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RELATIVE EFFICIENCIES OF FARM TENURE CLASSES IN INTRAFIRM RESOURCE ALLOCATION

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AND HOWARD W. OTTOSON

Agricultural Experiment Stations of

Illinois	Minnesota
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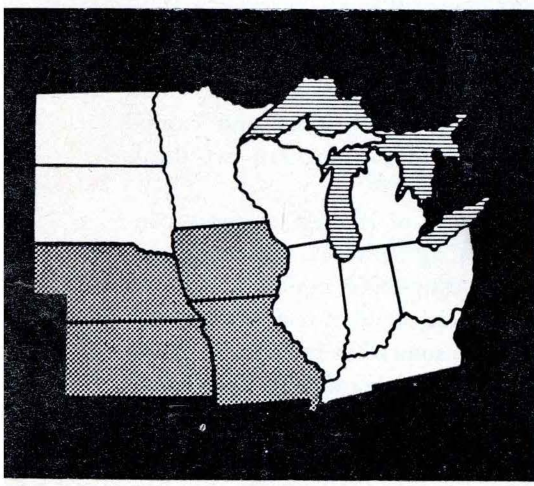

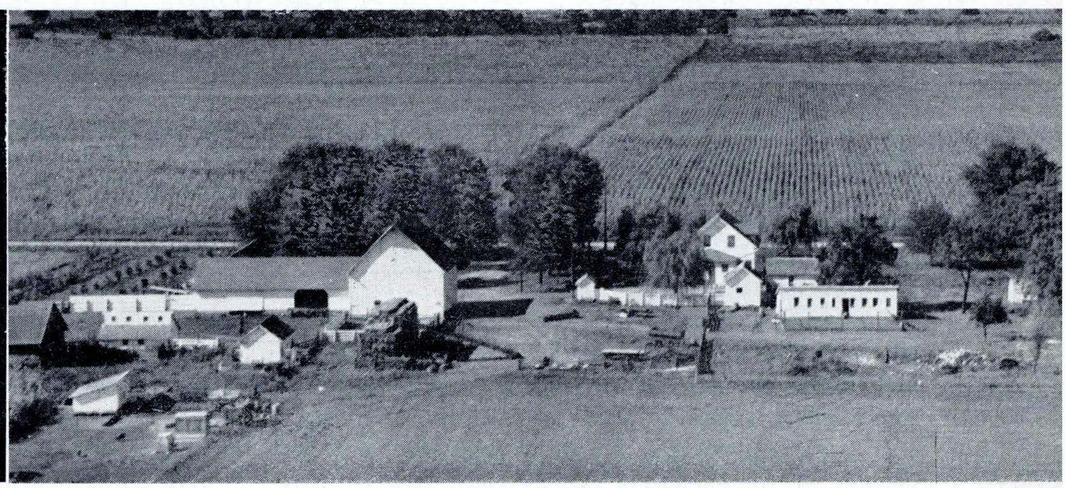

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FOREWORD

This publication reports studies carried on cooperatively under a memorandum of agreement between the agricultural experiment stations of Missouri, Iowa, Nebraska and Kansas, the University of Chicago, and the Farm Economics Research Division, Agricultural Research Service, with assistance from the North Central Land Tenure Research Committee (NCR-6) and the Farm Foundation.

Recognizing the importance of improving the land tenure arrangements on many farms in the North Central Region and the need for research with regard to the relative efficiency of alternative tenure arrangements, the cooperating agencies initiated a study to determine (1) the impacts of various tenure arrangements on farming efficiency, (2) the attributes of tenure arrangements that constitute obstacles to efficiency and (3) the remedial methods for minimizing the obstacles observed.

The work reported here represents the first phase of that study, which is being continued by the cooperating agencies. It is the product of a pilot study concerned with the analysis of relationships between some of the conventional land tenure classes—owner-operators, livestock-share renters and crop-share-cash renters—and the use and productivities of land, labor and capital services employed in Iowa and the northern two-thirds of Illinois.

The findings will likely be of interest to those concerned with efficiency in agriculture. The study explores the use of single estimating equations for determining differences in efficiency between land tenure classes. Hence the report is somewhat technical in parts and is, in this respect, of particular interest to research workers engaged in the analysis of land tenure and resource-allocation problems.

The data upon which the analysis is based were collected for the 1954 production year in a livestock marketing study by Iowa State College in cooperation with the University of Illinois. The latter study was initiated and largely financed by the Chicago Stockyards and Transit Company.

Noble Clark, Administrative Advisor
North Central Regional Land Tenure Research Committee

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SUMMARY

This report covers the results of a study of the effects of farm operators' tenure status on resource allocation. The primary objective of the study was to observe the way in which resources are used within agricultural firms operated under different farm tenure classes. The tenure classes considered were owner-operators, and livestock-share and crop-share-cash renters. The data used were obtained from Iowa and northern Illinois for the 1954 production year.

The major hypotheses that set the course of the study were concerned with the relations between the selected tenure classes and (1) the levels of marginal returns and resource inputs and (2) the deviations of the actual from the optimum combinations of resources. The basic estimating equations used in testing the hypotheses were of the form,

$$\log \hat{Y} = \log a + \sum_{i=1}^{3} b_i \log X_i$$

in which Y denotes gross production in dollars and the resource categories, X_i's, refer to land and capital services in dollars and labor in weeks.

The analysis of resource marginal returns showed that the kinds of resource readjustments needed to approach optimum production levels vary to some extent according to tenure class. For owner-operators, the marginal return to labor is low, and the return to capital services is high in relation to the opportunity costs assumed. This means that resource allocation could be improved with the use of more capital services by owner-operators. But part of the lower productivity of labor under owner-operatorship might be attributed to its quality. The patterns of marginal returns to resources under the two lease types are similar; all the marginal returns are higher than the opportunity costs assumed. Land is the most limited resource because the marginal returns to other resources are not significantly higher than the related opportunity costs; only the differences for land are significant.

The analysis of resource combinations at the respective mean value of outputs for each tenure group showed that the younger owners are the least efficient. They show the largest deviation of actual "costs" from the minimum costs attainable. Livestock-share renters are the most efficient. The differences between the tenure groups in their deviations from minimum costs could be due to chance. Hence, there are doubts as to whether the traditional broad classes of tenure examined differ in the aggregate with respect to the level of efficiency achieved in terms of resource combinations.

The nature of the adjustments needed to approach an optimum combination of resources, however, varies between owners and tenants. Owner-operators should have used less of both land and labor and more capital to achieve the optimum combinations. Owner-operators are the only ones to show a deficit in capital services. Tenants are most efficient in the use of labor services, but they are excessive in capital services and deficient in land. The most significant inefficiencies are in terms of the land-capital substitution in both types of leases. These occurrences could be due partly to the values used as land inputs, as well as to the differences between tenure classes in variability of the marginal rates of substitution.

For a similar output for all tenure classes, the total value (costs) of resources required on the average livestock-share farm is considerably less than the quantities required on farms of the other tenure groups. This situation may stem either from management or product combination, or both, as factors that presumably are not independent of the tenure classification.

The foregoing hypotheses require additional testing because of the aggregative nature of the analytical methods used. But, even with refinements of the methods used, it is suspected that further analysis of the traditional tenure classes may not show meaningful differences in the use of resources. This is because of the various characteristics and tenure arrangements that affect production decisions in different ways within each class. First, evidence points toward the need for removing the effects of such factors as quality of labor, managerial ability, capital position of the firm and work preferences that affect resource use and productivities and that are important to the extent to which they are functionally related to the age of farm operators. Second, even if significant differences between tenure-age classes are observed, the specific reasons for the differences as well as the reasons for the deviations of actual resource inputs from optimum quantities will not be identified. Therefore, the effects of tenure arrangements that may generate compensating forces to cover up resource malallocations within a tenure-age class remain to be isolated through methods and procedures still to be developed.

Relative Efficiencies of Farm Tenure Classes in Intrafirm Resource Allocation

BY WALTER G. MILLER, WALTER E. CHRYST AND HOWARD W. OTTOSON[1]

An examination of the literature on land tenure suggests that more information is needed about the effects of farm tenure on agricultural efficiency.[2] Further development of the techniques by which tenure-engendered inefficiencies may be analyzed adequately is also needed. The study on which this report is based was undertaken to bring into sharper focus some of the analytical problems involved, and to provide a frame of reference for some of the empirical studies pertaining to the allocative efficiency of tenure arrangements.

CURRENT TENURE-RELATED RESOURCE ALLOCATION PROBLEMS

Many of the current problems in economics may be defined in terms of deviations of actual situations from one or more of the conditions (criteria) suggested by economic principles for optimum (efficient) resource allocation. Certain tenure arrangements should be expected to account for at least a part of the deviations from optimum resource allocation that may be present within a farm.[3] But it has been well observed that "...... the nature of deviations from optimum (resource allocation) are quite subtle and not immediately obvious from a cursory examination of American farms operating under different types of tenure arrangements."[4]

Consequently, one problem is to determine what part of the deviations from optimum resource use can be attributed to characteristics of the tenure system. The magnitudes of the deviations caused by tenure arrangements are unknown. Similarly, knowledge of the extent to which tenure arrangements facilitate or impede optimum adjustments in resource use is lacking. However, some clues have been obtained from previous empirical observations. It has been observed that some of the current farm rental practices in the Midwest are not in accord with those that would constitute an optimum on the basis of theory.[5] In other studies it has been found that there are differences in the way resources are used by farmers operating under different methods of rental payment.[6] Although no attempt was made in these studies to "measure" the deviations from optimum arising from tenure relationships, they do provide some evidence that there could be divergencies between the actual and the ideal in resource organization on rented farms.

But tenure inefficiencies are not a function of leasing arrangements alone; owner-operators as well may make decisions under tenure-oriented conditions that motivate departures from optimum resource use.[7] These sources of inefficiencies would be expected to differ from those on fully rented farms. For instance, under owner-operatorship, inefficiencies may be caused partly by capital rationing or by fixed and regressive taxes, interest charges and amortization rates. Supposedly, in the case of tenancy, additional inefficiencies are introduced by certain methods of sharing costs and returns or short-term contracts. But these "imperfections" in leasing arrangements may be mitigated by such characteristics of tenancy as the joint contributions of landlord and tenant to the total farm assets and the sharing of uncertainties.

Apart from discovering resource malallocations that can be attributed to tenure, measures to improve resource use are contingent upon isolating the effects of specific types of tenure arrangements.[8] Theoretical explanations that have been advanced in the literature on tenure economics represent mere predictions about

[1]Walter G. Miller and Walter E. Chryst are agricultural economists, Farm Economics Research Division, Agricultural Research Service, U. S. Dept. of Agriculture. Howard W. Ottoson is an agricultural economist, Nebraska Agricultural Experiment Station. The contributions of the Subcommittee on Relative Efficiencies of Alternative Tenure Arrangements of the North Central Land Tenure Research Committee in planning the study and evaluating the results are acknowledged. These members include, in addition to the authors, Drs. Joseph Ackerman, Marshall Harris, Virgil Hurlburt, D. Gale Johnson, Frank Miller, Wilfred H. Pine, Philip M. Raup, S. D. Staniforth and John F. Timmons. The authors also wish to thank Professor C. B. Baker for his helpful suggestions.

[2]For a statement on specific research needs in land tenure see the Interregional Land Tenure Research Committee's report: Agricultural land tenure research, scope and nature: reappraisal, 1955. Farm Foundation, Chicago, Ill. 1955.

[3]In terms of efficiency, the basic problem in resource allocation may be defined in one of two ways: (1) For a given level of resource use within a firm, the associated value of production is not being maximized; or conversely, (2) for a given level of production, the associated costs are not being minimized.

[4]D. Gale Johnson. Resource allocation under share contracts. Jour. Polit. Econ. 58: 114. 1950.

[5]Virgil L. Hurlburt. Farm rental practices and problems in the Midwest. North Central Reg. Land Tenure Res. Com., North Cent. Reg. Publ. 50. 1954. (Iowa Agr. Exp. Sta. Res. Bul. 416).

[6]Reference is made to the following studies: Earl O. Heady and Earl W. Kerberg. Relationship of crop-share and cash leasing systems to farming efficiency. Iowa Agr. Exp. Sta. Res. Bul. 386. 1952; Lee Monroe Day. Comparative efficiency of farm operators under alternative leasing systems. Unpublished Ph.D. thesis. Univ. of Minn. Library, Minneapolis, Minn. 1953; Marvin W. Kottke. A study of decision sharing, tenure uncertainty and the choice of farm enterprise combinations under leasing systems in Minnesota. Unpublished Ph.D. thesis. Univ. of Minn. Library, Minneapolis, Minn. 1955; Alvin C. Egbert. A study of resource use on crop-share and livestock-share rented farms in central Kentucky. Unpublished M.S. thesis. Univ. of Ky. Library, Lexington, Ky. 1955.

