity).

The objective of this paper is to present an assessment of the returns to investments in agricultural extension.^{1/} This assessment is based primarily on a survey of published research that has investigated the separate contribution of agricultural extension to agricultural production and to resource allocation. The main conclusion is that the returns to extension, at least in the United States, are modest or better.

The paper is organized as follows. The first section reviews some economic models that incorporate extension as an explicit variable and discusses the direction of potential biases in previous estimates of returns to extension. The final section presents conclusions.

AN ASSESSMENT

Two different approaches to evaluation -- ex post and ex ante -- seem potentially useful in assessing the performance of public-sector extension. Policy makers are aided by good ex ante evaluations. They need to know the expected effects of alternative resource allocation policies. Good ex ante evaluation is, however, very difficult because it requires predicting future advances in technology and future problems arising from often unforeseen weather, agricultural pest, and market conditions. These predictions are subject to large errors, which reduce considerably the potential value of ex ante evaluations.

Researchers have developed some widely accepted rigorous methods for ex post

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evaluations. Most economic analyses involve developing and fitting models to historical data.^{2/} In these analyses, there is an attempt to find and statistically test for meaningful relationships between inputs of extension resources and some type of end results; e.g., output, profit, income, etc. The federal Extension Service has taken an alternative and more sociological approach to ex post evaluation (U.S. Dept. Agr. 1977). Greater emphasis is placed on intermediate ends; e.g., number of activities, and of people involved; opinions about activities; knowledge, attitudes, skills, aspirations, and practices changed. This emphasis on intermediate ends, which are of limited value themselves, has the potential for diverting attention and research away from the fundamental question of what are the returns to investments in extension. In this paper, an assessment of returns to extension is limited to ex post evaluations of the contribution of public-sector agricultural-extension input to agricultural production.

Economic Models

In a technically and economically dynamic environment, agricultural extension has the potential for enhancing technical and allocative efficiency of agricultural production. Both public and private institutions are engaged in supplying information to farmers. In public sector extension, agricultural extension personnel assemble, organize, and interpret market information and simplify technical information for dissemination to farmers. Also, they demonstrate new techniques and consult directly with farmers on specific production and management problems. The contribution of extension to enhancing the efficiency of agricultural production crucially depends on the dynamic nature of agriculture, which partly depends on the output of basic and applied agricultural research, the quality (and quantity) of extension personnel, the education level of farmers, and the knowledge gap between applied researchers and farmers. Agricultural extension activities might be viewed as attempting to close this knowledge gap.

Representatives of private firms engage in activities similar to those of public-sector extension. One might hope that publicly supported agricultural extension provides information that is objective and oriented closely to aiding farmers meet their objectives, rather than to meeting the objectives of private nonfarm firms.

Public-sector extension information has the potential for enhancing the efficiency of agricultural production. Consider the effect of extension on the efficiency of a competitive farm firm that produces two or more final products, uses two or more variable inputs, and one or more fixed inputs. There are two dimensions of efficiency -- technical and allocative. Extension increases technical efficiency if, for a given bundle of inputs, added extension information increases one or more final products, leaving the other final products unchanged. Thus, technical efficiency is measured against an output standard. Extension increases allocative efficiency if, for a given level of technical efficiency, added extension information increases firm profit, other things equal. In a dynamic environment, this increased profit might arise from correcting a failure of one or more of the following conditions for profit maximization: (1) marginal rate of product transformation equals the ratio of relative output prices, (2) marginal rate of substitution between pairs of variable inputs equals the ratio of relative input prices, and (3) value of the marginal product of each input is equal across separable production activities and equal to the marginal factor price for variable inputs.

Attempts to assess the marginal products of (or returns to) agricultural extension have concentrated almost exclusively on some form of production function estimation. Exceptions, however, are the attempts to incorporate the effect of extension into an adjustment function of a dynamic model (Huffman 1972, 1974, and 1977).

