RESOURCE PRODUCTIVITY ON TEST DEMONSTRATION FARMS IN SOUTHWEST VIRGINIA

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INTRODUCTION

All farm production results from combining labor, capital in various forms, land resources, and management. However, these productive resources may be combined in many ways, and the decision as to what combination of resources will produce optimum long time returns to the farm family rests solely with the farm manager.

Because of this farm organization problem, one of the primary concerns of farmers as managers is the productivity and returns from different resources which they use in their farm business. Reliable estimates of the productivity and returns from categories of resources used in different combinations should help the farmer to better determine how much of a resource to use and how resources should be combined.

The purpose of this study is to estimate the marginal productivity of the different classes of resources on Extension T. V. A. test demonstration farms in Southwest Virginia. Since different combinations of resources are used on different type farms, the type of farm may be a factor influencing resource productivity. Therefore, special attention is given to analysis of resource productivity by type of farm in this study.

The estimates which follow have been computed as aids to farmers and persons who advise farmers. They also serve as a study in methodology. Previously, little work has been done in Virginia in estimating the marginal productivity of farm resources used in different amounts and proportions on different type farms. It is believed that the estimates made will be particularly useful to persons working with active test demonstrators and to farmers in the area concerned.

Review of Literature

Production functions have been well explored, thanks mainly to the efforts of one of the great scholars of economics, Professor Paul H. Douglas of the University of Chicago. Douglas published his first article on production functions (together with C. W. Cobb) in 1928, 1/ and in 1934 he pursued the subject in his monumental Theory of Wages. 2/ In these and later works, Douglas studied the relationship between the three variables labor, capital, and product. He believed there was a more or less constant relationship between these variables and went into great detail to test this hypothesis.

The early efforts of Paul Douglas may be illustrated by presenting one of his earlier published analysis in the field of production functions. 3/ His data were annual series for the United States during the years 1900-1922. Douglas let P represent production (index of physical volume of manufacturing); L represent labor (index of the annual average number of wage earners in manufacturing); and C represent capital (index of fixed capital in manufacturing). All are expressed as indices, 1899 = 100. Douglas used a least squares equation

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1/ P. H. Douglas and C. W. Cobb: "A Theory of Production", American Economic Review, Vol. 18 (1928), supplement, pp. 139ff.

2/ P. H. Douglas: Theory of Wages, New York, 1934.

3/ P. H. Douglas and C. W. Cobb: Op. Cit.

to fit a function which is linear in the logarithm. This statistical procedure assumes that the errors of observation cancel out in the estimates of the coefficients. Douglas assumed that the sum of the two regression coefficients (exponents) is one. The production function fitted by Douglas, in non-logarithmic form is as follows:

$$P = 1.01L^{0.75} C^{0.25}$$

The exponents used are elasticities. Therefore, 0.75 represents the elasticity of production with respect to labor and 0.25 represents the elasticity of production with respect to capital. This would indicate that if labor is increased by one percent, product would increase by about 3/4 of one percent. Similarly, if capital is increased by one percent, then, total product would increase by about 1/4 of one percent.

In later studies Douglas did not assume the sum of the exponents to be one, 1/ but still the sum of the fitted elasticities remained very close to one. Therefore, Douglas concluded that the production function is a linear function of the amounts of the factors used, at least within a certain range.

Douglas' studies, although they spanned a number of years, were very limited in scope. That is to say, they dealt almost entirely with the distributive shares of labor and capital in manufacturing. This

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1/ P. H. Douglas and G. Gunn: "The Production Function for American Manufacturing in 1914", _Journal of Political Economy_, Vol. 50 (1942), pp. 595ff. See also P. H. Douglas and G. Gunn: "The Production Function for American Manufacturing in 1919", _American Economic Review_, Vol. 31 (1941), pp. 108ff.

fact is not offered as a criticism of Douglas' work, but to point out that he did not attempt to relate his findings to other production problems or business enterprises. However, his production functions opened the way to an entirely new approach to production problems. This is particularly true in the field of agriculture.

One of the first studies of the Cobb-Douglas type applied to agricultural data was made by Tintner and Brownlee at Iowa State College in 1944. 1/ They derived production functions for 468 Iowa farms using farm records for the calendar year 1939. The farm records were divided into five types - dairy, hogs, beef feeders, crop, and general - classified on the basis of the major source of farm income. As a regression equation, a function which was linear in the logarithm was used. This is similar to the production function employed by Paul Douglas in his later studies. That is, Tintner and Brownlee did not assume the sum of the exponents to be one.

The Cobb-Douglas function implies substitutability between the various production agents and permits diminishing marginal returns to come into play. Results show that all of the elasticities obtained in this analysis were smaller than unity. Therefore, marginal returns for each factor of production were diminishing. The sum of the elasticities for each type of farm except crops, and for the group consisting of all farms, show decreasing returns to scale. Such a result is to be expected since management was not included in the analysis. The authors

1/ Gerhard Tintner and O. H. Brownlee: "Production Functions Derived from Farm Records", Journal of Farm Economics, Vol. 26, 1944.

contend that if it were possible to include management in the analysis, it might be found that returns to scale were constant or even increasing in all of the various types of farming. Also, these farmers were members of the Iowa Farm Business Association and were know to be "above the average."

In 1944, Gerhard Tintner further tested the results of the previous study he did with Brownlee by deriving production functions from the business records of 609 Iowa farms for 1942. 1/ The records were grouped into four main types of farming (dairy, hogs, beef feeders, and crops). Aside from the difference in grouping, the methodology employed in the two studies was the same. Results indicated that all types of farming (except dairy production) and all farms grouped show decreasing returns to scale. These findings are identical to those of his earlier study with Brownlee. In connection with this later study, Tintner designed a statistical significance test for returns to scale. To accomplish this, he assumed the hypothesis that if constant returns to scale existed, the sum of the regression coefficients would be one. The results of the test did not disprove the hypothesis. Hence, it was assumed that the sum of the regression coefficients could be one, or constant returns to scale could exist.

The two functions previously mentioned were derived from business data for individual farms. Both of these, however, were for farms above

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1/ Gerhard Tintner: "A Note on the Derivation of Production Functions from Farm Records", Econometrica, Vol. 12, No. 1, January 1944, pp. 26-34.

average in respect to scale of operation and techniques employed. Therefore, economists believed that somewhat different statistical results could be expected for an average group of farms. To test whether some farms were operating under different conditions of returns, Heady derived production functions from a random sample of 738 Iowa farms in 1946. 1/ As in previous studies, results indicated decreasing returns to scale, although the farms were classified by size.

