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CAPITAL PRODUCTIVITY ON SPECIALIZED SWINE FARMS IN SOUTHERN BRAZIL

by

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Summary

The following report is the third in a series of studies investigating capital use and productivity at the farm level in Brazil. Data for these studies were collected in 954 individual farm interviews in southern Brazil during 1965-66.

In the present study, information from a sub-sample of 217 specialized hog farms is used to study capital productivity through the estimation of production functions. The estimated production coefficients are derived by the use of least squares regression techniques fitted to cross-sectional data, and used to calculate marginal value productivities of factor inputs. Cobb-Douglas production functions are fitted to the selected variables for different size farm groups.

Constant or slightly decreasing returns to scale are suggested for small and medium size farms. Large farms indicate fairly strong decreasing returns to scale.

Marginal value productivities of aggregate operating expenses and working assets capital and of their respective components vary among different farm size groups. Operating expenses, when considered in the aggregate, yield positive but different marginal value products for all size groups. On the small farms, all individual components of operating expenses capital have high marginal value products. For the larger farms, marginal returns for hired labor (a cash expense which competes with alternative uses for operating capital) and crop cost components are relatively high, whereas returns to machine and animal costs are low.

The marginal returns to aggregate farm working assets are positive and in all cases slightly greater than imputed marginal costs. Non-mechanized equipment is a profitable item for all farm size groups.

Mechanized equipment, however, shows a negative marginal product for small farms and positive returns for the larger farms.

Both family labor (a non-cash expense variable) and land demonstrate low marginal returns for all farm size groups. Average product per hectare of land decreases with increases in farm size. Family labor is somewhat more productive on larger farms.

The implication for agricultural policy is that considerations other than increased farm size may make a greater contribution to increased agricultural output. For example, high marginal returns to various capital inputs may indicate the existence of external capital rationing. Additional credit availability may foster increased use of these inputs.

In general, the analysis points to the desirability from a production viewpoint, of expansion in output at the intensive margin.

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Capital Productivity on Specialized Swine Farms in Southern Brazil

Donald M. Sorensen[1]
Norman Rask
Francis E. Walker

The purpose of this study is to estimate the productivity of capital at the farm level in Southern Brazil through the estimation of production functions. The production coefficients are estimated by the use of least squares regression techniques from cross-sectional data and are used to calculate marginal value productivities of factor inputs.

The data were obtained as part of a general study of capital use and productivity at the farm level in Brazil. Farms from several regions of southern Brazil were selected using a random cluster sampling technique.[2] To provide relative homogeneity of specific capital inputs only swine farms are selected for analysis in this study.[3] A swine farm is defined as one that receives 60 percent or more of its total crop and livestock income from the sale of swine or swine products (average of 82 percent for the 217 swine farms).

Specialized swine farms account for about one-fourth of all farms surveyed in the general study and are the predominate major enterprise in the sample population. Data are for the 1965 calendar year.

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[1]Donald M. Sorensen is Assistant Professor of Economics at Colorado State University, Norman Rask is Associate Professor of Agricultural Economics at Ohio State University and Francis E. Walker is Professor of Agricultural Economics at Ohio State University.

[2]For a detailed description of the methodology and farm description for the general study, see Norman Rask, "An Analysis of Agricultural Development Problems at the Farm Level - Southern Brazil, Methodology and General Farm Description," AFC Research Report 120, Department of Agricultural Economics and Rural Sociology, The Ohio State University, Columbus, Ohio, 1968.

[3]For a similar analysis of other farm types, see Norman Rask, "Analysis of Capital Formation and Utilization in Less Developed Countries," Economics and Sociology Occasional Paper No. 4, Department of Agricultural Economics and Rural Sociology, The Ohio State University, Columbus, Ohio, December, 1969.

The sub-sample consists of 217 swine farms located in five municipios in the two southernmost states of Brazil. (Fig. 1). Farm size ranges from 2.3 hectares to 101.9 hectares of cultivable land equivalents.[4] The average size farm is 14 hectares. The farms are sub-grouped into three size classes (Table 1). There are 81 farms with less than 10.0 hectares, 100 with 10 to 19.9 hectares, and 36 with 20 hectares or more of cultivable land equivalents.

The intensity with which available land is utilized reflects close integration of crop and swine production enterprises on the farms studied. Of the 14 hectares of cultivable land equivalents on the average farms, 12 hectares are used for crop production, principally corn. Moreover, 97 percent of all corn production is utilized on the farm, with the remaining three percent sold as cash grain.

Farm labor resources consist primarily of available family labor which ranged from an average of 2.4 man equivalents on the smaller to 3.6 on the larger farms with three man equivalents being the average for all farms.[5]

Only 20 farms employed full-time non-family labor while 77 farms made use of seasonal labor during the peak periods of crop planting and harvesting. The predominance of family labor is a reflection of the tenure situation where 88 percent of the swine farms are partially or fully owned by the resident operator.

The remaining data concerning production resources as well as farm output are expressed in value terms of the new cruzeiro. During 1965,

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[4]Hectare equivalents are based on amount of land actually used for agricultural production. Area in crops is added to area in imporved pasture and one-third of the area in native pasture to give total hectares of cultivable land equivalents. One hectare is equivalent to 2.47 acres.

[5]A man equivalent is defined as 300 days of productive labor available on the farm from an adult male (age 18-59). The sex, age, and place of residence of all family members are weighted to determine the total man-year equivalents of available family labor.