Production Functions

Agriculture is a multiproduct industry, and farms are multiproduct firms. Let Y be a vector of $m \geq 2$ final products, X be a vector of n variable inputs ($n \geq 2$), Z^0 be a vector of fixed inputs or endowments, and E a vector of environmental variables, including extension. Most studies attempt to explain the total value of farm output from aggregate or microdata; i.e., $Y^* = \sum_{i=1}^m P_i Y_i$ where P_i is the price received by the firm for Y_i . By estimating an empirical specification of $Y^* = \sum_{i=1}^m P_i Y_i = F(X; Z^0, E)$, one can test the hypothesis that extension contributes to the efficiency of agricultural production. In this multiproduct framework, the marginal product of extension is, however, a partial measure

of a combination of technical and allocative efficiency effects.^{3/}

Most empirical studies have chosen a functional specification between the total value of farm output and extension of the following type:

$$1) \ln Y^* = A + B \ln X + C \ln Z^o + g \text{ Ext}$$

where A, B, C, and g are unknown parameters, and Ext is a measure of agricultural extension. This functional specification implies that the marginal production of extension is proportional to the total value of farm output, the marginal product is increasing as extension increases, and the marginal product increases as the size of farm output increases.

Adjustment Functions

An alternative model and one more suited to exploring the effects of extension on allocative efficiency is a dynamic model in which extension affects the rate of adjustment to disequilibria. Consider the three equations relating to the n factor demand functions for X of a competitive firm:

$$2) X_{it}^* = D_i (P_t^*; Z^o, E), i = 1, \dots, n$$

$$3) X_{it} - X_{it-1} = \beta_i (X_{it}^* - X_{it-1}), 0 \leq \beta_i \leq 1,$$

$$4) \beta_i = \beta_i(E).$$

The demand function for input X_i in time period t (X_{it}^*) is a function of a vector of anticipated farm input and output prices (P_t^*), a vector in inputs fixed to the firm (Z^o), and a vector of environmental variables (E), including extension. The adjustment or reaction equation (3) specifies that the change in usage of the i-th variable input between time period t and t-1 is proportional to the gap between the demanded quantity X_{it}^* and the actual quantity in period t-1. The adjustment coefficient β_i summarizes the rate that farmers adjust actual input usage to the optimal usage. The novelty of the model is that the adjustment coefficient is specified as a vector of environmental variables, E, including extension. The variable adjustment specification of the dynamic model permits a test of the hypothesis that agricultural extension enhances adjustment to changes in economic incentives, which is one aspect of allocative efficiency.^{4/} Closing the disequilibrium gap increases farm profit.

Empirical Analyses

The size of constant dollar U.S. expenditures on public sector extension has a persistent upward trend of about 4 percent per annum over the period 1930 to 1975 (Table 1). Although extension expenditures cover nonagricultural production areas -- 4-H activities, home economics, etc., it is useful to compare the relative distribution of expenditures on extension with the distribution of farms by agricultural production region. This comparison is instructive even though the total share of the extension budget allocated to agricultural extension changes over time, if the share of total expenditures on agricultural extension activities remains similar over the regions. This comparison assumes, however, that average constant dollar expenditures per farm is a meaningful measure of the cross-sectional intensity of agricultural extension. With this measure, the Northeast, Mountain, and Pacific regions have had persistently above average extension intensity, and the Lake states, Northern Plains, and all regions of the South (for 1930 and 1955) have had below average intensities. Furthermore, the changing distribution of farms is slow to be reflected in the distribution of extension expenditures. For example, between 1930 (1955) and 1975, the Corn Belt, Lake states, and Northern Plains have shown a 17.7 (15.2) percentage point gain in the share of all farms in the United States, but these states show as a group, a -1.4 (0.5) percentage point fall (gain) in the share of expenditures on extension.

Cline provides estimates of agricultural production-oriented extension expenditures for production regions. I have deflated these data by the number of farms in the region to obtain a second measure of the changing intensity of agricultural extension. These data show dramatic increases in the intensity of extension, which are the result of steadily increasing real expenditures and a large decline over the period in farm numbers. The Northeast, Southeast, and Delta states regions have shown the most dramatic rise in intensity of extension, and the Lake states, Corn Belt, and Northern Plains regions have shown the smallest increase.

The quality of extension information and the demand for information by farmers seems likely to be related to the output of agricultural research. Column (5) of table 1 provides

Table 1. Distribution of Expenditures on Public Sector Extension by Agricultural Production Region:
1930-1955-1975.