[7]Cf. Interregional Land Tenure Research Committee, *op. cit.*, pp. 9-10.

[8]Referred to as specific types of tenure arrangements are such conditions as terms of amortization or tax payments, terms used for sharing costs and returns on rented farms, or the length of leases.

empirical relationships whose validity must be established before they can serve as sound bases for action.

Among the difficulties faced in the analysis of empirical data on tenure are those of identification and measurement. First, the extent of deviations from specified optimum conditions should be determined. Further, the effects of specific tenure arrangements, such as methods of sharing costs and/or products and effects of "tenure status" of farm operators on the organization of resources need to be estimated. Thus, the estimation of cause and effect relationships within a tenure system has as one of its prerequisites the choice of appropriate analytical models.

Problems Investigated

The specific problems for this study involve the effects of the tenure status of farm operators on resource allocation within the firm. These effects were examined under owner-operatorship and under livestock-share and crop-share-cash leasing.

Existing theories, as well as previous empirical studies, suggest that the selected tenure classes cause actual resource organization to depart from the conditions necessary for efficient production within a farm firm.[9] This analysis was concerned with departures from two of these conditions: (1) the optimum levels of resource inputs and (2) the optimum combination of resources for a given level of production. These conditions apply to all firms and may serve as the standards for evaluating the extent to which farm firms allocate resources efficiently.[10] A major analytical problem was then one of detecting the deviations of actual patterns of resource use from the optimum conditions by the tenure classes.

No attempt was made in the study reported here to isolate the effects of intratenure class sources of inefficiencies, such as tenure-engendered rationing of capital, "imperfections" in leasing arrangements or other more specific tenure-oriented obstacles to efficiency. Nor were the kinds of action necessary to minimize observed inefficiencies treated.

Objectives of Investigation

In view of the reasons for which this analysis was undertaken, the study was partly methodological. Consequently, the immediate objectives were twofold: (1) to gain further insight into the relationships between the tenure status of farm operators and the use and productivities of land, labor and capital services used in Iowa and northern Illinois, the area from which data were obtained, and (2) to evaluate the usefulness of single equations for estimating and comparing efficiency in resource use within farms operated under different tenure classifications.

The Study Area

The data on which the following analysis is based were obtained by personal interview at 3-month intervals during 1954 from a stratified random sample of 588 farmers in Iowa and the northern two-thirds of Illinois. The sample was originally designed to obtain data on livestock production only; however, data on the tenure of the farm operator were obtained also. In addition, sufficient information on resources used and production activities for the 1954 production year were obtained to make possible the estimation of production functions for each tenure group.

Thus, although the sample was not originally designed for the analysis reported here, the results obtained are representative of an important part of the Corn Belt. The data used were fairly complete and probably as accurate as can be obtained through field surveys. (Further details on the sample design are presented in Appendix A.)

Analytical Approach

The study reported here differs from previous studies in at least two respects. First, the a priori assumption that the owner-operator class of tenure represents a "standard" against which the performances of other classes may be appraised, was relaxed. Instead, the goals of "optima" in the amounts and combination or resources were used to measure the levels of efficiency attained, regardless of the tenure status of the farm operator. Second, previous resource-productivity studies have compared qualitatively only the levels of marginal returns of each resource with their respective prices. Conclusions with regard to resource malallocations have been drawn by inference. In the analysis that follows, estimates were made of the extent of malallocations in terms of deviations from optimum resource combinations for given levels of production. In addition, a comparison of the estimated values of productive services required by each tenure class for the same level of production was made to give further evidences of relative efficiencies.

The analytical model used in estimating the degree of effectiveness (in terms of achieving efficiency) of the respective tenure classes rested heavily on statistical "production functions" fitted to the cross-section data used. Marginal returns for each resource were estimated and analyzed by tenure classes. Next, estimates were made of the extent of deviations from the optimum resource combination for each tenure class. Concomitantly, the types of adjustments that would improve resource organization were suggested. The value of the analytical model used was also assessed.

METHOD OF INVESTIGATION AND ANALYSIS

The two common approaches to the analysis of efficiency in contemporary agricultural economics research are: (1) studies of the economics of specific farm situations and (2) studies of statistical populations of

[9]Granting the usual assumptions that the agricultural firm operates under perfect competition and seeks to maximize net returns from investments, the three basic criteria to guide decisions for efficient production may be restated as follows: (1) extend the services of a resource to the point at which the value of the marginal product is equal to the price of the resource service; (2) substitute resource services until the ratio of the value of the marginal product of each pair of resources is proportional to the respective resource prices; and (3) allocate resource services between competitive products so that the values of their marginal products are equal.

[10]There may be limitations to a universal application of an efficiency goal because the "extra-market values" sometimes attached to the ownership of land may be competitive with efficient resource use, or one may prefer to forego income (work) for leisure. But the goal of efficiency can be justified on at least two grounds: (1) it is useful for operational purposes and (2) people ordinarily do prefer "more" to "less."

farms. The latter approach only is followed here. It is proposed that groups of farms classified by the criterion of the tenure status of the operator are different populations. The parameters and relationships derived for each population are taken to represent those of the average farm within each group.

Hypotheses Directing the Inquiry

Many propositions have been advanced about the effects of tenure arrangements and the tenure status of farm operators on resource allocation within the firm.[11] Empirical work in testing these propositions, however, has been limited. The present analysis is concerned with only a part of the problems of tenure in resource allocation. No hypotheses of a "diagnostic" nature that relate to the specific reasons for existence of the problems were tested. The empirical phases of the study were restricted to a test of these major hypotheses: (1) That levels of resource use are affected differently by the tenure status of farm operators. These differences are reflected in the patterns of marginal returns to the resources employed. (2) That the departures from the optimum combination of land, labor and capital services at given levels of production differ according to the tenure status of farm operators.

An examination of the broad tenure classes may have inherent weaknesses for analytical purposes because of the variations of tenure arrangements within these classes of farm operators that affect production decisions. Nevertheless, the conventional classification was used in the present study as a matter of convenience. If production decisions vary considerably between the selected tenure classes, there should be differences among them in the patterns of resource use. It was supposed that in the allocation of resources there would be sufficient homogeneity within, and heterogeneity between, the populations considered to reveal significant differences.

Methods Used for Testing Hypotheses

In testing the hypotheses, the analytical techniques included (1) the estimation of marginal returns to resources and (2) an approximation of optimum resource combinations and the deviations of actual resource inputs from estimated optimum quantities. Actually, average intrafarm relationships were estimated from interfarm or cross-section data. Consequently, it should be recognized that the estimates obtained are not the true empirical counterparts of the theoretical concepts of intrafarm relationships and resource productivities; they are reasonable approximations. It follows that estimates of resource deviations from the optima are also approximations.

FORM OF THE BASIC ESTIMATING EQUATIONS

The basic estimating equations used are popularly known as the Cobb-Douglas type.[12] They have been used extensively in resource productivity studies but only to a minor extent in the analysis of tenure efficiency specifically.[13] The functions derived were of the form,

$$\hat{Y} = aX_1^{b_1} X_2^{b_2} X_3^{b_3},$$

in which $\hat{Y}$ = estimated gross production in dollars, X_1 = land in dollars, X_2 = labor in weeks, and X_3 = capital services in dollars. The compositions of these variables were as follows:

Y refers to the sum of sales of livestock and livestock products, home-used livestock and livestock products, change in livestock inventory and value of crop production for the year, less livestock purchases during the year.[14]

X_1 refers to the "market value" of land used (input), as quoted by the respondent—owner-operator or tenant.

X_2 refers to labor, measured in weeks, which is a sum of: operators', hired and family labor, and 20 percent of the amount paid for custom work ($40 to equal 1 week).[15]

X_3 refers to an estimate of capital services (flows) which is the sum of the money values for seeds, fertilizer, lime, insecticides, grains, silage, hay and commercial feeds, veterinary expenses and building repairs; 20 percent for depreciation on machinery; 3 percent of livestock purchased during the year; and 6 percent of the beginning inventory of livestock (January 1954).

ESTIMATION OF RESOURCE MARGINAL RETURNS

Marginal returns to land, labor and capital services were estimated from the basic estimating equations. The marginal return to resource X_i is, by definition:

$$\partial\hat{Y}/\partial X_i = b_i \hat{Y}/X_i.$$

Differences between the marginal returns, estimated at the geometric means, and the respective resource prices were used as first approximations of existing inefficiencies.[16] Any difference between the price of a resource and its marginal return was accepted as evidence of inefficiency, with "the magnitude of the difference . . . a clue to the extent of inefficiency."[17] The difference in the marginal returns between tenure classes may arise from one or more causes: (1) differences in the quality of the resource employed under each tenure

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[11]See for example: Rainer Schickele. Leases and farming efficiency. Jour. Farm Econ. 24: 112-127. 1941; T. W. Schultz. Capital rationing, uncertainty and farm tenancy reform. Jour. Polit. Econ. 48: 309-324. 1940; Johnson, *op. cit.;* Earl O. Heady. Economics of agricultural production and resource use. Prentice-Hall, Inc., New York. 1952. Ch. 20-22; S. V. Ciriacy-Wantrup. Resource conservation: economics and policies. Univ. of Calif. Press, Berkeley and Los Angeles. 1952. Ch. 12, 13; Howard W. Ottoson. Application of efficiency to farm tenure arrangements. Jour. Farm Econ. 37: 1341-1353. 1955.

[12]In the study reported here the functions were derived for each tenure class through weighted least squares because the data fitted were obtained through a sample stratified by farm size (classes 1, 2 and 3) with different sampling proportions applied to each class. The data and weighting process used are discussed in Appendix A.

[13]Egbert, *loc. cit.;* Day, *loc. cit.;* Earl O. Heady. Marginal resource productivity and imputation of shares for a sample of rented farms. Jour. Polit. Econ. 36: 500-511. 1955. The usage of the function in resource productivity studies can be accounted for by certain considerations as noted by Gerhard Tintner. A note on the derivation of production functions from farm records. Econometrica. 12: 26-27. 1944.

[14]This aggregation was unavoidable because no information was available on the division of the resources used between enterprises. A separate function for each major enterprise would give greater comparability between the relationships and estimates made.

[15]The aggregation of these categories of labor is probably a limiting feature as it implies homogeneity of the different labor services.

[16]These prices were estimated opportunity costs of 6 percent per year for land, $40 per week for labor and 10 percent per year for capital services.

[17]George J. Stigler. The theory of price. Rev. ed. The Macmillan Co., New York. 1954. p. 102. The concept of "opportunity cost" (alternative cost) was applied to make the necessary comparisons; i.e., the cost of a productive service in a given use is equal to the largest value of the marginal product of that service in its other possible uses.

TABLE 1. AGE DISTRIBUTION OF FARM OPERATORS WITHIN EACH TENURE CLASS.

Age interval	Age distribution		
	Owner-operators	Livestock-share renters	Crop-share-cash renters
(years)	percent	percent	percent
70 and over	6.2	0.4	0.0
65-69	6.6	0.0	2.2
60-64	9.9	1.4	3.9
55-59	20.0	4.6	4.8
50-54	19.3	4.6	11.8
45-49	14.6	4.9	13.8
40-44	10.8	16.2	14.0
35-39	5.4	19.0	15.5
30-34	3.7	31.0	20.5
25-29	3.4	15.1	13.5
24 and under	1.0	2.8	0.0
Totals	100.0	100.0	100.0

class, (2) differences in the levels and combinations of resources and (3) differences in combinations of products.[18]

It is suggested that as the age distribution is more negatively skewed for owner-operators (table 1 and fig. 1), the quality of labor under owner-operatorship should be inferior to that of the two tenant classes.[19]

In view of the differentials in age distribution between tenure classes, marginal returns to labor might vary between these classes to the extent that age is negatively correlated with labor quality and that the greater proportion of the farm labor is performed by the operator himself.[20] To make some observations on the age factor (and attempt to minimize its effects) estimates were made also for two age groups of owner-operators, in addition to those for owners as a whole, from estimating equations derived separately for each age group. The two groups selected were (1) owners under 45 years of age and (2) owners over 54, with the hypothesis that the older group would show a marginal return to labor lower than that of any other tenure group analyzed.[21]

Differences in marginal returns arising from resource combinations can be detected only if the production surfaces (elasticities of production) are the same. To detect the effects of resource combinations on marginal returns, the individual regressions for livestock-share and crop-share-cash tenants were pooled to obtain production elasticities for tenants as a group.[22] It was supposed that these tenant classes had similar production surfaces but, because of different resource combinations, the marginal returns would be different.