In recent years the Cobb-Douglas type analysis has been applied to studies of the earning power of farm investments and expenses. Professor Glenn Johnson, working with data from 30 West Kentucky farms, used "gross income" as the dependent variable and grouped items of investments and expenses into independent variable categories. 2/ Factors of production having a high correlation, such as "forage and livestock investments", were grouped together as one independent variable category. Other independent variable categories used were: acres of land, man-months of labor, machinery investment, and other expenses. Results indicated that raw land earned virtually nothing, labor earned about $55 a month, machinery investment returned about 4 percent, livestock and forage investment returned about 56 percent, and other expenditures returned about 86 percent. Therefore, the following general conclusions were drawn from this study:

1/ Earl O. Heady: "Production Functions from a Random Sample of Farms", Journal of Farm Economics, Vol. 28, November 1946, pp. 989-1004.

2/ Glenn L. Johnson: "Sources of Incomes on Upland Marshall County Farms", Progress Report 1, Kentucky Agricultural Experiment Station. See also other reports in same series.

1. Investment in forage production and livestock was the most important factor determining the earning power of Marshall County farms.
2. Initial investments in forage productions and livestock pay far higher rates of return than investments in machinery or expenditures for labor.
3. The earning power of labor could be increased by associating sufficient livestock and forage production with labor.
4. In most cases, Marshall County farmers could expand their investments in livestock and forage production sufficiently to make farm machinery moderately profitable.
5. It was not profitable for individual farmers to buy more land for farming purposes until present land holdings were fully developed.
6. Differences in managerial ability may account for differences of $3,000 or over in gross farm income.

In 1953, Earl O. Heady of Iowa State College used a Cobb-Douglas type function in his resource productivity analysis. 1/ In this study, Heady attempted to derive the average and the marginal productivity of resources when used to produce crops and when used to produce livestock. In the analysis he used one basic equation for crops and another for livestock. The results of this study indicate that capital-labor

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1/ Earl O. Heady: "Productivity and Income of Labor and Capital on Marshall Silt Loam Farms in Relation to Conservation Farming", Iowa Research Bulletin, 401, October 1953.

productivity was high in livestock production. Heady also points out that constant returns to scale may well exist over the range of livestock investments used in the study.

In 1954, Drake used a Cobb-Douglas function in deriving a method by which farmers may estimate gross profit and marginal value productivity. 1/ Drake derived several equations from 108 Michigan farm account records and used these results in his analysis. Results show that functions of this type may have an important place in farm management, extension work, and education.

In summary, it may be said that investigators have shown that the Cobb-Douglas type function is a valuable tool in agricultural research. They have also shown that, in spite of the fact that this function does not perfectly fit agricultural data, its advantages more than compensate for its shortcomings.

Source of Data

The data for this study were taken from farm records kept by T. V. A. Unit Test Demonstrators in Southwest Virginia during 1951. The keeping of the records was supervised by county agents or assistant county agents. The records were summarized in the Agricultural Economics Department at Virginia Polytechnic Institute and the record books

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1/ Louis S. Drake: "A Method of Showing Farmers How to Estimate Gross Income and Marginal Value Products", Journal of Farm Economics, Vol. 36, No. 1, February 1954, pp. 66-77.

were returned to the farmers. Thus, the data used were taken from a summary form kept in the files of the Extension Service.

Farms in this study are not homogeneous in respect to soils. In selecting Test Demonstration farms, an attempt is made to get a cross-section of soils in each county. Since the farms in this sample are located in nine counties, a number of soil types are included. However, the pattern of soils in Southwest Virginia do not vary greatly from one county to another. Therefore, variation in soil types should be only slightly greater for this sample than it is within any one county in Southwest Virginia. The farms in the sample are somewhat above average size both in acreage and in earning ability for Southwest Virginia.

There were 136 available T. V. A. Test Demonstrator records for the year 1951. Eleven records were discarded because of incompleteness or apparent inconsistences, and 19 records were discarded because they fell in type-of-farm classifications which were not included in the analysis. This left 106 usable records for the study. These records were adjusted where necessary to inventory values based on the same price for the beginning and the end of the year. No other change was made in the original farm records.

Records for the year 1951 were chosen for the study because 1951 is the most recent year in which there was more or less favorable weather conditions and prices. In 1952 there was unfavorable weather (drought) and relatively favorable prices, and in 1953 there was unfavorable weather and less favorable prices.

RESEARCH METHODS

The Cobb-Douglas Function

In fitting a Cobb-Douglas type analysis to farm business data, income is usually taken as the dependent variable and productive agents are grouped into independent variable categories. The input categories are grouped on the basis of production economics theory and a knowledge of agriculture. These input categories are groups of productive factors in the farm business which play a major part in determining the physical output of the farms. However, it is impossible to include all the factors which determine output (gross income) in these groups. Weather and management are excluded as inputs because of measurement difficulties.

In natural numbers the equation for a Cobb-Douglas type production function is written $Y = aX_1^{b_1} X_2^{b_2} \cdots X_n^{b_n}$. In the equation "Y" represents gross income (output) and the "X's" represent the independent variable categories. The letter "a" is fitted constant in the equation and geometrically is the intercept point on the Y axis. The exponents (b's) are elasticities of the dependent variable with respect to their respective category of inputs. That is, any single "b" measures the percentage change in gross income which would be caused by a one percent change in the corresponding input category with other input categories held constant.

In logarithmetic form the equation is linear, and it is easily fitted by linear multiple correlation least squares techniques. Written in logarithmetic form, the equation becomes: $\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + \text{-----} b_n \log X_n$.

The major advantages of the Cobb-Douglas type equation in farm management-production economics research are as follows:

1. It immediately gives elasticities of the dependent variable with respect to the different factors of production.
2. It permits the phenomenon of decreasing returns to come into evidence while preserving a maximum degree of freedom. Diminishing returns would not be reflected by a linear arithmetic function. On the other hand, a quadratic function would reflect decreasing returns, but the number of degrees of freedom remaining for estimating error would be substantially decreased.
3. This technique makes it possible to estimate marginal value productivity for the different categories of inputs.
4. The function assumes substitutability between various productive agents.

One of the chief disadvantages of the Cobb-Douglas function is that it will handle relationships for firms in only one stage of production at a time. This condition is brought about by the fact that the elasticities are constant for the entire function.

Classification by Type of Farm

The 1951 farm records were first divided according to the way in which farm income was derived on the individual farms. That is, a farm was considered to be of the beef brood 1/ type if the cattle kept were of the beef type and approximately two-thirds of the farm's gross income came from the sale of cattle. If a farm derived two-thirds of its gross income from the sale of Grade A milk it was classified as a Grade A dairy farm. Similarly, a farm which derived two-thirds of its gross income from the sale of Grade C milk was classified as a Grade C dairy farm. Farms which did not derive two-thirds of their gross income from the sale of cattle, hogs, sheep, poultry, milk or other livestock products were classified as general farms. The "general" farm grouping is very broad in the sense that it includes farms using various combinations of crop and livestock enterprises in no set proportions.