Region - fiscal year	Total exp. on extension, constant 1967 dollars (\$1000)	Percent of U.S. total		Estimated prod.- oriented exten. per farm (const. 1967 \$1 farm)	Ratio of State Agr. Exp. Sta. expenditures to est'd prod.-oriented extension expenditures
		Extension expenditures	No. of farms		
U.S. (48 states)	(1)	(2)	(3)	(4)	(5)
1930	48,195	100.0	100.0	4.3	1.18
1955	121,273	100.0	100.0	9.3	2.45
1975	276,431	100.0	100.0	62.5	2.75
Northeast					
1930	9,347	19.4	8.5	9.9	1.38
1955	18,057	14.9	7.9	17.6	2.72
1975	38,069	13.8	6.3	136.5	2.57
Lake states					
1930	3,596	7.5	8.5	3.8	1.45
1955	10,337	8.5	9.6	8.3	2.78
1975	23,419	8.5	12.3	43.2	2.95
Corn Belt					
1930	8,349	17.3	17.3	4.3	1.16
1955	17,501	14.4	18.8	7.2	2.28
1975	39,862	14.4	25.9	34.7	2.40
Northern Plains					
1930	3,349	6.9	7.3	4.1	1.11
1955	8,372	6.9	7.2	8.9	2.39
1975	20,484	7.4	12.6	36.9	2.83
Appalachian					
1930	5,859	12.2	16.3	3.2	0.79
1955	18,200	15.0	18.2	7.7	1.45
1975	40,769	14.7	12.6	73.1	1.96
Southeast					
1930	4,725	9.8	11.6	3.7	0.89
1955	12,081	10.0	11.0	8.5	2.54
1975	31,538	11.4	6.1	116.4	2.87
Delta states					
1930	3,414	7.1	11.4	2.7	0.76
1955	9,608	7.9	9.9	7.5	1.99
1975	20,171	7.3	4.5	101.4	2.67
Southern Plains					
1930	3,528	7.3	11.1	2.9	1.01
1955	9,177	7.6	8.6	8.2	2.10
1975	20,621	7.4	9.1	51.1	2.26
Mountain					
1930	3,219	6.7	3.8	7.5	1.54
1955	7,539	6.2	3.8	15.4	2.87
1975	20,231	7.3	5.3	85.9	2.84
Pacific					
1930	2,811	5.8	4.2	6.1	1.94
1955	10,401	8.6	5.1	15.8	4.11
1975	21,268	7.7	5.3	91.5	5.21

Sources: Cline for 1930 and 1955 and unpublished Federal Extension table and U.S. Dept. of Agr. (1976) for 1975.

data on the ratio of state agricultural experiment station expenditures to expenditures on public sector production-oriented agricultural extension. These data show, for all regions, an increase from 1930 to 1975 in the research-to-extension intensity. Except for the Appalachian and Southern Plains regions, which are relatively extension intensive, and Pacific region, which is relative research intensive, the other seven regions have similar agricultural research-to-extension intensities.

Studies by Griliches (1964), Evenson (1968), and Cline (1973) report ex post estimates for the United States of rates of return to combined investments in agricultural research and extension. In the 1970s, several studies have reported ex post analyses of the separate contribution of agricultural extension to agricultural production and resource allocation. These studies, although they are not limited to the United States, are summarized in table 2. Four of the studies are for the United States, two are for India, and one each is for Brazil, Kenya, and the Philippines. All studies present estimates of returns to extension derived from an estimated agricultural production function, except for Huffman 1974 and 1977, which report returns to extension derived from an estimated adjustment model.

In assessing the returns to extension, four major potential sources of bias must be considered. First, all the effects of extension cannot be captured in one empirical model. One reason is that our methods for estimating one type of effect of extension on efficiency often preclude the estimation of other effects. For example, when the marginal product of extension is obtained from an estimated production function, the returns to extension from its effect on factor choice are missed because the inputs are included in the estimated equation as independent variables. Thus, a single comprehensive estimate of the marginal product of extension is generally impossible, and adding up separate effects creates potential problems with omissions and double counting. To the extent that some of the positive effects of agricultural extension are omitted, the returns to extension will be biased downward. None of the studies in table 2 report comprehensive estimates of the different effects of agricultural extension.