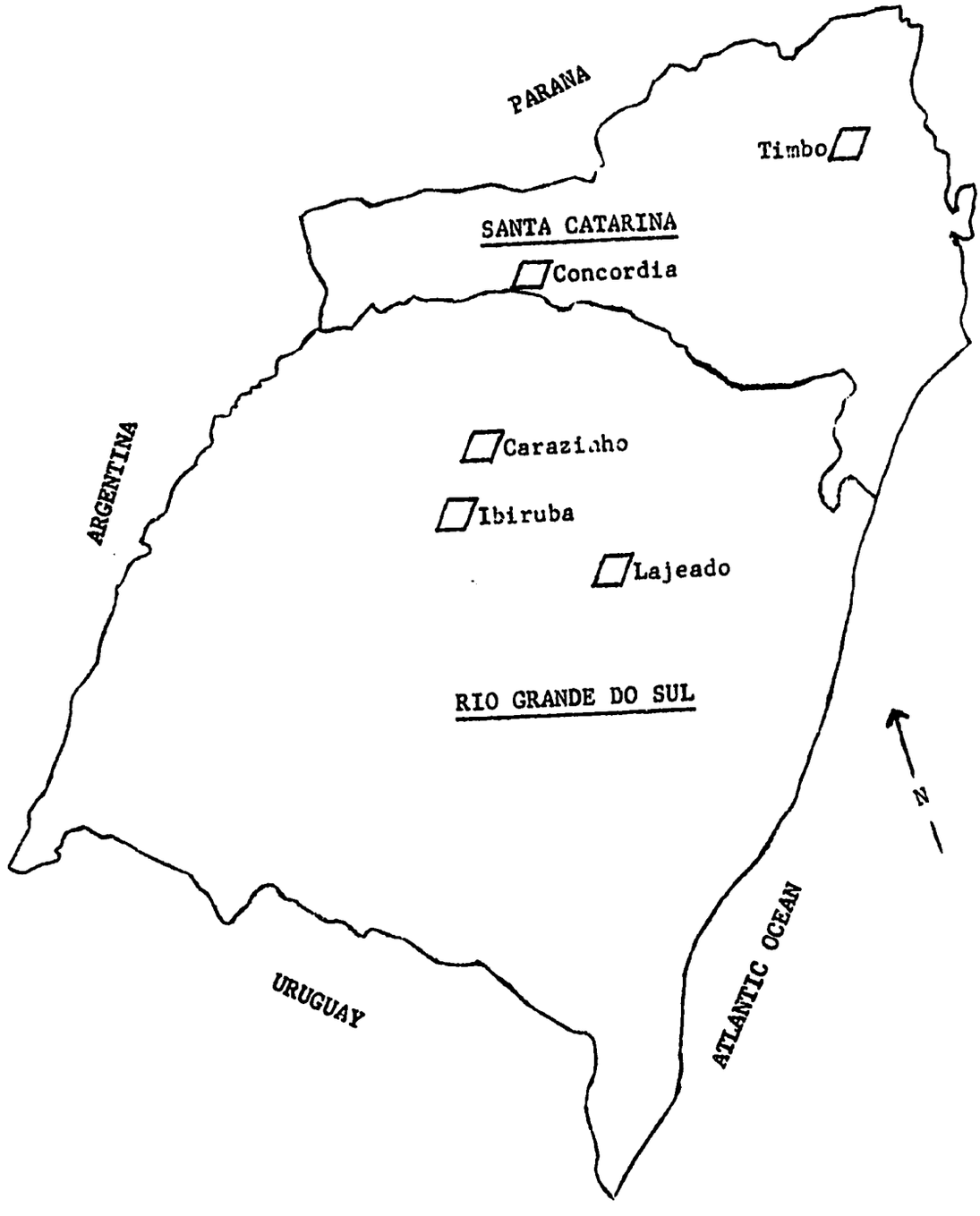

Fig. 1. -- Location of the five municipios in southern Brazil from which the sample of 217 swine farms was taken--1965.

the "old cruzeiro" was still in criculation and exchanged at the rate of 1,830 to $1.00 U. S. for most of the year. The exchange value of the new cruzeiro, equivalent to 1,000 old cruzeiros, was approximately equal to $.55 U. S. in 1965. All value data are transformed into new cruzeiro equivalents and are expressed as new cruzeiros (NCr $).

TABLE 1

FARM SIZE DISTRIBUTION BY MUNICIPIO
217 Swine Farms -- Southern Brazil -- 1965

Municipio	Farm Size			
	All	2.3-9.9 ha.	10-19.9 ha.	20-101.9 ha.
	(Number of Farms)			
Ibiruba	59	6	29	24
Lajeado	41	25	15	1
Carazinho	11	--	4	7
Concordia	99	44	51	4
Timbo	7	6	1	--
TOTAL	217	81	100	36

Two forms of capital are used in the analysis. They are: (1) operating expense capital which is that capital used up in a given production cycle, and (2) working asset capital which is non-real estate capital with a useful life for periods extending beyond a single production cycle.[6]

Use of operating expense and working asset capital varies considerably, both in absolute amounts and in intensity of use per hectare of land. Total operating expenses per farm range from NCr $5 to NCr $4,133 with an average expenditure for all farms of NCr $565 (Table 2). The intensity of operating expenses per hectare ranges from NCr $1.00 to NCr $343 and averages NCr $42. Total working assets capital investment varies from

[6]For a full definition of the distinction between the two types of capital, see the section on capital variable definition on Page 11.

NCr $395 to NCr $21,480 (average NCr $2,940) and asset intensity varies from NCr $55 to NCr $743 per hectare (average NCr $234). The wide variance in the use of both types of capital suggests that analysis of capital productivity would be facilitated by sub-grouping the farms to reflect alternative levels of capital use intensity as well as the use of alternative proportions of the two types of capital relative to each other. Therefore, seven sub-groups based on intensity combinations are formed. The resource and output data for each are presented in Table 3. The seven sub-groups are determined by first dividing the farms into two groups on the basis of working assets, then each of these groups is further divided by level of operating expenses.

The composition of each type of capital is also given in Table 3. The largest component of operating expenses is animal costs. Similarly, productive livestock is the item of greatest importance in working assets. Since swine production is the predominant activity of the farms studied, the relative importance of these two capital items is expected. Crop cost and machinery cost components of operating expenses increase more than in proportion to total operating expenses as farm size increases. Mechanized equipment is a rather significant component of working assets only on farms 20 hectares or greater in size.

The value of gross farm output averages NCr $2,225 per farm or NCr $176 per hectare on all farms. Gross farm output is the sum of farm cash sales, the change in animal inventory, and production for family consumption. Farm cash sales accounted for NCr $1,769 of the NCr $2,225 average gross farm output during 1965. The sale of swine and swine products represents 82 percent of total farm cash sales.

A brief review of farm practices indicates the nature of management on the swine farms. Livestock practices considered are the raising of

improved breeds, feeding of purchased feed supplements, and other recommended practices. Of the 217 swine farmers interviewed, 135 raise improved breeds of swine, 86 use purchased feed supplements, 159 clip needle teeth, 179 take steps to control internal parasites, and 73 vaccinate swine. The number of pigs weaned per sow per year ranges from 1.6 to 20 with an average of 8.87. Average age of swine marketed is 11 months, with some swine reaching the market at 24 months. Swine are marketed at an average weight of 102 kilograms.[7]

Concerning crop practices, 134 of the 217 farmers plant improved seed, 45 apply commercial fertilizer, and 73 use insecticides and fungicides.

Although specialized, wide variability in gross farm output, use of production inputs and management is characteristic of the swine farms studied. The purpose of the present study is to examine the relationships between gross farm output and the use of capital inputs. In a subsequent publication, the management factor will be introduced and that study will examine the interrelationships between management performance, use of capital inputs, and gross farm output.

Methodology

The method of analysis chosen to study the value productivity of capital at the farm level is the estimation of production functions. The estimated production coefficients are derived by use of least squares regression techniques fitted to cross-sectional data. The data were obtained through farmer interviews based on farmer recall. The production coefficients generated by the analysis are used to calculate marginal value productivities of factor inputs.

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[7] A kilogram is equal to 2.2 pounds.

TABLE 2

AVERAGE INPUT AND OUTPUT DATA BY FARM SIZE
217 Swine Farms -- Southern Brazil -- 1965

Factor Input	Range of Farm Size			
	All Farms	Small Farms 0-9.9 ha.	Medium Farms 10-19.9 ha.	Large Farms 20+ ha.
Number of Farms	(217)	(81)	(100)	(36)
Cultivable Land Equivalents (hectares)	14.0	7	14.2	29.9
Family Labor (man-year equivalents)	3.0	2.4	3.3	3.6
Operating Expenses (new cruzeiros) Total	565	326	518	1236
Labor Costs	24	16	24	42
Crop Costs	58	21	39	197
Machinery Costs	69	19	76	161
Animal Costs	304	182	279	649
Working Assets (new cruzeiros) Total	2940	1945	2850	5433
Production Livestock	1790	1271	1780	2982
Unmechanized Equipment	481	352	497	729
Mechanized Equipment	448	132	343	1451
Gross Farm Output Total	2225	1354	2337	3872
Gross Farm Output per Hectare	176	206	165	137

TABLE 3

AVERAGE INPUT AND OUTPUT DATA BY

LEVEL OF CAPITAL USE INTENSITY

217 SWINE FARMS -- SOUTHERN BRAZIL -- 1965

	Low Asset Intensity Farms 0-199 NCr$/Hectare			High Asset Intensity Farms 200 NCr$/Hectare or Greater			
	0-19[a] NCr$	20-39 NCr$	40-49 NCr$	0-19 NCr$	20-39 NCr$	40-79 NCr$	80+ NCr$
Number of Farms	(53)	(32)	(16)	(20)	(34)	(37)	(16)
Cultivable Land Equivalents (hectares)	15.6	16.8	16.4	10	14.5	12.1	11.1
Family Labor (man-year equivalents)	3.1	3.3	3.1	3.2	3.0	2.9	2.4
Operating Expenses (new cruzeiros) Total	147	489	905	140	456	676	1658
Labor Costs	4	23	39	3	19	22	86
Crop Costs	21	81	78	14	71	66	103
Machinery Costs	13	70	125	8	67	105	144
Animal Costs	58	258	472	66	224	349	1008
Working Assets (new cruzeiros) Total	2053	2512	2399	2611	3755	3907	3442
Production Livestock	1507	1734	1747	1689	1983	1876	2176
Unmechanized Equipment	428	557	512	526	493	499	400
Mechanized Equipment	--	56	--	235	1024	1234	409
Gross Farm Output Total	1497	2475	2477	1524	2303	2428	3441
Gross Farm Output per Hectare	103	150	153	165	179	217	321

[a]All ranges in this row reflect alternative levels of operating expense intensity for each of two levels of working assets.

