AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

RATES OF RETURN TO AGRICULTURAL RESEARCH AND EXTENSION IN THE SOUTHERN REGION

Fred C. White and Joseph Havlicek, Jr.

The interregional transfer of agricultural research results has long been recognized by sociologists and economists [10, pp. 524-526]. The first major economic study in this area was reported in 1957 by Griliches [7]. However, many economists have failed to account for this type of transfer in estimating rates of return for agricultural research investment at the state level. A possible explanation for the failure to account for this transfer is that many analyses at the state level are modeled after national studies. Though researchers estimating a national rate of return may not feel a need to account for interregional transfers, these transfers clearly cannot be ignored at the state or regional levels. Latimer and Paarlberg [9] and Bauer and Hancock [2] estimated aggregate production functions for states and had difficulty finding a statistically significant relationship between research expenditures within the state and agricultural output. Bauer and Hancock finally estimated a lagged relationship that is in conflict with other conceptual and empirical models. Latimer and Paarlberg concluded that research is so pervasive that there are no measurable differences in levels of farm income attributable to differences in research inputs by states [9, p. 239]. More recently, Bredahl and Peterson [3] examined the differences in rates of return to cash crops, dairy, poultry, and livestock research among states. These estimates are appropriate if agricultural research results are limited by state boundaries. The interregional transfer of agricultural research results needs to be taken into account in estimating the returns to agricultural research at a regional level.

The objective of this article is to estimate the effect of investments in agricultural research and extension on agricultural production in the Southern region.[1] The authors estimate the separate effects of investments in agricultural research and extension within the region and of agricultural research outside the region. This approach provides estimates of the marginal rate of return on regional investments in agricultural research and extension net of interregional effects. Also, the effects arising from a failure to account for interregional transfers is measured.

ANALYTICAL FRAMEWORK

The input-output relationship for agriculture can be broadly defined to include conventional inputs of land, labor, and capital as well as inputs such as research, extension, and education. The contribution of the latter inputs to agricultural production can be estimated by fitting a production function for a commodity or the agricultural sector as a whole in such a manner that these inputs are included as separate variables. A principal advantage of including such variables directly in the production function is that it may quantify the effect of research and extension on agricultural output. This approach identifies the marginal product of research and extension, which is useful for guiding research and extension investment decisions.

The time path of output response to increased expenditures on research is particularly important in estimating the benefits from research. If the output response is not forthcoming in the same year that the investment is made, the estimated marginal product overstates the marginal returns from research investment. Evenson [6] was perhaps the first to identify the nature of the lag between the research input and increased output. He found that, in response to increased expenditures on research, agricultural output first increased and then decreased, with the average response reaching a maximum in the sixth year. At the regional level this lagged relationship is hypothesized to exist for research investments both within the region and outside the region.

Fred C. White is Associate Professor, University of Georgia. Joseph Havlicek, Jr., is Professor, Virginia Tech.

This research was funded by USDA/SEA-CR under cooperative agreement 12-15-77-18.

[1] As defined in this study, the Southern region includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.

However, there may be a slight delay in adopting research results from outside the region. Measuring the influence of extension on agricultural productivity separately from research has proved difficult in the past [e.g., 6, p. 1421]. Therefore, within-region research and extension expenditures are combined into one variable.

Formal education of farm managers and workers is hypothesized to increase productivity by improving labor skills and managerial ability. An index of years of schooling weighted by schooling-class incomes has been used in previous studies as an educational attainment index [6]. A similar approach is used here.

The model used to estimate the effect of research on production is:[2]

$$(1) \qquad Q_t = L_t^{\beta_1} \, C_t^{\beta_2} \prod_{i=0}^{m} X_{t-i}^{\beta_{3+i}} \prod_{i=0}^{n} Y_{t-i}^{\beta_{m+4+i}}$$

where

Q is output per acre of cropland (yield)
L is labor input, adjusted for educational attainment, per acre of cropland
C is capital input per acre of cropland
X is agricultural research and extension expenditures within the Southern region
Y is agricultural research expenditures outside the Southern region
m is the length of lag on expenditures within the region
n is the length of lag on expenditures outside the region.