Table 2. Summary of Returns to Extension

Study	Country (data set year)	Type study	Conclusion
1. Patrick and Kehrberg (1973)	Brazil-Eastern (1968)	Production function	Extension, number of direct contacts of farmers with extension agents during the study year, had positive but generally not statistically significant effects on value added in farm production.
2. Evenson and Jha (1973)	India (1953-54 to 1970-71)	Productivity change	Extension, index of maturity of extension program, contributes significantly to agricultural productivity change only through interaction with research programs. Investment in extension programs yields a 15-20 percent social rate of return.
3. Huffman (1974)	U.S.A. Corn Belt (1959-64)	Allocative efficiency-production	Extension (days, average for 1958 and 1960, allocated to crops by agents doing primarily agricultural work) and education are substitutes in inducing optimal nitrogen fertilizer usage on hybrid corn. The marginal value of extension time on this one decision is estimated at \$4.48 per hour of extension agent time allocated to crops or a social rate of return of 1.3 percent. Total social return from enhanced decision-making suggested to be in excess of 16 percent.
4. Mohan and Evenson (1975)	India (1959-60 to 1970-71)	Productivity change	The Intensive Agricultural Districts Program (presence vs. absence) contributed to more rapid agricultural productivity change. The social rate of return realized on the investment was 15-20%.
5. Huffman (1976a)	U.S.A.-Ia, N.C., Okla. (1964)	Production function	Extension, agent days allocated 3 years earlier to crops and livestock activities by agents doing primarily agricultural work, contributes significantly to level of agricultural production. The marginal product of extension is \$1,000-3,000 per day.
6. Moch (1976, 1978)	Kenya-Vihiga, a western division (1971)	Production function	An index of crop related extension contact with male and female farm operators during the last year contributes significantly to corn (maize) yields. Extension and education are substitutes in corn production; extension interacts positively with the rate of nitrogen fertilizer application on male operated farms (1978).
7. Huffman (1976b)	U.S.A.-Ia, N.C., Okla (1964)	Production function	Same as for Huffman (1976a) except marginal product of extension \$1,000-2,500 per day.
8. Halim (1977)	Philippines-Laguna Province (1963-68-73)	Production function	An index of extension contact with farms, derived by weighting frequency of contact over previous 5 years, contributes positively and significantly to agricultural production. Marginal products imply a "relatively high return of extension contact."
9. Huffman (1977)	U.S.A.-Corn Belt (1959-64)	Allocative efficiency	Same as Huffman (1974) except marginal value of extension time on this one decision is estimated at \$600 per day of extension agent time allocated to crops or a social rate of return of 110 percent.
10. Evenson (1978)	U.S.A. (1949-71)	Productivity change	Extension, expenditures per commodity per region, interacts negatively with education and positively with applied research. The rate of return to extension is 110 percent.
11. Huffman (1978b)	U.S.A.,-Ia, N.C., Okla. (1964)	Production function	Extension is measured as days allocated to crops, livestock, and planning and managing farm businesses and as days allocated to the separate components. Emphasis is placed on holding factors constant that may be correlated with the extension variables. Marginal product of extension is sensitive to output mix (livestock vs. crop), ranging from very large to negative values. Crop extension performs better than other components.

Second, extension contact with farmers probably creates a form of capital that affects the efficiency of production for more than one period. Although information supplied by extension workers and demanded by the farmers is time and subject specific, the useful information content seems likely to last longer than one year. Thus, it is not the extension contact during one year that affects the efficiency of production, but it is the accumulated net investment in extension information or the stock of useful information. Let the gross input of extension in year t be E_t^* , let benefits start immediately, and let the annual depreciation rate because of changing technology and changing market and environmental conditions be δ . The relevant stock of extension is $Ext_t = \sum_{i=0}^{\infty} (1-\delta)^{t-i} E_{t-i}^*$; i.e., a weighted summation of current and past contact between farmers and county extension agents. To illustrate the nature of the bias, assume that E_t^* is equal for all t (i.e., $E_t^* = E^*$); then $Ext_t = E^* \sum_{i=0}^{\infty} (1-\delta)^{t-i} = E^* / [1 - (1-\delta)] = E^* / \delta$. If extension is measured empirically as $E^* (= \delta EXT_t)$, rather than as Ext_t , then the least-squares estimate of the coefficient of E^* in a linear regression equation like equation (1) is, in general, a biased upward estimate of the "true" coefficient of Ext_t . The magnitude of the bias is $1/\delta$. For example, if the annual depreciation rate on extension contact is 50 percent, $\delta = 0.5$, the bias is 2; i.e., the estimated coefficient and marginal product of E^* is twice as large as the "true" coefficient and marginal product of Ext_t .

