THE PRODUCTIVITY OF AGRICULTURAL RESEARCH AND EXTENSION EXPENDITURES IN THE SOUTHEAST

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With current high food prices and increasing talk about a world food crisis, there is renewed interest in production agriculture and in the allocation of resources to agriculture. It would seem, therefore, that estimates of agricultural production functions and their associated marginal products would be useful to those responsible for resource allocation to the agricultural sector. This paper intended to give policymakers information on which to base decisions relative to the impact of investments in agricultural research and extension activities. The level of appropriations to such activities can be considered a proxy measure of technology. Most researchers familiar with this area feel that the total effect of new technology on production does not occur at one momemt in time, but may be spread over a number or years. Considering this, a distributed lag on research and extension expenditures was incorporated into the production function estimated in this paper.

OBJECTIVES

The objectives of this study were:

1. To estimate marginal productivity of research and extension activities by estimating an agricultural production function for the Southeast.
2. To measure the timepath of the effect of research and extension activities.

PROCEDURE

A Cobb-Douglas production function was estimated using ordinary least squares regression technique. The timepath of research and extension activities effect was estimated by using a general polynomial distributed lag technique, developed by Tom Johnson [4].

The states considered in the study were the southeastern states — Alabama, Arkansas, Florida, Georgia, Kentucky, Louisana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia. They were selected to be a fairly homogeneous group. The model used both time series and cross-sectional data. Cross-sectional aspects of the data were partially accounted for with the use of intercept dummies.

The time period covered was 1949 through 1968.[1]

STATISTICAL MODEL

The statistical model used in this study was similar to those used by Griliches [3] and Evenson [2]. The primary differences were in aggregation of certain variables and in method of handling the lagged effect of technology.

A Cobb-Douglas production function was estimated of the general form[2]:

$$Q = f(T, L, F, S, C, D)$$

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[1] In order to estimate the distributed lag function imposed on technology, data for research and extension appropriations extended back beyond 1949.

[2] In the most strict sense, this was not a production function because measurement was in dollars rather than physical quantities. Due to problems of measuring physical quantities, deflated dollar values were used with the assumption that the deflation removed the influence of price variation.

where:

Q = gross agricultural *output* in each state in millions of 1968 dollars. The variable was the sum of farmer cash marketings, government payments to farmers, value of home consumption of farmers, and net farm inventory change [6]. The deflator was the index of prices received by farmers for all farm products [1].

T = *technology*. This variable was the yearly sum of research and extension appropriations measured in 1968 dollars.[3] Research appropriations plus state appropriations less the balance from the previous year. Values were converted to 1968 dollars by the implicit price deflator for the total gross national product [1].

L = expenditures for agricultural hired *labor*. This variable was the total expenditure for farm hired labor in each state in thousands of 1968 dollars [6]. The deflator used was the index or prices paid for hired labor [5].

F = total expenditures for *feed and livestock* in each state in thousands of 1968 dollars [6]. The data were deflated with the index of prices paid for feed and livestock respectively [5].

S = total expenditures for *seed, fertilizer, lime and miscellaneous* expenses in each state in thousands of 1968 dollars [6]. The deflator used was prices paid for seed, fertilizer and all items in production respectively [5].

C = *captial and depreciation.* This variable was the farm expenditures for repair and operation of capital items, and depreciation and other consumption of farm capital in each state measured in thousands of 1968 dollars [6]. This series was deflated by the index or prices paid for all items in production [5].

D = state *dummy variables.* These variables were zero-one dummy variables for the thirteen southeastern states, i.e., this variable was equal to one for all observations for a particular state and zero otherwise.

RESULTS

The estimated coefficients of the production function appear in Table 1. The t-values were used to test the hypothesis $b_i > 0$ in the case of coefficients of real variables, and $b_i = 0$ in the case of dummy variables. In other words, a one-tail test was performed on coefficients of real variables and a two-tail test on those of dummy variables. The tests were conducted in this manner because it was felt *a priori* that coefficients of the real variables should be greater than zero.