ESTIMATION OF DEVIATIONS OF ACTUAL RESOURCE INPUTS FROM OPTIMUM RESOURCE COMBINATIONS

The optimum combinations of resources were estimated at the geometric means of output by using the basic estimating equation obtained for each tenure class. The objective was to solve for the condition where the ratios of the marginal return for each resource to the opportunity cost of the respective resource were equal. This equality of ratios,

$$\frac{b_1\overline{Y}/X_1}{P_1} = \frac{b_2\overline{Y}/X_2}{P_2} = \frac{b_3\overline{Y}/X_3}{P_3},$$

yields the lowest possible costs for the given level of production and resource "prices." In the equation, the subscripts 1, 2 and 3 denote the resources—land, labor and capital, respectively; bY/X represents the resource marginal return; and P represents the opportunity cost of the resource. The values for the resource inputs (X_i) are the optimum quantities and were the unknowns.[23] The deviations from the optimum were considered to be the differences between the geometric means of the inputs and the estimated optimum inputs.

The optimum solution is analogous to equating the marginal rates of substitution of resources with the inverse of the respective price ratios. One difference is that opportunity costs are used instead of actual factor prices. From the basic estimating equation used, the marginal rate at which resource X_j substitutes for X_i is defined as

$$\partial X_j/\partial X_i = b_i X_j / b_j X_i\,.$$

The condition for optimum combination of resources requires that

$$b_i X_j / b_j X_i = P_i/P_j$$

for all possible pairs of resources. P_i and P_j are, re-

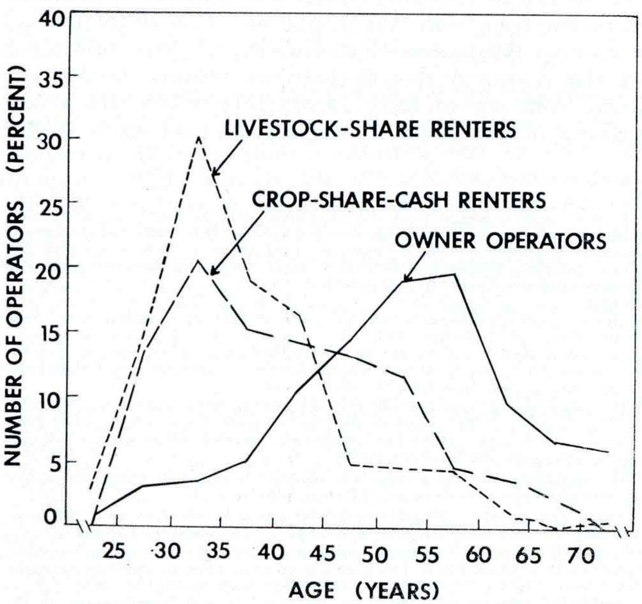

Fig. 1. Age distribution of farm operators within each tenure class.

[18]Marginal returns will be the same for the tenure classes only if their basic estimating equations are identical with "constant returns to scale" and each class is, on the average, operating at the optima, using the same set of prices as the choice criterion.

[19]The quality of land may vary also between tenure types; however, in this study, land units are "standardized" in terms of market value. But since the values used are obtained from tenants as well as owners, one can suspect "subjective underestimation" by tenants on the average. If the "underevaluation" is uniform, the estimated elasticity of land need not be affected.

[20]Most of the farm production functions fitted have failed to yield regression coefficients for labor that differed significantly from zero. But no observations have been made on the relationships that might exist between the quality of labor, as affected by age, and the sizes of these coefficients.

[21]This assumes that the "inferior" quality of labor is not counteracted by "superior" quality of management of the older operator. Intercorrelation, if present, may also affect the marginal returns to labor and thus confound any effect that could stem from the quality of labor. With cross-section sampling data, the amount of labor used as reported by farmers may be relatively "constant." Hence, labor becomes the weaker variable, and its effects on production may be reflected in some other regression coefficient.

[22]The regressions were pooled by summing the weighted corrected sums of squares and cross products for each lease type to obtain coefficients common to both lease types.

[23]The algebraic solution and computation procedure used to determine the optimum resource inputs appear in Appendix B.

TABLE 2. REGRESSION CONSTANTS, PRODUCTION ELASTICITIES AND CORRELATION INDEXES OF THE ESTIMATING EQUATION FOR EACH TENURE CLASS.[a]

Tenure class	Regression constant (a)	Production elasticities: Land (b_1)	Labor (b_2)	Capital services (b_3)	Sum of elasticities (Σb_i)	Correlation index (R^2)
Owner-operators	1.7795	0.1054	0.1109[b]	0.8381	1.0544	0.735
Livestock-share renters	6.4759	0.2315	0.1845	0.5330	0.9490	0.676
Crop-share-cash renters	3.4166	0.2937	0.2472	0.4782	1.0191	0.728

[a]The estimating equation for owner-operators, for example, is

$$Y = 1.7795\ X_1^{0.1054}\ X_2^{0.1109}\ X_3^{0.8381}$$

Where X_1, X_2 and X_3 refer to the quantities of land, labor and capital services, respectively.
[b]Significantly different from zero at the probability level of 10 to 20 percent. All other values are significant at probability levels of 10 percent and less.

spectively, the "prices" of resources X_i and X_j. Thus the deviations of the marginal rates of substitution of resources, at the geometric means, from the inverse of the respective "price" ratios were used as a means of testing for inefficiencies in the combination of resources.

BASIC EQUATIONS AND RESOURCE INPUTS USED FOR ESTIMATING MARGINAL RETURNS AND DEVIATIONS FROM OPTIMUM RESOURCE COMBINATIONS

Estimates of marginal returns to land, labor and capital services and the estimates of deviations of these resource inputs from the quantities needed for the optimum combinations depend upon the basic estimating equations derived. In addition, the estimates made for this report also depend upon the mean values of the resource inputs and production observed for each tenure class. Hence, a brief examination of the production elasticities (regression coefficients) and the other parameters obtained follows.

Production Elasticities and Related Statistics

The production elasticities for land, labor and capital services (table 2) represent the percentage change in the value of production associated with a 1-percent change in the respective resource input, assuming other inputs to be unchanged. The land elasticity b_1, would then represent the percentage increase in production associated with a 1-percent increase in the amount of land.

It is noticeable (table 2) that differences between the elasticities of each resource for the two lease types are smaller than the differences that result when owner-operators are compared with either type of tenant. As a matter of contrast, a 1-percent increase in land results in a change of only 0.1054 percent in production for owner-operators as compared with 0.2937 percent for crop-share-cash renters. With respect to capital services, the relative values are reversed—the elasticity of 0.8381 for owner-operators is remarkably larger than that of 0.4782 for crop-share-cash renters. One might then suspect that there are different "biases" in the elasticities obtained. For example, it is not unlikely that, under owner-operatorship, management is more highly intercorrelated with capital services and hence might result in a coefficient for capital larger than the coefficients for the other groups.[24] Furthermore, differences in elasticities may stem from the way in which products or factors were aggregated.[25] The scale of operations, product combination and resource quality can also affect the sizes of the elasticities; they are particularly important to the extent that they are not independent of tenure classification in this analysis.

Except for the effects of labor quality, the causes for differences in the production elasticities obtained were not tested; the foregoing explanations are only tentative. With regard to labor, the relative sizes of the elasticities follow to some extent a pattern of age distribution previously shown (table 1 and fig. 1). When the age distribution is more negatively skewed (owner-operators), the labor elasticity (0.1109) is small. When the age distribution is more positively skewed, the labor elasticities are larger (0.1845 for livestock-share renters and 0.2472 for crop-share-cash renters).

As anticipated, the labor elasticity of 0.1719 for the younger age group of owner-operators is larger than that of 0.0171 for the older age group (table 3). It will be seen in table 4 that the difference of 0.1548 is not very significant (20 to 30 percent). But it is consistent with logic.

Significance of Differences in Production Elasticities

Differences between owner-operators and both lease types in the production elasticities for land and capital services are highly significant, but those for labor are not. The two lease types do not differ significantly in any of the elasticities.

Production elasticities for the younger owner-opertors are more similar to those of the lease types than are the elasticities of owner-operators as a whole. That is, the probability levels for the differences between tenant operators and owner-operators, as a whole, are greater than those for the differences between them

[24]See Glen L. Johnson. Problems in studying resource productivities and size of business arising from managerial processes. In Earl O. Heady *et al.*, eds. Resource productivity, returns to scale and farm size. Iowa State College Press, Ames, Iowa. 1956. p. 16-23.

[25]Production elasticities are "unstable" in the sense that if some resource category is regrouped, the elasticity of the "unregrouped" resource(s) may be reduced or increased. Therefore, differences between tenure classes in the elasticities at one level of resource aggregation need not be the same at another level of aggregation. For a further discussion on the general problem of aggregation consult James S. Plaxico. Problems of factor-product aggregation in Cobb-Douglas value productivity analysis. Jour. Farm Econ. 37: 664-675. 1955.

TABLE 3. REGRESSION CONSTANTS, PRODUCTION ELASTICITIES AND CORRELATION INDEXES OF THE ESTIMATING EQUATION FOR TWO AGE GROUPS OF OWNER-OPERATORS.

Age group of owner-operator	Regression constant (a)	Production elasticities: Land (b_1)	Labor (b_2)	Capital services (b_3)	Sum of elasticities (Σb_i)	Correlation index (R^2)
Under 45 years	4.0200	0.0919[b]	0.1719[b]	0.7351[a]	0.9989	0.761
Over 54 years	2.6755	0.2239[a]	0.0171[c]	0.6950[a]	0.9360	0.913

[a]Significantly different from zero at probability levels of less than 1 percent.
[b]Significantly different from zero at probability level of 10 to 20 percent.
[c]Nonsignificant.

TABLE 4. VALUES OF t FOR DIFFERENCES IN PRODUCTION ELASTICITIES BETWEEN TENURE GROUPS.

Tenure groups compared	Value of t for difference in production elasticities: Land	Labor	Capital services
All owner-operators and lease types			
Owner-operator vs. livestock-share renters	7.15[a]	0.67	7.72[a]
Owner-operators vs. crop-share-cash renters	9.65[a]	1.04	12.01[a]
Livestock-share vs. crop-share-cash renters	1.08[f]	0.47	0.57
Age groups of owner-operators and lease types			
Owner-operators: age under 45 vs. livestock-share renters	1.99[c]	0.12	1.50[e]
Owner-operators: age under 45 vs. crop-share-cash renters	2.67[b]	0.59	1.86[d]
Owner-operators: age under 45 vs. age over 54 years	1.70[d]	1.09[f]	0.43

[a]Significant at a probability level less than 0.1 percent.
[b]Significant at a probability level of 0.1 to 1 percent.
[c]Significant at a probability level of 1 to 5 percent.
[d]Significant at a probability level of 5 to 10 percent.
[e]Significant at a probability level of 10 to 20 percent.
[f]Significant at a probability level of 20 to 30 percent.
All other values of t are nonsignificant at probability levels of 30 percent and less.

and owner-operators of the younger group. It would thus appear that if age were held constant, the analysis of relative efficiencies of tenure classes would be improved. More useful information should be obtained if the same age groups in different tenure classes were compared rather than a cross-section sample of tenure classes disregarding the age factor.

Apart from the possible effects of the qualities of labor and management, further consideration of "age effects" is also important to the extent that the age of an operator is not independent of the capital position of the firm and work preferences. These factors are not peculiar to any form of tenure, hence they might distort the results if they are not taken into account.

The production surfaces for livestock-share and crop-share-cash renters are assumed to be the same. This assumption is based on the logic that if the individual elasticities of all the factors do not differ between tenure classes significantly (table 4) then the production surfaces are the same. Therefore, the individual elasticities were pooled to obtain those common to both lease types (table 5).[26]

It may be noted that the production elasticities of the pooled regression are about the average of those for the individual regressions, which are presented again in table 5. The more important observation, however, concerns the relative values for the correlation indexes (R^2 and R'^2). The variation in production under livestock-share accounted for by the pooled regression is only 0.3 percent less than that accounted for by the individual regression. Similarly, the variation under crop-share-cash accounted for by the pooled regression is only 0.1 percent less. Therefore, the amount of confidence one may place in the estimates is not substantially reduced by pooling the individual regressions.

[26]The way in which the pooling was done was explained previously.

