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Relative efficiencies of farm tenure classes in resource use

Walter G. Miller
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RELATIVE EFFICIENCIES OF FARM TENURE

CLASSES IN RESOURCE USE

by

Walter G. Miller

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major Subject: Agricultural Economics

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1956
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INTRODUCTION

Historically, tenure in land with its associated problems has been a subject of social interest.¹ Within the agricultural sector of the economy, several measures have been designed to alleviate land tenure problems. These measures have been mainly concerned with promoting fee-simple ownership of lands and improving credit and leasing arrangements. Still, problems seem to persist. Among the persistent problems are the impacts of tenure arrangements upon the use and productivities of resources in agriculture.² This area of problems has not been entirely neglected in agricultural economics research; but little empirical analysis of the effects of tenure arrangements on production efficiency has been completed. The empirical studies have been mostly descriptive in character.³

An examination of the literature on land tenure, however, suggests that more information about the effects of tenure upon agricultural

¹The concept of "tenure in land" means the relations between man, and between man and the public, giving rights to the use and control of land. The rights to land use and control may be distributed through different forms of land ownership and leasing, through mortgaging and through rights reserved by the state. The institutions of ownership, tenancy, credit and taxation are therefore integral parts of the land tenure system.

²The term "tenure arrangement" embraces the specific condition under which rights to the use or occupancy of land are held.

efficiency and upon society is desirable. The North Central Regional Land
Tenure Research Committee and the United States Department of Agriculture,
recognizing the importance of tenure arrangements in the agricultural
economy and the need for further evidences with regard to the "relative
efficiency of alternative tenure arrangements", have initiated a study with
the intents to determine: (1) the impacts of various tenure arrangements
upon resource allocation, (2) the attributes of tenure arrangements that
constitute obstacles to improved resource use and (3) remedial methods for
minimizing the obstacles observed. This study is undertaken with the hopes
of bringing into focus some of the analytical problems involved and
providing a frame of reference for some of the empirical studies pertaining
to the allocating efficiency of tenure arrangements.

Importance of Tenure Arrangements in Resource Allocation

Presumably, the apparent inadequacy of empirical investigations into
the effects of tenure on resource allocation has been due to the complexities
of the American tenure system and also to the many subtle ways in which the
patterns of resource organization can be affected by tenure arrangements.
The effects of tenure arrangements on production efficiency may be adverse;
nevertheless, tenure arrangements appear to be particularly necessary and
important in a society where private property is an accepted institution.

1For a recent statement on specific research needs in land tenure see:
Interregional Land Tenure Research Committee. Agricultural land tenure,
These arrangements have grown from the distribution of rights in land between individuals as well as from the distribution of control over non-land resources required to complete production processes. The control over agricultural resources may be acquired (or transferred) either through ownership, leasing, or borrowing; and tenure arrangements make it possible for people to pool resources for enhancing production.

Each resource contributor as well as society at large is therefore affected by the institutional arrangements surrounding ownership, leasing, and borrowing. Land owners, lending agencies, tenants and taxing bodies are affected to some extent. In turn, consumers may be ultimately affected through the kinds, amounts and prices of goods and services produced as influenced by the types of tenure arrangements under which production decisions take place.

Illustrative of the importance of "tenure and the value of production" are data for the United States from the 1950 agricultural census: these data reveal that more than one-half of the agricultural output (gross sales) from commercial farms was produced on farms fully or partly rented. Therefore, if leasing arrangements have adverse effects upon production

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1 Percentages calculated from the U. S. Dept. Agr. Agricultural statistics, 1954. Washington, D. C., U. S. Govt. Print. Off. 1954. p. 487, show that for the United States in 1953, approximately 5 per cent of farm operators' production expenses went to landlords as net rent, 2 per cent went to farm mortgages interest, and 1 per cent to farm real estate taxes. (No data are available on the net income of tenants.)

efficiency then it is reasonable to suppose that a substantial portion of
agricultural production could be obtained at lower "costs". Similarly, if
tenure arrangements other than leasing, do have some adverse effects also,
it means that the "costs" of agricultural production could be reduced
further. Social welfare would be increased accordingly.

It should then be in society's interest to understand the behavior of
resource contributors under different types of tenure arrangements, and to
be able to explain and predict the patterns of resource use resulting from
their decisions. The general questions to be answered are these: what
types of tenure arrangements adversely affect efficiency; and on the
positive side, what are the types that further efficiency? To what extent
does each type of tenure arrangement impede the attainment of optimum
resource allocation? Answers to these questions are necessary in developing
a valid basis for minimizing the adverse effects by expanding those types of
arrangements that would improve efficiency (resource allocation).

Nature of Current Tenure-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) set forth by economic principles for optimum (efficient) resource
allocation. Allegedly, tenure arrangements as shown later can account for
at least a part of the deviations from optimum (resource use) that may be
present within an agricultural firm. 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.\footnote{D. Gale Johnson. Resource allocation under share contracts. Jour. Pol. Econ. 58:114. Apr. 1950.}

Consequently one set of problems is to determine what part of the deviations from the optimum conditions can be attributed to characteristics of the tenure system. At this moment the magnitudes of the deviations generated by tenure arrangements are unknown. Knowledge on the extent to which tenure arrangements facilitate or impede optimum adjustments is similarly lacking. However, ample clues have been given by previous empirical observations that there are possible sources for inefficiencies arising from tenure arrangements. It has been discovered, for example, that current farm rental practices in the Midwest are not in accord with the practices that would constitute an optimum on the basis of theory.\footnote{Virgil L. Burlburt. Farm rental practices and problems in the Midwest. Ia. Agr. Exp. Sta. Res. Bul. 416. 1954. (No. Cent. Reg. Land Tenure Res. Com. Ne. Cent. Reg. Publ. 50.)} In other words, incentives are present on rented farms to cause deviations from the optimum conditions for production. Other studies found that there are differences in the way resources are used by farmers operating under different methods of rental payment.\footnote{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. Ia. Agr. Exp. Sta. Res. Bul. 386. 1952; William D. Toussaint. Farm rental obstacles to land improvements and suggested solutions. Unpublished Ph.D. Thesis. Ames, Iowa, Iowa State College Library. 1953; Marvin W. Kottho. A study of decision sharing, tenure uncertainty and the choice of farm enterprise combinations under leasing systems in Minnesota. Unpublished Ph.D. Thesis. Minneapolis, University of Minnesota Library. 1955; Alvin C. Egbert. A study of resource use on crop-share and livestock-share rented farms in central Kentucky. Unpublished M.S. Thesis. Lexington, Kentucky, University of Kentucky Library. 1955.} While these studies did not seek to "measure" the
deviations from optimum arising from tenure relationships, they provide some evidence that there are divergences between the actual and the ideal in resource organization on rented farms.

But theoretically, tenure inefficiencies are not a function of leasing arrangements alone—owner-operators as well may make decisions within a tenure system that motivates departures from optimum resource use.¹ These sources of inefficiencies should, of course, be expected to differ from those on fully rented farms. For instance, inefficiencies are engendered partly by capital rationing or fixed and regressive taxes, interests and amortization rates under owner-operatorship. In the case of tenancy however, additional inefficiencies are introduced by "imperfections" in leasing arrangements such as the methods of sharing cost and returns or limited planning horizons.

Apart from discovering deviations from optimum conditions which can be attributed to tenure, solutions to reduce the deviations (improve efficiency) are contingent upon isolation of the effects of specific types of tenure arrangements.² Yet, there appear to be doubts and confusion about the way in which certain types of tenure arrangements affect efficiency in the agricultural economy. Doubts are cast, for example, upon the net effects of "tenure uncertainty" since different propositions regarding


²Referred to as specific types of tenure arrangements are, for instance, terms of amortization or tax payments, the terms used for sharing costs and returns on rented farms, or length of leases.
its effects can be advanced. However, theoretical explanations (hypotheses) represent mere predictions about empirical relationships. Insofar as it is possible these hypotheses are left to be empirically verified since they may be invalid in reality.\(^1\)

An attempt to isolate the effects of different types of tenure arrangements appears to be crucial to the solution of the basic problem of deviations from the "optima" in resource allocation. But, the empirical determination of effects poses a fundamental analytical problem which is one of the concerns of this study. In essence, the difficulties faced in the analysis of empirical data on tenure are those of identification and measurement.\(^2\) In the first place, the extent of deviations from specified

\(^1\)Although much has been said in favor of "certainty of tenure expectations" as means for gaining efficient resource use, this question can be viewed from different angles. For instance, while tenure uncertainty (insecurity) may lead to inefficient resource use it may also impel one to make more cautious decisions and to work more diligently. On the other hand, the certainty (security) of the "debt-free" owners (for example) may lead to lethargy and laxity. Thus, it is presumably difficult to make predictions on a complex reality with its attendant vagaries in individual behavior, regarding the ultimate effects of either certainty or uncertainty of tenure. In a population of farm operators the effects may differ according to the attitudes of the individuals and not because of tenure per se.

\(^2\)Refined theories, though meaningful, do not always lend themselves to empirical tests. With existing data it is difficult and may be impossible to determine the validity of theorems in tenure economies. However, this does not preclude attempts to have them verified or refuted.

\(^3\)These difficulties are not unique to tenure problems since finding appropriate analytical tools continues to be a fundamental problem in the investigation of economic relations: it has been noted that "... comparative efficiency of sizes of firms are difficult to make and that considerable ambiguity attaches to almost all existing measures." George J. Stigler. The theory of price. Rev. ed. New York. The Macmillan Co. 1954. p. 143. The analysis of tenure efficiency then becomes more complex. On the one hand, there are inefficiencies inherent in certain types of leasing arrangements. On the other hand, leasing facilitates operations larger than owner-operatorship, so efficiency in resource use can be affected in a different way.
optimum conditions should be determined or approximated. Further, the effects of specific tenure arrangements such as methods of sharing costs and/or products, and the effects of the tenure status of farm operators on the organization of resources need to be isolated and estimated. Determination of cause and effect relationships within the tenure system then has as one of its prerequisites the choice of appropriate analytical models.

Specific Problems Investigated in this Study

An inquiry into tenure arrangements, as they affect efficient resource use could cover a vast territory. This statement holds true for a comprehensive theoretical analysis and, more so, for the empirical counterpart of the theory. Hence, the specific problems delimited for this study involve the effects of the tenure status of farm operators upon resource organization within the firm. These effects are examined ex post under owner-operatorship, part-ownership and tenancy for one production year. Of the tenancy group, only the sub-classes of livestock-share and crop-share-cash (as lease types) are dealt with specifically.

Theoretically the patterns of resource allocation under these tenure classes should be different and should not correspond with the optima. Thus, parts of the basic problems of resource allocation on farms may stem from the tenure status of the operator. In terms of efficiency, the basic

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1 Problems of interfarm resource allocation as affected by tenure are not ignored but are not within the scope of this study.
problem may be defined in one of two ways: (1) for a given level of resource use the associated value of production is not being maximised; or conversely, (2) for a given level of production the associated costs are not being minimized. More specifically, problems in resource allocation exist if it is known or there are reasons to believe that there are departures of actual resource organization from any one of the three necessary (optimum) conditions for efficient production of the firm. This investigation is mostly concerned with departures from two of the conditions: (1) the "optimum" quantities of resources and hence optimum level of production, and (2) the "optimum" resource combination for given levels of production. These optimum conditions apply to all firms and should serve as the "norms" (or standards) for evaluating the degree to which agricultural firms allocate resources efficiently, regardless of the tenure class in which they are placed.

The major analytical problem in this study is one of detecting deviations from the optimum conditions. Approximations of the optimum

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1These conditions are restated in the following chapter.

2No attempt is made to estimate departures from optimum combination of enterprises. Hypotheses tested are limited to an extent by the available data.

3The extra-market values attached to ownership may however be in conflict with an efficiency objective on some owner-operated farms. Also, individual preferences for "leisure instead of work" may interfere with the attainment of efficiency as defined in this study. But the goal of efficiency is justified for analytical purposes on the grounds that (1) people usually prefer "more rather than less" and (2) it lends itself as a useful operational norm.
conditions (norms) and the existing (actual) situation become critical elements of the problem. They are critical in the sense that if no deviations of actual resource use from the "optima" are detected, then either no economic problems arising from tenure exist in reality, or the analytical models used are inappropriate for revealing them. Assuming that deviations are found, the magnitudes of the deviations for each tenure type should be indicative of separate "problem situations" since the causes for inefficiencies within a tenure class conceivably differ.

But no attempt is made in this study to identify or isolate the effects of intra-tenure class sources of inefficiencies such as tenure-associated rationing of capital, imperfections in leasing arrangements or other more specific tenure-oriented obstacles to efficiency. Only the broad classes of tenure are examined. The variations of tenure arrangements within each class are recognized, but cannot be treated in a study of this scope. By addition, the kind of remedial action necessary to minimize inefficiencies, while important, cannot be analyzed here — this study represents an attempt to obtain further clues as to "what is the situation?" regarding the effects of the selected tenure classes on resource use. It is not "problem solving" in the precise meaning of the term.

Objectives of the Investigation

In view of an apparent need for procedures by which the magnitudes of resource malallocation may be estimated, some attention is hereafter concentrated on analytical methods for comparative analysis of efficiency
as affected by the tenure status of farm operators. This study is therefore partly methodological. As a result, the general objectives guiding the study become twofold: (1) to further explore single equation models as means for estimating and comparing efficiency in resource use within farms operated under different tenure classifications; and conjointly, (2) to gain further insights into the relationships between the tenure status of farm operators and the use and productivities of resources employed in Iowa and Illinois, the area from which data were obtained. More specifically an attempt is made to discover the relative efficiencies of the selected tenure classes in (a) the use of gross resource services and (b) the use of the resource categories — land, labor and capital services.

Analytical Procedure

The procedure used is comprised of two major phases: (1) a general theoretical analysis extracting some of the salient features of the tenure system is first outlined and (2) an empirical investigation is made into the specific problems delimited for this study.

First: in the theoretical part of the study an effort is made to present a framework within which the allocative efficiency of tenure arrangements may be analyzed. The framework is developed primarily for the purposes of (a) bringing current problems of tenure in resource allocation into a sharper perspective, and (b) suggesting the types of hypotheses which need to be tested. The theoretical analysis is treated
in the immediately succeeding chapter as a frame of reference, while the
remaining chapters are devoted to the empirical analysis.