The fact that tobacco was grown on some farms and was not grown on others necessitated a further division of the records on this basis. This was necessary since the Cobb-Douglas type equation is such that gross income (Y) is zero if any input (X) is zero. On the other hand, if tobacco were not considered as a separate input, estimates of the productivity of the other aggregates would be biased.

When the farm records were divided in the described manner, they fell into eight type-of-farming groups. These groups were: beef brood farms with and without tobacco, Grade A dairy farms with and without tobacco, Grade C dairy farms with and without tobacco, and general farms with and without tobacco. However, the numbers of Grade "C" and Grade "A" dairy

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1/ Defined as farms selling primarily feeder calves.

farms with and without tobacco were too small to permit separate estimates. Thus these records were discarded, leaving beef brood farms with and without tobacco and general farms with and without tobacco for the study.

Method of Aggregation

The data from the 1951 TVA farm records were aggregated into input and output categories partly on the basis of previous work done by other investigators 1/ and partly on the basis of a preliminary analysis of the data used. Beginning and ending inventories were adjusted to inventory values based on the same price for the beginning and the end of the year. This was done to prevent biases in the data caused by price changes during the year. Also, input and output data were transformed to yearly figures so that the productivity of inputs could be estimated for a one year period. Input categories made up of substitutes were measured according to (what the investigator believes to be) the common denominator causing them to be good substitutes. For example, the input category, labor, was measured in months and includes both family and hired labor according to the number of man-month-equivalents contributed by each group. Inputs which were found to be complementary to a high degree were grouped together into a single input since the level of one would necessarily influence the level of the other. Complements were

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1/ Glenn L. Johnson: Op. Cit.
Thomas G. Toon: "Marginal Value Productivities of Inputs, Investments, and Expenditures on Upland Grayson County Farms During 1951", Unpublished thesis, University of Kentucky, 1953.

measured by a preliminary correlation analysis of input groups.

The categories of independent variables, as they were aggregated from the 1951 farm records, are as follows:

X_1 = Land
X_2 = Labor
X_3 = Machine and power services
X_4 = Livestock services
X_5 = Tobacco

Land (X_1) was measured in acres of open land. It was computed by adding acres of open permanent pasture and acres of crops. This method of measuring land input is not entirely satisfactory since it ignores variations in the quality of land. However, the investigator believes that it is more satisfactory than the dollar value of land and buildings as estimated by farmers. Location of farms in respect to roads and other landmarks, and the time the farm records were begun, influence farmers' estimates of land values as much as the inherent capacity of the land to produce.

Labor (X_2) was measured in man-months. It included the labor of the operator plus all family and hired labor used on the farm during the year. The man-months contributed by family labor was estimated by the farmer in man-month-equivalents. For example, the twelve months labor of a fifteen-year-old boy may be carried as five months, if, in the judgment of the farmer, the fifteen-year-old boy could perform five months man equivalent of labor in twelve months. The data on hired labor were considered to be quite accurate, and the labor of the operator and other family labor was the estimate submitted by the record keepers.

Machine and power services (X_3) were measured in dollars. It is the estimated cost of owning and operating machinery during the year.

The cost of machinery and power services included depreciation on machinery, equipment, and work horses, plus expenses attributed to repairs, farm auto and truck, oil and gas, twine, horse shoeing, hauling, and hired machinery. Depreciation on machinery and equipment was estimated by adding one-half of the value of purchases during the year and subtracting one-half of the value of sales during the year from the beginning inventory and then multiplying by fifteen percent. Work horses were depreciated by taking fifteen percent of beginning inventory.

Livestock services (X_4) were measured in dollars. It represents the estimated yearly cost of owning livestock. The cost of livestock services included depreciation on breeding stock, plus cost of young stock purchased, cow testing fees, breeding fees, veterinary fees, medicine, feed, and salt. Depreciation on breeding stock was estimated by taking a percent 1/ of beginning inventory for cattle and sheep (fifteen percent for cattle and ten percent for sheep). As livestock inputs and feed crop inputs were found to be highly correlated they were aggregated into one input category. The input of feed crops was represented by feed crop expense. It included seed, fertilizer, lime, and the yearly cost of depreciation and maintance of existing alfalfa stands.

Tobacco (X_5) was measured in acres of burley tobacco.

1/ This figure is based on the average time animals are keptin breeding herds and the expected yearly death loss. The estimates were made by qualified persons in the Animal Husbandry Department.

Gross income (Y) was taken as the dependent variable. It included: the sale of crops, livestock (excluding horses), and livestock products; plus or minus changes in the inventory of feed, seed, and young stock; plus miscellaneous receipts. Gross income does not include the value of farm products used by the farm family or the rental value of the farm house. These items were excluded from the gross income figure because of the difficulty of obtaining accurate value estimates from the farm records. However, since gross income includes the total value of the yearly farm production, both landlord and tenant shares were included.

ESTIMATES OF COEFFICIENTS

Overall Statistics and Regression Coefficients by Resources and Farm Type

Table 1 presents the overall statistics of the Cobb-Douglas type function fitted to 63 beef brood farms with tobacco. The multiple correlation coefficient (R) was computed to be .92400. A figure this large is statistically significant at the 1 percent level of probability. This means that there is less than one chance in 100 that a correlation as high as this could have arisen by chance alone if the true correlation coefficient of the population was zero. Therefore, this estimate indicates that there is a true positive regression in the data.

The coefficient of determination (R^2) was computed to be .85378. This indicates that 85 percent of the variance in the log of the dependent variable (gross income) is associated with the independent variables. For this sample, an explained percentage this high is significant at the 1 percent probability level. Therefore, 15 percent of the variance in gross income is due to other factors not included in this function. The lack of homogeneity in this sample from the standpoint of management, weather conditions, soil types, and valuation of inputs may account for much of the unexplained variance.

The regression coefficients or elasticities of production ("b" values) with respect to the input categories and their respective

Table 1. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 63 T. V. A. Test Demonstration Beef Brood Farms with Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	136.76	.25365*	.11476	2.21
Labor (months)	21.96	-.01869	.10696	-0.17
Machinery & Power (dollar)	760.78	.10059	.07085	1.41
Livestock & Feed Crops (dollar)	1789.00	.53414***	.06372	8.38
Tobacco (acres)	1.58	.07606	.07608	1.00
		.96444		

Overall Statistics

R^2 = .85378** R = .92400** F = 66.55 a = 1.20219

Av. Log. Gross = 3.83731 $\hat{Y}$ = $6,875.57 $\bar{Y}$ = $9,265.08

* Significant at 5 percent level.
** Significant at 1 percent level.
*** Significant at .1 percent level.

standard errors and "t" values for the beef brood farms are also shown in Table 1. The regression coefficients show the estimated percentage change in total product (gross income) which might be forthcoming if the input of any one resource is increased by 1 percent. For example, a 1 percent increase in land input is associated with an increase of .25365 percent in gross income. On the other hand, a 1 percent increase in the livestock and feed crop input is associated with an increase of about .53414 percent in gross income. All the regression coefficients shown in Table 1 are less than 1. Therefore, diminishing marginal returns are indicated for each individual production factor.