Geometric Means of Production and Resource Inputs

The resource inputs shown in table 6 are not unexpected. It is noticeable that except for the younger owners with 91 weeks of labor, the mean quantities of labor employed are quite comparable. Apparently the similarities arise from the constant nature of operator and family labor. Between farms, the close comparisons may reflect a weakness in the way labor services are measured, specifically with regard to the assumption of homogeneity of labor services employed within a farm. However, with these data, differences in resource ratios should arise mainly from differences in the quantities of land and capital services used in combination with labor.

The possible tenure-oriented sources for differences in the resource ratios are these: (1) "imperfections" in share leasing arrangements, as nonoptimum sharing of costs and returns; (2) capital rationing so far as it causes restrictions in the quantities of land and/or capital services used in relation to labor; and (3) use of the rental device by farmers as a means of getting control of greater quantities of land and capital services. On share-rented farms, the first and third sources logically operate in opposite directions: the first is restrictive in use of capital services while the third enables use of greater quantities of capital services through the sharing of uncertainties and the joint contributions of landlord and tenant to the total farm assets.[27] Related to this point is the observation that owner-operators show the smallest quantities of both land and capital services (table 6).

As would be expected, the land/labor and land/capital ratios of \$352 per week and \$4.40 per dollar of capital services, respectively, under owner-operatorship are smaller than those under any other group of operators. This suggests a greater intensity of use of both labor and capital with respect to land. The reasons for this situation are two-fold: (1) owner-oper-

[27]Logically, the aggregation of capital into a single productive service tends to conceal differences between tenure groups in the use of specific capital items as fertilizer and machinery, as well as inefficiencies in different phases of farm operations.

TABLE 5. REGRESSION CONSTANTS, PRODUCTION ELASTICITIES AND RELATED STATISTICS OF "INDIVIDUAL" AND "POOLED" ESTIMATING EQUATIONS FOR TWO LEASE TYPES.

Lease type	Regression constant	Production elasticities: Land	Labor	Capital services	Sum of elasticities	Correlation index
Individual regression estimates						
	(a)	(b_1)	(b_2)	(b_3)	(Σb_i)	(R^2)
Livestock-share renters	6.4759	0.2315	0.1845	0.5330	0.9490	0.676
Crop-share-cash renters	3.4166	0.2937	0.2472	0.4782	1.0191	0.728
Pooled regression estimates						
	(a')	(b_1')	(b_2')	(b_3')	($\Sigma b_i'$)	(R'^2)
Livestock-share renters	4.7327	0.2708	0.2237	0.5026	0.9971	0.673
Crop-share-cash renters	3.8950	0.2708	0.2237	0.5026	0.9971	0.727

TABLE 6. GEOMETRIC MEANS OF GROSS PRODUCTION AND RESOURCE INPUTS, AND RESOURCE RATIOS BY TENURE CLASSES AND BY TWO AGE GROUPS OF OWNER-OPERATORS.

Tenure group	Geometric means				Resource ratios		
	Production	Land[a]	Labor	Capital services	Land/labor	Capital/labor	Land/capital
	($)	($)	(wk)	($)	($/wk)	($/wk)	($/$)
Owner-operators	12,697	27,504	78	6,230	352.0	80.0	4.4
Livestock-share renters	22,936	45,884	77	9,566	596.0	124.0	4.8
Crop-share-cash renters	15,105	41,506	76	6,517	546.0	86.0	6.4
Owner-operators: age under 45	17,714	27,551	91	8,794	303.0	97.0	3.1
Owner-operators: age over 54	10,690	25,924	72	5,188	360.0	72.0	5.0

[a]The areas represented by these land values are roughly as follows: 143 acres for owner-operators, 180 acres for livestock-share renters and 184 acres for crop-share-cash renters.

ators have no intrafirm dissociations of costs and returns and ordinarily would tend to push the use of resources to a further extent than would operators under share leases; but (2) under owner-operatorship the funds available to acquire more land may be inadequate. The first reason is conducive to efficiency; the second is not. The latter may result in excess labor in relation to the total stock of farm assets, land or capital. The smallest capital/labor ratio of $80 per week for owner-operators appears to bear out the foregoing point.

The data in table 6 show also that the amounts of land and capital services used under owner-operatorship are less than those used by the other groups of farmers. That is, under owner-operatorship, the amount of land used may have been restricted because of limited funds. Thus, the low land/labor ratio need not be due to the incentive of owner-operators to extend the use of labor services further than other groups.

Significantly, the greatest land/labor and capital/labor ratios (of $596 per week and $124 per week, respectively) are associated with farms operated under livestock-share contracts. Again, these observations would confirm the theories that surround livestock-share leases. In the first place, the effects of capital rationing are reduced to a "minimum." Both landlord and tenant contribute to the acquisition of farm assets. But, in addition, and in contrast to the usual crop-share-cash contracts, the presence of landlords in the farm operations minimizes the restrictive effects of external rationing of capital.

In terms of land/capital combination, the estimate of $4.80 of land for each dollar of capital services for livestock-share renters is interesting. The ratio is similar to the ratio of $4.40 per dollar for owner-operators. The two groups are equally intensive in the use of capital services per unit of land. This assumes that the land values reported by owner-operators are comparable to those reported by tenants; but this need not be the case. Tenants might be expected to "undervalue" the land they operate.

A comparison of the land/capital ratio of $6.40 per dollar for crop-share-cash tenants and that of $4.80 per dollar for livestock-share tenants suggests that there is less capital restriction under livestock-share leasing. Other things being equal, this observation would possibly verify the hypothesis that the nonoptimum sharing of costs and returns under crop-share-cash leasing caused restrictions in the use of capital services. In the case of livestock-share farms, all costs of "variable capital" are usually shared and in the same proportion—50 percent—as the sharing of products.

The reasons for the smaller land/labor ratio—$546—per week for crop-share-cash renters as compared with $596 per week for livestock-share renters are not those suggested by theory. The intensity of labor should be less if the costs of labor are not shared proportionately with production or if no compensatory adjustments are provided for by the sharing of other costs. That is if the share tenant is not rewarded for the full marginal value product (through the sharing of production) of his labor, he is inclined to restrict its application.[28] The seeming contradiction of empirical observation and theoretical expectations is negated when the land/labor ratios are transformed (from dollars per week) to acres per week. The land/labor ratio of 2.4 acres per week (table 7) for crop-share-cash is slightly greater than the ratios of 2.3 acres per week for livestock-share renters. This difference is intuitively negligible; hence it might be inferred that, on the average, there are really no differences between these types in land-labor combinations.

In summary, the differences observed between the tenure classes in resource ratios are largely what one would expect. With lower land/labor and capital/labor ratios for owner-operators, the marginal productivity of labor can be expected to be low, and returns to land and capital high relative to that of labor. A lower land/capital ratio would suggest a lower marginal productivity of capital in relation to that of land. However, resource productivities also depend upon the relative values of the elasticities of production.

In addition, the marginal productivity of labor for livestock-share renters is expected to be higher than that for any other group, partly because of the higher land/labor and capital/labor ratios. Conversely, the marginal productivity of land and capital should be relatively low. But these estimates depend also on the effects of the land/capital ratio, the coefficients of all the resources and the constant of the basic estimating equation. An examination of the marginal returns to resources which follows shows that only the marginal return to capital is relatively low; that for labor is the highest of all groups. Differences in resource ratios are

[28]However, the differences observed could well be due to differences in the pattern of production that might (but need not) be functionally related to the leasing arrangements. It could also be argued that the assumption of homogeneity of labor services distorts these comparisons; but it can be further assumed that errors of this kind are the same within each tenure class.

TABLE 7. LAND-LABOR AND LAND-CAPITAL RATIOS IN TERMS OF ACRES BY TENURE CLASSES.

Tenure classes	Resource ratios	
	Land/Labor	Land/Capital
	(A./wk.)	(A./$)
Owner-operators	1.8	0.023
Livestock-share renters	2.3	0.019
Crop-share-cash renters	2.4	0.028

only rough indices of differences in resource organizations.[29]

INEFFICIENCIES OBSERVED THROUGH THE PATTERNS OF RESOURCE MARGINAL RETURNS

Clues to inefficient resources use are obtained from examination of marginal returns to each resource and comparisons of these marginal returns with the opportunity costs of the respective resources. If the ratio of a marginal return to the resource price is greater than unity, it is indicative that the resource is limitational and could be profitably extended in use; or if it is lower than unity it means that the use of that resource should be contracted if improved efficiency is desired. Thus the condition for efficient resource use with which a part of the analysis is concerned sets the limits to which resources should be extended, or contracted, to obtain optimum production levels. However, under the phenomenon of increasing or constant returns to the scale of operation, there are no determinate optimum quantities of resources if the amounts of all resources are increased.[30] Consequently, the following analysis on the deviations from optimum levels of production (with the associated amounts of resources) is largely qualitative in character.

Levels of Marginal Returns to Resources

Marginal return or marginal value product (table 8) is the additional return per unit of input if one more unit of the resource were added at the geometric means. On the premise that the different production elasticities are peculiar to the tenure classes, a part of the analysis on marginal returns is based on the individual estimating equations.[31] Next, an attempt is made to indicate the possible effects of labor quality on the marginal productivity estimates as suggested by the differentials in age distributions. Finally, differences in marginal returns that could be attributed more specifically to resource combinations of the lease types are analyzed by using the coefficients from the pooled regression.

TABLE 8. MARGINAL RETURNS AND MARGINAL RETURN OPPORTUNITY-COST RATIOS AT THE GEOMETRIC MEANS OF RESOURCE INPUTS AND RELATED VALUES OF t FOR THE DIFFERENCE OF THE RATIOS FROM UNITY BY TENURE CLASSES.

Tenure class	Land	Labor	Capital services
	Marginal returns to resources		
	($/$)	($/wk)	($/$)
Owner-operators	0.049	17.96	1.708
Livestock-share renters	0.116	54.79	1.278
Crop-share-cash renters	0.107	48.98	1.108
	Marginal-return-opportunity-cost ratios[a]		
Owner-operators	0.82	0.45	1.55
Livestock-share renters	1.93	1.36	1.16
Crop-share-cash renters	1.78	1.23	1.01
	Values of t for differences of the ratios from unity		
Owner-operators	0.58	1.75[c]	3.90[b]
Livestock-share renters	2.69[b]	0.64	1.07[d]
Crop-share-cash renters	2.99[b]	0.42	0.06

[a]As a reminder, the opportunity costs assumed were 6 percent for land, $40 per week for labor and 10 percent for capital services.
[b]Significant at a probability level less than 1 percent.
[c]Significant at a probability level of 5 to 10 percent.
[d]Significant at a probability level of 20 to 30 percent.
Other values of t are nonsignificant at probability levels of 50 percent or less.

MARGINAL RETURNS UNDER OWNER-OPERATORSHIP

The rather high marginal return of 70.8 percent to capital services under owner-operatorship (table 8) suggests that on the average capital services is the limiting resource for owner-operators. To increase net returns, it means that the use of capital could be extended until its marginal return equals (or approaches) the assumed opportunity cost of 10 percent. With such an increase in the use of capital, the productivities of both land and labor that are now below their opportunity costs of 6 percent and $40 per week, respectively, would be increased.

The present pattern of resource productivities then suggests that owner-operator farms have excess labor but are short on capital services. Superficially, land appears also to be in excess, but the marginal return is not significantly below 6 percent (table 8).[32] On the basis of these observations, one might conclude that capital rationing operates more to limit the use of capital services than to limit the use of land. In essence, the findings would support the hypothesis that prior commitments to land purchases force restrictions in the use of capital services. Thus, the amount of capital used falls short of the amount that would be most profitable for the average owner-operator farm.

MARGINAL RETURNS UNDER LIVESTOCK-SHARE LEASING

Unlike the inferences drawn for owner-operators, there are no evidences of resource excesses for livestock-share renters. All the marginal returns here are above the opportunity costs of resources. It means that the use of all the resources might be extended profitably.

However, it is noticeable (table 8) that the return to land is 93 percent above the "cost" of land (the highest of the tenure classes listed) and substantially above that of 36 percent for labor and 16 percent for capital services. Consequently, from the standpoint of increasing net returns, through increase in production, land is evidently

[29]If production elasticities differ between tenure groups, the inferences drawn in terms of resource ratios may be misleading. The marginal productivity of a resource depends on the levels of the resource inputs as well as the sizes of the elasticities. Even if resource combinations (ratios) are the same, the estimates on marginal returns and deviations will vary between tenure classes if the basic estimating equations are different.