The variables included in this study are gross farm output (the dependent variable) regressed on land, family labor, operating expenses, and working assets (the independent variables). The definition, composition and unit of measurement for each variable is given in the following section.

The Variables

Gross Farm Output

The dependent variable is gross farm output defined as the total value of farm production during the year 1965. By using gross farm output, all resource inputs are included whether owned, rented, or borrowed, and the return to the resource is not subtracted out as a debit in the case of rented land, borrowed equipment, hired labor, or borrowed funds. Gross farm output is expressed in value terms of the new cruzeiro.

Gross farm output is computed by summing the total value of livestock and livestock products sold, adjusted for changes in animal inventory (including purchased livestock), value of crop production sold and value of livestock and crop production consumed by the farm family.[8] The value of products used for home consumption represents an important component of total production on farms located in southern Brazil, particularly on the smaller farms,each of which consumes a substantial proportion of its total production.

Land

Farms included in this study use land in three basic ways for agricultural production: cultivation of crops, improved pasture, and native

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[8]Heady and Shaw include home consumption of crops and livestock in their definition of gross output. See Earl O. Heady and Russell Shaw, "Resource Returns and Productivity Coefficients in Selected Farming Areas of Iowa, Montana, and Alabama", Iowa State Agricultural Experiment Station, Research Bulletin No. 425, April, 1955.

pasture. One the swine farms, agricultural land is used predominantly for crop production with an average of 86 percent (12 of 14 hectares of cultivable land equivalents) being devoted to this activity.

To measure the land resources available for agricultural production, a weighting procedure is used to take account of different land use patterns. Cultivated land is that land tilled for annual crop production. All such land is given unit value in the weighting index. Improved pasture is an annual crop used to supplement native pastures which lie dormant during the winter months. Native pastures are areas which have remained in grasses without substantial modification due to management practices. Since the same inputs required for cultivated crops also are required for improved pasture and since productivities are comparable, equal weight is given to improved pasture in the area measure.

Although the effective stocking rate of improved pasture is five times that of native pasture, the normal practice is to use the former as a supplement to native pasture only during the winter months. This indicates a one to three ratio (improved to native) is a more accurate relationship of the relative productivities of the two types of pasture.

Total land resources available for agricultural production on each farm, therefore, is computed by taking one-third of the area in native pasture and adding this to the area in cultivated crops and improved pasture. This total becomes hectares of cultivable land equivalents.

Labor

Two measures of labor input are used. The first measure, representing labor as an independent variable in the production function, is man-equivalents of family labor available from the farm family. A man-equivalent is defined as 300 days of productive labor available on the farm and is determined by age and sex of family members. The second measure of labor is non-family or hired labor. This labor input has a cash cost associated

with its use. Wages paid to hired labor compete with alternative uses for operating capital, hence, are included as a component of farm operating expenses.

Capital

Capital, as employed in agricultural production, is a multi-component conglomeration of items measured in two basic dimensions, as a flow and as a stock. Since capital is made up of numerous components, aggregation into these two categories is required to form a stock variable and a flow variable in the aggregate model. The flow variable consists of those items of capital that are consumed or totally used up in the process of a single production cycle.[9] Cash operating expenses composed of crop, livestock, machinery repair, fuel, and hired labor costs are classified in the flow variable of capital.

The stock measurement of capital consists of farm working assets valued at a given point in time. Components of the stock variable are productive livestock, work stock, mechanized equipment, and unmechanized equipment. The wide variation in type and amount of equipment found on sample farms makes a constant rate of depreciation unrepresentative of the useful life of each equipment item; therefore, no attempt was made to convert the stock components to flow measurement in this study.

The Components of Cash Operating Expenses and Farm Working Assets

To study the relative productivity of individual components of capital used on swine farms, each capital variable (stock and flow) is disaggregated into several individual categories. In essence, each component

[9]Recognition is given to the fact that certain residuals from fertilizer applications, for example, can be carried over to succeeding years, thus, technically not completely consumed in a given production cycle. However, the expenditure for fertilizer is generally based on the assumption that current crop production will recoup costs of fertilizer application.

of the stock and flow variables contains an aggregation of items that are either good complements or good substitutes for each other.[10] This restriction determines component composition. Items that are highly correlated are put into a single component to reduce, insofar as possible, high inter-correlations of capital components. Individual items are grouped into components for a second reason. If all capital items are included independently in the model, this limits the statistical significance of the estimated elasticity coefficients. However, if too few variables are specified in the model, the estimated elasticity coefficients are of little practical value for policy recommendations. Within a given input component, some quality differences can be expected. No means short of controlled experiment could eliminate these differences.

The components of operating expenses are measured in value terms by farm-level expenditures for each during the 1965 crop production year. These components are crop cost, livestock cost, labor cost, machinery cost, and general costs. Crop costs are the costs incurred in raising crops and include purchased seed, fertilizer, insecticides, machine hire, crop insurance, and marketing costs. Livestock production costs include purchased feed, livestock minerals, medications, and marketing costs. Labor cost is wages paid to hired non-family labor during the year. Machinery costs include gasoline, oil, tires, parts, repairs, tools, and insurance. General expenses include other miscellaneous expenses not covered in the above specific expense categories.

The components of farm working assets are the current value of assets measured at the farm level. Production animals are all animals

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[10]See Glenn L. Johnson, "Classification and Accounting Problems in Fitting Production Functions to Farm Record and Survey Data," in Resource Productivity Returns to Scale and Farm Size, edited by Heady, Johnson, and Hardin, Iowa State University Press, 1956, pp. 90-96. Also Zvi Griliches, "Measuring Inputs in Agriculture: A Critical Survey," Journal of Economics, Volume XXXXII, 1960, pp. 1411-1427.

used to produce meat and milk, predominantly pork on the swine farms. Mechanized equipment includes all motorized equipment, tractors, and tractor-drawn machinery. Non-mechanized equipment includes all work stock, equipment using animal power (oxen, mules, and horses) and manual equipment.

Land and buildings are not measured in value terms nor are these items included as farm working assets. In the case of buildings, difficulty in measuring their contribution to production precludes their use as a working asset. Since land is included as a physical unit, the inclusion of land investments in farm working assets would amount to double counting of land.

Selection of Function

The Cobb-Douglas production function -- that is, an equation linear in the logarithms of the variables -- is chosen for this study. Characteristics of this type function include: (1) the phenomenon of diminishing marginal returns of each factor, and (2) the implicit assumption of marginal rates of substitution, at a diminishing rate, among factors, thereby causing productivity of one factor to be dependent on the magnitude of the others. Due to the limited number of total observations, both dissaggregation of the data and disaggregation of the capital variables require selection of a function that minimizes use of degrees of freedom, yet represents the underlying production relationship. The Cobb-Douglas function uses up fewer degrees of freedom while retaining consistency with underlying economic theory. Since the function is a linear equation in logarithms, it can be estimated by the method of least squares.