[3]The data for extension were provided in mimeographed sheets provided by the Federal Extension Service of USDA. The research data were obtained from the published annual reports of the branch of USDA responsible for administering funds to state experiment stations. The name of this branch changed several times during the time span of the data used in this study, but is presently known as the Cooperative State Research Service.

Table 1. ESTIMATED COEFFICIENTS AND LEVEL OF SIGNIFICANCE OF AN AGRICULTURAL PRODUCTION FUNCTION FOR THE SOUTHEASTERN UNITED STATES

Variable	Estimated coefficient	(t-value)	Level of significance[a] (Percent)
Constant term	-2.203		
Real Variables			
Labor	.171	(6.639)	1
Feed and livestock	.211	(9.424)	1
Seed, fertilizer, lime, miscellaneous	.537	(13.169)	1
Capital and depreciation	.022	(.419)	N.S.
Technology (research and extension)	.059	b	b
State Dummy Variables			
Kentucky	.048	5.450	1
North Carolina	.041	2.570	5
Oklahoma	.042	1.390	N.S.
Tennessee[c]	0	--	--
Louisiana	-.026	-1.651	10
Mississippi	-.027	-2.363	5
Texas	-.032	- .816	N.S.
Arkansas	-.033	-2.549	5
South Carolina	-.039	-2.976	1
Alabama	-.051	-3.750	1
Georgia	-.064	-4.887	1
Florida	-0.75	-3.660	1
Virginia	-.075	-7.239	1

[a]Null hypothesis $b_i > 0$ for real variables, $b_i = 0$ for state dummy variables.

[b]The estimated lag distribution parameter was significant at the 10% level.

[c]Tennessee omitted in estimation to avoid singularity.

The estimated coefficients for labor, feed and livestock, and seed, fertilizer, lime and miscellaneous were all significantly greater than zero. That for technology was not estimated directly, but the estimated coefficient of the lag distribution imposed on this variable was significant at the 10% level. The sum of the coefficients for this estimated Cobb-Douglas production function was one. This implied constant return to scale, an assumption commonly made in economics.

It was assumed that the production function was the same in all states, i.e. the slope coefficients were assumed to be the same, differences between the states being handled with intercept dummies. As shown in Table 1, all dummy variable coefficients were significantly different from zero, at least at the 5% level, with three exceptions — Louisana, Oklahoma and Texas. This meant that intercept values for all but these three states were statistically different from the intercept for Tennessee. However, when these values were translated into dollars terms (Table 2),[4] the difference between the highest and lowest values, Kentucky and Virginia, was $1,700. This indicated that, all other things constant, the difference in total farm output among the states was quite small. Since the

[4]This translation was made by adding, since the variables were multiplicative in a Cobb-Douglas function, each respective state dummy variable coefficient to the overall regression constant term which was the intercept for Tennessee. The antilog of each was taken and changed from millions of dollars, the unit of measure of the dependent variable, to the dollar figures reported in Table 2.

Table 2. ESTIMATES OF INTERCEPTS FOR EACH STATE IN AGRICULTURAL PRODUCTION FUNCTION FOR SOUTHEASTERN UNITED STATES

State	Intercept ($)
Kentucky	6,998
North Carolina	6,891
Oklahoma	6,485
Tennessee	6,256
Louisiana	5,899
Mississippi	5,892
Texas	5,820
Arkansas	5,813
South Carolina	5,729
Alabama	5,568
Georgia	5,408
Florida	5,271
Virginia	5,268

geometric mean of dollar output in these states over the period covered was almost 768 million 1968 dollars, it could be concluded that each state's production function was essentially at the same level since intercept values differed by such small amounts. The difference in the value of farm output from these states could be attributed to different levels of various inputs, given the model's assumption that there were no differences in slopes among the states.

MARGINAL PRODUCTS

Policy-makers, responsible for allocation of funds to agriculture, need to know what the benefits are to research and extension activities. Marginal products are one source of such information.