[30]Except for livestock-share renters, increasing returns to scale are observed for all tenure classes. (The sums of the elasticities—table 9—are greater than unity). Thus a calculated optimum of production would be infinitely large. If constant returns to scale prevail, the solution also becomes indeterminate. Thus, there is no optimum level of production with constant or increasing returns unless at least one resource is held fixed in quantity. The sum of the elasticities of the resources varied must be less than one. But, with a resource fixed in quantity and the use of other resources extended (or contracted) the optimum obtained would be more analogous to that for the "short run," which is not of immediate concern here. Other reasons for exercising caution in finding optimum levels of production are that estimates removed from the means are subject to larger standard errors, and there is the possibility of extrapolation; i.e., going beyond the range of the data.

[31]The statistic used to test for inefficiencies (table 8) was

$$t = \frac{M_i - P_i}{s(m_i)}$$

in which M_i is the marginal return of a resource at the geometric means; P_i is the opportunity cost for the respective resource, X_i; and $s(m_i)$ is the standard error of the marginal return that was obtained from the variance formula shown in Appendix C. If the difference, $M_i - P_i$, is not significantly different from zero, it implies that the marginal-return-opportunity-cost ratio is not different from unity. The ratio of unity is the "criterion of efficiency" used in this part of the analysis.

[32]This nonsignificant difference, however, does not imply that the use of land does not differ significantly from optimum for the present level of production; the optimum condition requires that, in order to minimize costs, the ratios of the resource marginal returns to the opportunity costs of the resources be equal. Therefore, the marginal returns need not be equal to the cost per unit of the resources, especially if increasing or constant returns to scale are present.

the most "limitational" of the three resource categories. Further, the marginal return to land is significantly above its opportunity cost at a probability level of less than 1 percent. Therefore, for the firm, the quantity of land used under livestock-share leases should be extended. The relatively high marginal return to land is also related to the "high" capital/land ratio observed for livestock-share renters.[33]

The marginal return to capital services is the return that could be logically expected. It is not significantly above the opportunity cost of capital. The possible reasons for this lower level of return are: (1) there is little or no incentive present in livestock-share leasing through sharing of costs of returns to cause restrictions in the amounts of capital services employed; (2) the effects of capital rationing are minimized by the joint contribution of landlord and tenant to the total farm assets, coupled with the sharing of risks of a larger scale of operations; and (3) the presence of the landlord in the farm operations dampens the exogenous rationing of capital that might operate adversely under the other types of leasing. Although nothing has been said specifically of the marginal return to labor ($54.79 per week), it is implied that the rationing of capital affects labor productivity indirectly. That is, as indicated earlier, the higher land/labor and capital/labor ratios result in higher marginal return to labor, and the cost of production per unit of labor is reduced.

MARGINAL RETURNS UNDER CROP-SHARE-CASH LEASING

On further inspection of the marginal returns (table 8), it is apparent that the patterns of resource productivities under the two lease types are similar but differ from the productivities under owner-operatorship. As in the case of livestock-share, neither the marginal return to labor nor that to capital services for crop-share-cash leases differs significantly from the respective opportunity costs assumed. Only the marginal return to land is significantly greater.[34]

Possibly, the consistently lower marginal returns (to all resources) under crop-share-cash versus those under livestock-share leasing could be related to (1) superior management or (2) different combination of enterprises for livestock-share tenants, or both. These inferences are based on the larger regression constant observed for livestock-share renters despite a smaller sum of the elasticities (table 2). Put in another way, the estimate of a marginal return also depends upon the height of a marginal productivity curve, which is a function of a constant. The regression constant is one of the parameters that define the constant associated with the marginal productivity curve. Differences in the sizes of the constants could be due to differences in management or enterprise combination.

[33]There is no accurate measure of the rental rate on these farms because landlord's returns are not "pure" rent. They include rewards for other contributions made by the landlord. But it is noted, parenthetically, that the average landlord's return amounts to 19.3 percent on land investment, a value that is significantly greater than the marginal return to land of 11.6 percent. The difference is significant at a probability level of less than 1 percent, but this assumes no errors in the estimate of the landlord's returns.

[34]Similar to livestock-share, the difference is significant at a probability level of less than 1 percent. But in contrast, the calculated average landlord's return is only 10.8 percent (10.8 cents per dollar of land) which does not differ significantly from the estimated marginal return of 10.7 percent.

The "low" marginal return to capital services of 10.8 percent under crop-share-cash leases does not coincide with what is expected theoretically. The alleged non-optimum sharing of costs and returns should be reflected in a higher marginal return (relative to owner-operators) for capital services because of restrictions in these resource inputs.[35] But the marginal return to capital is nearer to the "optimum" than that of any other tenure group analyzed. The data (table 8) show that the marginal return to capital is a negligible 1 percent above the opportunity cost of capital services. In effect, it appears that the "imperfections" under crop-share-cash leasing may be negated by such factors as the sharing of uncertainties and that capital rationing may be dampened by the joint contributions of landlords and tenants to the total assets of the farm.

Differences Between Tenure Classes in Marginal Returns

MARGINAL RETURNS USING INDIVIDUAL ESTIMATING EQUATIONS

As suggested previously, differences in marginal returns of similar resources under different tenure classes are ordinarily expected using separate (individual) estimating equations. These differences are more important from the standpoint of transferring resources from one farm firm to the other and less important from the standpoint of comparing intrafarm adjustments. That is, given different estimating equations ("production functions") the marginal returns will differ at the "optima" even under the same set of prices for productive services as the choice criterion.

However, the significant differences occur (1) in the marginal returns to land and (2) in the marginal returns to capital services for owner-operators compared with the two lease types (table 9). Other differences are not significant at acceptable levels of probability, arbitrarily chosen as 10 percent and less. Of particular import, the marginal return to owner-operators' labor

[35]No data are available on the way costs are shared in relation to returns. However, it is likely that the majority of farms included under crop-share-cash leasing do not share costs in the same proportion as the products from different enterprises are shared. Inefficiencies of individual farms, however, may be counterbalanced by efficiencies of others. The latter statement applies to all tenure types and not particularly to crop-share-cash leasing.

TABLE 9. VALUE OF t FOR DIFFERENCES BETWEEN TENURE GROUPS IN MARGINAL RETURNS AT THE GEOMETRIC MEANS OF RESOURCE INPUTS.

Tenure groups compared	Values of t for differences		
	Land	Labor	Capital services
All owner-operators and lease types			
Owner-operators vs. livestock-share renters	2.36[a]	1.41[c]	1.87[b]
Owner-operators vs. crop-share-cash renters	2.20[a]	1.24[d]	2.49[a]
Livestock-share vs. crop-share-cash renters	0.34	0.18	0.61
Age groups of owner-operators and lease types			
Owner-operators under age 45 vs. livestock-share renters	1.31[c]	0.66	0.85
Owner-operators under age 45 vs. crop-share-cash renters	1.13[c]	0.49	1.50[c]
Owner-operators under age 45 vs. age over 54 years	0.80	1.20[d]	0.20

[a]Significant at probability level of 1 to 5 percent.
[b]Significant at probability level of 5 to 10 percent.
[c]Significant at probability level of 10 to 20 percent.
[d]Significant at probability level of 20 to 30 percent.
Other values of t (those not noted) are nonsignificant at probability levels of 30 percent and less.

of only \$17.96 per week differs from the marginal return to labor under the two lease types at probability levels not usually accepted as significant. This statement is especially relevant with regard to the comparison with livestock-share renters who show a marginal return to labor of \$54.79 per week.

It is likely that the nonsignificant differences are due partly to the large variances of the marginal returns and that they would be different if the basic estimating equations had indices of correlation (R^2-s) larger than they are. But the coefficients of the estimating equations may be "biased" in such a way as to show differences in marginal returns. Further, the fact that tenants are likely to "underestimate" land values (inputs) in their quotations can affect the comparisons. That is, the estimated mean values of land for the two lease types may be smaller than they really are in relation to that for the owner-operators, hence their (the lease types) marginal returns to land are "overestimated." Because the marginal return to a resource depends also on the levels of other resource inputs, it is implied that the estimates of marginal returns to capital (for the two lease types) are not exactly comparable to those for owner-operators,[36] and when age is taken into account, the significance of the differences becomes questionable. The most significant differences are reduced from a probability level of 1 to 5 percent to a level of 10 to 20 percent (table 9).[37]

MARGINAL RETURNS AS AFFECTED BY THE AGE FACTOR

The seeming coincidence of the relationship between age distribution (fig. 1) and the pattern of marginal returns to labor (table 10) deserves some comments. The age distribution of owner-operators is more negatively skewed (the proportion of older operators is greater), with a marginal return to labor of \$17.96, which is lower than those for the lease types. Conversely, with the age distributions of the two lease types more positively skewed (greater proportions of young operators) the marginal returns to labor of \$54.79 and \$48.98 for livestock-share and crop-share-cash renters, respectively, are higher than that for owner-operators. Although these evidences may not be sufficient, the general tendency for low labor returns to follow the negatively skewed age distribution bears out the expected relationship between age, quality of labor and labor productivity.

[36]Owner-operators may tend also to undervalue the land they operate, but this tendency is counterbalanced by other owners who may subjectively overvalue the land they own.

[37]In a study in which crop functions were used, only the marginal returns to land were found to differ significantly between the tenure groups compared. However, the possible effects of age differentials were not examined. Cf. Heady, Marginal resource productivity and imputation of shares on a sample of rented farms, *loc. cit.*, p. 503.

TABLE 10. MARGINAL RETURNS TO RESOURCES AT THE GEOMETRIC MEANS OF PRODUCTION AND RESOURCE INPUTS FOR TWO AGE GROUPS OF OWNER-OPERATORS.

Age groups	Marginal returns to resources		
	Land	Labor	Capital services
	(\$/\$)	(\$/wk)	(\$/\$)
At mean resource inputs of younger owners			
Under 45 years	0.059	33.50	1.480
Over 54 years	0.127	2.95	1.242
At mean resource inputs of older owners			
Under 45 years	0.041	27.39	1.627
Over 54 years	0.092	2.54	1.433

Furthermore, the marginal returns to labor for the different age groups of owner-operators (table 10) are as expected. For the younger owner-operators, the marginal return is \$33.50 and for the older operators \$2.54 at the geometric means of resources for the respective age groups. Nevertheless, the difference between these values is significant only at a 20- to 30-percent probability level. The findings suggest that in the comparisons of the patterns of resource productivities between tenure classes, the age factor should be considered further. Probably, "management" has dampened the real difference stemming from the quality of labor.[38]

From previous discussions, it will be recalled that differences in intercorrelation, and in resource and enterprise combinations can also affect the levels of resource-productivity estimates. But it is doubtful that (with these data) the amounts and combinations of resources seriously affect the inferences made with regard to the differences that arise from labor quality. First, the average amount of labor used by the younger age group is greater than that used by the older group—91 as compared with 72 weeks (table 6). Thus, a lower marginal return for the younger operators should be expected, other things being equal. Second, the marginal return to labor for the older group is only \$2.95—a value not significantly different from \$2.54—using the younger operators' resource inputs in the older operators' estimating equation. But if the resource inputs of the older owners were used instead with the estimating equation of the younger owners, the return to labor for the younger owners would be \$27.39 per week (table 10).

It is also noticeable that the younger owners' marginal return to labor as expected, is more comparable with those for the tenant operators, which are composed predominantly of younger farmers. That is, the differences between the marginal returns to labor for owner-operators, as a group, and the two lease types are greater than the corresponding differences in the estimates for the younger age group of owners (table 9). The differences among the other marginal returns to other resources are smaller also. As suggested before, marginal returns can be affected indirectly by the age factor because of the quality of the human agent, capital position and work preferences. Therefore, the causes of differences between tenure classes need not be entirely tenure oriented.

With respect to the previous analysis of marginal returns under owner-operatorship (as a group), it was suggested that owing to the significant difference[39] between the marginal return to labor and the opportunity cost, labor was in excess. However, the corresponding difference is reduced for the younger owners and is not significant.[40] This reduction in the significance level does not substantially alter the inferences drawn previously on resource malallocations under owner-operatorship; it does reduce the confidence one can place in statements made about the excess of labor or rationing of other resources. The readjustments needed in resource use for owner-operators under 45 years of age

[38]It is suggested further that more extreme age groups would reveal sharper differences than those observed in the present study.

[39]$0.10>p>0.05$

[40]$0.40>p>0.30$

are in the same direction as those for owner-operators as a whole, but they would differ in magnitude as the levels of marginal returns are different.