The general form of the Cobb-Douglas function in logarithms is expressed as:

$$\text{Log } Y = \log a + b_i \log X_i + \epsilon$$

where:

Y = the dependent variable

X_i = the set of independent variables

Log a = the constant term, denoting level of function

b_i = the set of regression coefficients giving the elasticities of production

ϵ = error term, variation not explained by variables included in the function

The Cobb-Douglas function yields regression coefficients (b_i's) that can be interpreted directly as the elasticities of production indicating percentage change in output associated with a one percent change in the various input factors.[11] The marginal value product of each input factor is computed directly from the elasticities by use of the following formula:

$$MP_i = b_i \frac{\bar{Y}}{\bar{X}_i}$$

where

MP_i = the marginal productivity of X_i

b_i = the regression coefficient (elasticity of production) of log X_i

$\bar{Y}$ = the geometric mean of gross farm receipts

$\bar{X}_i$ = the geometric mean of the ith independent variable X_i

This derivation of marginal productivities of the various input factors allows inferences to be drawn relative to resource utilization and efficiency.

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[11]For an explanation of statistical estimates related to Cobb-Douglas functions, see Cecil B. Haver, "Economic Interpretations of Production Function Estimates," E. O. Heady, G. L. Johnson, and L. S. Harden (eds.), Resource Productivity Returns to Scale and Farm Size, Iowa State University Press, Ames, Iowa, 1956, pp. 146-150.

DATA ANALYSIS

Two equations, one with capital components aggregated into two variables (operating expenses and working assets) and one with operating expenses and working assets disaggregated into their respective components, are employed in the analysis of capital productivity. Both equations are fitted to the logarithms of the data for all 217 swine farms taken together and for three sub-groups divided by farm size (0-9.9 hectares, 10-19.9 hectares and 20 or more hectares per farm). The number of observations within each farm size sub-group is 81, 100, and 36 respectively.

Capital Productivity -- Aggregate Model

The Aggregate Five-Variable Production Function

The aggregate production functions fitted to the logarithms of the data generated by the 217 swine farms are estimated by the following five-variable equation:

$$\text{Log } Y = \log b_0 + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4$$

where:

Y = Gross farm output measured in value terms (new cruzeiros NCr, 1 NCr = approximately $.55 U. S.)

X_1 = Hectares of cultivable land equivalents

X_2 = Man year equivalents of family labor

X_3 = Farm operating expenses measured in value terms

X_4 = Farm working assets measured in value terms

The derived regression (elasticity) coefficients, together with other relevant statistics for all groups, are presented in Table 4. For all functions, each of the elasticity coefficients are less than one, indicating

diminishing (or negative) marginal returns to each production factor; i.e., holding each of the other factors constant, the marginal return of each factor will decrease as more of the factor is used. The sum of the elasticity coefficients indicates the percentage by which the total value of product increases as all factors (X_1, X_2, X_3, X_4) are increased by one percent. The sum of elasticities for the function fit to the data for all 217 swine farms is .96, implying slightly decreasing returns to scale.[12]

Land is statistically significant for the largest two sub-groups of farms only. For the 10-19.9 hectare sub-group the land coefficient is significant at the level of .05 and for the 20 or greater hectare group at the level of .20. Failure of the land variable to prove statistically significant for all farms taken together may be due to the high correlation between land and working assets. Estimates of the land coefficients have large variances; therefore, results are non-significant and unstable. Specification of the land variable in terms of hectares of land equivalents may also contribute to low statistical significance. While taking into account different patterns of land use, this measure does not distinguish quality differences. The negative coefficient estimated for farms greater than 20 hectares in size suggests that perhaps insufficient capital inputs are being employed relative to the land base.

Family labor is not statistically significant for any of the farm groups. This may be attributable to specification of available family labor as the explicit labor variable in the equations; although the importance of labor is implicit in specialized swine production, available family labor may overstate the labor input. Generally, there is a redundant

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[12]See Earl R. Swanson, "Determining Optimum Size of Business from Production Function," Heady, Johnson, and Dillon, Agricultural Production Functions, Ames, Iowa, Iowa State University Press, 1961, pp. 131-143.

TABLE 4

ELASTICITY COEFFICIENTS AND RELATED STATISTICS OF THE ESTIMATED AGGREGATE FIVE-VARIABLE PRODUCTION FUNCTIONS BY FARM SIZE
217 Swine Farms -- Southern Brazil -- 1965

	All 217 Farms	0-9.9 Hectares	10-19.9 Hectares	≥20 Hectares
Factor Input				
	L A N D			
Elasticity Coefficient b_1	.0590	.0318	.3814	-.6873
Standard Deviation of Elasticity Coefficient S_{b1}	.0883	.2417	.1879	.4405
T-Test[a] for $H:b_1=0$	.6679[b]	.1317[b]	2.0304[c]	-1.5601[d]
	F A M I L Y L A B O R			
Elasticity Coefficient b_2	.0153	-.1001	-.0418	.1257
Standard Deviation of Elasticity Coefficient S_{b2}	.0904	.1563	.1016	.2789
T-Test for $H:b_2=0$	.1751[b]	-.6401[b]	-.4348[b]	.4506[b]
Multi-Correlation Coefficient R	.7712	.7161	.7454	.8021
Coefficient of Multiple Determinant R_2	.5948[e]	.5129	.5557	.6433
Factor Input	O P E R A T I N G E X P E N S E S			
Elasticity Coefficient b_1	.2982	.2783	.1958	.5554
Standard Deviation of Elasticity Coefficient S_{b1}	.0443	.0816	.0475	.1263
T-Test[a] for $H:b_1=0$	6.7352	3.4110	4.1201	4.3964
	W O R K I N G A S S E T S			
Elasticity Coefficient b_2	.5894	.7046	.5648	.5944
Standard Deviation of Elasticity Coefficient S_{b2}	.1044	.2052	.1142	.2719
T-Test for $H:b_2=0$	5.645	3.4339	4.9456	2.1865[c]
Sum of Elasticity Coefficient Σb_1	.962	.915	1.101	.588
Number of Observations	217	81	100	36

[a]All coefficients without letter indications are statistically significant at a level of .01 or higher.
[b]Coefficient is not statistically different from zero
[c]Coefficient is statistically significant at the level of .05.
[d]Coefficient is statistically significant at the level of .20.
[e]All coefficients of multiple determination are significant at the level of .01.

quantity of family labor on the swine farms. This suggests that little added contribution to production could be achieved by the availability of more family labor. Moreover, use of man-year equivalents to specify the family labor variable measures only the amount of labor available but may not measure accurately the contributions of family labor to the production process. While peak periods of planting or harvesting may require full participation of family labor, the slack periods probably result in some underemployment of family labor in the absence of alternative off-farm employment opportunities. If, on the average farm, family labor is underemployed, little additional product could be expected from the addition of another man-year equivalent of family labor. On the other hand, marginal off-farm labor hired periodically on certain farms is included in operating expenses and may account for part of the lack of significance of the labor coefficients.

The estimated elasticity coefficients for farm operating expenses, X_3, are statistically significant for all farm groups at the level of .01 or higher. The relative size of the estimated coefficients indicate that the larger farms will provide a greater response than other groups from an additional one percent invested in operating expense.

Farm working assets, X_4, is a statistically significant variable for all farm groups. Whereas operating expense generates a greater output response on the larger farms, the smaller farms provide the greatest response (.7046) to an increase in working assets.