Second: the empirical part of the study consists of an analysis of
the tenure and lease types, listed previously, as means through which
agricultural efficiency may be achieved. The more important aspect of
the investigation is concerned with estimating the degree to which each
tenure or lease type achieves the "optima" in resource allocation. The
analysis 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 of tenure may
be appraised, is relaxed. The theoretical objectives of "optima" in the
amounts and combination of resources are used to measure the degree to
which efficiency is achieved 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"; and by inferences, conclusions with regard to
resource malallocations are drawn. This study further attempts to estimate
the extent of malallocation, in terms of deviations from optimum resource
combinations for given levels of production. Logically, the tenure class
with the smallest deviation from optimum resource use, should be accepted
as operating more efficiently.

The analytical model used for estimating the degree of effectiveness
(in terms of efficiency) of the respective tenure classes rest heavily upon
single estimating equations derived through regression analysis. Statistical
"production functions" are fitted to cross-section data obtained from a stratified-random sample of farms in Iowa and northern Illinois. From some of the functions derived, the relationships between gross returns and resource services "used up" are estimated. From other functions, marginal returns are estimated and analysed for each resource category by tenure and lease types. Next, approximations are made on the extent of deviations from the optimum resource combination for each tenure class considered. Concomitantly, the types of adjustments that would be necessary to improve resource organization are also suggested. Finally the value of the analytical model and data used are assessed.
THEORETICAL ANALYSIS OF TENURE-ORIENTED INEFFICIENCIES IN RESOURCE USE

Economic logic for appraising allocative efficiency has been applied to the institutions of land ownership and tenancy; but the application thus far appears to be partial and perhaps fragmentary. To form a suitable framework within which tenure arrangements may be analysed, an attempt is made to bring together some of the more relevant propositions which have evolved in connection with tenure economics. Such a framework is developed to aid in pointing up some of the more crucial variables in the tenure system and their functional relationships and in formulating hypotheses to be tested empirically. The effects of tenure arrangements will be analyzed conceptually, subsequent to a restatement of the criteria for production efficiency of the firm, reviewed as an analytical point of departure.

Criteria for Production Efficiency of the Firm

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 about resource use may be restated as follows: ¹

1. Extend the services of a resource to the point where 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.

3. Allocate the services of a resource between competitive products so that the values of each marginal product are equal.

When these three criteria are met the firm is said to be in static (intra temporal) equilibrium. That is, it would be impossible to increase net returns by reallocating the productive services employed among the different products. However, to closer approach reality, time becomes an additional variable. To introduce time into the static model, Hicks treats physically the same resource services used at different dates (production intervals) as "different" services and the same products turned out at different dates as "different" products. Further, to fit the intertemporal allocation problem the static prices of resources and products are replaced by discounted prices. The production plan yielding the maximum present value is achieved if decisions are guided by the three criteria stated for static equilibrium as adjusted for time.

1Hicks, op. cit., p. 86-87, lists 3 "stability" conditions which must hold to provide a stable equilibrium and determinate solution. In fact, these 3 conditions may be reduced to 1, and covered by a basic assumption; i.e., the marginal productivity of each resource is a monotonically decreasing function of the amount of resources employed.

2Hicks, op. cit., p. 197. With n resources and m products (in the static model at time t = 0), and a planning period extending over T intervals, the number of products and resources entering entrepreneurial calculations become nT and mT, respectively, with a similar number of discounted prices.
The first criterion is meaningful only in special cases, i.e., where the quantities of the productive services being varied are not limited. It sets the maximum to which productive services should be carried, and yields the optimum amount of a product and resource (holding other products and resources constant). The second criterion establishes the least-cost combination of productive services at any level of production, while the third criterion establishes the maximum value of production from a given stock of resources. Logically, when these internal conditions of equilibrium are satisfied the basic economic theorem of equimarginality for allocating resources optimally between alternative products (enterprises) is also satisfied.

Although the above model may, seemingly, impose limitations in its application to short-run decisions, no serious violence is done here in

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1More precisely: given (1) the production functions (technical relations connecting products, \( y_1 \), and productive services, \( x_1 \)); (2) substitute resources, \( x_1 = 1-n \); with prices \( p_{x_1} \); (3) competitive products, \( y_1 = 1-n \); and (4) derived marginal productivity functions, \( VMP_{y_1 x_1} \), optimum amounts of products and resources employed in producing each product is achieved if:

\[
\frac{VMP_{y_1 x_1}}{p_{x_1}} = \frac{VMP_{y_1 x_2}}{p_{x_2}} = \ldots = \frac{VMP_{y_1 x_n}}{p_{x_n}} \leq 1
\]

for all \( m \) products \((y_1)\).
view of the purpose for which the review was intended. \(^1\) That is, to provide a first approximation and general context within which propositions relating to the effects of tenure arrangements upon production efficiency may be developed.

**Possible Sources of Farm Tenure Effects on Production Efficiency**

If fewer uncertainties were associated with agricultural production, and if all costs and returns of the farm firm were incident on an individual (the farm operator) who had assurance of control over the farm assets for optimum planning periods, extension of the pure theory of the firm to agriculture would be less questionable. Ordinarily, depending to a degree upon the tenure status of the farm operator, the decision-making environment of the agricultural firm is characterized by one or a combination of the following elements: (1) tenure associated rationing of capital funds due to uncertainties, (2) intrafirm disassociations of costs and returns and (3) limited planning horizons and uncertainty of tenure expectations. The discussion to follow will be geared to these elements which appear to be the basic sources of inefficiencies of the tenure system. An effect is made to show the ways in which achievement of the optimum conditions

\(^1\)Since all productive services are assumed to be variable, the equilibrium obtained is that for the long run; and therefore is applicable to special cases. Usually a firm finds itself with a given stock of at least one resource that influences decisions made in the short run. However, while a resource may be momentarily fixed, in form and quantity, the services of the resource can be treated as variable. Moreover, in short run analysis the first equilibrium criterion becomes quite applicable.
(equilibrium criteria) may be impeded or facilitated through different types of arrangements and under different tenure status of farm operators.

**Tenure associated rationing of capital**

Capital rationing supposes that there are restrictions imposed upon the amounts of funds used within the firm, where greater quantities could be profitably employed. Rationing is not peculiar to any form of tenure but its nature and severity differ according to the tenure status of farm operators. The rationing may be due to exogenous forces (outside the firm) or endogenous forces (within the firm).

**Exogenous capital rationing.** Exogenous rationing implies that the restrictions imposed upon the use of funds (resources) are caused by the policies of lenders. Funds, at the disposal of one individual, to be allocated between the acquisition of land resources and other necessary assets for farm operations are usually limited. Farming operations, however, may be expanded (or initiated) through borrowing. But credit institutions are reluctant to lend more than a limited amount to a single farmer, because such agencies desire to avert risks. Little regard is given by lenders to the potential productivity of funds in alternative uses. Instead, loans are extended on the basis of equity of the borrower. Farmers with the higher equity (and better capital position) are most likely to be less deficient in capital but more qualified for extension of credit under customary lending policies. As a result, funds may be channeled to farms where the potential productivity of capital is lower, and away from farms where capital is more "needed" (higher marginal product
of capital).

The effects of this type of rationing on owner-operated farms may be as follows: prior investments in land resources (plus demands for the household) force a restriction on the amount of other needed capital assets. Therefore, either the amount of land resources or other capital items may be inadequate for given labor resources (operator and family). The possible results, in terms of resource productivities, are low marginal products for labor. However, relatively low productivities for all resources may be expected if the farm unit operated is one of low quality lands. Economic units of the better quality lands require greater initial outlays. Hence, imperfections in the capital market renders it difficult to acquire an adequate quantity and quality of physical assets. Young owner-operators, especially those having insufficient equity, are faced with the problem of acquiring more economic farm units.

Although the tenancy system has disadvantages, the effects of

1Low labor productivity among owner operators may, however, be traced to two possibilities: (1) small amounts of capital and/or land in the case of the younger group of owners; and (2) the low "quality" of the labor used on farms operated by the older age group.

2Some owner-operators do have economic farm units, but partly through "historical accident". Moreover, if capital accumulation progresses with age, older owners will find themselves in a better capital position with improved access to credit. The effects of exogenous capital rationing should then be less severe. In the analysis of tenure and resource allocation, age of the operator creeps in as an additional factor to be considered. Different resource organizations can be expected on farms operated by different age groups, not only because of different "work preferences", but also because of differences in capital availability.
exogenous rationing of capital may be minimized through the joint contributions of landlord and tenant to the total farm assets. On the average the stock of capital and the amount of land used under tenant operators may then be more in line with the optimum quantities required than they would be under owner-operators having made land investments. As suggested earlier, with limited funds, under owner-operatorship the amount of land and other capital assets are ordinarily restricted. These restrictions are circumvented more readily through renting. The amount which would be used for land purchasing by a tenant is used for acquiring other capital items.¹

No presupposition is made that rented farms are always adequately equipped with capital.² With creditors requiring "insurance" (collaterals and desire for low risk debtors) the tenant logically can be placed in an inferior position in terms of access to credit. Because of low "landed"

¹Schultz puts it in this way:
Faced with the necessity of supplementing his own limited assets with outside funds a farmer has two alternatives—he may rent or he may borrow. These two are direct substitutes when the use of farm land and the capital opportunities fixed to farm land are being purchased while machinery, livestock, fertilizer, seed and the services of labor are met as a rule rentable. Under existing institutional facilities, a farmer is allowed to rent a volume of capital (in the form of land and buildings) larger than he is permitted to borrow. The smaller the total assets the farmer owns the greater the relative difference between the amount of capital that is rentable and the amount that is borrowable.


²Younger tenants in particular may also have an insufficient amount at their disposal and limited access to credit. This is most likely to be true for pure crop-share leases, since the tenants usually fall in the lower age group of tenants.
assets and uncertainty in the minds of creditors about the expected
duration of occupancy of the tenant, discriminatory credit terms may
ensue to make borrowing appear prohibitive, that is if credit facilities
are made available at all. It is conceivable that a tenant may be willing
in some instances to make major investments but because he does not have
title to the land no credit will be made available in the absence of the
landlord's participation. Accordingly, because of the usual presence of
the landlord in the farming operations under livestock-share leases the
effects of exogenous rationing should be less severe on such farms.

**Endogenous capital rationing.** Endogenous rationing refers to the
restrictions placed upon further investments from decisions made within
the firm. This is usually a result of (1) uncertainty of expectations
about future net revenue and (2) the "principle of increasing risks"; that
is, risks of losses of owned assets increase as the ratio of borrowed
equity to owned equity increases.\(^1\) In the decision making process, due
to allowances for uncertainty, investments will be restricted to amounts
short of that which would be profitable with uncertainties reduced.\(^2\)

Under owner-operatorship with full equity and exogenous rationing of

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\(^1\)Michal Kalecki. *Essays in the theory of economic fluctuations*,
also, Robert W. Rudd and David L. MacFarlane. The scale of operations in

\(^2\)Of course, endogenous restrictions in the use of capital may also
arise from circumstances which are not tenure oriented. Such types of
restrictions are due to demand for funds needed in activities other than
production and are not peculiar to any form of tenure.
capital relaxed, rationing may still be present due to endogenous forces. Risks of losses increase with expansion of outlays, hence the returns from greater outlays will be discounted heavily by a farmer. In the case of owner-operators where all the risks associated with a larger scale of operations are borne by one proprietor, the restrictions should be more severe. If the associated risks are spread over more than one proprietor, however, as in the case of partnerships or tenancy under share leases, it is reasonable to expect larger outlays. The impacts of endogenous rationing are thus reduced through partnerships and share leasing.

Apart from greater risks due to uncertainties surrounding larger scale of operations, there is a different element of risk due to reduction of the proportion of owned equity. As noted previously, farming operations may be expanded either through borrowing or renting. But with borrowing, the "principle of increasing risks" encourages restrictions in the amount which will be borrowed, even if lenders were willing to reduce equity requirements. A farmer is unwilling to borrow so much as to risk wiping out the equity he owns. On the other hand, with renting as an alternative means of gaining resource control, the contributions of landlord and tenant to the total farm assets may be adequate enough to avoid the restrictions that would arise if funds had to be borrowed.

The increasing risk factor then suggests that the scale of production will be larger under renting than under a single proprietorship (the

1It is assumed that uncertainty may be subjectively measured by the range or dispersion of possible outcomes—gains and losses. This range increases with the scale of operation and therefore investments.
owner-operator). Procuring resource services through renting does not involve the same thinning out of equity as does procuring of resources through ownership. Further, the risks associated with larger outlays are spread under share leases. "Accordingly, the uncertainties surrounding larger operations are less under renting than under ownership." Therefore, if discounting increases with uncertainty then the discounting of future returns should be less under tenancy than under ownership. With lighter discounting one might then predict that resources will be extended further to conform more with the optimum amounts needed.  

Different classes of tenants are, however, subjected to different motivations which will affect the extent to which resources are employed. In the case of cash tenants, rental payment represents a fixed commitment. Land will be extended until its discounted marginal product is equal to the rental rate. The risks in farming operations fall solely on the tenant-operator, just as they fall on the owner-operator. But, acquiring the

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2The resources referred to are the basic categories of farm real estate, capital and labor services. No such implications are intended at this point with reference to specific resources such as fertilizer, which may be on the "periphery of profitability".

3Differences observed between classes of tenure in the amount of land used may, however, be more apparent than real. Tenure status is evidently a function of land productivity which may be negatively correlated with farm size. Tenant-operated farms appear in geographic clusters and on the more productive lands. Owners may tend to operate larger farms but of lower productivity, partly because of the initial investment required to acquire the better lands. Lands of low productivity offer less attraction to tenants than do lands of high productivity, particularly if the rents (cash per acre, or share of crop) are the same.
services of land through cash rental does not involve fixed commitments
by the tenant extending over a long period and hence risks as high as they
would be with purchase contracts having extended periods of amortization.
Also, owing to the fact that land resources are contributed by the landlord,
it can be expected that the cash tenant would operate a more adequate
amount of land (than would the average owner-operator), since he (the
tenant) does not divide his personal assets between the acquisition of land
and other operating assets. The "principle of increasing risks" that would
limit the amount of resources employed if funds were borrowed becomes less
effective.

In addition to dampening of the restrictive effects associated with
the "principle of increasing risks", under share leases the uncertainties
inherent in farm prices and yields are shared between tenants and landlords.
Sharing of uncertainties minimizes the incentives to restrict not only land
but other complementary resources. Explanations for "large" farms under
share contracts might then be found also in the sharing of uncertainties
that increase with the scale of farming operations. It is presumed that
ordinarily, the risks of losses on farms operated under share contracts
are greater than the amount to which either party to the lease would be
willing to expose himself, singly.