The sum of the elasticities (Table 1) indicates returns to scale on beef brood farms with tobacco. A sum of elasticities equal to 1 indicates constant returns to scale; a sum of elasticities less than 1 indicates decreasing returns to scale; and a sum of elasticities greater than 1 indicates increasing returns to scale. The sum of the estimated elasticities is .96444 in this case, thus denoting decreasing returns to scale. That is, an increase in the input of all resources by 1 percent will result in an increase in total product (gross income) of less than 1 percent.

When the "t" test of significance was applied to the estimated regression coefficients, two values were found to be statistically significant. The "b" value for land was found to be significantly different from zero at the 5 percent level of significance, and the "b" value for livestock and feed crop input was found to be significant at the .1 percent level (probability less than 1 in 1,000 that a "b" value this high could have arisen by chance alone if the true "b" value of the population was zero). None of the other "b" values shown in Table 1 were significantly different from zero at the 5 percent level. Hence, "b" values this high could have arisen with a probability of more than 1 in 20 even if the true population elasticities were zero.

Table 1 indicates that the standard errors of labor and tobacco are larger than their respective "b" values. This may be interpreted to mean that the random variations in the data are obscuring any regression effects which may be present in these cases. The fact that the "t" value for labor and tobacco is 1 or less also indicates that the above statement is true. The "t" value for machinery and power is greater than 1 (1.41), but it is not statistically significant except at the 20 percent level.

The estimated regression coefficient for labor (Table 1) is a minus quantity, but it is not significantly different from zero at the 5 percent level. Furthermore, the computed "b" value is meaningless since the relevant economic model does not permit negative elasticities. According to Tintner and Brownlee, "...negative elasticities, within the range of inputs, are meaningless". 1/

Table 2 presents the statistics of the Cobb-Douglas type function

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1/ Tintner and Brownlee, Op. Cit., p. 568.

Table 2. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 22 T. V. A. Test Demonstration Beef Brood Farms without Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	138.04	.44268	.29722	1.49
Labor (months)	18.91	.61998	.30676	2.02
Machinery & Power (dollars)	807.62	-.24493	.19948	1.23
Livestock & Feed Crops (dollars)	1796.80	.53404**	.17833	2.99
		1.59671		

Overall Statistics

R^2 = .71924** R = .84808** F = 10.89 a = .94268

Av. Log. Gross = 3.70765 $\hat{Y}$ = $5,101.00 $\bar{Y}$ = $6,606.09

** Significant at 1 percent level.

fitted to 22 beef brood farms without tobacco. All statistical estimates shown in Table 2 are subject to the same interpretations that were applied to the estimates in Table 1. The estimated R^2 in Table 1 indicated that 85 percent of the variance in output is associated with the quantity of resources used. Thus, in Table 2 approximately 72 percent of the variance in output is associated with the quantity of resources used in this case. In Table 2, both R and R^2 are statistically significant at the 1 percent level of probability.

All the "b" values shown in Table 2 are less than 1, but the sum of the "b's" is greater than 1 (1.59671). This indicates diminishing marginal returns to individual production factors, but increasing returns to scale for the farm unit. The estimated "b" value for all input categories, except machinery and power, indicate additional returns from additional inputs, and all the "t's" are greater than 1. The "b" value for livestock and feed crops is statistically significant at the 1 percent level, but none of the other estimates were found to be significantly different from zero at the 5 percent level of probability.

Table 3 presents the statistics of the Cobb-Douglas function fitted to 11 general farms with tobacco. The estimates of R and R^2 shown in Table 3 are relatively large and seem reasonable. They were statistically significant at the 5 percent level of probability.

In Table 3, all the "b" values are less than 1 and the sum of the "b's" is less than 1. When the "t" test was applied to the estimates,

Table 3. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 11 T. V. A. Test Demonstration General Farms with Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	93.77	-.01519	.17123	-0.09
Labor (months)	17.33	.01163	.33228	0.04
Machinery & Power (dollars)	324.85	.04384	.09695	0.45
Livestock & Feed Crops (dollars)	1480.70	.50507*	.14768	3.42
Tobacco (acres)	1.16	.22403	.10798	2.07
		.78457		

Overall Statistics

R^2 = .87906* R = .93758* F = 7.27 a = 1.75359

Av. Log. Gross = 3.68821 $\hat{Y}$ = $4,877.70 $\bar{Y}$ = $5,390.00

* Significant at 5 percent level.

only the "b" value for livestock and feed crops was found to be significantly different from zero at the 5 percent level of probability. The "b" value for tobacco seems reasonable, but was not statistically significant. It is interesting to note that in Table 3 the standard errors for land, labor, and machinery and power are all larger than their respective "b" values. The "t" values in these cases are all less than 1.

Table 4 presents the statistics of the Cobb-Douglas function fitted to 10 general farms without tobacco. The estimated R^2 indicates that in this case approximately 95 percent of the variance in output is associated with the quantity of resources used. In Table 4, both R and R^2 are statistically significant at the 1 percent level of probability.

All of the "b" values shown in Table 4 are less than 1 and the sum of the "b's" is extremely small (.05770). The "b" values for machinery and power and for livestock and feed crop inputs were statistically significant at the 5 percent level of probability. The "b" values for land and labor are both minus quantities. However, they were not found to be statistically different from zero at the 5 percent level.

It is regrettable that the regression coefficient estimates are statistically significant in such a few cases. If more regression coefficients were significant, interpretation of results would be easier and estimates would be more usable for predictive purposes. However, there are many factors which may explain why regression coefficients are insignificant in this study.

Table 4. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 10 T. V. A. Test Demonstration Beef Brood Farms without Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	108.09	-.36472	.26437	-1.38
Labor (months)	20.23	-.60769	.55702	-1.09
Machinery & Power (dollars)	743.13	.59990*	.19360	3.10
Livestock & Feed Crops (dollars)	1526.00	.43021*	.11979	3.59
		.05770		

Overall Statistics

R^2 = .94965** R = .97450** F = 23.58 a = 2.15423

Av. Log. Gross = 3.71071 $\hat{Y}$ = $5,137.00 $\bar{Y}$ = $6,214.90

* Significant at 5 percent level.
** Significant at 1 percent level.