DATA AND PROCEDURES

The contribution of research and extension investment to farm production in the Southern region was estimated using time series data for the period 1949-1972. Data on research and extension expenditures covered the 1929-1972 period to account for the lag response to these expenditures. Sources for research and extension expenditures include the *Budget of the United States Government* [4]; *Combined Statement of Receipts, Expenditures and Balances of the United States Government* [15]; *Funds for Research at State Agricultural Experiment Stations and Other State Institutions* [11]; and *Annual Report of Cooperative Extension Work in Agriculture* [14]. Agricultural input and output data were obtained from *Farm Income State Estimates, 1949-1972* [13] and *Changes in Farm Production and Efficiency* [12].[3]

The model parameters of equation 1 were estimated by using the Almon [1] distributed lag procedure. On the basis of the work of Evenson [6] and Cline [5] a second degree polynomial was selected as most appropriate. Because the error terms were serially correlated when the raw data were used, all variables were adjusted using a first-order autoregressive scheme.

RESULTS

Regression Results

Two regression equations estimated for the Southern region are reported in Table 1. In the first formulation (Model I), the Southern region is characterized as an isolated region with no interregional linkages of agricultural research results or technology. All increases in productivity are attributed to research and extension investments within the region. The second formulation (Model II) allows for interregional transfer of agricultural research results and technology. This equation quantifies the separate effects of (1) research and extension investments within the Southern region and (2) research investments outside the Southern region. This formulation should indicate the relative importance of research outside the region in increasing productivity within the region.

On the basis of earlier work of Evenson [6] and Cline [5], the 13-year lag was selected as the appropriate length. It was further assumed that research investment outside the Southern region would not affect regional output for the first four years. Then for the next 13 years, investment outside the region would affect regional output. The regression results, which show the contribution of regional research and extension to agricultural productivity, are given in Table 1. The high coefficients of determination for the two regression models indicate that both formulations do a good job of explaining the variation in agricultural output over time. Estimated regression coefficients for conventional inputs of labor and capital in both models are positive, less than one as expected, and statistically significant at the 0.10 level or higher.

[2]For a production function with output and conventional inputs expressed on a per acre of cropland basis as used in this study, the elasticity of production for cropland is one minus the sum of elasticities for other conventional inputs.

[3]Agricultural output is the sum of farmer cash marketings, government payments to farmers, value of home consumption of farmers, and net farm inventory change deflated by the index of prices received by farmers for all farm products. The capital input includes (1) expenditures for feed and livestock deflated by the index of prices paid for feed and livestock, respectively; (2) expenditures for seed, fertilizer, lime, and miscellaneous expenses deflated by prices paid for seed, fertilizer, and all items in production, respectively; and (3) expenditures for repair and operation of farm capital items and depreciation and other consumption of farm capital deflated by the index of prices paid for all items in production. The labor variable is hours of farm labor in the Southern region adjusted by an educational attainment index.

TABLE 1. TWO ALTERNATIVE PRODUCTION FUNCTIONS FOR THE SOUTHERN REGION OF THE UNITED STATES

	Model I		Model II	
	Coefficient	Standard Error	Coefficient	Standard Error
Labor	0.20327*	0.09183	0.19125*	0.10298
Capital	0.82222**	0.07551	0.77155**	0.20790
	Research and Extension Within the Region Coefficient		Research and Extension Within the Region Coefficient	Research Outside the Region Coefficient
t	0.00000		0.00000	0.00000
t-1	0.00329		0.00232	0.00000
t-2	0.00603		0.00425	0.00000
t-3	0.00822		0.00579	0.00000
t-4	0.00986		0.00695	0.00000
t-5	0.01096		0.00772	0.00215
t-6	0.01151		0.00811	0.00394
t-7	0.01151		0.00811	0.00537
t-8	0.01096		0.00772	0.00644
t-9	0.00986		0.00695	0.00716
t-10	0.00822		0.00579	0.00752
t-11	0.00603		0.00425	0.00752
t-12	0.00329		0.00232	0.00716
t-13	0.00000		0.00000	0.00644
t-14	0.00000		0.00000	0.00537
t-15	0.00000		0.00000	0.00394
t-16	0.00000		0.00000	0.00215
t-17	0.00000		0.00000	0.00000
Sum	0.09974		0.07025	0.06516
ρ[a]	0.47683		0.53920	
DW[b]	1.98099		2.01107	
R^2	0.99		0.99	

[a]The estimated value of the first-order autoregression coefficient of the disturbances.