1The functioning of the tax system may also create interacting forces
but which operate in a more subtle fashion. A "real estate tax", for
example, if it is "regressive", that is, decreases with increases in the
present market value of land (due to valuation for tax assessment purposes),
creates an environment to control a larger amount of land. The "marginal
tax" is a decreasing function of the value of (or amount of land). However,
this incentive should affect the sizes of all farms regardless of the tenure
status of the operator. The idea is simply introduced here in order to
recognize the possible effects of a tax structure.
The growing presence of part-ownership is ample evidence of the role of tenancy in influencing farm size and scale of operations. It is proposed that this is due, at least in part, to the minimization of the forces of capital rationing. In general, for a farm with a given area the marginal product of the final acre should not remain substantially above rental rates. If it does, the farmer should find it profitable (and will do so, if there is the opportunity) to rent additional land and extend its use until the marginal value product (discounted) approximates the rental rate. The expansion is more likely to occur through leasing, partly because risks are shared and partly because of the equity which would be required if funds had to be borrowed for purchasing.

Capital rationing as discussed so far refers to the manner in which long-run decisions and hence the long-run optima in resource use can be affected. It would appear that the effects on owner-operatorship would be, on the average, more severe than they would be under tenancy. Therefore, to the extent that there are some economies due to larger scale of production, in the sense of lower per unit cost of machinery or labor, for example, owner-operatorship is in a less favorable position, while the tenancy system may facilitate adjustments in that direction.

Intrafirm disassociation of costs and returns

Under the assumption that limitationality of capital or other

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1 It is recognized that in reality expansion of farm size does not take place in terms of an "additional acre" but in lumpy changes. This setting, however, does not affect the argument. Instead of small changes (1 acre), more discrete changes (10, 30, 50 acres) can be substituted for an approximation of the solution.
resources is absent, optimum resource use may still be impeded if all costs and returns within the firm are not incident on the farm operator. Therefore, under leasing, shifts in the incidence of costs and returns are possible. That is, the returns each participant receives may not be associated with the costs he (tenant or landlord) contributes, and vice versa, the costs each pays may not be associated with the returns each receives. As will be observed, those possibilities are a function of the methods of sharing returns and costs on tenant operated farms.

Methods of sharing costs and returns. In essence, imperfections in methods of sharing costs and returns imply that the returns received by a resource contributor may not be functionally related to the costs he contributes. This may occur within a given production interval (intratemporal) or over several production intervals (intertemporal). But from the definition of a firm as a maximizing unit, the intertemporal aspects will be discussed later since the firm changes its identity if the planning agent changes. This section deals with intrafirm and not interfirm disassociations.

Immediately in point are cases where share leasing agreements stipulate that the returns from a product be shared without appropriate sharing of the cost of the productive services which yield that product. If the tenant (or landlord) is required to pay for all of the resource services, there is incentive to restrict the use of that service to an amount less than
that which would be most profitable for the firm.\(^1\) The proposition applies not only to different capital services but also to the services of the human agent.\(^2\) It would be more "profitable" to shift these services from the firm to alternative lines of investments (or leisure) since both the tenant and landlord seek to maximize their own positions.

Such alternatives are encouraged under share leases. On the other hand, there is less likelihood of livestock-share farmers to be so motivated, since the conditions ordinarily are more akin to partnership agreements. Usually, all costs and returns are supposedly shared proportionately. Problems may, of course, arise due to substantial differences in the subjective valuation of personal contributions. In both cases (of crop-share and stock-share leases) if the parties related to the contract are not aware of the inter-personal disassociations of costs and returns which may be present, there need not be any restrictions in resource use, but instead a transfer of income. That is, resources may be used optimally at a given time although all of the rewards to each resource are not received by the contributor of the resource. Under cash rental, there is no possibility of disassociations of returns from variable costs since the tenant receives all the output which is uniquely a function of the variable

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\(^2\)The effect should become more apparent if these services are to be purchased. Moreover, if "capital funds" are viewed as the "command" over resources (i.e., one is able to purchase different forms and quantities of productive services) then no further qualification is necessary. The proposition has general applicability to all variable services.
services. But disassociations may arise if (1) the rental payment is below the marginal product of the farm real estate, or if (2) the marginal product of land exceeds the rental rate (plus a "risk premium"). In the first case, there would be an income transfer to the tenant. In the latter case there would be an income transfer to the landlord.

The probability of income transfers implies that landlords may also react unfavorably if rental payments (or landlord returns), cash or share of products, are such that the landlord receives less than the marginal value products of the resources he contributes. He will contract his contributions (in buildings or other land improvements) if he receives no direct reward from them. He is not urged to provide or maintain such items beyond that which would make the farm reasonably attractive in the rental market. In short, both tenant and landlord seeking to maximize their individual ends will restrict the use of resources if they do not receive all the returns which are functionally related to the resources they contribute individually. Each considers only those returns which accrue to him and those costs he is required to pay.¹

¹Problems of disassociations of costs and returns may also arise in the case of part-ownership if returns and costs are not shared optimally between landlord and tenant. Particularly if capital is a limiting resource, the part-owner (in the case of share contracts) would naturally be inclined to restrict the use of such resources to that part of the land which he owns, regardless of the potential production responses of resources on that part of the land which is rented. See Handy, op. cit., p. 620–621; Howard W. Ottosen. Application of efficiency to farm tenure arrangements. Jour. Farm Econ. 37:1344. Dec. 1955.
preceding discussion assumed tacitly that the firm produced a single commodity. However, on farms where there are two or more enterprises, tenure arrangements obviously become more complex. Conceivably there are several different alternatives for sharing products from different enterprises, but imperfections in the bases for sharing may result in non-optimum combination of enterprises.

If the products of two or more enterprises are shared differently, there is economic inducement to allocate resources in favor of the enterprise (s) from which the largest return (value) is received. The value of the marginal products of each enterprise would be different and the value of production less than the maximum possible with the given stock of resources employed.¹ This distortion presupposes relative market prices to be the index of consumer satisfaction and the choice-criterion for optimum allocation of resources between alternative products. But actually, disproportionate sharing of products may be an accounting device to adjust for differences in the contributions (of landlord and tenant) to total costs, and therefore, cannot always be taken as prima facie evidence of resource malallocation. This proposition on sharing of products of necessity must be tied to the sharing of costs. If differentials in the sharing of products is compensated for by differentials in the sharing of

¹Consult Heady, op. cit., p. 602-604 for a detailed discussion and graphical proof of this hypothesis.
associated costs, there need not be any deviations from equilibrium production. The significant point, however, is that sharing of products in different proportions creates a decision-making atmosphere in which there might (but need not) be departures from an optimum allocation of resources between competitive enterprises.

Limited planning horizons and uncertainty of tenure expectations

The effects of both these phenomena on resource use are presumably the same, and are particularly relevant to conservation decisions. The separation is made because of differences in the decision-making environment, not because of differences in motivation. With respect to limited planning horizons it is assumed that decisions are made for known periods (expected duration of occupancy) that fall short of optimum planning periods. In the case of uncertainty of tenure expectations, fear of dispossession of the farm assets or lack of interest appear to be the more crucial considerations. Under the former, tenure may be said to be definitely limited; while under the latter, tenure may be said to be

1For instance, if an enterprise is labor intensive and the landlord received 50 per cent of the resulting product without subscribing proportionately to the labor services, it would be in the tenant's interest to contract the use of his labor in that product and employ it elsewhere (divert it to leisure, or be satisfied with an excess labor capacity). To avoid such a situation, a proportion of the product greater than 50 per cent might be offered to the tenant in lieu of the landlord's contribution to labor services. This question is particularly relevant in cases where labor becomes a limitation resource.

insecure or indefinite.

**Limited planning horizons.** Limited planning horizons connote that the periods for which planning is made is inadequate from the viewpoint of optimum intertemporal allocation of resources. Optimum intertemporal allocation would be encouraged if the planning horizons are identical with optimum planning periods. That is, periods over which investments in permanent improvements (or resources such as fertilizer) would be profitable for both the planning agent and society.

It has long been recognized that investments of a durable or semi-durable nature (typically land improvements) which yield returns over an extended period, may be adversely affected under tenancy. This is expected where the planning horizons of the tenant fall short of optimum planning periods, and there are no provisions for compensation of unexhausted improvements when the rental contract is dissolved. If the returns from investments accrue after occupancy ceases, they represent benefits to future occupants and costs to the present. Production decisions are then made to ensure that returns will accrue before expiration of the contract (the planning horizon). Therefore, all the possible returns accruing at future dates, beyond the expiration of the lease (optimum planning periods) are discounted and do not enter into entrepreneurial calculations. Accordingly, investments will be restricted on rented farms.

Further, in the absence of landlord cooperation, durable investments (e.g., buildings and tiling) may not be undertaken because of "specificity"
in use. In case of removal, possible relinquishment of usership would represent a sacrifice which the tenant seeks to avert. At the same time, landlords are likewise reluctant to cooperate in major improvements because they may be inappropriate for the incoming tenant. In other words, the landlord's expected value of the returns from improvements to him may be insufficient to induce him to make the necessary investments.

Restrictions in investment are not peculiar to tenants with planning horizons shorter than optimum planning periods, and with no assurance for adequate compensation. Operators of life estates may also have little or no personal economic interest to keep physical assets intact for the successors. The result may then be depletion of the farm assets (for present income), which will be a "cost", in terms of low productivity or rehabilitation of assets, to future occupants.

Uncertainty of tenure expectations. As indicated before, the effects of tenure uncertainty on intertemporal resource use are analogous to the effects where planning horizons are known but limited. Consequently, the following discussion should amount to an extension of the effects just indicated.

Obligations to make fixed annual costs — interest, amortization payments and taxes — must be met by owner operators in order to maintain control of resources. Fear of foreclosure or dispossession creates an

1 Many important propositions on the possible effects of the credit and tax system will not be pursued in this discussion. But, they must be recognized as important in an analysis of the tenure system. For a discussion, see Ciriacy-Wantrup, op. cit., Ch. 12, 13.
environment, especially in the periods of production hazards or depressed prices, that encourages heavy discounting of future returns to maximize current incomes. Heavy discounting might cause a deflection from the optimum production plan. It may appear temporarily expedient to mine soil resources to avert loss of operating assets. Over time the production response of land, as well as the productivity of complementary resources will diminish. As a concomitant result, resources may be shifted, inadvertently, to products not in line with consumers' "time preference." That is, because of the pressures for immediate income, enterprises yielding quick turn-overs (such as crops or hogs) are substituted for enterprises yielding more distant and slower rates of return (such as breeder cattle).

The diminution in resource productivities over time, accompanied with distortion of enterprise combinations, as a result of tenure uncertainty, may also be expected in cases other than owner-operators. Tenants are similarly subjected to insecure tenure but of a different species: those tenants having short-term or oral leases, not knowing if their leases will be renewed or terminated, will find it personally profitable to disinvest soil resources (substituting land or labor for conservation "inputs"), although investment would be economical under a more definite expectation of occupancy. However, if both the landlord and the tenant participate in planning the farm operations there is no reason to expect a marked difference between a tenant-operated farm and an owner-operated farm in

Farmers in the low income group should be particularly vulnerable to these effects by magnifying the inducement for resource depletion on the already lower productive and uneconomic unit. Walter Wilcox. The economy of small farms in Wisconsin. Jour. Farm Econ. 28:461-462. May 1946.
Certain qualifications are necessary here: short term leases may be satisfactory to the parties engaged in lease contracts to evade frictions in the execution of lease agreements. Resource readjustments to price changes to maintain or improve farm income are possible only if some time-flexibility is allowed in leasing arrangements. Further, short-term leases might also provide means for periodic reviews of the performances of tenants, and motivate tenants (who wish to continue occupancy or establish a good record) to maximize not only their own ends but the interests of the firm as a going entity.

Hypotheses Directing the Inquiry

Implicit in the foregoing theoretical analysis are a host of hypotheses about the effects of tenure arrangements and the tenure status of farm operators upon resource allocation within the firm. That is, predictions or tentative propositions are advanced with respect to empirical relationships or unknown phenomena on which little or no observations have yet been made. However, from the stated objectives of this study it should be apparent that the empirical analysis will be concerned with only a small part of the problems of tenure in resource allocation. Therefore, most of the hypotheses implicit in the theoretical analysis will not be tested in

1 There are cases in which landlords require set patterns of land use without being aware of the economic implications. That is, using market prices as the choice-criterion of allocating resources between enterprises to obtain the maximum value from production.
this study. Attention is confined to hypotheses of an initial type only.
No hypotheses of a "diagnostic" nature which relate to the specific reasons for the existence of the problems will be tested.

With the foregoing limitations in mind, the major hypotheses directing the empirical phases of this investigation are posed in quite general terms as follows:

1. Output-input functions relating the gross value of production to the gross value of resources "used up" during a production year are affected by tenure status; and they should differ between agricultural firms according to the status of the operations. It should be inferred that the test of this hypothesis involves comparison and analysis of aggregate relationships only.

2. If resource organization is conditioned by the tenure status of farm operators, there should be differences reflected in the patterns of marginal returns to the resources employed. It should follow that there are differences in the departures of marginal returns from the respective "prices" of resources. These "prices" serve as limits to which resources should be expanded or contracted to achieve optimum production levels. In contrast to the first hypothesis (above), it is implied that an approximation of efficiency in the use of specific resource categories would be obtained by the test of this hypothesis. But a closer approximation to the test of efficiency is assumed by stating a related
3. That tenure status theoretically impedes the achievement of efficiency in resource use; hence it can be predicted that there are corresponding differences in the deviations of actual resource combination within the firm, from the optimum combination of land labor and capital services at given levels of production.

From the theoretical analysis of farm tenure effects on resource use it should be recognized that the broad tenure classes, selected for this study, might have inherent weaknesses for analytical purposes. Within such populations of farm operators, there can be many variations of tenure arrangements and characteristics that affect production decisions. Thus inefficiencies within each of the tenure and lease types may be compensating or concealed. Hence the classification is adopted as a matter of convention. However, it may be stated as a central hypothesis that if production decisions are conditioned to any significant extent by these tenure classes, as populations, then there should be differences between them in the patterns of resource use.
METHODS OF INVESTIGATION AND ANALYSIS

There are two common approaches to the analysis of efficiency in contemporary agricultural economics research: (1) studies of the economics of specific farm situations and (2) studies of statistical populations of farms. It is not implied that a study of farm populations is a direct alternative to the analysis of particular farms or vice versa. They serve different purposes and may be undertaken jointly as complements. Studies of particular farm situations are more appropriate to establish benchmarks for making specific recommendations; they do not provide general information—on average relationships or on the status quo—that might be useful as directives in the formulation of public policy. The latter approach only is followed in this investigation. This is presumed by the application of regression analysis. It is assumed that groups of farms classified by the criterion of the tenure status of the operator are different populations. The parameters and relationships of each population are taken to represent those for the average farm firm within each group.