Possible reasons for the insignificant "b" values shown in Tables 1 through 4 are the following:

1. Individual farms in each type of farming group may be operating in different stages of production. That is, some of the farm businesses included in each sample may be operating in a portion of the production function where returns to scale are increasing, some in a portion where returns to scale are constant, and some in a portion where returns are declining. To overcome this difficulty completely, one would have to make a firm-by-firm examination to determine the conditions of returns to scale to each. Since the Cobb-Douglas type function can handle only one condition of return to scale at a time, and if data from firms having different conditions of returns to scale are used in the same fitting, meaningless values may be obtained for the constants. This may possibly be the case in this study.

2. The land input is not homogeneous since available farm records were used in this study. Heterogeneity in land input would cause spurious estimates to be indicated for land and for other categories.

3. Since there is no objective measurement of management, the assumption is made in this study that management is a random variable. If this is not true, the estimated "b" values will be either larger or smaller than they should be. If, for example, there is a correlation between the level of use of a particular measured input and an unmeasured input such as management ability, then the "b" value determined for the measured input will be either higher or lower than it should be.

4. Improper aggregation is another possible cause of insignificant "b" values. Inputs were aggregated by logic, observation, and limited investigation. If some inputs are included in one group which should be in another, insignificant estimates may result.

5. Important production factors may be left out of the equation. Since it was not feasible to include all the variables in the equation, estimates may be biased because of their omission. For example, since there is no known way to measure management, it is not included as an independent variable. If it were possible to include management and all other variables in the equation, the estimated "b" values might be somewhat different.

6. The basic data may be incorrect or biased. The valuation figures used were estimates made by individual farmers, and thus their accuracy depends upon the farmers' judgment. If all estimates had been made by the same person, results might have been more significant than those computed in this study.

As a crude test of the hypothesis that the different types of farms, as classified in this study, are on different production functions, farm groups having the same input categories were grouped together. That is, beef brood and general farms with tobacco were aggregated into one group, and beef brood and general farms without tobacco were aggregated into the second group. The Cobb-Douglas type function was then fitted to each of these groups. This procedure is not offered as an entirely valid test of the hypothesis, but should give some indication whether resources employed on beef and general farms yield similar returns. It would appear that, if these farms are on the same production function, regression coefficients for the group should show greater significance because of the larger sample size and because an equally good fit is expected. However, if the estimated regression coefficients do not show a greater significance for the group, this would indicate that the farms are on different production functions and cannot be explored by the same function.

Table 5 presents the statistics of the Cobb-Douglas function fitted to 74 beef brood and general farms with tobacco. The estimates of R and R^2 shown in Table 5 are statistically significant at the 1 percent level of probability. All the "b" values are less than 1 and the sum of the "b's" is less than 1. When the "t" test was applied to the estimates, the "b" value for livestock and feed crops was statistically significant at the .1 percent level, and the "b" value for tobacco, although not significant in Tables 1 or 3, was found to be significant at the 5 percent level. None of the other "b" values were found to be significantly different from zero at the 5 percent level. Although the "b" value for land was significant in Table 1, it was not significant in this case.

These results would indicate that beef brood and general farms with tobacco are on different production functions since the regression coefficients did not show greater significance when the groups were aggregated, but indicated somewhat different results instead.

Table 5. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 74 T. V. A. Test Demonstration Beef Brood and General Farms with Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	129.37	.18101	.09322	1.94
Labor (months)	21.20	.00985	.09975	0.10
Machinery & Power (dollars)	670.40	.10053	.05450	1.84
Livestock & Feed Crops (dollars)	1739.40	.53636***	.05648	9.50
Tobacco (acres)	1.38	.14109*	.06050	2.33
		.96884		

Overall Statistics

R^2 = .84803** R = .92089** F = 75.90 a = 1.23126

Av. Log. Gross = 3.81515 $\hat{Y}$ = $6,533.00 $\bar{Y}$ = $8,689.00

* Significant at 5 percent level.
** Significant at 1 percent level.
*** Significant at .1 percent level.

Table 6 presents the statistics of the Cobb-Douglas function fitted to 32 beef brood and general farms without tobacco. The estimates of R and R^2 shown in Table 6 were both significant at the 1 percent level of probability. When the "t" test of significance was applied to the estimated "b" values, the "b" value for labor and the "b" value for livestock and feed crops were found to be statistically significant. The "b" value for labor was not significantly different from zero in Tables 2 and 4, although the "b" value for machinery and power was significant in Table 4.

The results would indicate that beef brood and general farms without tobacco are also on different production functions since aggregation did not increase the significance of the "b" values.

Although logic and observation would suggest fairly high returns to the tobacco input, the "b" value for tobacco was not statistically significant on either beef brood or general farms. Since there was no apparent reason for these low estimates, the same function was fitted to the farms with the tobacco input omitted from the estimating equation. This was done to test, in a crude manner, the hypothesis that the low estimated "b" values were caused by correlation of input of categories. That is, if there is no correlation between the input categories, the dropping out of a term in the equation that is "not significant" should not alter the value of the remaining "b's". If there is correlation between the inputs, then the elimination of a term may increase the value of the remaining "b's".

Table 6. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 32 T. V. A. Test Demonstration Beef Brood and General Farms without Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	127.88	.19763	.19917	0.99
Labor (months)	19.32	.72231**	.24294	2.97
Machinery & Power (dollars)	786.90	-.07716	.13360	-0.58
Livestock & Feed Crops (dollars)	1707.40	.56565***	.13251	4.27
		1.40843		

Overall Statistics

R^2 = .72001** R = .84853** F = 17.36 a = .75843

Av. Log. Gross = 3.70860 $\hat{Y}$ = $5,112.00 $\bar{Y}$ = $6,483.84

** Significant at 1 percent level.
*** Significant at .1 percent level.

Table 7 presents the statistics of the Cobb-Douglas type function fitted to 63 beef brood farms with tobacco, with the tobacco input omitted from the estimating equation. In Table 7 all the "b" values, except one, are larger than they were in Table 1. The greatest increase in indicated for machinery and power input. This is because the productivity of the tobacco input is reflected in these other inputs.

These results indicate that the estimated "b" value for tobacco was low on beef brood farms partially because of correlations with other input categories. Appendix Table 1 also indicates that tobacco input is correlated with the other input categories.

Table 8 presents the statistics of the Cobb-Douglas type function fitted to 11 general farms with tobacco, with the tobacco input omitted from the estimating equation. In Table 8 all the "b" values are larger than they were in Table 3. The "b" value for labor increased tremendously in this case. Thus, the "b" value for tobacco was low on general farms partially because of correlation with the labor input. Appendix Table 3 indicates that the above statement is true since tobacco and labor are highly correlated in this case. Correlations between input variables on all the farm types studied are shown in Appendix Tables 1 through 6. These tables indicate that the variables are correlated to come extent in all the type-of-farm groups. However, this was expected since there is no known way to aggregate inputs so that no correlation exists between them.