The relative importance of individual variables is determined by their net or standardized regression coefficients. The standardized beta coefficient formula for the Cobb-Douglas regression coefficient is:

TABLE 5

STANDARDIZED REGRESSION COEFFICIENTS FOR INDEPENDENT VARIABLES OF THE AGGREGATE PRODUCTION FUNCTIONS BY FARM SIZE
217 Swine Farms--Southern Brazil--1965

Variable		RANGE OF FARM SIZE			
		All 217 Swine Farms	0-9.9 Hectares	10-19.9 Hectares	Greater than 20 Hectares
		Standardized Regression Coefficients			
Farm Working Assets,	X_4	.4016	.3925	.4357	.3596
Farm Operating Expenses,	X_3	.4094	.3779	.3452	.5990
Cultivable Land Equivalents,	X_1	.0412	.0120	.1511	-.2123
Family Labor,	X_2	.0099	-.0538	.0303	.0489

TABLE 6

CORRELATION COEFFICIENTS BETWEEN GROSS FARM OUTPUT, LAND, FAMILY LABOR, OPERATING EXPENSE AND WORKING ASSETS BY FARM SIZE
217 Swine Farms--Southern Brazil--1965

	RANGE OF FARM SIZE															
	All 217 Swine Farms				Farm Size 0-9.9 Hectares				Farm Size 10-19.9 Hectares				Farm Size ≥ 20 Hectares			
	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4
Y	.498	.171	.703	.710	.274	-.093	.655	.655	.378	.055	.609	.666	.177	.150	.764	.601
X_1	--	.420	.460	.661	--	.240	.303	.409	--	.204	.209	.370	--	.098	.278	.605
X_2	--	--	.075	.285	--	--	-.105	-.005	--	--	-.115	.220	--	--	.119	.141
X_3	--	--	--	.681	--	--	--	.681	--	--	--	.525	--	--	--	.606

$$B_i = b_i \frac{S_{xi}}{S_y}$$

where: B_i = the standardized regression coefficient

b_i = the estimated regression coefficient

S_{xi} = the standard deviation of the explanatory variable (in logarithms)

S_y = the standard deviation of the dependent variable (in logarithms)

In all cases, the two most important variables are operating expenses and working assets; however, their order changes from group to group (Table 5). The two types of capital appear about equally important for all 217 farms taken together and for farms in sub-group 0-9.9 hectares. For the 10-19.9 hectares group the most important variable is working assets. For the larger farms (20 or more hectares), operating expenses assume greater importance than working assets. Family labor adds little to the explanation of total variation in gross farm output for all farm sub-groups. With the exception of the 10-19.9 hectare sub-group, land contributes very little to explained variations in gross farm output.

The simple correlation coefficients between each pair of variables are calculated and the values are presented in Table 6. The variables most highly correlated with gross farm output are operating expenses and working assets. Among the independent variables, the highest correlation exists between the two capital variables.

In summary, for all cases, working assets and operating expenses variables are the most significant. Computed "t" statistics, standardized beta coefficients and partial correlation coefficients all substantiate this conclusion. The same statistical tests computed for the family labor and land variables indicate the low level of impor-

tance associated with their contribution to the explanation of variations in gross farm output. The estimated elasticities of production for operating expense and working asset capital for all farm groups indicate that, on the average, swine farmers are operating within the area of diminishing returns with respect to each type of capital.

Marginal Value Product of Operating Expenses and Working Assets

Marginal value productivities from logarithmic production functions are computed at the geometric mean of all variables. There are two sources of variation that affect computation of marginal value productivity; i.e., the estimated elasticity coefficient and the level of the respective factor input. For all farm groups, marginal value productivities are calculated for the four factor inputs and the results are given in Table 7.

Interpretation of marginal value productivities is subject to the reservations associated with the statistical non-significance of certain of the elasticity coefficients used in computation of the MVP's. For example, all estimated regression coefficients of family labor are non-significant; hence, the coefficients are not different from zero in a statistical sense and marginal value products could be considered as zero. The land variable is of little significance for all of the 217 swine farms taken together and for the 0-9.9 hectare group; consequently, the same reservations with respect to interpretation of estimated marginal value productivity of land apply.

The estimated marginal value productivity of land is NCr $8.59 for all 217 farms taken together and varies from NCr $55.86 for the 10-19.9 hectare farm group to a minus NCr $70.55 for the farms of 20 or more hectares. The relatively low marginal return to land suggests that land alone is not a constraining factor to increased gross output. Rather,

TABLE 7

MARGINAL VALUE PRODUCTIVITY AND GEOMETRIC MEAN LEVEL OF LAND, FAMILY LABOR, OPERATING EXPENSE AND WORKING ASSETS BY FARM SIZE
217 Swine Farms--Southern Brazil--1965

Farm Group	FACTOR INPUT			
	Land	Family Labor	Operating Expense	Working Assets
	Marginal Value Productivity			
All 217 Swine Farms	(8.59)[a]	(9.94)	1.64	.41
By Size Group				
0-9.9 hectares	(5.34)	(-50.09)	1.55	.44
10-19.9 hectares	55.86	(-29.83)	1.22	.44
≤ 20 hectares	-70.55	(103.78)	2.12	.39
	Geometric Mean Input Level			
All 217 Swine Farms	11.7 (Hectares)	2.7 (man-equivalents)	310 NCr$	2444 NCr$
By Size Group				
0-9.9 hectares	6.5	2.2	195	1741
10-19.9 hectares	13.9	3.0	325	2591
≤ 20 hectares	28.2	3.4	758	4452

[a]Marginal value productivities in parentheses are calculated with the use of statistically non-significant elasticity coefficients (at the level of .20).

the low return to land may mean that resources other than land are scarce on these farms; hence, increasing land area alone will not have an important effect upon gross output. Thus, rather than expanding the extensive margin of cultivation, it may be more profitable on the average to expand at the intensive margin.

The mean level of family labor available for the three sub-groups of farms increases with farm size (2.2, 3.0, 3.4 man-equivalents). If it is assumed that family size is not related to farm size, the increasing average amount of family labor available as farm size increases suggests that family participation in agricultural production depends on farm size. Alternatively, the relatively reduced scale of operation on farms in smaller size groups may mean that some family members are employed full or part time in off-farm work, and thus, not included in the calculation of available family labor.

Farm operating expenses and working assets are the most important variables in explaining variations in gross farm output. The estimated marginal value productivity of farm operating expense is NCr $1.64 per new cruzeiro for all 217 swine farms taken together. Since one new cruzeiro of the marginal value product is the recovery of the original investment, the net marginal value product for all farms is NCr $.64. Given this rate of return, farmers could afford to borrow money at commercial rates of interest which run from 30-36 percent per annum. Alternatively, the practice of subsidizing interest rates on loans to farmers (farmer cost of 12-15 percent) may indicate that farmers in southern Brazil require a rather substantial margin to cope with widely fluctuating and unstable prices for agricultural commodities if they are to undertake further capital expenditures.

The farms of 20 or more hectares have the highest marginal value product for operating expenses with a gross return of NCr $2.12. This group of farmers could productively incur additional operating expenses even if payment of commercial interest rates is made. On the average, this group has a net marginal value product of NCr $1.12 which implies that these farmers are a good distance from the intensive margin in use of operating capital. The farms in size range 10-19.9 hectares have the lowest marginal value product of the three groups for operating expenses (NCr $.22).

The farms of the 0-9.9 hectare group have a net marginal value productivity for operating expenses of NCr $.55, which is between that of the other farm size groups.

The estimated marginal value productivity of farm working assets for all 217 swine farms taken together is NCr $.41 per new cruzeiro investment in farm assets. Since several production periods may be required to return the investment in farm working assets, their marginal value productivity represents only that return for one year and not the entire return to investment.