Kind and Source of Data Used for Testing Hypotheses

The data used for testing hypotheses are obtained from a two-phase stratified-random sample of farms in Iowa and the northern two-thirds of Illinois. Records were obtained from 583 farmers through a series of quarterly personal interviews for the year 1954. The sample was designed originally to estimate livestock production; it was not designed for a
tenure study per se. However, information on the tenure status of respondents was obtained. Except for some limitations, sufficient data were also obtained on production and resources used during 1954 to provide information for deriving cross-sectional "production functions" and for estimating other tenure characteristics. No information was obtained on the division of resources between different enterprises. Further, other data that would be useful, such as the contributions made by landlords and tenants to "variable" resources, were not available.

The first phase of the design dealt with obtaining a relatively large sample of farmers of all kinds and for each farmer some information was obtained 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. 1

In the second phase of the design a randomized sample of 1/3 of class 1 farms, 1/4 of class 2 farms and 1/1 of class 3 farms was selected for the final panel of farmers who were interviewed for details on production activities. As a result, the final panel of farmers interviewed in phase II of the sample contained 586, with the numbers drawn from each class shown below (Table 1).

Of the 586 farm operators in the sample, 536 responded for all of the

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1 The number of farms identified in phase I of sample was 2,240 and was distributed as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Expected sales in animal units</th>
<th>Number of farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49 and under</td>
<td>1,991</td>
</tr>
<tr>
<td>2</td>
<td>50 - 124</td>
<td>685</td>
</tr>
<tr>
<td>3</td>
<td>125 and over</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2,240</td>
</tr>
</tbody>
</table>
four quarters (in 1954). Therefore, only the latter number of schedules was edited for adequacy of answers to questions in the schedules pertaining to tenure and production. Farms of less than 30 acres were dropped. Other schedules were excluded either because of incomplete answers or because of being unclassified with respect to a single tenure status. With these eliminations, only 432 schedules were finally selected as usable. The

Table 1. Farm operators interviewed and their distribution between classes of farm size

<table>
<thead>
<tr>
<th>Class</th>
<th>Farm size</th>
<th>Number of farm operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;small&quot;</td>
<td>246</td>
</tr>
<tr>
<td>2</td>
<td>&quot;medium&quot;</td>
<td>176</td>
</tr>
<tr>
<td>3</td>
<td>&quot;large&quot;</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>588</td>
</tr>
</tbody>
</table>

The universe represented by this number of schedules then consists of farms 30 acres or more and the tenure types listed in Table 2.

It might be observed (Table 2) that although 20 per cent of the farms in the universe are under crop-share leases, only 27 observations are included in the sample, as compared to 29 per cent 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 also be noted that with such limited data on crop-share and cash leases (27 and
Table 2. Farm operators analyzed and their distribution in per cent between tenure and lease types

<table>
<thead>
<tr>
<th>Tenure type</th>
<th>Number of operators</th>
<th>Per cent of total^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner-operatorship</td>
<td>155</td>
<td>39</td>
</tr>
<tr>
<td>Part-ownership</td>
<td>76</td>
<td>15</td>
</tr>
<tr>
<td>Full tenancy</td>
<td>108</td>
<td>36</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>432</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lease type</th>
<th>Number of tenants</th>
<th>Per cent of total^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock-share</td>
<td>76</td>
<td>29</td>
</tr>
<tr>
<td>Crop-share-cash</td>
<td>75</td>
<td>42</td>
</tr>
<tr>
<td>Crop-share</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>Cash</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>198</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

These percentages cannot be obtained directly from the number 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. The percentage distributions of classes of farms within owner-operatorship and part-ownership, livestock-share and crop-share-cash leasing are shown in Table 3.

1% (respectively) these lease types are not analyzed specifically.¹

According to Table 3, the greatest and smallest per cent of "small" sized farms are under owner-operatorship and livestock-share lease, respectively. In addition, it is also noticeable that the steepest

¹It was considered more plausible to have a minimum of 30 degrees of freedom for the regression analyses. Moreover, owing to the stratification of farms into 3 classes, the number of degrees of freedom lost is 3 times as many as that which would be lost if the sample were completely random.
Table 3. Distribution of classes of farms in per cent within each tenue and lease type analyzed

<table>
<thead>
<tr>
<th>Class of farm size</th>
<th>Owner operators</th>
<th>Part owners</th>
<th>Livestock-share renters</th>
<th>Crop-share-cash renters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent</td>
<td>Per cent</td>
<td>Per cent</td>
<td>Per cent</td>
</tr>
<tr>
<td>1 &quot;small&quot;</td>
<td>71</td>
<td>57</td>
<td>43</td>
<td>69</td>
</tr>
<tr>
<td>2 &quot;medium&quot;</td>
<td>25</td>
<td>34</td>
<td>41</td>
<td>22</td>
</tr>
<tr>
<td>3 &quot;large&quot;</td>
<td>4</td>
<td>9</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Gradient (percentagewise) from "small" to "large" farms is under owner-operatorship and the lowest gradient under livestock-share lease. These distributions reflect what should ordinarily be expected: the sample is "weighted" in favor of livestock producers—livestock production is the criterion of size classification. It is evident that size classification is most probably not independent of tenue classification in the universe represented by the sample. ¹

Analytical Models Explored and Tests of Hypotheses

In order to test the hypotheses stated previously, the analytical

¹When the tenue classes (Table 3) and farm size are tested for independence, an interaction chi-square value of 70.51, significant at a probability level less than 0.05 per cent, is obtained. Bernard Ostle. Statistics in research. Ames, Iowa, Iowa State College Press. 1954. p. 68-71, 447.
techniques used entail estimation of (1) gross average output-input relationships by tenue and lease types, (2) marginal value products (returns) to resources and (3) "optimum" resource combinations and the deviations of actual resource inputs from the calculated optimum quantities. Actually, average intrafarm relationships are estimated from interfarm or cross-section data. Consequently, estimates obtained are not the true empirical counterparts of the theoretical concepts of intrafarm relationships and resource marginal productivities; they are reasonable approximations. It follows that estimates of resource deviations from the optima are approximations also. The analysis should reveal, however, differences in resource use if there is sufficient homogeneity within and heterogeneity between the populations analyzed.

Two types of functions are fitted to the data for each tenue and lease type by weighted least squares: (1) a simple regression model, \( Y = \mu + \beta X + \epsilon \), employed for estimating and testing for differences in aggregate "output-input" relationships and (2) a multiple regression model linear in logarithms, \( \log Y = \log \mu + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \log \epsilon \), through which marginal returns to resources and the optimum resource combinations are estimated. Since the data fitted to these functions are from a sample stratified by farm size (classes 1, 2 and 3) with different sampling proportions systematically applied to each class, the functions are derived through weighting of the moments for each class.\(^1\)

\(^1\)The weighting process used is shown in Appendix A.
Estimation of gross average output-input relationships

Individual regressions are fitted for each tenure and lease type to yield the estimating equation:

\[ Y = a + bX \]

where \( Y \) = Gross production in dollars \\
\( X \) = Aggregate of resource services in dollars

The compositions of the variables \( Y \) and \( X \) are as follows:

\( Y \) refers to the sum of: livestock and products sales, home used livestock and products, change in livestock inventory and the value of crop production for the year, less livestock purchases during the year.

\( X \) refers to the estimated total value of resource services "used up" during the year. This means the sum of: \( \frac{3}{4} \) per cent of land valued at "market price", labor valued at \$30.00 per week for operator and hired, and \$30.00 per week for family labor, and the value of capital services shown as \( X_j \) in Type II function below.

The equation is used to reveal differences between tenure status in aggregate relationships between production (\( Y \)) and input (\( X \)). The relative sizes of the regression coefficient, \( b \), are taken to be rough indicators of efficiency, in the sense that it shows the amount of product associated with a unit increase in resource services used up during the year.\(^1\)

Also, some notion of relative (comparative) efficiency is sought by a comparison of predicted production, for each tenure class, from given levels of investment (resource services used up). Introduced is an "index of comparative efficiency": \( \left( \frac{\hat{Y}_0}{\hat{Y}_{\text{max}}} \right) \times 100 \) per cent, where \( \hat{Y}_{\text{max}} \) denotes the average net return" in per cent is estimated by \((b-1)100\).\(^1\)
maximum production obtained from the estimating equation of the tenure class yielding the highest predicted value (of production), and $Y_0$ denotes the predicted value of production of the other tenure classes. Evidently this index supposes that the tenure or lease type that shows the greatest level of production is, in relative terms, the most efficient with its efficiency ratio (above) being equal to 100 per cent.\(^1\)

Estimation of marginal returns to land, labor and capital services

Marginal returns are obtained from the estimating equation popularly known as the cross-section variant of the Cobb-Douglas function.\(^2\) The estimating equation derived for each tenure and lease type is as follows:

$$Y = a X_1^b_1 X_2^b_2 X_3^b_3$$

where $Y$ = Gross production in dollars  
$X_1$ = Land in dollars  
$X_2$ = Labor in weeks  
$X_3$ = Capital services in dollars

$Y$ refers to the aggregate value of production as in the preceding

\(^1\)It should be noted that originally the regression model assumed a priori was of the quadratic form $Y = \alpha + \beta_1 X_1 + \beta_2 X_2^2 + \epsilon$. After plotting the data, however, there was no perceptible curvilinearity portrayed by the scatter. Therefore, the linear regression was fitted. But still, as will be pointed out later, this model yielded results of rather little meaning. Hence its application was not extended.

function. This aggregation was unavoidable since no information was available on the division of the resources used between enterprises. Ideally, separate functions for each major enterprise are desirable to obtain more comparability of the relationships and estimates made.

$x_1$ refers to the "market value" of land used (input) as quoted by the respondent—owner-operator, part owner or tenant.

$x_2$ refers to labor measured in weeks, which is a sum of: operators', hired and family labor and 20 per cent of the amount paid for custom work ($240,00 equal 1 week). The aggregation of these categories of labor is presumably another detracting feature since it implies homogeneity of the different labor services.

$x_3$ 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, building repairs, 80 per cent custom work, electricity, fuel and machinery repairs and 20 per cent depreciation, 3 per cent of livestock purchased during the year and 6 per cent of the beginning inventory of livestock (January, 1954).

Although the Cobb-Douglas function has been employed extensively in resource productivity studies, it has been used only to a minor extent in the analysis of tenure efficiency specifically. Its frequent usage is accounted for by certain attributes of the function. First, the function allows diminishing returns to be observed without using as many degrees of freedom as would be used up in quadratic functions. In effect, the function implicitly takes care of possible interaction between the independent variables. Second, the function yields directly the elasticities of production (expressed by the exponents of the independent variables) and


enables easy computations of the marginal return of each resource category. Third, the function implies substitutability of resources. But since the equation is in double logarithms it gives constant production elasticities. Hence, the isoproduction contours are asymptotic to the resource axes and that need not be the case in actual relationships.

Marginal returns to land, labor and capital services are estimated from the basic estimating equations derived. That means the partial derivative of production with respect to each resource is taken. Thus the marginal return to resource \( X_1 \), say, is

\[
\frac{\partial Y}{\partial X_1} = b_1 X_1
\]

These estimates are made at the geometric means of the variables—production and resource inputs—since errors of the estimates get progressively larger further away from the geometric means. Differences between an estimated marginal value product for each resource (at the geometric means) and the respective resource "price" is used as a first approximation of existing inefficiencies: a difference between the "cost" of a resource and the value of its marginal product is evidence of inefficiency and "the magnitude of the difference is a clue to the extent of inefficiency."\(^1\)

\(^1\)George J. Stigler. The theory of price. Rev. ed. New York, The Macmillan Co. 1954, p. 102. The concept of "opportunity cost" (alternative cost) is 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. Admittedly, the concept of opportunity (or alternative) cost has an arbitrary element but serves as a useful tool in the analysis of resource allocation.
One of the hypotheses directing this inquiry is that the differences in resource organization caused by the tenure status of farm operators would be reflected in different patterns of marginal returns to resources. These differences in marginal returns may arise from one or a combination of reasons: (1) differences in the quality of resource employed under each tenure and lease type, (2) differences in resource combinations and (3) differences in product combinations.

It is proposed that since the age distribution is more negatively skewed for owner-operators, (Table 4, Fig. 1), the labor quality under
Fig. 1. Age distributions of farm operators by tenure and lease types
owner operatorship should be inferior to the quality of labor under the
other groups of operators analyzed. The peak (modal value) of the age
distribution for part owners is within the 55 to 59 years age interval.
On the other hand, and as expected, the age distributions of two lease
types are more positively skewed (greater proportions of younger operators)
with the peaks of the distribution within the age intervals of 30 to 34
years. Further, with regard to part-owners, the age distribution approaches
"normal".

In view of the differentials in age distributions between tenure
groups, it is possible that differences in marginal returns to labor could
be affected by these age differentials, to the extent that age is nega-
tively correlated with labor quality and the greater proportion of the
farm labor is performed by the operator himself. In order to make some
observation on the age factor (and attempt to minimize its effects)
estimates of marginal returns are also made for two age groups of owner-
operators from estimating equations derived for each age group individually,
in addition to estimates for owners as a whole. The two age groups
analyzed are (1) those owners age under 45 years and (2) those owners age
over 54 years. The hypothesis is that the older age group should show a
marginal return to labor lower than those returns for any other group
analyzed because of inferiority of the labor used. It is recognized that
the difference in the marginal returns to labor (connected with labor

1 The quality of land may also vary between tenure types; however, in
this study land units are "standardized" in terms of market value. But as
indicated later, there are reasons to believe that the "quantity" of land
as reported (in terms of dollars) is subject to errors.
quality), between these age groups, can be dampened by superior management in the older age group. ¹

To detect the effects of resource combination, under livestock-share and crop-share-cash leasing the individual regressions of these two lease types are pooled to obtain production elasticities common to both groups. ²

The reason for obtaining common production elasticities is that differences in marginal returns arising from resource combination can only be detected if the "production surfaces" (elasticities) are the same. In other words, it is assumed that livestock-share and crop-share-cash renters have similar production surfaces but are operating at different points on the same surface because of different resource combinations. Hence marginal returns are different.