Since this is partially a study in methodology, the same function

Table 7. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 63 T. V. A. Test Demonstration Beef Brood Farms with Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	136.76	.28391*	.11068	2.57
Labor (months)	21.96	.00553	.10438	0.05
Machinery & Power (dollars)	760.78	.10184	.07099	1.43
Livestock & Feed Crops (dollars)	1789.00	.52408***	.06309	8.31
		.91536		

Overall Statistics

R^2 = .85046**   R = .92220**   F = 82.48   a = 1.22541

Av. Log. Gross = 3.83731 $\hat{Y}$ = $6,875.57 $\bar{Y}$ = $9,265.08

* Significant at 5 percent level.
** Significant at 1 percent level.
*** Significant at .1 percent level.

Table 8. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 11 T. V. A. Test Demonstration General Farms with Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	93.77	-.15642	.19563	-0.80
Labor (months)	17.33	.47934	.30399	1.58
Machinery & Power (dollars)	324.85	.07221	.11954	0.60
Livestock & Feed Crops (dollars)	1480.70	.51215*	.18385	2.79
		.90728		

Overall Statistics

R^2 = .77491* R = .88029* F = 5.16 a = 1.59775

Av. Log. Gross = 3.68821 $\hat{Y}$ = $4,877.70 $\bar{Y}$ = $5,390.00

* Significant at 5 percent level.

was fitted to all the type-of-farm groups combined to determine how the estimates would have varied if this procedure had been followed in the study. Table 9 shows the statistics of the Cobb-Douglas type function applied to 106 beef brood and general farms with the tobacco input omitted from the estimating equation. In Table 9, both R and R^2 are statistically significant at the 1 percent level. All of the "b" values are less than 1 and the sum of the "b's" is greater than 1. The "b" values for all the inputs, except machinery and power, were found to be statistically significant.

The usefulness of the coefficients depends upon their accuracy. When the statistical standard errors are large, as they are for some of the estimated coefficients in this study, more judgment is required in interpreting the estimates. The estimated regression coefficients are accurate within their errors. Therefore, within these limits, judgment may be exercised to further refine our knowledge of the relation between input categories and gross income.

The object of estimating the regression coefficients of elasticities of production of the input categories was to describe the relationship between input categories and gross income. The inputs of the farm businesses were formulated into categories and mathematically correlated with gross income in an attempt to derive accurate estimates of regression coefficients between each input category and gross income which could be used in computing marginal value product estimates.

Table 9. Elasticities of Production, Standard Errors, "t" Values, and Miscellaneous Statistics in the Relationship of Input Factors to Gross Income with 106 T. V. A. Test Demonstration Beef Brood Farms with and without Tobacco and General Farms with and without Tobacco in Southwest Virginia, 1951.

Input Aggregate	Average Value of Input	Elasticity of Production	Standard Error	"t" Value
Land (acres)	128.69	.22308*	.09695	2.30
Labor (months)	20.53	.25208*	.10035	2.51
Machinery & Power (dollars)	692.61	.05044	.05814	0.87
Livestock & Feed Crops (dollars)	1715.60	.49585***	.05857	8.47
		1.02145		

Overall Statistics

R^2 = .76214** R = .87301** F = 80.09 a = 1.23039

Av. Log. Gross = 3.77889 $\hat{Y}$ = $6,010.30 $\overline{Y}$ = $7,944.16

* Significant at 5 percent level.
** Significant at 1 percent level.
*** Significant at .1 percent level.

Marginal Value Productivities by Resources and Farm Type

The estimated regression coefficients are not meaningful from a decision making standpoint until the marginal value productivities are computed. Therefore, the next step was to compute the marginal value productivities of the different input categories for the different types of farms studied. The formula used to estimate the marginal value products of inputs is as follows:

$$MVP_i = \frac{b_i \hat{Y}}{X_i}$$

All marginal productivities shown in Table 10 were derived from the previously estimated regression coefficients and were computed at the geometric mean of the sample in each type of farm group. The marginal value productivity estimates indicate the return (in dollars) which may be expected on the average from the addition of one unit of the various inputs, when the other inputs are held constant. For example, Table 10 presents the marginal value productivity estimates for beef brood farms with tobacco. These estimates indicate that an additional acre of land, when used on the average beef brood farm with tobacco, would earn $12.75. Similarly, an additional month of labor would earn -$5.85, an additional dollar invested in machinery and power would earn $0.90, an additional dollar invested in livestock and feed crops would earn $2.05, and an additional acre of tobacco would earn $330.40. As stated previously, these are expected earnings for the marginal unit at the geometric mean of the sample (typical farm) when other inputs are held constant. Therefore, the computed estimates do not necessarily apply to any individual farm in the group. These figures indicate high marginal returns to the livestock and feed crop input and to the land input, but low marginal returns to the inputs of labor, machinery and power, and tobacco. If maximum profit is the goal, these results may be interpreted to mean that the marginal value product estimates were low on beef brood farms with tobacco because the inputs of land and livestock and feed crops were too low relative to other inputs. That is, since the productivity of one resource depends upon the level of another, the productivity of labor and machinery and power would increase if greater amounts of land and livestock and feed crops were used.

Table 10. Marginal Value Productivities by Inputs and Farm Type in Southwest Virginia, 1951.

Farm Type	Input				
	Land 1/	Labor 2/	Machinery and Power 3/	Livestock and Feed Crops 3/	Tobacco 1/
Beef Brood					
with tobacco	$12.75	$ -5.85	$ 0.90	$ 2.05	$330.40
without tobacco	16.36	167.33	-1.55	1.52	
General					
with tobacco	-0.79	3.27	0.66	1.66	939.60
without tobacco	-17.33	-154.31	4.15	1.45	

1/ Dollar return per added acre.

2/ Dollar return per added month.

3/ Dollar return per added dollar of investment (based on yearly cost).

Furthermore, since the estimated coefficient for the livestock and feed crop input is highly significant (.1 percent level) and the marginal productivity is also high, this indicates that an additional investment in livestock and feed crops would be a good investment on the typical beef brood farm with tobacco. The same is true for the land input in this case. However, since land is significant at a lower level (5 percent level) than livestock and feed crops, the probability of additional land being a good investment on the typical farm is smaller. When the level of significance of inputs is low and the marginal productivity estimates are also low, as they are for labor, machinery and power, and tobacco, this indicates that additional units of these inputs would not be a good investment on the typical beef brood farm with tobacco. However, since the level of significance is low in these cases additional inputs may be good investments on some farms. That is, the marginal productivity of the input varies widely from farm to farm so that the predicted marginal value product is subject to a large error. Similar statements would also be true if significance levels were low and marginal productivity estimates were high.