Table 3. MARGINAL PRODUCTS (DOLLAR CHANGE IN FARM OUTPUT PER DOLLAR CHANGE IN VARIABLE) OF ESTIMATED COBB-DOUGLAS PRODUCTION FUNCTION FOR SOUTHEASTERN UNITED STATES

Variable	Marginal product
Labor	$1.50
Feed and livestock	$1.69
Seed, fertilizer, lime, miscellaneous	$3.88
Capital and depreciation	$ .11
Technology (research and extension)	$5.84

The marginal product for each variable is presented in Table 3. The formula used in the calculation was:

$$MP_{X_i} = b_i \frac{\hat{Q}}{\overline{X}_i}$$

where $\overline{X}_i$ was the geometric mean of independent variable i and $\hat{Q}$ the predicted value of Q with all inputs at their respective geometric mean.

The reported marginal products were changed from the units used in estimation to a dollar change in farm output per dollar change in the respective input. For example, in the case of labor, the estimated coefficient was .171 and the geometric mean was $88,841. The predicted value of the dependent variable with each independent variable at its geometric mean was approximately $777 million. Therefore, the estimated marginal product for labor was:

$$MP = .171 \ \frac{777}{88,841} + \quad .00150$$

or $.00150 million of farm output per thousand dollars of hired labor, which translates to $1.50 per one dollar of hired labor. Each $1 increase in expenditures for hired labor would, on the margin, add $1.50 to farm output. This applied only to hired labor since it was not feasible to accurately quantify non-hired labor. However, it would seem safe to assume that the non-hired labor contributed to the marginal productivity of hired labor.

The marginal product for feed and livestock expenditures variable was $1.69, indicating that there was still room for profitable expansion in livestock enterprises.

The marginal product of $3.88 for seed, fertilizer, lime and miscellaneous expenditures indicated that it would be highly profitable to expand these items considerably. This would seem to be building a case for increased supplies of high quality seed and fertilizer in the Southeast.

The estimated marginal product of the capital and depreciation variable was $.11. Each additional dollar spent on capital items increased the dollar value of farm output by $.11, a rate of return that was at least favorable when compared to the interest paid on savings accounts.

The marginal product for technology was $5.84 — for every dollar increase in research and extension appropriations, farm output was increased by $5.84. For example, if research and extension appropriations in the thirteen southeastern states were increased by 10 million dollars, farm output from this change would eventually increase, ceteris paribus, by $58.4 million. This was assuming the increase in appropriations was a one-time occurrence, i.e. appropriations return to their original level. This increase would occur over a nine-year period rather than wholly in the year of increased expenditures; i.e., the estimated lag distribution indicated that 11.1% of this total effect would occur in each of nine years, the current year plus eight more.

A lag distribution of this configuration was not what was hypothesized. It was expected that the distribution would have a "hump", i.e. the annual effect of technology on output was expected to build up to a maximum during some time period after the appropriation, the declining with the passage of time. In this study, however, the reported lag distribution best fitted the data when compared to distributions of different shapes, including different time periods of research and extension data.

CONCLUDING STATEMENT

The estimated marginal product of $5.84 for research and extension expenditures indicated a high return to appropriations in this area. Because the statistical model used in this study was relatively simple, some implicit underlying assumptions should be mentioned.

The "somewhat heroic[5] assumptions" was made that all advances in technology are due to research and extension expenditures. However, if only half the estimated marginal product of technology were the result of research and extension activities in Land-Grant Universities, the $2.92 increase in value of farm output per dollar appropriation could still be considered a high return. Data on agricultural research and education activities of the private sector is scarce, making the division of the technology variable into public and private contributions a difficult task, if not an impossible one.

Perhaps a more important assumption is that of a perfectly elastic demand for farm output. With the inelastic demand that exists (as increased technology results in larger farm output, causing prices to fall) consumers are the ultimate benefactors.

Even though the implicit inclusion of these assumptions might have altered the magnitude of estimated coefficients and marginal products, it was felt they did not change the conclusion that research and extension activities have a positive and substantial effect on agricultural output. This would seem to be important in a time of high food prices, world food shortages and tight state and federal budgets. Of course, this is only one area with which governmental decision-makers have to deal. In the process of allocating scarce revenue, the policy-maker would have to consider the return to monetary resources in all uses. Hopefully, this article pointed out substantial benefits to appropriations for agricultural research and extension activities.

[5]These are the words of one of the anonymous reviewers. The authors recognized this problem, but it is perhaps better that it be stated explicitly.

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