Certain problems of product combination (or aggregation of products)

¹The general problem of multicollinearity may also affect the marginal returns to labor and thus confound whatever effects that could stem from labor quality. For example, it is hypothesized that if the coefficient of variation of a resource (independent variable) is small in relation to those of both production (dependent variable) and another resource (independent variable) the resource with the comparatively small coefficient of variation should show up as having little or no effect on production response. Its effect will be absorbed in the resource having the higher variation. With cross-section sampling data the amount of labor used as reported by farmers may be relatively "constant"; hence its effects on production may be reflected in some other regression coefficient. Labor becomes the weaker variable. See: Karl A. Fox and James F. Cooney, Jr. Effects of intercorrelation upon multiple correlation and regression analysis. U. S. Dept. Agr., Agricultural Marketing Service, Washington, D. C., April 1954.

²The regressions are pooled by summing the moments of variation and covariation of the variables (corrected sums of squares and cross-products) for each lease type.
are also involved. But nothing is done in this study with regard to this area of problems because needed data were not available. This question, however, is particularly relevant if it is true that imperfections in leasing cause non-optimum combination of enterprises. The value of production from a given stock of resources is reduced accordingly. Thus the effects of production combination may be reflected in the coefficients of the estimating equations and thus in the marginal productivity estimates.

Other factors that may cause biases in the coefficients of the estimating equations and hence in the marginal returns must also be recognized. For example, unless management is uniform between tenure types in the universe, differentials in marginal returns will not be explained completely. Also, if management happens to be intercorrelated with any other resource category for any particular tenure group, its effects are likely to cause over-estimation of the productivity of that resource to which it is correlated. Consequently, results obtained must


2 Marginal returns to a resource category may also be affected by the aggregation of resource categories. In short, production elasticities are "unstable" in the sense that if other resources are regrouped, the elasticity of the "unregrouped" resource may be reduced or increased. Therefore, differences between tenure classes in marginal returns at one level of resource aggregation need not be the same at another level of aggregation.

be interpreted cautiously.

Estimation of deviations of actual resource inputs from "optimum" resource combinations

Previous resource productivity studies (using the Cobb-Douglas function) have concluded the analysis by drawing inferences about resource reallocation if divergences between marginal returns and the respective resource "prices" are observed; but as suggested before this procedure is used only as a first approximation in a test for inefficiencies. The analysis is extended further in this study in order to determine how far away each tenure and lease type is removed (deviations) from the optimum in resource allocation. The tenure or lease type with the smallest deviation in terms of reduction in the "total value of productive services" (costs) is accepted to be the most efficient (or least inefficient).

The optimum in resource combinations are estimated at the geometric means of production. The objective is to achieve the condition where the ratios of the marginal value product (from each resource) to the opportunity cost of the respective resource are equal. This equality of ratios:

\[
\frac{\text{MVP}_d}{P_d} = \frac{\text{MVP}_l}{P_l} = \frac{\text{MVP}_c}{P_c} = X
\]

yields the lowest possible costs for the given level of production and resource "prices". In the equation, the subscripts d, l and c denote land, labor and capital respectively, MVP represents marginal value product
(return) and \( P \) represents the opportunity cost.\(^1\) The assumptions made on opportunity costs in the analysis are as follows: 6.0 per cent for land, \$40.00 per week for labor, and 10.0 per cent for capital services.\(^2\)

The basic estimating equations used for determining the optimum combination of resources are the same as those used for estimating marginal returns. Therefore, any biases to which the marginal returns are subjected will also distort the estimates of the deviations from optimum. That is, the results depend upon the basic estimating equations used.

The extent of deviations are obtained and expressed as resource excesses and/or deficits in absolute terms and in terms of per cent from the optimum quantities needed. Also, the total value of productive services (\( TC \)) at actual resource inputs, \( (X_{1-g}) \), is compared with the value (\( TC^+ \)) associated with the calculated "optimum" resource inputs \( (X_{1-g}^+) \). The difference, \( TC - TC^+ = D \) is the average reduction in costs (or average deviations from minimum costs). Then the efficiency index becomes \((D/TC^+)\)100 per cent reduction in costs. Hence, the tenure class with the smallest reduction in costs is said to be closer to the

---

\(^1\) It should be apparent that the solution is analogous to equating the marginal rates of substitution of resources with the inverse of their price ratios. The exceptions are: physical production is replaced here by value of production and actual resource prices are replaced by opportunity costs.

\(^2\) An arbitrary risk premium of 1.5 per cent is added to the mortgage rate of interest of 4.5 per cent for land, 4.0 per cent is added to the interest for capital of 6.0 per cent and \$40.00 per week for labor is an estimate of the going weekly wage rate for farm labor in 1954, for the universe from which the data were obtained. It must be recognized that if different sets of prices are assumed, the calculated optimum resource combinations will be different.
optimum combination of resources and thus operating the "most efficiently".\(^1\)

Tests of Significance

Under the assumption that the estimating equations derived are independent the coefficients (elasticities) for both the simple and the multiple regression model are tested, in pairs, for differences with the statistic

\[
t = \frac{b_{ij} - b_{ik}}{se_{b_{ij} - b_{ik}}}
\]

where the subscripts \(j\) and \(k\) represent the tenure, lease types or other groups compared. The related statistic, \(se_{b_{ij} - b_{ik}}\), is the standard error of the difference, \(b_{ij} - b_{ik}\). The test for differences in the estimated marginal returns is comparable to that for the regression coefficients, except that the values of the regression coefficients \((b_{i-s})\) are replaced by the marginal returns to each resource and the standard error of the difference in marginal returns becomes \(se_{b_{ij} - b_{ik}}\).\(^2\)

Two additional tests of significance used in this study may be mentioned at this point: (1) in the analysis of marginal returns, the estimated marginal return to each resource is compared with the opportunity

\(^1\)The algebraic solution and computational procedure for the optimum resource combinations are shown in Appendix B.

\(^2\)The variance formulas used in all cases are given in Appendix C.
cost of that resource for statistical difference, using the null hypothesis. Again, using the null hypothesis (2) the marginal returns at the calculated optimum resource combination are tested for differences with the marginal returns at the geometric means. The former test is used to establish some confidence in statements made about departures of marginal return-opportunity cost ratios, from unity. If the differences are "non-significant" it limits the inferences that can be drawn about rationing or excesses of resources with the firm. The latter test, on the other hand, is presumed to be an approximate test for deviations of actual resource inputs from the quantities calculated for the optimum combination. Similarly, if the differences in marginal returns are non significant at acceptable probability levels, less confidence can be placed in the observations regarding the actual extent of deviations from optimum resource organization.
RELATIVE EFFICIENCIES IN TERMS OF GROSS AVERAGE
OUTPUT-INPUT RELATIONSHIPS

Guided by the first hypothesis, previously stated, separate (individual) estimating equations of the form, \( Y = a + bX \), are derived for each tenure and lease type as a means of comparing the output-input coefficients \((b-s)\) and the values of estimated production from given levels of resource services. Attempt is made to introduce the use of an "index of comparative efficiency" by which tenure types may be compared in terms of the degree of effectiveness to which similar levels of resource services are utilized.

Gross Average Output-Input Coefficients by Tenure and Lease Types

The regression coefficients observed (for each tenure and lease type) show the average response evoked in gross production by a unit change in the gross value of resource services committed to production. This measure—the regression coefficient—is compared between tenure types on the premise that the tenure types with the larger values utilize resources most efficiently. In other words, the larger output-input coefficients are indicative of superior resource use. However, as will be pointed out presently, no conclusive evidence is obtained by this analysis. On the one hand most of the resulting differences observed are non-significant. On the other hand, where significant differences are observed the
Table 5. Regression coefficients and related measures from estimating equations for gross average output-input relationships by tenure and lease typesa

<table>
<thead>
<tr>
<th>Item</th>
<th>Tenure and lease types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Owner-operators</td>
</tr>
<tr>
<td>Regression constant (a)</td>
<td>-752</td>
</tr>
<tr>
<td>Regression coefficient (b) (or gross average output-input coefficient)</td>
<td>1.3055</td>
</tr>
<tr>
<td>Correlation index (r²)</td>
<td>0.72</td>
</tr>
</tbody>
</table>

*The estimating equation for owner-operators, for example, is: Y = -752 + 1.3055X where both Y and X are in thousands of dollars, and r² = 0.79.

relationships appear to be unstable.

From the results (Table 5), a few unexpected observations can be made on inspection of the data: the largest regression (output-input) coefficient of 1.4401 is associated with crop-share-cash leases and the smallest of 1.2230 is associated with livestock-share leases. However, on the basis of economic logic pertaining to tenure the predictions could have been that livestock-share leases should to the contrary reveal the higher coefficient—they are ordinarily less subjected to leasing.
"imperfections". Therefore, a higher return per unit change of investment (resources) should be expected, if the "imperfections" are present and operative. From the regression coefficient it is suggested that under livestock-share leasing the "average net return" is approximately 22.0 per cent, (1-b)100, whereas under crop-share-cash leasing the return is approximately 14.0 per cent, a value that is intuitively too high and out of proportion. But, part of the difference probably arises from the larger scale of operations under livestock-share leasing. It could be that these farms are operating more in an area of "decreasing returns".

The absolute values of the corresponding estimates of the regression coefficients for owners, part-owners and full tenants (as a group) appear to be more plausible than those for the two lease types. Still, their relative values can be questioned. It was anticipated, for example, that part-owners would reveal a higher estimate mainly because of the hypothesis that they are usually comprised of better managers. However, one likely reason for the small differences (in the estimates) is the possibility of inefficiencies within each group cancelling out each other. And, as would probably be expected, the unexplained variation in production is greater under full tenancy than the other two major forms of operatorship—the correlation index is 69.0 per cent versus 79.0 per cent for owner-operators: theoretically, full tenants constitute a more heterogeneous group and should therefore vary more, in terms of output-input relationships.

The values of t for differences in regression coefficients (Table 6)
show that the differences between the three major classes of operators—owners, part-owners and full tenants—are non-significant at acceptable probability levels. Only the difference between the coefficients for livestock-share and crop-share-cash is significant at a probability level of 5 to 10 per cent. However, as suggested before, while this difference is significant, the relationships appear to be unstable. That is, if production estimates are made at levels of resource input greater than $27,043 the estimates for crop-share-cash tenants exceed those for livestock-share. On the other hand, production estimates made below $27,043 are smaller for crop-share-cash tenants. Therefore the predictions made from

Table 6. Values of t for differences between tenure and lease types in regression coefficients and corresponding levels of significance

<table>
<thead>
<tr>
<th>Tenure and lease type compared</th>
<th>Values of t for difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
</tr>
<tr>
<td>Owner-operators vs. part owners</td>
<td>0.79</td>
</tr>
<tr>
<td>Owner-operators vs. full tenants</td>
<td>0.64</td>
</tr>
<tr>
<td>Part-owners vs. full tenants</td>
<td>0.60</td>
</tr>
<tr>
<td>Livestock-share renters vs. crop-share-cash renters</td>
<td>1.92</td>
</tr>
</tbody>
</table>
the estimating equations reveal unstable relationships—there is no "consistent" difference in the estimates of production from the regression equations. As suggested before such relationships could possibly arise from differences between the lease types in the average size of operations. Such a reason would suggest the need for stratification by an appropriate size criterion. On the other hand a substantial difference in crop-livestock combination could also distort the relationships.

Test of Comparative Efficiency in the Use of Gross Resource Input

Since the relationships revealed by the estimating equations for livestock-share and crop-share-cash tenants appear to be unstable a test of comparative (relative) efficiency is not carried out for these lease types. Attention is confined to owner-operators, part-owners and full tenants. That is, in spite of non-significant differences in the regression (output-input) coefficients, significant differences in predicted production (by tenure types) at similar levels of resource use, are possible. The possibility exists to the extent that the regression constants (Table 5) are different and so influence the positions of the regression lines.

With efficiency basically defined as maximum production from a given stock (level) of resources or minimum cost for a given level of production, the estimated production \( \bar{Y}_e \) for each tenure type is compared with that estimated for full tenants \( \bar{Y}_{\text{MAX}} \), at given levels of resource input. The estimates of other tenure types are compared with that for full tenants since their (tenants') estimate of production is the highest for any given
Table 7. Arithmetic means of gross production and gross resource inputs by tenure and lease types

<table>
<thead>
<tr>
<th>Item</th>
<th>Owner-operators</th>
<th>Part-owners</th>
<th>Full tenants</th>
<th>Livestock-share renters</th>
<th>Crop-share-cash renters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic mean of production ($)</td>
<td>15,575</td>
<td>19,695</td>
<td>18,017</td>
<td>21,457</td>
<td>16,871</td>
</tr>
<tr>
<td>Arithmetic mean of resource services ($)</td>
<td>12,506</td>
<td>15,111</td>
<td>13,178</td>
<td>16,385</td>
<td>12,724</td>
</tr>
</tbody>
</table>

level of resource use within the relevant range of observations. Put in another way: in terms of the other tenure types analyzed the results show that full tenants on the average are "100 per cent efficient". It is significant to note, however, that no implication is made that tenants are actually efficient—the statement above is relative.

To obtain different estimates of production, the resource levels arbitrarily used are selected from those shown in Table 7. The mean values of $12,506 for owner-operators and of $15,111 for part-owners are selected since they represent the two extremes of the mean resource inputs for the three tenure groups being analyzed.

For the two levels of resources used, the production of tenants is greater than the other two lease types, with that for owners being the
Table 8. Estimated production for selected values of resource services for three tenure types and the related index of comparative efficiency

<table>
<thead>
<tr>
<th>Tenure type</th>
<th>Estimated production ($)</th>
<th>&quot;Comparative efficiency index&quot; (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With resource services valued at $12,506</td>
</tr>
<tr>
<td>Owner-operators</td>
<td>15,575</td>
<td>91.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Part-owners</td>
<td>16,145</td>
<td>94.4&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Full tenants</td>
<td>17,097</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With resource services valued at $15,011</td>
</tr>
<tr>
<td>Owner-operators</td>
<td>18,975</td>
<td>91.8&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Part-owners</td>
<td>19,698</td>
<td>95.3&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Full tenants</td>
<td>20,665</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>An approximate test of the significance of the index is made as follows:

\[ t = \frac{\hat{Y}_6 - \hat{Y}_0}{\sqrt{\frac{S_n^2}{n_6} + \frac{S_o^2}{n_0}}} \]

where \(\hat{Y}_6\) and \(\hat{Y}_0\) are the estimates of production for tenants and the other tenure types, respectively. (Tenants' production \((\hat{Y}_6)\) is assumed to be 100 per cent). The standard error of the difference is shown in Appendix C.