The marginal value productivity of working assets must be sufficiently large to cover two items of cost, interest on investment, and depreciation in value of the asset. Interest charges may be considered either as an incurred expense or as an opportunity cost that represents earning potential had alternative investments been made. Commercial bank interest rates on borrowed funds during the period of study average 3 percent per month or 36 percent per annum.[13] Thus, the marginal value product (NCr $.41) obtainable from investment in farm assets for

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[13]Although the borrowing rate over-estimates the earnings possible on farmers' internal, surplus funds, it is used here since a large number of farmers borrow for both operating expenses and working asset investment.

all farms is slightly above the commercial lending rate of 36 percent. However, in addition to interest expense, depreciation should be charged on certain types of farm assets. Excluding such non-depreciable items as livestock, assets subject to depreciation account for an average of 20 percent of all farm working assets on the swine farms sampled. On the average, annual capital replacement for depreciable items was slightly above ten percent. Although the largest proportion of this annual investment is made to maintain present inventory value of working assets, the use of ten percent allows some increment of new capital accumulation.

Assuming a replacement rate of approximately 10 percent, a return of .46 (.36 + .10) is necessary if interest and replacement costs are to be covered on depreciable working assets. Taking the proportion of non-depreciable working assets (80 percent) to depreciable assets (20 percent) the combined interest and replacement rate computed over total farm working assets averages 38 percent. Consequently, all 217 swine farms are operating on an average margin of three percent above interest and replacement rates. The estimated marginal value product of working assets in NCr $.44 for both the 0-9.9 and the 10-19.9 hectare sub-groups and yields a margin of six percent above interest and replacement costs. The relatively low marginal value product of working assets for the farms of 20 or more hectares in size means that after allowing for costs involved only a one percent margin remains.

In sum, the analysis of factor productivity by means of the aggregated five variable production functions fitted to the data for all 217 swine farms taken together and by farm size reveals that little, if any, output change would result from increasing the quantity of available family labor. Further, for all 217 farms taken together, additional units of land would generate little additional output. The 10-19.9 hectare

group has a significant marginal product for land which suggests that some additional land could profitably be used. The relatively minor importance associated with family labor and land resources, aside from measurement and related problems discussed previously may be partially attributable to use of inadequate amounts of other production inputs. In essence, production can be expanded most profitably by expanding at the intensive margin rather than at the extensive margin of production.

Given that expansion at the intensive margin is the most profitable course to follow, factor constraints imposed by inadequate use of some production inputs must be eased. The relatively high significance of the operating expenses and working assets variables in all functions estimated and the value of the estimated marginal value productivities suggests that capital may be a constraining factor for some farms. This is particularly true of operating expense capital which has a net marginal value productivity somewhat above its marginal cost for all groups of farms with the exception of the 10-19.9 hectare farm size group.

Although the two types of capital on the average farm contribute about equally to the explanation of variations in gross farm output, their relative importance changes between size groups. The similar degree of importance of operating expenses and working assets for all 217 farms taken together suggests that, on the average, allocation of capital resources between the two items is done in a manner that both types contribute about equally to gross farm output. This does not imply that swine farmers are utilizing the two types of capital in an optimum manner; it simply means that operating expenses and working assets are being used at some level in a balanced manner in terms of their respective contributions to gross farm output. The marginal value productivity of both types of capital used on small farms is of sufficient size to make

investment in either a profitable undertaking. For medium size farms, the most productive investment is in working assets. Conversely, working assets appear to be employed in relative abundance compared to operating expenses on the large farms. The high marginal value product for operating expenses on large farms suggests that substantial increases in output would be realized through investment in additional operating expenses.

The analysis of capital productivity for all 217 farms taken together and by farm size reveals that capital productivity varies substantially among swine farms. Moreover, wide variability exists in the amount of capital employed in swine production. Both the wide variability in productivity and use of capital inputs suggest further analysis of relationships between capital use and gross farm output.

Capital Productivity-Disaggregated Capital Variable Model

Analysis of the aggregate five-variable model fitted to all 217 swine farms taken together and by farm size reveals that working assets and operating expenses contribute significantly to gross farm output. The working assets and operating expenses variables are now disaggregated into individual components to estimate their respective contributions to gross farm output.

Three modifications are made in specification of the estimating equation. First, productive livestock is deleted to permit more precise estimation of the remaining variables. Several considerations lead to this decision. The nature of swine production in southern Brazil involves a close tie between land, productive stock, and operating expenses. The amount of land controlled by an individual producer determines to a large extent the quantity of productive livestock he can maintain. In that the bulk of animal feed supplies are grown on the farm, animal numbers are subject to this constraint. Granting the close tie between land

and livestock, livestock (in this case, swine) may be considered a fixed production factor. The relationship of land to animal quantities means that the variation in swine production occurs in response to alternative swine and crop production practices and to the amount of variable inputs used. The essential means of acquiring variable inputs is through operating expenditures; hence, analysis focuses on those components of operating expenses that are expected to explain variation in gross farm output. Second, general expense and other equipment components of the aggregated capital variables are omitted since computation of their marginal value productivity would provide little guidance for investment decisions.

The final modification involves re-specification of the functional relationship among variables so that all variables are expressed as a ratio to land. The initial fitting of the disaggregated production functions to the data for all 217 farms and by size group revealed a high correlation between land and the individual components of operating expenses. Therefore, all other variables are expressed as a ratio to land, which reduces the high correlations between the subject variables. After computation of the functions in ratio form, the total product function is obtained by multiplying both sides of the equations by the geometric mean level of land area. Since the ratio equation is linear in the logarithms of the variables, the estimated regression coefficients are unaffected by multiplications by land area to obtain the total product function. The elasticities and marginal value productivities are derived in the normal manner for logarithmic production functions.

Mathematical properties associated with the ratio function do not permit estimation of the statistical significance of the land variable. This constraint together with the adjustment role assigned to the land

variable cautions one in the interpretation of the land coefficient and resulting marginal value products computed for land. However, if the derived coefficient for land is considered as an elasticity, the sum of elasticities will be equal to unity for all equations. The land coefficient obtainable from the total product function is computed as: b_1 (land) = $(1 - \sum_{i}^{8} b_{2i}$

The estimated elasticity coefficients and related statistics for the average production functions fitted to the disaggregated variables for all 217 farms taken together and by size group are presented in Table 8. In all equations, the unmechanized equipment and animal cost variables are statistically significant at the level of .05 or higher. Family labor, although not statistically significant for individual farm size groups is significant at the level of .20 for all 217 swine farms taken together. The crop cost coefficients for all farms and for the large farms are significant at the level of .10. Machine cost is a significant variable for the function fitted to the medium size farms at the level of .05. The remaining coefficients are not statistically different from zero.

The multiple correlation coefficients associated with the ratio function of disaggregated variables are considerably higher than those generated by the aggregate five-variable model fitted to the same farm groups.

Standardized beta coefficients reveal that in all cases unmechanized equipment is the most important variable in explaining variation in gross farm output (Table 9). The second most important is animal costs. Crop costs, machine costs, family labor, hired labor, and mechanized equipment explain rather limited amounts of variation in gross output.