[b]Durbin-Watson "d" statistic.

*Statistically significant at the 0.10 level.

**Statistically significant at the 0.01 level.

The sum of the regression coefficients of the research and extension variable in Model I is 0.10 indicating that a 1 percent increase in research and extension expenditures increases output per acre in the Southern region by 0.10 percent over its lifetime. The individual coefficients show the distribution of this impact over time. By accounting for interregional flow of agricultural research results and technology, Model II shows that regional research and extension investments have a smaller impact on regional output. In fact, the sum of the coefficients for research and extension within the region is only 0.07 in this model.

Marginal Product and Internal Rate of Return

The marginal product of research and extension investment can be calculated from the two regression equations. Because the regression coefficients are elasticities, the marginal product of research can be calculated as:

$$(2)\quad TMPR = \sum_{i=0}^{m} MPR_i = \sum_{i=0}^{m} \beta_i (\overline{TQ}/\overline{TR})$$

where

TMPR is marginal product of research and extension expenditures aggregated over the lifetime of the investment

MPR_i is the marginal product of research and extension expenditures in year i

$\overline{TQ}$ is geometric mean for regional agricultural output

$\overline{TR}$ is geometric mean for regional research and extension expenditures.

The marginal product for research and extension expenditures for both models is shown in Table 2. If all increases in productivity are assumed to be attributable to regional research and extension investments, the marginal product for these expenditures is $11.56. However, the marginal product drops to $7.99 if research investments outside the region are taken into consideration.

TABLE 2. MARGINAL PRODUCTS AND MARGINAL INTERNAL RATES OF RETURN TO RESEARCH AND EXTENSION INVESTMENTS IN THE SOUTHERN REGION OF THE UNITED STATES

	Marginal Product	Internal Rate of Return
	(Dollars)	(Percent)
Model I	11.56	50.8
Model II	7.99	39.8

The internal rate of return is that discount rate which would make the current value of all future marginal increases in value of agricultural output equal to the incremental cost of generating it. The internal rate of return (IRR) is calculated as:

$$\sum_{i=0}^{m} \frac{MPR_i}{(1 + IRR)^i} = 1. \quad (3)$$

The rate of return calculated from Model I is 50.8 percent (Table 2). After correction for the influence of research outside the region, the rate of return drops to 39.8 percent. These results indicate that failure to account for interregional transfer of agricultural research results inflates estimated returns on research and extension investments in the Southern region by more than one quarter.

CONCLUSIONS AND IMPLICATIONS

The results of this study demonstrate that increases in productivity within a region result from research and extension investments both within the region and outside the region. The model provides an estimate of a factor long recognized but not measured. The transfer of agricultural research results across state boundaries within a homogeneous production region such as the Southern region may be more prevalent than the transfer among heterogenous production regions (e.g., the Southern region versus the rest of the nation). This additional transfer of research results, which is not considered in the authors' study, would result in lower within-state returns for within-state research and extension investments than the reported regional returns.

Activities other than public research and extension may contribute to quality improvements in agricultural inputs. Private research is an important source of improved productivity that is not considered in this study. Because no attempt is made to estimate the effect of private research on productivity, the marginal product and rate of return estimates may be biased. Some authors have argued that because private research has been of about the same magnitude as public research the marginal product for research and extension should be reduced by one third. This argument is based on the assumption that public and private research have grown at approximately the same rate over time. However, there appears to be little evidence that private expenditure patterns are directly related to governmental appropriations for public research. The authors believe that the lack of available data on private research does not seriously affect the basic conclusion of the study—that interregional transfers of research results should be taken into consideration in calculating rates of return on investment.