<sup>b</sup>Significantly different from 100 per cent at a probability level of 10 to 20 per cent.

<sup>c</sup>Significantly different from 100 per cent at a probability level of 40 to 50 per cent.

<sup>d</sup>Non-significant at a probability level less than 50 per cent.
smallest (Table 3). Consequently, owner-operators show up to be the least efficient: the efficiency indexes being 91.1 per cent and 91.8 per cent at the different resource levels.\(^1\) In other words, owner-operators are 91.1 per cent and 91.8 per cent as efficient as full tenants at the respective levels of resource input. Similarly, part-owners are 94.4 per cent and 95.3 per cent as efficient as full tenants; but are not as inefficient as owner-operators.

These conclusions on relative efficiencies are superficial: when tested, the departures of the efficiency indexes from 100 per cent are non-significant at probability levels ordinarily regarded as acceptable. The only index that might be accepted is that for owner-operators 91.1 per cent, since the related t-value (Table 3) is significant at a probability level of 10 to 20 per cent.\(^2\)

With non-significant differences in the estimates and the apparent unstable character of the relationships the extension of this model (simple regression) is not pursued in this study. It is presumed that more meaningful results could have been obtained with less unrefined data. The actual relationships can be interrupted or concealed by (1) the heterogeneity of the area of analysis, (2) aggregation of production and the valuation of resource services, (3) difference between tenure and lease

\(^1\)As a reminder, these indexes are calculated as follows: \((\bar{y}_0 + \bar{y}_{\text{max}})100.\) So, with respect to owner-operators, for example, 91.1 per cent = \((15.575 + 17.097)100.\)

\(^2\)It might be noted, however, that there is nothing sacred about significant probability levels of 10 per cent or less. An individual with a "high risk preference" might also accept the probability of an event occurring 51 times rather than 10 times out of 100.
types in the scale of operations and (4) the broad classification of tenur
classes.

For the latter reason, full tenants as a group are not analyzed
further in the succeeding parts of this investigation dealing with the
second and third hypotheses about resource marginal returns and optimum
resource combinations—the group is too heterogeneous. Very little useful
information would be obtained from further analysis of full tenants as a
class. Instead, attention is directed toward the sub-classes of livestock-
share and crop-share-cash tenants.
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 deviations of inputs of these resources from the quantities at the
optimum combinations are obtained from the basic estimating equations (the
Cobb-Douglas function) derived for each tenue and lease type. Therefore
the values obtained for marginal returns as well as the estimated optimum
resource quantities (hence the deviations from these quantities) are
dependent to a significant extent upon the sizes of the production
elasticities (regression coefficients) used. In addition, the foregoing
estimates (as made in this study) also depend upon the mean values of the
resources and production observed for each tenure class. Hence, a brief
examination of these parameters involved in testing the remaining major
operational hypotheses will occupy the present chapter in order to form a
background for making subsequent observations and for drawing inferences.

Production Elasticities and Related Statistics

The data in Table 9 are associated with the estimating equation,
\[ \hat{Y} = b_1 X_1 + b_2 X_2 + b_3 X_3 \]
where \( X_1 \) refers to land, \( X_2 \) refers to labor and
\( X_3 \) refers to capital services. \( \hat{Y} \) denotes the estimated value of production.
The production elasticities \( b_1 \), \( b_2 \) and \( b_3 \) for land, labor and capital
services, respectively, represent the per cent change in the value of
Table 9. Regression constant, production elasticities and correlation index of the estimating equation for each tenure and lease type a

<table>
<thead>
<tr>
<th>Tenure and lease type</th>
<th>Regression constant (a)</th>
<th>Land (b_1)</th>
<th>Labor (b_2)</th>
<th>Capital services (b_3)</th>
<th>Sum of elasticities (&lt;= b_4)</th>
<th>Correlation index (r^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner-operators</td>
<td>1.7795</td>
<td>0.1054</td>
<td>0.1109 b</td>
<td>0.5381</td>
<td>1.0534</td>
<td>0.735</td>
</tr>
<tr>
<td>Part-owners</td>
<td>1.5206</td>
<td>0.2432</td>
<td>0.1491</td>
<td>0.6719</td>
<td>1.0642</td>
<td>0.782</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>6.4759</td>
<td>0.2315</td>
<td>0.1845</td>
<td>0.5330</td>
<td>0.9490</td>
<td>0.676</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>3.4166</td>
<td>0.2937</td>
<td>0.2472</td>
<td>0.4782</td>
<td>1.0191</td>
<td>0.728</td>
</tr>
</tbody>
</table>

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

\[ y = 1.7795 x_1^{0.1054} x_2^{0.1109} x_3^{0.5381} \]

where \( x_1, x_2 \) and \( x_3 \) refer to land, labor and capital services, respectively.

b Different from zero at the probability level of 10 to 20 per cent. All other values are significant at probability levels of 10 per cent and less.
production associated with a one per cent change in the respective resource input holding other things unchanged. For example, the land elasticity, \( b_1 \), represents the per cent increase in production associated with a one per cent increase in the quantity of land.

Apart from the general problems of intercorrelation of the independent variables that affect multiple regression analysis, differences between tenure and lease types may arise from (1) the aggregation of production and resource categories and/or (2) the quality of resources employed. Hence biases may be obtained in the estimates made from the individual regressions if these factors are not considered.\(^1\)

The aggregation of production in this study into a single category is, admittedly, undesirable. This is so because enterprises are not combined in the same proportions on all farms. On theoretical grounds, different proportions are expected between tenure and lease types. Consequently, differentials in product prices may affect the size of elasticities obtained, and hence adversely affect the comparability of estimates.\(^2\) It is noticeable Table 9 that the elasticities for owner-operators are not as comparable as those obtained for the other tenure and lease types. As a

\(^1\)As mentioned previously, the exclusion of management as an independent variable may also cause biases; but these biases may be considered as aspects of the general problems of intercorrelation, the problems of resource quality or both.

\(^2\)Different functions for crops and livestock would reduce the biases that may arise, but not completely since the crop combination and livestock combinations may also differ between tenure and lease types. That is, apart from differentials in price effects, the physical response of different products to similar resources are not the same.
matter of contrast, a 1 per cent increase in land results in a change of only 0.1054 per cent (in production) for owner-operators as against 0.2937 per cent (greater than doubled) for crop-share-cash renters. With respect to capital services the relative values are reversed—the elasticity of 0.8361 for owner-operators is remarkably larger than that of 0.4762 for crop-share-cash renters.\footnote{The sum of the elasticities for owner-operators and crop-share-cash renters are not significantly different.} One might then suspect that there are more biases, for one or more reasons, in the elasticities obtained for owner-operators. Also it is not unlikely that under owner-operatorship management is more highly intercorrelated with some element included in capital services and so results in a coefficient for capital larger than those for the other groups. Further, it is conceivable that with a different level of aggregation the set of elasticities obtained would be different from those shown in Table 9.

Except for the effects of labor quality, the causes for differences in the production elasticities obtained have not been tested—the foregoing explanations advanced are only tentative. With regard to labor, the relative sizes of the elasticities follow to some extent a pattern of age distributions, previously shown in Table 4 and Fig. 1. Where the age distribution is more negatively skewed (owner-operators) the labor elasticity (0.1109) is small. Where the age distribution is more positively skewed the labor elasticities are larger (0.1545 for livestock-share renters and 0.2472 for crop-share-cash renters). This is not concrete evidence of the effects of labor quality on the elasticities (or labor
productivities) since the observations may be confounded by other factors.

However, to gain further insights, owner-operators are divided into two age groups—those under 45 years and those over 54 years—to observe if there are any differentials in the labor elasticities. The production elasticities and related statistics for these two age groups are shown in the following table.

Table 10. Regression constant, production elasticity and correlation index of the estimating equation for two age groups of owner-operators

<table>
<thead>
<tr>
<th>Age group of owner-operators</th>
<th>Regression constant (a)</th>
<th>Production elasticities</th>
<th>Sum of elasticity (≤ b₁)</th>
<th>Correlation index (R²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 45 years</td>
<td>4.0200</td>
<td>0.0919b</td>
<td>0.1719b</td>
<td>0.7351a</td>
</tr>
<tr>
<td>Over 54 years</td>
<td>2.6755</td>
<td>0.2239a</td>
<td>0.0171c</td>
<td>0.6950a</td>
</tr>
</tbody>
</table>

*Significantly different from zero at probability levels less than 1 per cent.

bSignificantly different from zero at probability level of 10 to 20 per cent.

cNon significant.

As anticipated, it is observable (Table 10) that the labor elasticity of 0.1719 for the older age group of owner-operators is larger than that for younger operators of 0.0171. However, it will be seen presently that the difference of 0.1548 is not very highly significant (in a probability sense). Therefore, some doubts might be cast on the validity of the
hypothesis concerning the effects of age and labor quality. Nevertheless, the "non-significant" difference does not deny the possibility that the marginal return to labor is a function of labor quality. That is, the labor elasticity might be similar in a probability sense, but the marginal returns differ.

Significance of Differences in Production Elasticities

Differences in the production elasticities for land and capital services are highly significant, but those for labor are not. Particularly, the apparent difference in the labor elasticities for owner-operators and crop-share-cash renters is significant only at a probability level of 20 to 30 per cent (Table 11a). Then, too, the difference observed in the elasticities of the two age groups of owner-operators is also significant at a similar level of probability (20 to 30 per cent). However, it can be noted (from the t-values in Tables 11a and 11b) that the elasticities for the younger owner-operators are probably more similar to those of the other tenure and lease types than the elasticities of owner-operators as a group. That is, the significance levels for the differences with owner-operators, as a whole, are greater than those for the differences with owner-operators of the younger age group.

Therefore, it would appear that if age is adjusted for (age groups within each tenure class made more comparable than in this study) the analysis of relative efficiencies of tenure classes would be improved. It is suggested, in other words, that if the same age groups of different
Table 11a. Values of t for differences in production elasticities between tenure and lease types

<table>
<thead>
<tr>
<th>Tenure and lease type compared</th>
<th>Value of t for difference in production elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land</td>
</tr>
<tr>
<td>Owner-operators vs. part-owners</td>
<td>2.36&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Owner-operators vs. livestock-share renters</td>
<td>7.15&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Owner-operators vs. crop-share-cash renters</td>
<td>9.65&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Part-owners vs. livestock-share renters</td>
<td>6.90&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Part-owners vs. crop-share-cash renters</td>
<td>2.65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Livestock-share vs. crop-share-cash renters</td>
<td>1.08&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant at a probability level less than 0.1 per cent.

<sup>b</sup>Significant at a probability level of 0.1 to 1 per cent.

<sup>c</sup>Significant at a probability level of 1 to 5 per cent.

<sup>d</sup>Significant at a probability level of 20 to 30 per cent.

All other values of t are non-significant at probability levels of 30 per cent and less.
Table 11b. Values of t for differences in production elasticities between owner-operators, age under 45 years, and other tenure and lease types

<table>
<thead>
<tr>
<th>Operatorship groups compared</th>
<th>Values of t for differences in production elasticities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land</td>
</tr>
<tr>
<td>Owner-operators: age under 45 vs. age over 54 years</td>
<td>1.70</td>
</tr>
<tr>
<td>Owner-operators: age under 45 vs. part-owners</td>
<td>2.09</td>
</tr>
<tr>
<td>Owner-operators: age under 45 vs. livestock-share renters</td>
<td>1.99</td>
</tr>
<tr>
<td>Owner-operators: age under 45 years vs. crop-share-cash renters</td>
<td>2.67</td>
</tr>
</tbody>
</table>

*Significant at a probability level less than 1 per cent.

Significant at a probability level of 1 to 5 per cent.

*Significant at a probability level of 5 to 10 per cent.

Significant at a probability level of 10 to 20 per cent.

*Significant at a probability level of 20 to 30 per cent.

*Significant at a probability level of 30 per cent or less.

Other values are non-significant at probability levels of 30 per cent or less.

tenure classes are compared rather than a cross-section sample of tenure classes (disregarding the age factor) more useful information should be obtained. 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, but will affect the results if they are not taken
into account.

With the exception of livestock-share and crop-share-cash renters it
can be concluded that each tenure and lease type is operating on a different
"production surface". This statement is based on the logic that if at least
one elasticity differs the surfaces are different. Therefore the production
surfaces for livestock-share and crop-share-cash renters are assumed to be
the same since there is most likely no difference (Table 11a) between the
surfaces of these lease types. Thus the individual estimating equations
are pooled in the manner indicated before, to obtain a common set of
elasticities (Table 12).

As previously indicated, differences between tenure types in the
patterns of marginal returns due to differences in resource combinations
might be cancelled by differences in the sizes of the production
elasticities. To test, more specifically, the effects of resource
combination the basic estimating equations for each group compared must be
similar. However, only the elasticities from the pooled regression are
made identical in this analysis (Table 12). The intercepts (regression
constants) differ for each lease type.\(^1\) It is to be noticed that the pro-
duction elasticities of the pooled regression are about the average of

\(^1\) Presumably a difference in intercepts could be due to product
combination or management. The difference, however, does not affect
substantially the "pattern" of resource marginal returns; it does affect
the levels of marginal returns to all resources, given similar production
elasticities.
Table 12. Regression constants, production elasticities and related statistics of "individual" and "pooled" estimating equations for two lease types

<table>
<thead>
<tr>
<th>Lease type</th>
<th>Regression constants</th>
<th>Production elasticities</th>
<th>Capital services</th>
<th>Sum of elasticities</th>
<th>Correlation index</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b₁)</td>
<td>(b₂)</td>
<td>(b₃)</td>
<td>(≤ b₁)</td>
<td>(r²)</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>6.4759</td>
<td>0.2315</td>
<td>0.1845</td>
<td>0.5330</td>
<td>0.9490</td>
<td>0.676</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>3.4166</td>
<td>0.2937</td>
<td>0.2472</td>
<td>0.4782</td>
<td>1.0191</td>
<td>0.728</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lease type</th>
<th>Regression constants</th>
<th>Production elasticities</th>
<th>Capital services</th>
<th>Sum of elasticities</th>
<th>Correlation index</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a¹)</td>
<td>(b₁¹)</td>
<td>(b₂¹)</td>
<td>(b₃¹)</td>
<td>(≤ b₁¹)</td>
<td>(r²¹)</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>4.7327</td>
<td>0.2708</td>
<td>0.2237</td>
<td>0.5026</td>
<td>0.9971</td>
<td>0.673</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>3.8950</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>
those for the individual regression (represented in Table 12).