MARGINAL RETURNS AS AFFECTED BY RESOURCE COMBINATIONS

As stated before, differences in marginal returns resulting from differences in resource combination could conceivably be compensated for by differences in production elasticities. To test the extent to which this is true, estimates on marginal returns that were obtained with the common (pooled) set of elasticities for the two lease types are shown in table 11.

Although the absolute differences in the levels of marginal returns change when similar (common) elasticities are used, there are no changes from the patterns of marginal returns obtained by using the individual elasticities. The returns under livestock-share remain consistently above those under crop-share-cash leases. Hence the differences in resource combinations (resource ratios) are not great enough to cause different patterns of marginal returns.

Only a part of the difference in marginal returns can be attributed to differences in resource combinations. On the one hand, the higher land/labor ratio of livestock-share ($596 per week versus $546 per week) suggests a lower marginal return to land for livestock-share renters. On the other hand, the lower land/capital ratio for livestock-share ($4.80 per dollar versus $6.40 per dollar) suggests a higher land return. Thus, the differences in these resource combinations exert influences going in opposite directions. It may be concluded that capital restriction on the crop-share-cash farms (lower capital/land ratio) is the more dominant force influencing the difference in marginal returns to land. That is, the greater amount of capital used by livestock-share renters accounts for the higher marginal value product of land.

The hypothesis that "imperfections" in crop-share-cash leasing cause restrictions in the use of capital services would be confirmed by the foregoing conclusion. But that conclusion is subject to a qualification: Product combination and management may also have influenced the differences in marginal returns. When the effect of the regression constant is removed, the marginal return to land for livestock-share leases is decreased to 11.1 percent as compared with 13.5 percent (table 11). If the 11.1 percent is compared with the marginal returns of 9.9 percent for crop-share-cash, the difference is not highly significant. Further as the differences in marginal returns to labor and capital are not significant (either with or without the effect of the regression constant removed) it is doubtful that the patterns of marginal returns are affected by the difference in resource combinations under the two lease types.

TABLE 11. MARGINAL RETURNS TO RESOURCES USING COMMON PRODUCTION ELASTICITIES FOR THE LEASE TYPES AT THEIR OWN GEOMETRIC MEANS.

Lease type	Marginal returns to resources		
	Land	Labor	Capital services
	($/$)	($/wk)	($/$)
Livestock-share renters	0.135	66.42	1.205
Crop-share-cash renters	0.099	44.32	1.165

TABLE 12. OPTIMUM RESOURCE COMBINATION AND DEVIATIONS OF ACTUAL RESOURCE COMBINATION FROM THE OPTIMUM AT THE GEOMETRIC MEAN OF PRODUCTION FOR EACH TENURE CLASS.

Item	Resource combinations		Average deviation of actual from optimum combination	
	Actual[a]	Optimum	Amount[b]	Percent
Owner-operators under age 45 with production at $17,714				
Land ($)	27,551	22,518	+5,033	+22.4
Labor (wk)	91	63	+28	+44.4
Capital services ($)	8,794	9,825	-1,031	-10.4
Total value of services ($)[c]	14,087	13,696	391	2.9
Livestock-share renters with production at $22,936				
Land ($)	45,884	65,238	-19,354	-29.7
Labor (wk)	77	78	-1	-1.3
Capital services ($)	9,566	8,181	+1,385	+12.0
Total value of services ($)[c]	15,399	15,215	184	1.2
Crop-share-cash renters with production at $15,105				
Land ($)	41,506	59,389	-17,883	-30.1
Labor (wk)	76	75	+1	+1.3
Capital services ($)	6,517	5,274	+1,243	+23.6
Total value of services ($)[c]	12,047	11,837	210	1.8

[a]Geometric mean.
[b](+) indicates an excess (or greater than the optimum), and (-) indicates a deficit (or less than the optimum).
[c]Land services are valued as 6 percent of the total market value of land and labor services at $40 per week.

INEFFICIENCIES OBSERVED IN TERMS OF DEVIATIONS FROM OPTIMUM RESOURCE COMBINATIONS

The preceding analysis was concerned primarily with the marginal value products of resources in the different tenure classes. In comparing these marginal returns with assumed opportunity costs of the resources, inferences were drawn as to the direction of changes in resource inputs that might be economic with consequent changes in output. In the succeeding analysis, production is held fixed and resources are reallocated to obtain the minimum-cost combination of resources. That is, the ratios of marginal return to the opportunity cost of the respective resource are made equal. The opportunity costs assumed are as before.[41] Given these cost assumptions and the basic estimating equations, the calculated resource quantities for the optimum combinations represent the mean resource inputs necessary to achieve the minimum cost attainable at the mean values of production.

DEVIATIONS FROM OPTIMUM RESOURCE COMBINATIONS

According to the data in table 12, the younger owner-operators are the least efficient, when compared with the tenant-operators—the average excess of annual inputs above minimum cost being $394, or 2.9 percent. On the other extreme, livestock-share renters are the most efficient with an excess of annual inputs of $184, or only 1.2 percent. Crop-share-cash renters are more similar to livestock-share renters, their average excess being $210, or 1.8 percent. It is doubtful, however, that the small differences in average deviations (or levels of in-

[41]These were 6 percent for land, $40 per week for labor and 10 percent for capital services. Consequently, owner-operators as a group are dropped from this section of the analysis as the "opportunity cost" for their labor is probably lower than $40 per week, if the assumption of $40 for the other tenure groups has any validity.

efficiency) are significant in a probability sense.[42] The small differences may be partially explained by possible errors in measurements. Greater contrasts and variations in resource excesses and deficits are observed, however, by examination of the deviations with respect to each of the resource categories.

DEVIATIONS UNDER OWNER-OPERATORSHIP

For owner-operators (younger age group) there are indications of deficiencies in capital services and excesses in both land and labor. It is the only group that shows an excess ($5,033) in the amount of land needed to achieve the optimum combination.[43] At the same time, the group shows an excess of labor of 28 weeks. Thus, to improve resource allocation, capital services to the extent of $1,005 should be substituted for land and labor. This amount is the only capital deficit found in the tenure groups.

According to economic reasoning, as outlined earlier, one can expect owner-operators on the average to be limited in land, capital services or both, as compared with labor, because of capital rationing. Prior commitments in land purchases may cause a restriction in the amount of other capital needed to operate most efficiently with a given quantity of labor. The excess land of $5,033 corresponds to approximately 26 acres. Therefore, the greatest excess of resources under owner-operatorship appears to be in labor inputs.[44]

DEVIATIONS UNDER LIVESTOCK-SHARE LEASING

Livestock-share renters are short on land of $19,354 (76 acres), or 29.7 percent. In contrast to owner-operators, livestock-share renters show an excess of capital services—12.0 percent of the optimum quantity. Hence, the readjustment of resources indicated for livestock-share leases would involve the substitution of land in place of capital services; the labor deficit of 1 week may be ignored. In short, these observations indicate that for the given level of production under livestock-share leasing, more land and less capital should be used to achieve an optimum. This less-than-optimum use of land may be associated with possible "undervaluation" as noted previously.

If the malallocations had been in terms of land/labor or labor/capital ratios, more plausible explanations could be advanced. For example, if the reorganization needed required the substitution of land for labor services, the inference could be drawn that landlords are in a better bargaining position than tenants. That is, landlords would be maximizing the marginal returns to land and minimizing the marginal returns to tenants' contribution in labor. But, this idea is not relevant in this case. Or, if the malallocations were in terms of excess capital and labor deficit, the conclusion could be that a premium is placed on minimizing irksome farm operations or leisure time.

However, there may still be a tendency in this tenure class for landlords to "ration" land, choosing instead to furnish additional capital that is matched by tenants' capital directly. If they provide more land, they may also have to provide more capital under the terms of the usual livestock-share arrangements.

DEVIATIONS UNDER CROP-SHARE-CASH LEASING

The deviations from optimum resource combination under crop-share-cash leasing are similar to those under livestock-share leasing, with a minor exception: crop-share-cash renters would require an additional week (1.3 percent) of labor while livestock-share renters should have used a week less. As in the analysis of livestock-share renters, this difference of a week may be ignored. Hence, the needed reorganization of resources, as in livestock-share, is predominately the substitution of land for capital services. The quantity of land used should be $17,883 (79 acres) more—a deviation from optimum of −30.1 percent, while capital services should be decreased by $1,243, or 23.6 percent. Of course, land may have been "undervalued" as under livestock-share leases.

Furthermore, one might have expected capital services to be limited in relation to land because of "imperfections" in cost sharing and external rationing of capital that crop-share-cash renters face. The improvements in resource use would then be in favor of capital services rather than land. The results do not support these hypotheses. It is likely that restrictions in specific kinds of capital items are concealed in the aggregation of capital services. It may also be true that under conditions of a landlord rental market, landlords allocate their land to tenants who have the largest amount of capital available.

Inasmuch as the directions of the resource malallocations observed do not differ between lease types, the total value of productive services required at the optima for a similar level of production would vary between them (table 13). With the same production of $17,714, the average livestock-share farm would use resources in the amount of $11,575. This is considerably less than the $13,853 required by the average crop-share-cash farm.

The total value of productive services required by the crop-share-cash farm would be 19.7 percent greater than the amount required by the average livestock-share farm. Also, the amount required by the average owner-operator farm would be higher by 18.3 percent. When owner-operator farms are compared with the crop-share-cash farms, the value of productive services is only 1.2

TABLE 13. RESOURCE QUANTITIES AND TOTAL VALUE OF PRODUCTIVE SERVICES REQUIRED AT THE OPTIMA BY EACH TENURE CLASS FOR A SIMILAR PRODUCTION LEVEL.

Tenure class	Production[a]	Resource requirements			Total
		Land	Labor	Capital services	value of services[b]
	($)	($)	(wk)	($)	($)
Owner-operators under age 45	17,714	22,518	63	9,825	13,696
Livestock-share renters	17,714	49,694	59	6,233	11,575
Crop-share-cash renters	17,714	69,423	88	6,168	13,853

[a]This level of production is that for the younger owner-operators.
[b]Productive services are valued as before.

[42]Interpreted in a different way: owner-operators under 45 are 97.1 percent efficient, livestock-share renters 98.8 percent and crop-share-cash renters 98.2 percent. The differences between these efficiency indexes are probably nonsignificant.

[43]It should be noted that this is the market value and not the "annual input" of the land.

[44]The excess labor for owner-operators can be identified, perhaps with the general belief that "there is too much labor in agriculture." But it should be noted that, on the average, between 20 and 25 percent of the total labor reported is from the operator's family.

TABLE 14. MARGINAL RATES OF SUBSTITUTION OF RESOURCES AT THE GEOMETRIC MEANS BY TENURE CLASSES AND THEIR DEVIATIONS FROM THE INVERSES OF THE RESPECTIVE RESOURCE PRICE RATIOS.

Tenure class	Marginal rate of substitution of		
	Land for labor	Capital for labor	Land for capital
	($/wk)	($/wk)	($/$)
Owner-operators under age 45	566	23	25
Livestock-share renters	475	43	11
Crop-share-cash renters	460	44	10
	Algebraic deviations of inverse of price ratio from marginal rate of substitution[a]		
Owner-operators under age 45	-100	-13	+7
Livestock-share renters	-191	+7	-7
Crop-share-cash renters	-206	+8	-8
	Value of t for difference between marginal rate of substitution and inverse of price ratio.		
Owner-operators under age 45	0.18	0.81	0.39
Livestock-share renters	0.89	0.37	3.50[b]
Crop-share-cash renters	0.93	0.36	2.67[c]

[a]The inverses of the price ratios of concern here were rounded as follows: Labor/land = 666; labor/capital = 36; and capital/land = 18.
[b]Significant at a probability level of 0.1 percent.
[c]Significant at a probability level of 1.0 percent.
Other values of t are not significant.

percent higher than that for the latter tenure class, a negligible difference.

The foregoing differences between the tenure classes in the total value of productive services required as well as the associated resource inputs are uniquely a function of the basic estimating equations representing each tenure class. The different estimating equations, in turn, cause differences in optimum resource requirements. To the extent that these differences are tenure oriented and significant, it is presumed that the livestock-share lease encourages superior management or selection of enterprises. Differences in the estimating equations may stem from such causes that are not directly accounted for in this analysis.

Significance Tests for Inefficiences in Resource Combinations

The significance of the deviations of actual resource inputs from the optimum inputs were first tested by comparing statistically the marginal rates of substitution of the resources at the geometric means with the inverses of the respective price ratios for the resources. Second, the differences between tenure classes in the absolute deviations of these substitution rates from the respective price ratios were examined.