TABLE 8

ELASTICITY COEFFICIENTS AND RELATED STATISTICS FOR THE ESTIMATED DISAGGREGATED PRODUCTION FUNCTIONS BY FARM SIZE
217 Swine Farms -- Southern Brazil -- 1965

Factor Input	All 217 Farms	0-9.9 Hectares	10-19.9 Hectares	≥ 20 Hectares
	LAND X_1[a]			
Elasticity Coefficient b_i	-.7593	-.8527	-.2170	-.3395
Standard Deviation of Ealsticity Coefficient S_{b_i}				
T-Test[b] for $H:b_i=0$				
	FAMILY LABOR X_2			
Elasticity Coefficient b_i	.2947	.3848	.0364	-.0654
Standard Deviation of Elasticity Coefficient S_{b_i}	.2028	.3722	.2124	.4483
T-Test for $H:b_i=0$	1.4529[f]	1.0337	.1714	-.1458
	HIRED LABOR X_{3a}			
Elasticity Coefficient b_i	.0481	.0643	-.0077	.0267
Standard Deviation of Elasticity Coefficient S_{b_i}	.0561	.1075	.0468	.0853
T-Test for $H:b_i=0$	.8570	.5977	-.1647	.3129
	CROP COST X_{3b}			
Elasticity Coefficient b_i	.1151	.1278	.0277	.1929
Standard Deviation of Elasticity Coefficient S_{b_i}	.0667	.1183	.0750	.0954
T-Test[b] for $H:b_i=0$	1.7244[e]	1.080	.3695	2.0212[e]
	MACHINE COST X_{3c}			
Elasticity Coefficient b_i	.0594	.0539	.0907	.0171
Standard Deviation of Elasticity Coefficient S_{b_i}	.0536	.1034	.0450	.0820
T-Test for $H:b_i=0$	1.1093	.5212	2.1378[d]	.2085

(Continued on next page)

TABLE 8 (continued)

Factor Input	All 217 Farms	0-9.9 Hectares	10-19.9 Hectares	≥ 20 Hectares
	ANIMAL COST X_{3d}			
Elasticity Coefficient b_i	.4311	.4668	.1940	.3120
Standard Deviation of Elasticity Coefficient S_{bi}	.0522	.0905	.0620	.1210
T-Test for $H:b_i=0$	8.2504[c]	5.1566[c]	3.2223[c]	2.5776[d]
	UNMECHANIZED EQUIPMENT X_{4a}			
Elasticity Coefficient b_i	.8412	.8049	.8705	.8081
Standard Deviation of Elasticity Coefficient S_{bi}	.0492	.0964	.0824	.1406
T-Test for $H:b_i=0$	17.084[c]	8.352[c]	10.559[c]	5.746[c]
	MECHANIZED EQUIPMENT X_{4b}			
Elasticity Coefficient b_i	-.0303	-.0498	.0054	.0481
Standard Deviation of Elasticity Coefficient S_{bi}	.0459	.0971	.0323	.0481
T-Test for $H:b_i=0$	-.6612	-.5132	-.1682	.9987
Multi-Correlation Coefficient R	.9510	.8898	.8676	.9371
Coefficient of Multiple Determinant R_2	.9044	.7918	.7527	.8781

[a]Since the elasticity coefficient is derived indirectly by using the average function, no statistical test of significance is associated with the land coefficient.
[b]All unlettered t values indicate that the coefficient is not statistically different from zero.
[c]Coefficient is significant at level of .01.
[d]Coefficient is significant at level of .05.
[e]Coefficient is significant at level of .10.
[f]Coefficient is significant at level of .20.

TABLE 9

STANDARDIZED REGRESSION COEFFICIENTS AND ORDER OF IMPORTANCE OF INDEPENDENT VARIABLES FOR THE DISAGGREGATED PRODUCTION FUNCTIONS BY FARM SIZE
217 Swine Farms -- Southern Brazil -- 1965

Variable		RANGE OF FARM SIZE			
		All 217 Farms	Small 0-9.9 ha.	Medium 10-19.9 ha.	Large ≥ 20 ha.
		Standardized Regression Coefficients			
Unmechanized Equipment,	X_{4_a}	.6349	.5312	.6989	.6183
Animal Costs,	X_{3_d}	.3092	.3730	.2271	.2840
Crop Costs,	X_{3_b}	.0507	.0727	.0229	.0173
Machine Costs,	X_{3_c}	.0284	.0341	.1220	.0176
Family Labor,	X_2	-.0295	.0066	.0100	-.0133
Hired Labor,	X_{3_a}	.0199	.0352	.0089	.0260
Mechanized Equipment,	X_{4_b}	-.0150	-.0292	.0945	.0785

Marginal Value Productivities of Component Factors of the Disaggregated Model

The computed marginal value productivities of the input factors specified in the disaggregated model are presented in Table 10. The marginal value productivities are estimated by holding all specified variables at their geometric mean levels (Table 11).

The marginal value productivity of crop costs vary from NCr $.52 for the medium size farms to NCr $3.48 for the small farms. However, the marginal value productivities of crop costs for all farms and for the large size group probably reflect more accurately the return to crop costs than do either of the more extreme values.

TABLE 10

MARGINAL VALUE PRODUCTIVITY OF LAND, FAMILY LABOR, AND INDIVIDUAL COMPONENTS OF OPERATING EXPENSE AND WORKING ASSETS BY FARM SIZE
217 Swine Farms -- Southern Brazil -- 1965

Factor Input		FARM SIZE GROUP			
		All 217 Farms	Small 0-9.9 ha.	Medium 10-19.9 ha.	Large ≥ 20 ha.
		(Marginal Value Products in New Cruzeiros)			
Land,	X_1	(-27.25)[a]	(-40.13)	(-7.01)	(-11.64)
Family Labor,	X_2	45.53	(54.01)	(5.42)	(-18.63)
Hired Labor,	X_{3_a}	(6.06)	(8.16)	(- .90)	(5.88)
Crop Costs,	X_{3_b}	2.26	(3.48)	(.52)	2.65
Machine Costs,	X_{3_c}	(2.50)	(3.85)	3.33	(.43)
Animal Costs,	X_{3_d}	1.41	1.55	.70	.96
Unmechanized Equipment,	X_{4_a}	.88	.88	.87	1.16
Mechanized Equipment,	X_{4_b}	(-3.77)	(-7.38)	(.69)	(4.72)

[a]Marginal value productivities in parentheses are computed from elasticity coefficients that are not statistically significant above the level of .20.

The marginal return to machine costs ranges from NCr $.43 to NCr $3.85. The estimated productivities suggest that all farm groups except the large farms could profitably incur additional machine expense. However, the low return to machine costs for large farms is less than the cost involved which is not consistent with economic utilization of resources.

The marginal value productivities of animal costs is highest for the small farms and lowest for the medium farms with an overall average

TABLE 11

GEOMETRIC MEAN LEVEL OF LAND, FAMILY LABOR AND COMPONENTS OF FARM OPERATING EXPENSE AND WORKING ASSETS BY FARM SIZE
217 Swine Farms--Southern Brazil--1965

Variable		RANGE OF FARM SIZE			
		All 217 Farms	Small Farms 0-9.9 ha.	Medium Farms 10-19.9 ha.	Large Farms ≥ 20 ha.
		Geometric Mean Level			
Cultivable Land Equivalents, (Hectares)	X_1	11.7	6.5	13.9	28.2
Family Labor, (Man-Year Equivalents)	X_2	2.7	2.2	3.0	3.4
Hired Labor Costs, (Value in NCr$)	X_{3a}	3.3	2.5	3.8	4.4
Crop Costs, (Value in NCr$)	X_{3b}	21.5	11.2	23.7	70.3
Machine Costs, (Value in NCr$)	X_{3c}	10.0	4.3	12.2	38.5
Animal Costs, (Value in NCr$)	X_{3d}	128.8	91.7	124.0	313.4
Unmechanized Equipment (Value in NCr$)	X_{4a}	401.5	277.9	448.9	673.9
Mechanized Equipment (Value in NCr$)	X_{4b}	3.4	2.1	3.5	9.8

of NCr $1.41. The relatively high return for animal costs on the small farms indicates that this group of farms could increase gross farm output by further expenditure for animal feed and related items. The low marginal value productivities (below opportunity costs) for the medium and large farms suggests that these two groups of farmers are incurring animal costs beyond the point where the marginal return is equal to marginal cost. Two possible explanations for this low marginal value productivity may be considered. First, the inflationary nature of the Brazilian economy may be such that animal costs (which are made up primarily of purchased feeds) rise more rapidly than swine prices. Thus, a disparity in normal price cost relationships is created and marginal returns are low. Secondly, swine prices were relatively depressed during 1965 and a more favorable marginal return would have occurred had prices retained a constant relationship to prices in previous years.