The more important observation, however, concerns the relative values for the correlation indexes \( R^2 - R_i^2 \). The variation in production under livestock-share accounted for by the pooled regression is only 0.3 per cent 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 per cent less. Therefore, the amount of confidence one can place in the estimates is not substantially reduced by the pooling of the individual regressions. On the other hand, the standard errors of the estimates \( s_y \) are increased by 4.7 and 7.3 per cent for livestock-share and crop-share-cash, respectively.\(^1\)

**Geometric Means of Production and Resource Inputs by Tenure and Lease Types**

Estimates of marginal returns presented in the following chapter are made at the geometric means of production and resource inputs for each tenure and lease type. Likewise the deviations from optimum resource combinations are made on the assumption that these mean resource inputs represent the actual (observed) average resource combination.

Marginal returns depend not only upon the sizes of the production elasticities but also upon the levels of resource inputs (resource ratios or combinations) at which estimates are made. Given the production elasticities, the marginal returns of labor, for example, will be

\(^1\)This increase is due in part to the extra (4) degrees of freedom lost by pooling the estimates.
relatively high if the land/labor and capital/labor ratios are high. On the other hand the marginal return to land and capital will be low—their relative values being dependent upon the land/capital ratio. However, if the production elasticities differ between tenure classes the inferences, in terms of resource productivities, drawn from inter-class differences in resource ratios may be misleading. In effect, the level of one resource input affects the marginal productivity of other resources. Then too the marginal productivity of a resource is not only dependent upon the levels of the other resource inputs but also depends upon their elasticities. In essence, resource marginal productivity estimates are interdependent.

Differences in resource ratios are therefore very rough indices of differences in resource organizations.

The resource ratios (Table 13) are in the main what could be expected. It is noticeable that, except for part-owners with 82 weeks of labor, the mean quantities of labor employed are quite comparable. Such similarities are apparently due to the small variation between farms, arising from given quantities of operators' and family labor. On the other hand the close

1 For example, part-owners have a land/labor ratio of $556.00 per week and a capital/labor ratio of $55.00 per week that are higher than the corresponding values of $546.00 and $56.00 for crop-share-cash renters (Table 13); yet, the marginal return to labor of $29.70 under part-ownership is lower than that of $45.98 under crop-share-cash leasing. This illustration is brought out in order to recognize that differences in resource combinations (resource-ratios) may be counterbalanced by compensating differences in the basic estimating equations.

2 On the other hand, even if resource combinations are the same, marginal returns will differ if the basic estimating equations are different. Marginal returns will be the same if, and only if, the basic estimating equations are identical and each tenure and lease type is on the average operating at the optima, using the same set of resource prices as the choice criterion.
Table 13. Geometric means of gross production and resource inputs, and resource ratios by tenure and lease types and by two age groups of owner-operators

<table>
<thead>
<tr>
<th>Tenure and lease type</th>
<th>Geometric means</th>
<th></th>
<th>Resource ratios</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production ($)</td>
<td>Land ($)</td>
<td>Labor (wk)</td>
<td>Capital services ($)</td>
<td>Land / labor $/wk</td>
<td>Capital / labor $/wk</td>
</tr>
<tr>
<td>Owner-operators</td>
<td>12,697</td>
<td>27,504</td>
<td>78</td>
<td>6,230</td>
<td>352.0</td>
<td>80.0</td>
</tr>
<tr>
<td>Part-owners</td>
<td>16,467</td>
<td>45,594</td>
<td>83</td>
<td>7,816</td>
<td>556.0</td>
<td>95.0</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>22,936</td>
<td>45,864</td>
<td>77</td>
<td>9,566</td>
<td>596.0</td>
<td>124.0</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>15,105</td>
<td>41,506</td>
<td>76</td>
<td>6,517</td>
<td>546.0</td>
<td>86.0</td>
</tr>
</tbody>
</table>

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

*The areas represented by these land values are roughly as follows: 143 acres for owner-operators, 226 acres for part-owners, 180 acres for livestock-share renters, and 184 acres for crop-share-cash renters.*
comparisons may reflect a weakness in the way labor services are measured; i.e., with regard to the assumption of homogeneity of labor services employed within a farm. However with these data, differences in resource ratios should mainly revolve around the 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 non-optimum sharing of costs and returns, (2) capital rationing insofar as it causes restrictions in the quantities of land and/or capital services employed in relation to labor, and (3) renting as a means of facilitating adjustments toward greater quantities of land and capital services under part-ownership and the two lease types being analyzed. On share-rented farms the first and third sources logically operate in opposite directions: The first is restrictive in the use of capital services; while the third enables use of greater quantities of capital services through the sharing of uncertainties and the joint contribution of landlord and tenant to the total farm assets. 1 Related to this point is the observation (Table 13) that owner-operators show the smallest quantities of both land and capital services.

As would be expected the land/labor and land/capital ratios of $352.0 per week and $4.4 per dollar of capital services, respectively, under

1 Admittedly, 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, or inefficiencies in different phases of farm operations. That is, if capital services are broken down into machinery, livestock (investments) or operating capital, etc., other relationships could be revealed.
owner-operatorship are smaller than those under any other group of
operators. This would suggest a greater intensity of use of both labor
and capital with respect to land. The reasons for this situation are
twofold: (1) owner-operators have no fear of disassociations of costs and
returns and ordinarily would tend to push the use of resources to a further
extent than would operators under share lease contracts;¹ but, (2) with
capital rationing, the funds available may be inadequate to acquire more
land under owner-operatorship to be used with the given labor supply. 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 of $80 per week for owner-
operators would seem to bear out the foregoing point.

The data (Table 13) show further that both the amount of land and the
amount of capital services employed under owner-operatorship are less than
those for the other groups of farmers. In other words, under owner-
operatorship the amount of land used may have been restricted through
limitation of 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.

It seems significant to observe that the greatest land/labor, and
capital/labor ratios (of $596.0 per week, and $124.0 per week, respectively)
are associated with farms operated under livestock-share contracts. Again,

¹An exception is to be reemphasized: renters under cash contracts would
be expected to use labor and capital as intensively as owner-operators.
these observations would confirm the theories surrounding 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 landlord's presence in the farm operations minimizes the restrictive effects of exogenous rationing of capital that could be otherwise adversely effective. In terms of land/capital combination, the value of $4.5 per dollar of capital services is also remarkable. When compared to owner-operator's value of $14.4 per dollar, there is probably no difference in these ratios. It is implied that both 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 with those reported by tenants; but that need not be the case. There should be a tendency for tenants to "undervalue" the land they operate.

A comparison of the land/capital ratio of $6.4 per dollar for crop-share-cash tenants and that of $4.5 per dollar for livestock-share tenants would suggest that there is less capital restriction under livestock-share leasing. Other things being equal, this observation would possibly verify the hypothesis advanced that the non-optimum sharing of costs and returns under crop-share-cash leasing causes restrictions in the use of capital services. In the case of livestock-share farms all the costs of "variable capital" are usually shared and in the same proportion—50 per cent—as the sharing of products.

The cause for a land/labor ratio of $36.0 per week for crop-share-
cash renters smaller than that of $596.0 per week for livestock-share renters does not, however, coincide with what is 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. In other words, if the share tenant is not rewarded for the full marginal value product (through sharing of production) of his labor he is inclined to restrict its application. ¹

The seeming contradiction of the foregoing observation with 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 14) for crop-share-cash is on the contrary slightly greater than that of 2.3 acres per week for livestock-share renters. This difference is, intuitively, negligible; hence, it might then be inferred that on the average there are really no differences between these lease types in land-labor combination.

In summary, the differences observed between tenure and lease types in resource ratios are largely as would be expected. With lower land/labor and capital/labor ratio for owner-operators the marginal productivity of labor can be expected to be low, and those returns to land and capital

¹However, 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 distort these comparisons; but it can be further observed that errors of this kind are the same within each tenure class.
Table 14. Land-labor and land-capital ratios in terms of acres by tenure and lease types

<table>
<thead>
<tr>
<th>Tenure and lease types</th>
<th>Land ratio (ac/wh)</th>
<th>Land ratio (ac/$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner-operators</td>
<td>1.5</td>
<td>0.023</td>
</tr>
<tr>
<td>Part-owners</td>
<td>2.5</td>
<td>0.029</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>2.3</td>
<td>0.019</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>2.4</td>
<td>0.028</td>
</tr>
</tbody>
</table>

high relative to that of labor. Lower land/capital ratio would suggest a lower marginal productivity of capital in relation to that of land; but, resource productivities finally 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 those 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 since these estimates also depend upon the effects of the land/capital ratio, the coefficients of all the resources, and the constant of the basic estimating equation, it will be seen by the examination of marginal returns, in the section that only the marginal return to capital is relatively low. That for labor is the highest of all the groups.
INEFFICIENCIES OBSERVED THROUGH THE PATTERNS OF RESOURCE

MARGINAL RETURNS

Clues to inefficient resource 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. First, if the ratios of the marginal return to the "price" of each resource are not equal for a firm there is evidence of inefficiency. The inequality suggests that production could be obtained at lower costs if resources are substituted in favor of that (those) which show the highest ratio (ratios). Second, if the ratios of marginal returns to the resource prices are different from unity, then it is indicative that some resource is limitation al and could be profitably extended in use. These two clues to inefficient resource use are predicated upon the respective optimum conditions of (1) cost minimization for given levels of production and (2) maximum net returns from given quantities of resources committed to production.

The second condition with which this section of the analysis is primarily concerned sets the limits to which resources should be extended (or contracted) to obtain optimum production levels. However, with the phenomenon of increasing or constant returns to the scale of operation there are not determinate optimum quantities of resources if all resources
are varied. Consequently, the analysis to follow immediately on the deviations from optimum levels of production (or optimum amounts of all resources) is largely of a qualitative character.

Levels of Marginal Returns to Resources by Tenure and Lease Types

Marginal returns (or marginal value products) (Table 15) mean the additional returns per unit of input if one more unit of the resource were added at the geometric means. Under contemporary theories outlined previously, different levels of marginal returns, between tenure and lease types, are predicted for these fundamental reasons: (1) "imperfections" in leasing arrangements, in terms of cost and product sharing that might cause restrictions in the use of some resources, and (2) rationing of capital, engendered by tenure relationships that might also cause differences in the use of land and other capital assets. For these two reasons, differences in resource combinations (resource-ratios) are expected, and should cause some difference in the patterns of marginal

1 Except for livestock-share renters, increasing returns to scale is observed for all tenure classes. (The sum of the elasticities, Table 9, is 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 one or more resource is held fixed in quantity. It means that to obtain an optimum by varying production levels, the sum of the elasticities of the resources varied must be less than unity. But, with a resource fixed in quantity and the use of other resources extended (or contracted) the optimum solution obtained would be more analogous to that for the "short run".

Other reasons for exercising caution in finding optimum levels of production are (1) estimates of production removed from the means are subject to larger standard errors, and (2) there is the possibility of extrapolation.
Table 15. Marginal returns to resources at the geometric means of production and resource inputs by tenure and lease types

<table>
<thead>
<tr>
<th>Tenure and lease types</th>
<th>Marginal returns</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land ($/$)</td>
<td>Labor ($/wk)</td>
<td>Capital servicesa ($/$)</td>
</tr>
<tr>
<td>Owner-operators</td>
<td>0.049</td>
<td>17.96</td>
<td>1.708</td>
</tr>
<tr>
<td>Part-owners</td>
<td>0.055</td>
<td>29.70</td>
<td>1.416</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>0.116</td>
<td>54.79</td>
<td>1.278</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>0.107</td>
<td>45.98</td>
<td>1.108</td>
</tr>
</tbody>
</table>

aThe differences in measurement of the resource categories may present a slight problem of interpretation. Land is measured in terms of investments and capital is measured in terms of resource services used up (or "sunk"). Therefore, with respect to owner-operators, for instance, to make the estimates comparable, the marginal return is 4.9 cents per dollar of land investment (or 4.9 per cent), and 70.5 cents per dollar of capital services (or 70.5 per cent). The extra dollar associated with the marginal return listed for capital services represents what has been used up in the production process, whereas land resources are left for future uses.

returns to resources.

But, as noted before, differences in marginal returns may arise also from differences between tenure types in the elasticities of production for similar resources and not from resource combinations per se. Therefore, differences between tenure and lease types in marginal returns due to differences in resource combination cannot well be isolated unless the basic estimating equations are similar for each tenure and lease type. Nevertheless, a part of the analysis on marginal returns will proceed with
the use of the individual (different) estimating equations derived on the premise that the different elasticities are peculiar to the tenure classes. Next, an attempt is made to indicate the possible effects on the marginal productivity estimates of differentials in age distribution. Finally, differences in marginal returns that could be attributed more specifically to resource combinations are analyzed.

Marginal returns under owner-operatorship

The rather high marginal return of 70.8 per cent to capital services under owner-operatorship (Table 15) suggest that capital services is on the average the limiting resource for owner-operators. To increase net returns (improve the present resource organization), it means that the use of capital could be extended profitably until the marginal return equals (or approaches) the opportunity cost (10 per cent) assumed. At the same time the productivity of both land and labor (that are now below their opportunity costs of 6.0 per cent and $40.00 per week, respectively) would be increased by removing the limitational effects of capital services. However, it must be noted that the marginal return of 4.9 per cent for land is not significantly different from the opportunity cost of 6.0 per cent; while the marginal return to labor is significantly below $30.00 per week (Table 16).¹

¹The significant difference between the marginal return to labor of $17.96 and $40.00 per week is supposedly due in part to the fact that the opportunity cost used ($40.00) is not universally applicable to all age groups of owner-operators. For operators in the older age group, this cost should be less. Moreover, it will be seen later that younger owners show up to have a higher marginal return for labor that is not significantly different from $40.00.
Table 16. Resource marginal return-opportunity cost ratios at the geometric means of resources by tenure and lease types, and related values of t for the differences of the ratios from unity

<table>
<thead>
<tr>
<th>Tenure and lease type</th>
<th>Land</th>
<th>Labor</th>
<th>Capital services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Marginal return-opportunity cost ratios&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner-operators</td>
<td>0.62</td>
<td>0.45</td>
<td>1.55</td>
</tr>
<tr>
<td>Part-owners</td>
<td>1.46</td>
<td>0.74</td>
<td>1.29</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>1.93</td>
<td>1.36</td>
<td>1.16</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>1.76</td>
<td>1.23</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>Values of t for differences of the ratios from unity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner-operators</td>
<td>0.58</td>
<td>1.75&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.90&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Part-owners</td>
<td>1.84&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.47</td>
<td>2.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>2.69&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.64</td>
<td>1.07&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>2.99&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.42</td>
<td>0.06</td>
</tr>
</tbody>
</table>

<sup>a</sup>To obtain these ratios the "opportunity costs" are $0.06, $40.00 per week and $1.10 for land, labor and capital services, respectively.