From a benefit-cost perspective, the bias is not this serious. When extension creates a capital input, the contribution of extension contact in any one year to output is distributed over several years. Assuming a 50 percent depreciation rate and a 15 (5) percent discount rate, one dollar of benefits appropriately distributed over current and future years has a present discounted value of \$0.89 (\$0.96). Thus, if one compares benefit-cost ratios, treating extension as a current input rather than a capital input causes an upward bias of roughly 5-10 percent. Because of the different empirical measures of extension for the studies summarized in table 2, care is required in drawing implications from the findings.

The third major potential source of bias arises from the interaction of research and

extension in agricultural production. The development of agricultural technology and quality of extension information seems likely to depend on agricultural research. We expect research and extension to interact positively in contributing to agricultural production, and failure to account for this interaction creates a specification error in a regression equation. The result is biased estimates of the coefficients of the included variables. I expected the bias of the coefficient of extension to be positive. Evenson and Jha (1973) and Evenson (1978) are the only studies to consider explicitly the research extension interaction.

The final major source of bias arises from the fact that private-sector information may be correlated with public-sector agricultural extension, but private-sector information is excluded from the empirical analyses because data are not available. If the information capital created from private-sector information and from public-sector extension has a positive effect on the efficiency of agricultural production, then the estimated coefficient of the public-sector extension variable will be biased upward by the exclusion of the private sector information variable. All the returns summarized in table 2 seem likely to be biased upward by the omission from the empirical analyses of private-sector information.

When these potential sources of bias are taken into consideration,^{5/} the rate of return to agricultural extension seems to be modest or better in the United States, modest in India, and difficult to assess in the other studies.

CONCLUSIONS

Although recent studies have added significantly to our understanding about the contribution of agricultural extension to agricultural production and decision making, further research is needed to guide public and private decision making. Some important research areas are:

- 1) Determine the type of interaction between education levels of farmers, agricultural extension, and agricultural research. To what extent are they complements to or substitutes for one another?

2) Determine the extent of differential effects of extension information on farms of different size.

3) Determine the relative magnitude of the technical and allocative effects of agricultural extension and determine how these effects depend on the output mix of farms and the quality of agricultural research.

4) Reinvestigate the contribution of extension to agricultural production by using more recent data, especially for the United States. This would permit us to check for significant changes in the marginal product of extension overtime.

5) Determine the extent to which private information sources substitute for or complement extension information.

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FOOTNOTES

* For the American Agricultural Economics Association meetings. Blacksburg, Virginia, August 6-9, 1978. Some parts of this paper draw from Huffman (1978). The author is Associate Professor of Economics, Iowa State University. Journal Paper No. J-9270 of the Iowa Agriculture and Home Economics Experiment Station. Project 2078.

1/ By agricultural extension, I mean the activities of extension directed to the dissemination of information on crops, livestock, and planning and managing farm businesses. This definition excludes extension activities directed to the dissemination of information on a wide range of other important topics.

2/ Some economic studies perform "cost-benefit" calculations that are of a nonstatistical nature.

3/ In a gross output formulation, allocative effects are captured only through the effects that E has on the choice of the output mix (and perhaps on the prices received for final products). A value-added or profit definition of "output" provides a potentially better specification for capturing a wider range of efficiency effects.

4/ This model also is applicable to the empirical analysis of adoption of new inputs or technology.

5/ Market prices might not reflect the marginal social value of agricultural output. The rest of the economy might not readily absorb resources released from agriculture.