Unmechanized equipment is a highly significant variable for all farm groups. The estimated marginal value productivities for all farms taken together and for the small and medium farms are consistent. After adjusting gross marginal value product to reflect commercial interest charges of 36 percent per annum and 10 percent replacement charges to retain asset value, the resulting net marginal value product is NCr $.42 (NCr $.70 on the larger farms).

The computed marginal value productivities of mechanized equipment for all farm groups varies widely. Although the elasticities are not statistically different from zero, the marginal value productivities calculated for the medium and large farms are of sufficient size to suggest some additional outlay for this component of working assets to be profitable. This relatively high marginal value productivity of mechanized equipment is attributable in part to the general scarcity of this

component on the swine farms surveyed. A total of 35 swine farms employed mechanized equipment, of which 7 also owned tractors. The apparently high marginal value product, however, must be evaluated in relation to the size of investment normally involved in the purchase of mechanized power and equipment. Most elements of this component come in discrete "doses"; hence, the investment tends to be "lumpy." That is, an agricultural producer desiring to purchase a tractor normally cannot buy a portion of the tractor and obtain productive services from that portion. Rather, the producer must buy the tractor as a unit which involves an outlay considerably larger than the incremental change usually associated with interpretations of the marginal value product. For example, the seven farms with tractors have an average investment of NCr $5,143 in this source of power. The average investment in mechanized equipment for the 35 farms having mechanized equipment is NCr $1,749. Due to the indivisibility of items in this component of working assets, extreme care must be taken in evaluating the profitability of the investment outlay in each case since size of farm and other factors influence the return from such investments.

Comparison of Aggregated and Disaggregated Capital Variable Models

Results of the disaggregated model compared with the of the aggregated function reveal that a greater amount of total variation in gross output is explained by the former. Use of a ratio function and disaggregation of the data may have contributed to this result.

The role of the land variable in the disaggregated model precludes direct comparison of its marginal value productivity as estimated by both equations. In all groups of farms except the largest, the estimated marginal value product of labor is higher in the disaggregated

variable analysis. The marginal value productivities for capital inputs estimated by the aggregate and dissaggregated models are compared in Table 11.

The operating expenses estimate in the aggregate model appear to be consistent with estimates of the components of operating expense when considered in relation to their relative size. The marginal value productivity of operating expenses in the aggregated model are estimated to be NCr $1.64 for all 217 farms taken together. Since animal costs comprise the largest proportion of operating expenses, the computed marginal value product of crop costs in the disaggregated model of NCr $1.41 balances the estimates of the remaining components of operating expense. The estimates of operating expense productivity generated by both models appear to be reasonably consistent.

In the aggregate model, the composite factor, working assets, is shown to have a marginal value product that approaches the marginal cost of asset acquisition. However, disaggregation of this variable reveals that not all components are equally remunerative. In the first place, productive livestock is omitted from the latter and no estimate is made of this component. The marginal value product of unmechanized equipment for all 217 farms taken together and for the small and medium farm size group is consistently estimated to be approximately NCr $.88. The larger farm group has a higher MVP of NCr $1.16. Mechanized equipment does not appear to be a profitable investment for the whole group of farms taken together. Indeed, the individibilities associated with this component of working assets and its relation to farm size determine the point at which investment in this component becomes profitable. Although little can be said about the profitability of investment in mechanized equipment due to the multi-component aspect of its specification and due to the

TABLE 12

COMPARISON OF MARGINAL VALUE PRODUCTIVITIES OF AGGREGATED CAPITAL VARIABLES WITH ESTIMATES OF INDIVIDUAL COMPONENTS OF CAPITAL VARIABLES BY FARM SIZE
217 Swine Farms--Southern Brazil--1965

Farm Size Group	OPERATING EXPENSE					WORKING ASSETS		
	Total Operating Expense	Hired Labor Costs	Crop Costs	Machine Costs	Animal Costs	Total Working Assets	Unmechanized Equipment	Mechanized Equipment
All 217 Farms	1.64	(6.06)[a]	2.26	(2.50)	1.41	.41	.88	(-3.77)
Small Farms 0-9.9 ha.	1.55	(8.16)	(3.48)	(3.85)	1.55	.44	.88	(-7.38)
Medium Farms 10-19.9 ha.	1.22	(- .90)	(.52)	3.33	.70	.44	.87	(.69)
Large Farms ≥ 20 ha.	2.12	(5.88)	2.65	(.43)	.96	.39	1.16	(4.72)

[a]Marginal value productivities in parantheses are computed from elasticity coefficients that are not statistically significant above the level of .20.

lack of information relative to the equipment costs, the relationship among farm size groups appears to reasonably reflect economic relationships. The negative product generated by an increment of investment in mechanized equipment on small farms is consistent with the thought that inadequate land base restricts the ability of these farms to productively employ mechanized equipment. However, some farmers in this size group may be purchasing mechanized equipment which is used for custom work on neighboring farms and home production is not expected to return the full investment. As farm size becomes larger, the marginal value productivity of mechanized equipment becomes larger, indicating that as the land base expands, mechanization can be expected to give a higher return.

The calculated marginal value productivities for the individual components of the capital inputs indicate that farmers are not employing capital resources in a balanced manner in terms of equating marginal products with each other or to the opportunity costs involved. The widely varying productivities of capital components, particularly for the medium and large farms could be partially attributable to management decisions concerning use of capital. Management determines both the particular items of capital that are acquired and to a large degree the efficiency with which it is employed.

Conclusions

Increased emphasis is being given by policy makers to the problems of stimulating basic agricultural production. Public policies conceived and implemented to foster agricultural development have included land reform, input stimulation, technology dissemination, and credit programs which feature subsidized interest rates, complementary management inputs, and other special provisions. These programs are based on production and/or social objectives. On the one hand, program objectives may be

merely to stimulate production of aggregate social agricultural product. Conversely, program objectives may dictate that production improvements be achieved by measures intended to benefit the mass of small producers through upgrading their technical capabilities or providing them with additional factor inputs. Regardless of policy orientation, emphasis usually is placed on the allocation and employment of factors of production.

From a production point of view, the findings of this analysis indicate that in southern Brazil, the greatest marginal returns are to be realized from expansion at the intensive margin of production. Thus, additional land and labor resources are not the initial requirements prerequisite to increasing agricultural production on these farms. Rather, the increased use of operating expenses and working assets capital together with better managerial performance could stimulate production on the farms studied. Therefore, programs designed to stimulate agricultural production should first encourage the efficient use of additional high-return capital inputs such as improved seed, fertilizer, insecticides, and livestock medication on existing farm units.

The high returns to capital may be attributable partially to internal and/or to external capital rationing. The relatively small farms of southern Brazil operating on a limited resource base may have such an aversion to risk that a self-imposed capital restriction prevents more intensive use of capital inputs. External capital rationing due to collateral requirements or to insufficient credit availability may be a constraining factor to greater capital use.

The high marginal returns to operating expenses on the average farm, therefore, mean that opportunities exist on the given size production units for profitable use of variable production capital. However, the

relatively greater marginal returns to mechanized and unmechanized equipment associated with larger farms means that equipment investment depends upon farm size. In order to make mechanization profitable, farms will need to be of sufficient size to utilize the equipment.

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