The marginal rates at which one resource substitutes for another were derived from the basic estimating equations. Using the basic equation for each tenure class, the marginal rate at which the resources substitute at the geometric means are as shown in table 14. In the case of owner-operators as an example, $566 of land are substituted for 1 week of labor;[45] and, ignoring the sign, the deviation from the respective inverse of the price ratio is $100 of land per week. The other rates are interpreted according to the units indicated by the table.

[45]In terms of land services (annual inputs of land) this marginal rate of substitution may be adjusted to $34 ($566 x 0.06) of land services for 1 week of labor. The same adjustment procedure may be followed for the other land-labor substitution rates as well as those for land-capital.

The objective here is to test for the significance of the deviations,

$$d_{j.i} = b_i\bar{X}_j/b_j\bar{X}_i - P_i/P_j .$$

The well-known condition for the optimum combination of resources is that the marginal rate at which one resource substitutes for another (b_iX_j/b_jX_i) must be equal to the inverse of the ratio of prices (P_i/P_j) for the respective resources. Clearly, if the observed value of $\bar{X}_j$ and $\bar{X}_i$—the geometric means—are optimum, the equality is achieved, and $d_{j.i}$ is zero.[46]

From the estimates in table 14, it will be noticed that none of the deviations are equal to zero. However, most of them are not significant. The most significant differences are in the deviations of the land-capital substitution rates for the two lease types. These are significant at probability levels of 1 percent. Although resource excesses and deficits (table 12) were observed for owner-operators, this test failed to show very significant inefficiencies in resource combinations among them. The values of t are not significant at probability levels of less than 30 percent. This occurrence may be related, at least partly, to the relatively larger variances of the marginal rates of substitution for owners.

The fact that there are resource malallocations in terms of the land-capital combinations for the two lease types is further revealed by looking at the significance of differences between marginal returns estimated at the geometric means of the inputs and those estimated at the optimum inputs.[47] The results presented in table 15 show that only the marginal returns to land and capital for the two lease types are significant. The more highly significant differences pertain to land. Again, no significant differences are revealed for owner-operators.

[46]The hypothesis was that the difference, $d_{j.i}$, was equal to zero. The statistical test employed was

$$t = \frac{b_i\bar{X}_j/b_j\bar{X}_i - P_i/P_j}{s(B_{j.i})} ,$$

where $s(B_{j.i})$ is the standard error of the marginal rate of substitution derived from the variance formula shown in Appendix C.

[47]The statistical test used was

$$t = \frac{M_{i.g} - M_{i.opt}}{s(m_{i.g})} ,$$

where $M_{i.g}$ and $M_{i.opt}$ are, respectively, the marginal returns to resource X_i at its geometric mean and its optimum; and $s(m_{i.g})$ is the standard error of $M_{i.g}$.

TABLE 15. MARGINAL RETURNS TO RESOURCES AT THE OPTIMUM RESOURCE COMBINATIONS AND VALUES OF t FOR THE DIFFERENCES WITH MARGINAL RETURNS AT THE GEOMETRIC MEANS.[a]

	Land	Labor	Capital services
	Marginal return at the optimum		
	($/$)	($/wk.)	($/$)
Owner-operators under age 45	0.072	48.22	1.325
Livestock-share renters	0.081	54.29	1.494
Crop-share-cash renters	0.075	49.79	1.370
	Value of t for difference with the marginal return at the geometric means		
Owner-operators under age 45	0.33	0.64	0.92
Livestock-share renters	1.87[b]	0.02	1.28[c]
Crop-share-cash renters	1.82[b]	0.03	1.47[c]

[a]Marginal returns to resources at the geometric means were presented in tables 8 and 10.
[b]Significant at a probability level of 5 to 10 percent.
[c]Significant at a probability level of 10 to 20 percent.
Other values of t are not significant at probability levels of 30 percent and less.

TABLE 16. VALUES OF t FOR DIFFERENCES BETWEEN TENURE CLASSES IN THE ABSOLUTE DEVIATIONS OF MARGINAL RATES OF SUBSTITUTION FROM THE INVERSES OF THE RESPECTIVE PRICE RATIOS.[a]

Tenure classes compared	Values of t for differences in deviations		
	Land-labor substitution	Capital-labor substitution	Land-capital substitution
Owner-operators under 45 vs. livestock-share renters	0.69	0.32	0.00
Owner-operators under 45 vs. crop-share-cash renters	0.52	0.51	0.20
Livestock-share renters vs. crop-share-cash renters	0.87	0.20	0.40

[a]The deviations were shown in table 14.

As mentioned before, the significance of the differences between tenure classes in the deviations of the marginal rates of substitution from the respective prices were also tested.[48] The results in table 16 show that for the values of t obtained none of the differences observed are statistically significant at usually accepted probability levels. These findings imply that the differences between tenure classes in the average deviations of actual total cost of productive services from the minimum costs attainable (table 12) are not significant.

CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

It has been shown that the types of resource adjustments needed to approach optimum production levels vary to some extent according to tenure status. But it was suggested also that part of the differences observed in marginal returns could arise from the nature of the estimating equations as well as from biases in the values on which land inputs were based. Furthermore, when the differentials in age distributions between tenure classes are taken into account, the levels of significance of the differences observed were reduced considerably.

The extent of deviations from the optimum resource combinations under each tenure class appears to be unimportant because the average reductions in cost, especially percentagewise, are "small" and do not differ significantly between the tenure classes. These observations then introduce the possibility that either no real economic problems exist for the broad tenure classes or the methods used are inadequate for detecting the inefficiencies present. On the one hand, it could be argued that the differences are hidden by the aggregative nature of the analytical model. On the other, one might say that within the broad tenure classes the heterogeneity of tenure arrangements[49] could have cancelled the inefficiencies (if any) present. Therefore, both facets of the problem require further inquiry.

The differences in the patterns of deviations (resource excesses and deficits) from the optimum resource combinations by tenure classes, however, suggest that each tenure class represents a different "problem situation" for further study as the causes for deviations from the optima conceivably vary according to tenure status. Further, for a similar production level, the average livestock-share farm had the lowest total resource requirement, which presumably is due partly to different combinations of enterprises and different management.

Some Limitations of This Analysis

As indicated throughout this report, the analytical models used have limitations with respect to (1) the aggregation of products and factors, (2) the exclusion of management as a factor and problems of intercorrelation and (3) the source of output-input data used.

No work was done on the problems involved in the aggregation of products because the kinds of data needed were not available. But if it is true that "imperfections" in leasing cause a nonoptimum combination of enterprises, this question is particularly relevant. The value of production from a given stock of resources is reduced accordingly. Therefore, the effects of product combination may be reflected in the coefficients of the estimating equations and hence the estimates derived from them. Different functions for crops and livestock would reduce the biases that may arise, but not completely as the crop combinations and livestock combinations may also differ between tenure classes. Apart from differentials in price effects, the physical response of different products to similar resources are not the same. Therefore, it is not immediately clear that the effects of tenure arrangements on product combinations can be treated adequately using the Cobb-Douglas type function.[50] A certain level of aggregation of products—crops and livestock products—is necessary, especially in light of the usual absence of information on the division of resources between crops and between the kinds of livestock.[51]

The aggregation of productive services into resource categories presents a weakness also. The estimate of productivity of a resource is expected to change if the categories of other resource inputs are altered. That is, the difference between tenure classes in the estimates for land or labor need not be the same if capital services are broken down further.[52] Lumping of capital services conceals the way in which more specific capital items are used. Productivity comparisons of such items as fertilizer and other variable productive services would be necessary in a rigorous analysis of tenure and resource allocation.

The exclusion of management as a factor may pose

[48]The statistical test used was

$$t = \frac{d_{j.ik} - d_{j.il}}{s(d_{j.ik} - d_{j.il})},$$

where $d_{j.i}$ denotes the deviation of marginal rate of substitution of resources X_j for X_i from the inverse of the respective price ratios (table 14). The subscripts k and l are the tenure classes compared, and $s(d_{j.ik} - d_{j.il})$ is the standard error of the difference in the deviations. The variance formula used for $d_{j.i}$ is shown in Appendix C.

[49]Hurlburt, *op. cit.*

[50]Possibly budgeting of some form would be more appropriate, recognizing that as a model it does not usually estimate existing relationships; it is a planning device. For the usefulness of linear programming see: W. D. Toussaint. Two empirical techniques applicable to land tenure research: linear programming and single equation models. Jour. Farm Econ. 37: 1354-1363. 1955.

[51]See Christoph Beringer. Estimating enterprise production functions from input-output data on multiple enterprise farms. Jour. Farm Econ. 37: 923-930. 1956.

[52]Of course, certain guidelines in the aggregation of factors are available, but these will not solve the problem: they improve the analysis so far as they help to reduce intercorrelation. See Plaxico, *op. cit.*

an additional limitation.[53] Unless management is uniform between tenure groups, differentials in resource productivities will not be explained completely. Further, if management happens to be intercorrelated with any other resource category for any particular tenure group, its effects are likely to cause errors in estimation of the productivity of the resource to which it is correlated. This problem, of course, is only a special case of the general problem of intercorrelation, which adversely affects regression analysis.

The question of intercorrelation is also of concern with regard to the analysis of labor productivity. With relatively small variation in labor inputs in a sample of farms, perhaps because of weaknesses in measurements, estimates on labor may be distorted through biases in the regression coefficients.[54]

The data on which this analysis is based was not obtained through a sample designed for a tenure study per se. Hence, the data used do not represent a true random sample of farms within the selected tenure classes. Also, as the tenure classes usually follow a geographic pattern, it is possible that such transitory and exogenous variables as weather and the extent of conservation measures that are likely to interfere with the estimates may have distorted the true differences that stem from tenure relationships. Consequently, a more homogeneous area of analysis is necessary. Accordingly, the concern about the valuation of land as an input would be avoided as that variable could be measured in terms of acres.

In summary, the estimates made in the study reported should be more reliable and useful if the methods are refined in line with the foregoing remarks. That is, separate functions for crops and kinds of livestock should yield more fruitful results. Examination of additional categories of capital services would yield more information. Labor services should be measured more accurately in terms of weeks of man equivalents and land measured in terms of acres.

Further Application of the Methods Used

The crucial observation from this study invites serious doubts as to whether the traditional classification of tenure groups, by owner-operatorship and the methods of rental payment considered, differ in the aggregate with respect to the levels of efficiency achieved in terms of resource combinations. Even with refinements of the model as recommended, it is suspected that further analysis of these broad classes would not show very meaningful differences in this respect. The specific causes for the differences could not be identified. As the small values obtained for the deviations from optimum resource combinations suggest that the inefficiencies of individual observations may be canceled by the efficiencies of other observations, it is implied that further analytical models should be designed to isolate the specific arrangements of tenure that are impediments to production efficiency.

In the first place, the need for removing the effects of factors that are not directly associated with tenure per se is indicated by examination of the age factor. Theoretically, factors such as labor quality, managerial ability, capital position of the firm and work preferences affect resource use and productivity estimates and are important to the extent that they are functionally related to the age of farm operators. Adjustments for "age effects" apparently become important. Probably in this connection, a multiple covariance model would be appropriate for the analysis. Or an analysis of variance model using two criteria of classification—age and tenure—could be explored to detect age and tenure effects on the pattern of marginal returns.

But still, it is not apparent that the effects of specific tenure characteristics can be isolated through the foregoing models, because within each tenure-age group different tenure arrangements may still generate forces going in opposite directions. For example, the incentives of an encumbered owner-operator need not be the same as those of one who is unencumbered. Also the effects of nonoptimum cost-sharing arrangements may be offset by the sharing of uncertainties under share contracts. Thus the results may remain confounded. It is then suggested that further analysis which attempts to isolate the effects of tenure arrangements should focus attention on the specific tenure arrangements themselves, using the conventional tenure classification as an initial device only. If estimating equations are used for this purpose, a relatively large sample would be needed of each tenure or lease type that could be broken down into "cells" of adequate sizes based on the tenure arrangements to be controlled. In making analyses of this kind, attention needs to be focused also on the effects of such arrangements on the combinations and intensities of resource use and on the combination of enterprises.

In addition to these analytical problems, a question to be resolved concerns the identification of the tenure-oriented part of the deviation from optimum, even under more "well defined" tenure classes. Resource readjustments are not actually made through continuous change, but through lumpy or step-by-step changes. Coupled with this question are the aspects of intertemporal resource allocation (over two or more production intervals) that remain to be investigated further.

[53]For discussions consult Glen Johnson, *op. cit.*; Zvi Griliches. Specification bias in estimates of production functions. Jour. Farm Econ. 39: 8-16. 1957.