The transfer of agricultural research results has important implications for the financing of agricultural research and for the allocation of funding among research activities. Results of previous research have almost always shown unusually high social rates of return on research and extension investments. However, previous estimates overstated the rates of return for a particular state or region by ignoring the transfer of research results from other states or regions. Because the estimated rate of return may be lower than has generally been assumed, policy makers at the state level will need to scrutinize research and extension expenditures more carefully in relation to other expenditure alternatives. Also, decisions to allocate funds among research areas in one state may need to take into consideration the type and amount of research being conducted in neighboring states.

The occurrence of interregional transfers of agricultural research results indicates a need for involvement by the federal government in financing agricultural research and extension activities. In determining the appropriate level of investment, policy makers at the state level have a tendency to be concerned only with the benefits to the state and to ignore benefits that transfer to other states. Consequently, the level of investment selected by states would generally be less than the socially optimum level of investment based on returns to the nation as a whole. Federal programs, such as intergovernmental transfers to finance agricultural research and extension, can be justified to finance benefit spillovers and ensure a socially optimum level of investment.

REFERENCES

[1] Almon, Shirley. "The Distributed Lag Between Capital Appropriations and Expenditures," *Econometrica*, Volume 30, January 1965, pp. 178-196.

[2] Bauer, Larry L. and Curtis R. Hancock. "The Productivity of Agricultural Research and Extension Expenditures in the Southeast," *Southern Journal of Agricultural Economics*, Volume 7, December 1975, pp. 117-118.

[3] Bredahl, M. and W. Peterson. "The Productivity and Allocation of Research: U.S. Agricultural Experiment Station," *American Journal of Agricultural Economics*, Volume 58, Number 4, Part I, November 1976, pp. 684-692.

[4] *Budget of the United States Government*, Washington, D.C., annual issues, 1929-1972.

[5] Cline, Philip Lee. "Sources of Productivity Change in United States Agriculture," Ph.D. thesis, Oklahoma State University, May 1975.

[6] Evenson, R. E. "The Contribution of Agricultural Research to Production," *Journal of Farm Economics*, Volume 49, December 1967, pp. 1415-1425.

[7] Griliches, Z. "Hybrid Corn: An Exploration in the Economics of Technological Change," *Econometrica*, Volume 25, October 1957, pp. 501-522.

[8] Griliches, Z. "Research Costs and Social Returns: Hybrid Corn and Related Innovations," *Journal of Political Economy*, Volume 66, October 1958, pp. 419-431.

[9] Latimer, R. L. and D. Paarlberg. "Geographic Distribution of Research Costs and Benefits," *Journal of Farm Economics*, Volume 47, May 1965, pp. 234-241.

[10] Peterson, Willis and Yujiro Hayami. "Technical Change in Agriculture," *A Survey of Agricultural Economics Literature*, Volume 1, Minneapolis: University of Minnesota Press, 1977, pp. 497-540.

[11] U.S. Department of Agriculture, Cooperative State Research Service. *Funds for Research at State Agricultural Experiment Stations and Other State Institutions*, Washington, D.C.: U.S. Government Printing Office, annual issues, 1965-1972.

[12] U.S. Department of Agriculture, Economic Research Service. *Changes in Farm Production and Efficiency*, Washington, D.C., September 1976.

[13] U.S. Department of Agriculture, Economic Research Service. *Farm Income State Estimates*, Washington, D.C., September 1974.

[14] U.S. Department of Agriculture, Federal Extension Service. *Annual Report of Cooperative Extension Work in Agriculture*, Washington, D.C.: U.S. Government Printing Office, annual issues, 1930-1956.

[15] U.S. Department of Treasury, Bureau of Accounts. *Combined Statement of Receipts, Expenditures, and Balances of the United States Government*, Washington, D.C.: U.S. Government Printing Office, annual issues, 1929-1972.