The estimated marginal productivity of inputs for all the type-of-farm groups shown in Table 10 may be similarly interpreted. High marginal productivity is indicated for the livestock and feed crop input on each type farm shown in Table 10. Furthermore, the coefficients related to livestock and feed crops were significant in all cases. No other coefficient was statistically significant in all cases.

When all types of farms are considered, the marginal productivity estimates indicate that basically the typical farm in this study had too little livestock and feed crops in relationship to the available amount of land, labor, and power and machinery.

REORGANIZATION OF FARMS ON THE BASIS OF THE ESTIMATES

In theory, the individual farmer may maximize profits from all productive resources used in his farm business by adjusting inputs to the point where marginal cost equals marginal revenue for all resources used. The theory assumes that capital is unlimited and that farmers wish to maximize profits from all productive resources. However, this is seldom true in real life. Most farmers have limited capital to invest in their businesses and are interested in maximum profits from the farm unit - not maximum profits from individual production factors. Therefore, in buying productive resources such as land, labor, machinery, and livestock, farmers seek the most profitable investments. This being true, they will invest in a particular productive resource only if the expected returns are greater than the expected returns from other productive resources used.

In this section, the estimated coefficients for the average beef brood farm will be treated as reliable enough for use in estimating gross income and marginal products for different combinations of resource use. Therefore, on the basis of the estimates, plans can be made for reorganizing and expanding the use of resources until a more desirable farm organization and level of income are determined. The estimates for this particular type farm are used to illustrate how previously derived estimates may be used in farm organization. However, the estimates for any of the other types of farms studied may be similarly used.

Table 11 presents the estimates of gross income and the marginal earning power of the different inputs used on the average beef brood farm. The estimates indicate that the earning power of an additional acre of land is very close to the break-even point when cost is considered. Thus, adding an additional acre of land would not have been a profitable change in organization. Similarly, the earning power of an additional month of labor is less than the market wage rate in the area, and the earning power of machinery and power services is low and would not have been a profitable change in organization. On the other hand, an additional dollar invested in livestock and feed crops input would have earned $2.01. Therefore, an increase in livestock and feed crop input would have been a profitable change in organization in this case.

Table 11. Average Organization, Estimated Gross Income, and Earning Power of Input Groups at the Margin, 63 Beef Brood Farms, Southwest Virginia, 1951.

Input Group	Average Amount Used	Marginal Earning Power
Land	137 (acres)	$14.27
Labor	22 (mos.)	1.73
Machinery and Power	$761	0.92
Livestock and Feed Crops	$1789	2.01
Estimated Gross Income	$6875	

Table 12 presents estimates of gross income and the marginal earning power of the different inputs when all inputs except livestock and feed crops are at the average levels. The livestock and feed crop input has been increased from $1789 to $2685. This is one and one-half times the average input. This change in organization would have increased gross income from $6875 to $8505, or by $1630. When the livestock and feed crop input is increased and the other inputs are held constant, the marginal earning power of the livestock and feed crop input is reduced. However, diminishing marginal returns would be obtained for any input group that was increased while other inputs were held constant. In spite of the fact that the marginal earning power of the livestock and feed crop input is reduced after the 50 percent increase, it still offers the best opportunity for further investments.

Table 12. Estimated Marginal Earning Power of Inputs and Estimated Gross Income When the Livestock and Feed Crop Input is Increased from $1789 to $2685 on the Average Beef Brood Farm, Southwest Virginia, 1951.

Input Group	Average Amount Used	Marginal Earning Power
Land	137 (acres)	$ 17.63
Labor	22 (mos.)	2.14
Machinery and Power	$761	1.14
Livestock and Feed Crops	$2685	1.66
Estimated Gross Income	$8505	

Table 12 shows that when the livestock and feed crop input was increased, the marginal value of product for each of the other input groups increased. The marginal earning power of land increased from $14.27 to $17.63 per acre, the marginal earning power of labor increased from $1.73 to $2.14 per month, and the marginal earning power of machinery and power increased from $0.92 to $1.14 per dollar invested. This shows that the level of use of each input influences the productivity of each of the other inputs. That is, other inputs are used more efficiently when a highly productive input, such as livestock and feed crops, is increased. Furthermore, the estimates show that each part of the farm business is interrelated with each other part and that farms must be reorganized as a unit.

Figure 1 shows how gross income increases when the livestock and feed crop input is increased and other inputs are held constant. As the livestock and feed crop input is increased, gross income increases at a diminishing rate. That is, larger increases in gross income are attained from the first increments of livestock and feed crops than from later increments. Thus, the curve tends to rise rather steeply at first and then to level off. In this case $2685 (1½ times the average input) invested in livestock and feed crops is still a good investment.