[54]For further comments on the problem of intercorrelation of input categories, see Glen L. Johnson. Results from production economic analysis. Jour. Farm Econ. 37: 211-212. 1955. See also, Karl A. Fox and James F. Cooney, Jr. Effect of intercorrelation upon multiple correlation and regression analysis. U. S. Agricultural Marketing Service, Washington, D. C. 1954.

APPENDIX A

Data Used and the Weighting of Regressions

KIND AND SOURCE OF DATA

The data analyzed were obtained from a two-phase, stratified random sample of farms. The first phase of the sample dealt with obtaining a relatively large number of farmers of all kinds, and some information was obtained from each farmer on the number of livestock (cattle and hogs) expected to be sold. Through this information, farms were grouped into three classes (sizes) according to the "size of expected sales" in terms of animal units. In the second phase, a randomized sample of one-eighth of class 1 farms, one-fourth of class 2 farms and all of class 3 farms were selected. As a result, the final panel of farmers interviewed for details on production activities contained 588 names.

With eliminations caused by nonresponse, incomplete schedules and farms of less than 30 acres, only 432 schedules were finally selected as usable. The universe represented by this number of schedules consists of farms of 30 acres or more and the tenure classes listed in table A-1.

It is observed (table A-1) that although 20 percent of the farms in the universe are under crop-share leases, only 27 observations are included in the sample, as compared with 29 percent under livestock-share leases with 78 observations. This seeming discrepancy is a result of the sample that concentrated on the larger livestock producers. It must be noted also that with such limited data on crop-share and cash leases (15 and 6 degrees of freedom, respectively), these lease types were not analyzed. Similarly, part owners and full tenants as tenure classes were not analyzed here because these groups are too heterogeneous.

According to table A-2, the greatest and smallest percentages of "small" farms are under owner-operatorship and livestock-share lease, respectively. It is also noticeable that the steepest gradient (percentagewise) from small to large farms is under owner-operatorship, the lowest gradient under livestock-share lease, and part-owner and crop-share-cash lease occupy intermediate positions. These distributions reflect what would ordinarily be expected: livestock production is the criterion of size classification. Thus more livestock-share renters are included in the sample. Size classification is evidently not independent of tenure classification in the universe represented by the sample.

TABLE A-1. FARM OPERATORS ANALYZED AND THEIR DISTRIBUTION IN PERCENTAGES BETWEEN TENURE AND LEASE TYPES.

Tenure type	Number of operators	Percentage of total[a]
Owner-operatorship	158	39
Part-ownership	76	15
Full-tenancy	198	46
Total	432	100
Lease type	**Number of tenants**	**Percentage of total[a]**
Livestock-share	78	29
Crop-share-cash	75	42
Crop-share	27	20
Cash	18	9
Total	198	100

[a]These percentages cannot be obtained directly from the numbers of operators indicated. The percentages are weighted according to the number of observations in each farm class (size) falling within each tenure and lease type.

TABLE A-2. DISTRIBUTION OF CLASSES OF FARMS IN PERCENTAGES WITHIN EACH TENURE AND LEASE TYPE ANALYZED.

		Tenure and lease types			
Class of farm	Farm size	Owner-operators	Part-owners	Livestock-share renters	Crop-share-cash renters
1	"small"	71	57	48	69
2	"medium"	25	34	41	28
3	"large"	4	9	11	3
Total		100	100	100	100

WEIGHTING OF REGRESSIONS

As the data used are from observations stratified by "farm size" (classes 1, 2, 3) with sampling proportions of 1/8, 1/4 and 1, respectively, applied to each class, the corrected sums of squares and cross products of the regression variables were weighted. These moments were calculated separately for the three classes of farms around the individual class means and then added over classes after applying the appropriate weights to each class as follows: Class 1 farms — $W_1 = 8/13$, class 2 farms — $W_2 = 4/13$, and class 3 farms — $W_3 = 1/13$. That is, denoting W_h as the weight of the h-th class, the weights are such that $\Sigma W_h = 1$.

To simplify the computations, the plain integers of 8, 4 and 1 were used as weights to obtain weighting desired. Thus,

(1) the weighted corrected sums of squares

$$= \sum^{3} W_h \sum^{n_h} x_i^2 \; ;$$

(2) the weighted corrected sums of cross products

$$= \sum^{3} W_h \sum^{n_h} x_i x_j \; ; \text{ and}$$

(3) the weighted means of the variables

$$= \frac{\sum^{3} W_h \sum^{n_h} x_i}{\sum^{3} W_h n_h} .$$

APPENDIX B

SOLUTION USED FOR OPTIMUM RESOURCE COMBINATION

With the basic estimating equations derived, the optimum combination of resources for each tenure class, respectively, was found by obtaining the equality,

$$\frac{\partial\hat{Y}/\partial X_1}{P_1} = \frac{\partial\hat{Y}/\partial X_2}{P_2} = \frac{\partial\hat{Y}/\partial X_3}{P_3}, \qquad (1)$$

where production was held fixed at the geometric mean. That is,

$$\frac{b_1\overline{Y}/X_1}{P_1} = \frac{b_2\overline{Y}/X_2}{P_2} = \frac{b_3\overline{Y}/X_3}{P_3}, \qquad (2)$$

the unknowns being the values to be determined for X_i that represent the optimum quantities called X_i^*.

It follows from equation (2) that

$$X_1P_1b_2/P_2b_1 = X_2 = X_1' \text{ , and} \qquad (3a)$$

$$X_1P_1b_3/P_3b_1 = X_3 = X_1'' \text{ .} \qquad (3b)$$

Substituting the left sides of equations (3a) and (3b) for X_2 and X_3, respectively, into the basic estimating equation, expresses that equation in terms of the variable X_1 only. That is,

$$\log \overline{Y} = \log_e a + b_1 \log X_1 + b_2 \log X_1' + b_3 \log X_1'' \text{ .} \qquad (4)$$

From equation (4), solve for X_1^* as follows:

$$\log X_1^* = 1/\sum_{i=1}^{3} b_i [\log \overline{Y} - \log a - \sum_{j=2}^{3} b_j (\log P_1/P_j + \log b_j/b_1)] \qquad (5)$$

The values for X_2^* and X_3^* were obtained by substituting X_1^* for X_1 into equations (3a) and (3b), respectively. Thus,

$$X_2^* = X_1^*P_1b_2/P_2b_1 \text{ , and} \qquad (6)$$

$$X_3^* = X_1^*P_1b_3/P_3b_1 \text{ .} \qquad (7)$$

At the values for X_i^* the marginal rates of substitution of the resources are identical to the inverse of the price ratios for the resources. It means that

$$\partial X_j/\partial X_i = b_iX_j^*/b_jX_i^* = P_i/P_j$$

for each pair of resources.

APPENDIX C

Variance Formulae Used

VARIANCE OF RESOURCE MARGINAL RETURN AT THE GEOMETRIC MEANS[55]

$$\hat{V}(m_i) = A^2 \frac{1}{n} \left(s_y \frac{b_i \overline{Y}}{\overline{X}_i} \right)^2 - c_{ii} \left(s_y \frac{\overline{Y}}{\overline{X}_i} \right)^2.$$

The factor A^2 is the adjustment of logarithms taken to the base 10; s_y is the standard error of the estimate; b_i is the regression coefficient for resource, X_i; and c_{ii} denotes the related diagonal element of the variance-covariance matrix.

VARIANCE OF THE MARGINAL RATE OF SUBSTITUTION OF RESOURCES AT THE GEOMETRIC MEANS

$$\hat{V}(B_{j.i}) = \left(\frac{b_i \overline{X}_j}{b_j \overline{X}_i} \right)^2 \left(\frac{s_i^2}{b_i^2} + \frac{s_j^2}{b_j^2} - 2r_{ij} \frac{s_i s_j}{b_i b_j} \right).$$

The ratio $b_i X_j / b_j X_i$ is the marginal rate of substitution of resource X_j for X_i at the geometric means; b_i and b_j are the regression coefficients for the respective resources; s_i and s_j are the standard errors of the regression coefficients; and r_{ij} is the net correlation coefficient between the respective resources.

The standard error of the difference between tenure classes in the deviations $(d_{j.i})$ of the marginal rate of substitution from the inverse of the price ratios was estimated by

$$s(d_{j.ik} - d_{j.il}) = \sqrt{\hat{V}(d_{j.ik}) + \hat{V}(d_{j.il})}\ .$$

The subscripts k and l denote the tenure classes compared; and

$$\hat{V}(d_{j.i}) = d_{j.i}^2 \left(\frac{s_i^2}{b_i^2} + \frac{s_j^2}{b_j^2} - 2r_{ij} \frac{s_i s_j}{b_i b_j} \right),$$

where $d_{i.j} = b_i \overline{X}_j / b_j \overline{X}_i - P_i / P_j$, or $b_i / b_j (\overline{X}_j / \overline{X}_i - X_j^* / X_i^*)$. The values for X_j^* and X_i^* are the resource inputs at the optimum combination.

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[55]Obtained from H. O. Carter and H. O. Hartley. A variance formula for marginal productivity estimates using the Cobb-Douglas function. (Unpublished manuscript). Iowa State College, Ames, Iowa. 1955.

SELECTED REFERENCES

Ackerman, Joseph. Status and appraisal of research in farm tenancy. Jour. Farm Econ. 23: 277-290. 1941.

Beringer, Christoph. Estimating enterprise production functions from input-output data on multiple enterprise farms. Jour. Farm Econ. 37: 923-930. 1956.

Day, Lee M. Comparative efficiency of farm operations under alternative leasing systems. Unpublished Ph. D. thesis. Univ. of Minn. Library, Minneapolis, Minn. 1953.

Egbert, Alvin C. A study of resource use on crop-share and livestock-share rented farms in central Kentucky. Unpublished M. S. thesis. Univ. of Ky. Library, Lexington, Ky. 1955.

Fox, Karl A. and Cooney, James F. Jr. Effects of intercorrelation upon multiple correlation and regression analysis. U. S. Agricultural Marketing Service, Washington, D. C. 1954.

Griliches, Zvi. Specification bias in estimates of production functions. Jour. Farm Econ. 39: 8-16. 1957.

Heady, Earl O. Economics of agricultural production and resource use. Prentice-Hall, Inc., New York. 1952.

——————— Marginal resource productivity and imputation of shares for a sample of rented farms. Jour. Polit. Econ. 63: 500-511. 1955.

——————— and Kerberg, Earl W. Relationship of crop-share and cash leasing systems to farm efficiency. Iowa Agr. Exp. Sta. Res. Bul. 386. 1952.

Hurlburt, Virgil L. Farm rental practices and problems in the Midwest. North Cent. Reg. Pub. 50. (Iowa Agr. Exp. Sta. Res. Bul. 416). 1954.

Interregional Land Tenure Research Committee. Agricultural land tenure research, scope and nature: reappraisal, 1955. Farm Foundation, Chicago, Ill. 1955.

Johnson, D. Gale. Resource allocation under share contracts. Jour. Polit. Econ. 58: 111-123. 1950.

Johnson, Glen L. Problems in studying resource productivities and size of business arising from managerial processes. In Earl O. Heady **et al.**, eds. Resource productivity, returns to scale and farm size. Iowa State College Press, Ames, Iowa. 1956. p. 16-23.

Kelso, M. M. A critique of land tenure research. Jour. Land and Pub. Utility Econ. 10: 390-402. 1934.

Kottke, Marvin W. A study of decision sharing, tenure uncertainty and choice of farm enterprise combinations under leasing systems in Minnesota. Unpublished Ph. D. thesis. Univ. of Minn. Library, Minneapolis, Minn. 1955.

Ottoson, Howard W. Application of efficiency to farm tenure arrangements. Jour. Farm Econ. 37: 1341-1353. 1955.

Plaxico, James S. Problems of factor-product aggregation in Cobb-Douglas value productivity analysis. Jour. Farm Econ. 37: 664-675. 1955.

Schickele, Rainer. Tenure problems and research needs in the Middle West. Jour. Farm Econ. 19: 112-127. 1937.

——————— Leases and farm efficiency. Jour. Farm Econ. 24: 185-207. 1941.

Schultz, T. W. Capital rationing, uncertainty and farm tenancy reform. Jour. Polit. Econ. 48: 309-324. 1940.

Tintner, Gerhard. A note on the derivation of production functions from farm records. Econometrica 12: 26-34. 1944.

Toussaint, William D. Two empirical techniques applicable to land tenure research: linear programming and single equation models. Jour. Farm Econ. 37: 1354-1363. 1955.