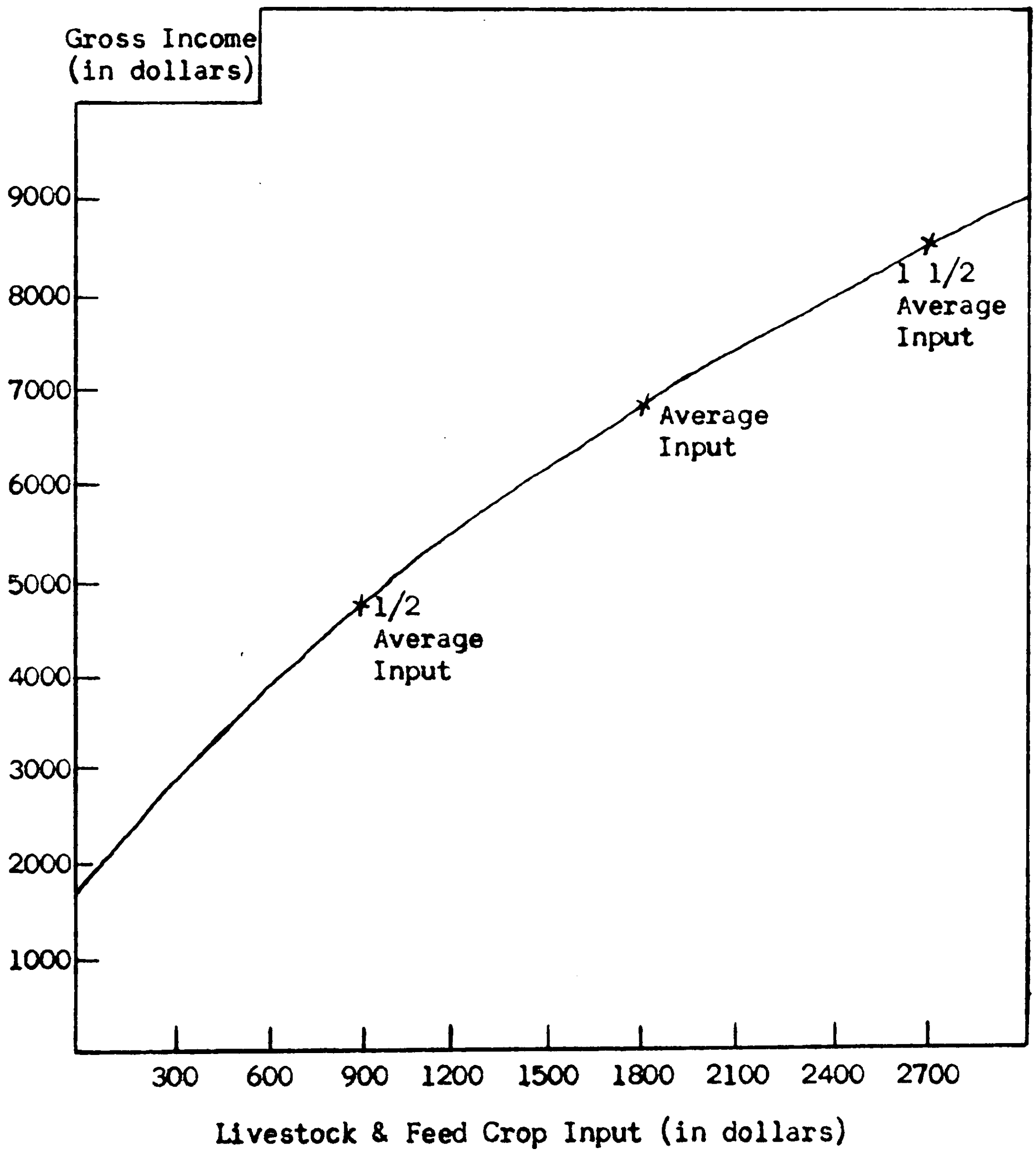

Figure 1. Estimated Gross Income when the Livestock and Feed Crop Input is Varied and Other Inputs are Held at Their Geometric Means.

SUMMARY AND CONCLUSIONS

This study presents estimates of the marginal productivity of the different classes of resources on Extension T. V. A. test demonstration farms in Southwest Virginia. The data were taken from 106 farm records kept by Unit Test Demonstrators in Southwest Virginia during 1951. The records were divided into four type-of-farm groups. These groups were beef brood farms with and without tobacco, and general farms with and without tobacco. The data were aggregated into independent variables of land, labor, machinery and power, livestock and feed crops, and tobacco. Gross income was taken as the dependent variable and production functions of the Cobb-Douglas type were fitted to the different farm types, and marginal value productivities were derived from the coefficients.

The marginal value product of each dollar invested in livestock and feed crops was high on each type farm studied. Marginal values were highest ($2.05) for beef brood farms with tobacco and lowest ($1.45) for general farms without tobacco. Furthermore, the coefficients related to livestock and feed crops were significant in all cases.

The marginal value product of land was relatively high ($12.75 per acre) on beef brood farms with tobacco and ($16.36 per acre) on beef brood farms without tobacco.

The marginal value product of machinery and power was $4.15 on general farms without tobacco and the coefficient was statistically significant in this case. However, estimates were extremely low for other type farms.

The marginal productivity of labor on beef brood farms without tobacco seems reasonable, but it was not statistically significant. The same is true of tobacco on general farms.

Generally the analysis indicated that:

(1) The typical Southwest Virginia farmer could apparently not profitably expand acreages until present acres used are more fully developed and stocked.

(2) The productivity of labor, and thus its earning power, can be increased on most Southwest Virginia farms by additional investments in high producing livestock and feed crops.

(3) Investments in livestock and feed crops were paying high returns on most Southwest Virginia farms in 1951 and could be profitably increased.

(4) Machinery and power were earning low returns on most Southwest Virginia farms in 1951.

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APPENDIX

Appendix Table 1. Correlations of the Logarithms of Each Input With Other Inputs and With Output for 63 Beef Brood Farms With Tobacco in Southwest Virginia, 1951.

	Months Labor X_2	Machine X_3	Live-stock X_4	Tobacco X_5	Gross Income Y
Acres Open Land X_1	.625	.608	.756	.447	.804
Months Labor X_2		.377	.636	.411	.615
Machine X_3			.465	.274	.550
Livestock X_4				.292	.900
Tobacco X_5					.372

Appendix Table 2. Correlations of the Logarithms of Each Input With Other Inputs and With Outputs for 22 Beef Brood Farms Without Tobacco in Southwest Virginia, 1951.

	Months Labor X_2	Machine X_3	Live-stock X_4	Gross Income Y
Acres Open Land X_1	.482	.736	.697	.715
Months Labor X_2		.293	.231	.533
Machine X_3			.572	.432
Livestock X_4				.734

Appendix Table 3. Correlations of the Logarithms of Each Input With Other Inputs and With Outputs for 11 General Farms With Tobacco in Southwest Virginia, 1951.

	Months Labor X_2	Machine X_3	Live-stock X_4	Tobacco X_5	Gross Income Y
Acres Open Land X_1	.267	.259	.523	-.145	.337
Months Labor X_2		.153	.152	.610	.407
Machine X_3			.600	.150	.608
Livestock X_4				.009	.806
Tobacco X_5					.480

Appendix Table 4. Correlations of the Logarithms of Each Input With Other Inputs and With Outputs for 10 General Farms Without Tobacco in Southwest Virginia, 1951.

	Months Labor X_2	Machine X_3	Live-stock X_4	Gross Income Y
Acres Open Land X_1	.669	.659	.491	.469
Months Labor X_2		.928	.635	.754
Machine X_3			.708	.881
Livestock X_4				.882

Appendix Table 5. Correlations of the Logarithms of Each Input With Other Inputs and With Outputs for 74 Beef Brood and General Farms With Tobacco in Southwest Virginia, 1951.

		Months Labor X_2	Machine X_3	Live-stock X_4	Tobacco X_5	Gross Income Y
Acres Open Land	X_1	.608	.575	.730	.354	.770
Months Labor	X_2		.376	.606	.433	.615
Machine	X_3			.460	.286	.553
Livestock	X_4				.246	.891
Tobacco	X_5					.384

Appendix Table 6. Correlations of the Logarithms of Each Input With Other Inputs and With Outputs for 32 Beef Brood and General Farms Without Tobacco in Southwest Virginia, 1951.

		Months Labor X_2	Machine X_3	Live-stock X_4	Gross Income Y
Acres Open Land	X_1	.475	.665	.650	.657
Months Labor	X_2		.468	.317	.579
Machine	X_3			.611	.552
Livestock	X_4				.764