<sup>b</sup>Significant at a probability level less than 1 per cent.

<sup>c</sup>Significant at a probability level of 2 to 5 per cent.

<sup>d</sup>Significant at a probability level of 5 to 10 per cent.

<sup>e</sup>Significant at a probability level of only 20 to 30 per cent.

Other values of t are non-significant at probability levels of 30 per cent or less.
owner-operated farms are in excess of labor and deficit in capital services. Superficially, land appears also to be in excess, but as noted, the marginal return is not significantly below 6.0 per cent.\footnote{This non-significant difference, however, does not imply that the use of land is not significantly different from optimum for the present level of production; the optimum condition requires that, in order to minimize costs, the ratio of the 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.} On the basis of the above observations one might conclude that capital rationing is more operative in restricting the use of capital services rather than in restricting the use of both land and capital services. In essence, the findings support the hypothesis advanced in the theoretical analysis that prior commitments to land purchases force restrictions in the use of capital services. Thus, the amount of capital employed falls short of that which would be most profitable for the average owner-operator farm.

**Marginal returns under part-ownership**

Like owner-operators the marginal returns to labor of $29.70 per week for part-owners (Table 15) are below the opportunity cost of labor. But it is also noticed (Table 16) that while for owner-operators the labor return was significantly different from $40.00 per week, that is not the case for part-owners—the difference is non-significant. Nevertheless, the higher marginal returns to land of 8.8 per cent, and to capital services of 41.6 per cent, relative to the lower marginal return for labor suggest that the use of both land and/or capital could be extended profitably. In other
words, there is excess labor under the observed organization of resources, and deficit in land and capital services. To absorb the excess labor (increase its marginal return and lower its cost per unit of production) the use of either land or capital must be expanded.

The "land-cost" ratio (Table 16) for part-owners indicates that actual marginal return to land is 46.0 per cent above the opportunity cost of land; but the capital-cost ratio indicates that the marginal return to capital is only 29.0 per cent above the opportunity cost of capital services. Therefore, land appears to be the more limitational of the two resources that are deficit. That is, from the standpoint of making readjustments, extension of the use of land might be given priority, in order to use more profitably the labor that is now in excess. It is noted, parenthetically, that under owner-operatorship the limitation appears to be in the use of capital services only, while under part-ownership the limitations are in both land and capital services. However, it is conceivable that there is a better balance in resource organization under part-ownership. That is, the deficit in capital services alone for owner-operators may supersede the deficit in both land and capital services for part-owners.

It is somewhat surprising that farms operated under part-ownership should be deficit in the amounts of land and/or capital. As expected, the average farm size in terms of land (value and acres) is larger than that of owner-operators (Table 13); but evidently not enough for the amount of labor

Of course, the pattern of resource productivities suggests another type of adjustment: labor could be contracted to the point where the marginal return to labor is equal to $40.00 per week. But the productivities of land and capital and the level of production would be reduced.
(52.0 weeks) used in combination with it. It is possible that the high marginal return on land represents a state of transition from smaller to larger units. It was previously stated as an hypothesis that, for a farm of a given size, the marginal return to land should not remain substantially above the rental rate or the annual cost of land. Expansion will take place so long as there is a differential, as observed in this study, and will more likely take place through renting rather than owning partly because of risk aversion and limited capital. So, the findings further suggest that the marginal return of 8.5 per cent for land under part-ownership may not be significantly different from the "rental rate".

Marginal returns under livestock-share leasing

Unlike the inferences drawn for the two tenure types (owner-operators and part-owners), there is no evidence 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 profitably extended.

However, it is noticeable (Table 16) that the return to land is 93.0 per cent above the "cost" of land (the highest of the tenure and lease types listed) and substantially above that of 36.0 per cent for labor and 16.0 per cent for capital services. Consequently, from the standpoint of increasing net returns (through increase in production) land is evidently the most "limitational" of the three resource categories. Further the marginal return to land is significantly above its opportunity cost at a
probability level less than 1.0 per cent. From the standpoint of the
firm the quantity of land used under livestock-share leases should be
extended, provided that the land values as quoted by tenants are not
underestimated. The relatively high marginal return to land can be tied
back to the "high" capital/land ratio observed for livestock-share
renters.¹

The marginal return to capital services is what could be logically
expected: it is not significantly above the opportunity cost of capital.
The possible reasons for this relatively lower marginal return are as
follows: (1) there is little or no incentive present in livestock-share
leasing through sharing of costs or 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 tenants to the total
farm assets, coupled with the sharing of risks of larger scale of operations;
and (3), the presence of the landlord in the farm operations dampens the
possibility of exogenous rationing of capital that might operate adversely
under other types of leasing. Although nothing has been said specifically
of the marginal return to labor ($54.79 per week) it is implied that

¹There is no accurate measure of the rental rate on these farms since
landlord's returns are not "pure" rent. They include rewards to other
contributions made by the landlord. But it is noted, parenthetically, that
the average landlord's return amounts to 19.3 per cent on land investment,
a value that is significantly greater than the marginal return to land of
11.6 per cent. The difference is significant at a probability level less
than 1.0 per cent, but this assumes no errors in the estimate of landlords'
returns. If the errors associated with the calculated value of 19.3 per
cent (landlord returns) are considered the level of significance would be
increased. But it can also be suggested that the estimate of the average
landlord's return is biased upward because of possible undervaluation of
the land by the tenant.
rationing of capital affects labor productivity indirectly. That is, as indicated before, 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 15), it is apparent that the patterns of resource productivities under the two lease types are quite analogous, and more in contrast with the productivities under owner-operatorship and part-ownership. As in the case of livestock-share, neither the marginal return to labor nor that to capital services for crop-share-cash leases is significantly different from the respective opportunity costs assumed; only the marginal return to land is significantly greater. Similar to livestock-share, the difference is significant at a probability level less than 1.0 per cent.¹

Possibly, the consistently lower marginal returns (to all resources) under crop-share-cash versus livestock-share leasing could be attributed to one or both of (1) inferior management and (2) different combination of enterprises for crop-share-cash tenants. These inferences are based on the larger regression constant observed for livestock-share renters in spite of a smaller sum of the elasticities (Table 11). Put in another way: the estimate of a marginal return is also dependent upon the position (level)

¹But in contrast to livestock-share renters, the calculated average landlord's return is only 10.8 per cent (10.8 cents per dollar of land) which is not significantly different from the estimated marginal return of 10.7 per cent.
of a marginal productivity curve, that is affected by a constant. The regression constant forms a part of the constant of the marginal productivity curve. Differences in the sizes of the constants could be due to differences in management or enterprise combination, in view of the analytical model used in this study.

The "low" marginal return to capital services of 10.5 per cent does not coincide with what is expected theoretically. The alleged non-optimum sharing of costs and returns should reflect in a higher marginal return (relative to owner-operators) for capital services, because of restrictions in these resource inputs.¹ But the marginal return to capital is in closer correspondence to the "optimum" than any other tenure group analysed. The data (Table 16) show where the marginal return to capital is a negligible 1.0 per cent above the opportunity cost of capital services. In effect, it appears that the imperfections under crop-share-cash leasing are on the average negated by the sharing of uncertainties and that capital rationing is dampened by the joint contributions of landlords and tenants to the total farm assets.

¹No data are available on the way costs are shared in relation to returns. However, it is unlikely that the majority of farms included under crop-share-cash leasing do share costs in the same proportion as products from different enterprises are shared. On the other hand, inefficiencies of individual farms may be counterbalanced by efficiencies of others. The latter statement, of course, applies to all tenure types, and not particularly to crop-share-cash leasing.
Significance of Differences between Tenure and Lease Types in Marginal Returns

Marginal returns using individual estimating equations

As suggested previously, differences in marginal returns of similar resources under different tenure and lease types are expected using separate (individual) estimating equations. Observations on 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, (turning to Table 17), the significant differences are few and are in (1) the marginal returns to land and in (2) the marginal returns to capital services for owner-operators versus the two lease types. All the other differences are not significant at acceptable levels of probability, arbitrarily chosen as 10 per cent or less. Of particular import: the marginal return to owner-operators' labor of only $17.96 per week is different from the marginal return to labor under the two lease types at probability levels not usually accepted as significant. This statement

1 Except for the two differences observed in the marginal returns to capital services (here in this study) similar findings were made previously where crop functions were considered: only the marginal returns to land were significantly different—the marginal returns to labor and capital services were not. Consult: Heady. Marginal resource productivity and imputation of shares on a sample of rented farms. Loc. cit. p. 503.
Table 17. Values of $t$ for differences in marginal returns of similar resources

<table>
<thead>
<tr>
<th>Tenure and lease types compared</th>
<th>Values of $t$ for differences in marginal returns</th>
<th>Land</th>
<th>Labor</th>
<th>Capital services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner-operators vs. part-owners</td>
<td></td>
<td>1.58&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.47</td>
<td>1.32&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Owner-operators vs. livestock-share renters</td>
<td></td>
<td>2.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.87&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Owner-operators vs. crop-share-cash renters</td>
<td></td>
<td>2.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.24&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.49&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Part-owners vs. livestock-share renters</td>
<td></td>
<td>1.14&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.79</td>
<td>0.61</td>
</tr>
<tr>
<td>Part-owners vs. crop-share-cash renters</td>
<td></td>
<td>0.25</td>
<td>0.63</td>
<td>1.29&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Livestock-share vs. crop-share-cash renters</td>
<td></td>
<td>0.34</td>
<td>0.18</td>
<td>0.61</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant at probability level of 1 to 5 per cent.
<sup>b</sup>Significant at probability level of 5 to 10 per cent.
<sup>c</sup>Significant at probability level of 10 to 20 per cent.
<sup>d</sup>Significant at probability level of 20 to 30 per cent.

Other values (those not noted) are non-significant at probability levels of 30 per cent and less.

is particularly relevant with regard to the comparison with livestock-share renters showing the marginal return to labor of $54.79 per week. One might then conclude that the differences anticipated in the patterns of resource productivities under the different tenure classes are not detected.
It is likely that the nonsignificant differences are, in part, due to the large variances of the marginal returns and would be different if the basic estimating equations had correlation indexes ($R^2 - e$) larger than they are. On the other hand it is probable that the foregoing differences observed in the marginal returns to land and capital would disappear with a superior aggregation of resource categories. There are also two more reasons to believe that these differences may not really exist: (1) as discussed before, the coefficients of the estimating equation for owner-operators appear to be "biased" in the direction to show the differences observed and (2) the possible tendency of tenants to "underestimate" land values (inputs) in their quotations can also 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 (lease types') marginal returns to land are "overestimated". Since the marginal return to a resource is also dependent upon the levels of other resource inputs it is implied that the marginal returns to capital (for the two lease types) are also not exactly comparable to those for owner-operators.¹

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 15) should not go without some comment: the age distribution of owner-operators is

¹Of course owner-operators for "evasive purposes" may also tend to undervalue the land they operate, but this tendency is counterbalanced by the other owners who may subjectively overvalue the land they own.
more negatively skewed (a greater proportion of older operators) with the marginal return of $17.96 to labor lower than any other group of operators. Second, the age distribution of part-owners is closer to normal distribution with a higher marginal return to labor of $29.70. Finally, with the age distributions of the two lease types more positively skewed (greater proportions of young operators) the marginal returns are $54.79 and $38.90, respectively, for livestock-share and crop-share-cash renters, and are higher than the other groups. These observations do not give concrete evidence; but, the general tendency for low labor returns to follow negatively skewed age distribution is some indication that, on the average, labor quality—related to older age—is of some influence in the patterns of marginal returns.

The figures on marginal returns to labor for different age groups of operators (Table 18) are as expected: for the younger owner-operators, the marginal return is $33.50, and for the older operators the marginal return is $2.50. Nevertheless, the difference between these values is significant only at a 20 to 30 per cent probability level. Although this difference is not highly significant it does throw some light on the differentials in labor productivity due to age of operators. The findings would suggest that in the comparisons of the patterns of resource productivities between tenures and lease types the age factor should be considered further. Probably "management" has dampened the real difference stemming from the
Table 18. Marginal returns to resources at the geometric means of production and resource inputs for two age groups of owner-operators

<table>
<thead>
<tr>
<th>Age groups of owner-operators</th>
<th>Marginal returns to resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land</td>
</tr>
<tr>
<td></td>
<td>$/#/</td>
</tr>
<tr>
<td>Age, under 45 years</td>
<td>0.059</td>
</tr>
<tr>
<td>Age, over 64 years</td>
<td>0.092</td>
</tr>
</tbody>
</table>

quality of labor.\(^1\)

However, it is noticeable that the younger owners' level of marginal return to labor is, as expected, more comparable with those for the tenure classes that are predominantly composed of younger farmers (the lease

\(^1\)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) resource combinations seriously affect the inferences drawn on possible differences arising from labor quality. First: the average amount of labor used by the younger age group is greater than that used by the older group (91.0 versus 72.0 weeks—Table 13). This would suggest a lower marginal return for the younger operators, other things being equal. Second: the marginal return to labor for the older group is only $3.50 (a value not significantly different from $2.50) if everything, except labor elasticity, is the same as those for the younger group.

It is suggested, further, that more extreme age groups would reveal differences sharper than those of the present study.
That is, the differences between the marginal returns to labor for owner-operators as a group, and the two lease types, although not significant, are greater than the corresponding differences in the estimates for the younger age group of owners (Tables 17 and 19). In addition, the differences with the other marginal returns are likewise smaller. As suggested in a previous section, 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 for differences between tenure classes need not be entirely tenure-oriented.

With respect to the analysis of marginal returns under owner-operatorship (as a group), it was suggested that owing to the significant difference 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. Of course, 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 about the excess of labor or rationing of other resources. The readjustments needed in resource 

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1 No test is made on the differences between the marginal returns to labor for the older owners versus the other tenure and lease types. By inspection of the relative values for these tenure classes the following observations can be made: (1) the difference with part-owners should be significant at a probability level close to that obtained for young owners versus old owners and (2) the differences with the two lease types would be more significant at levels, say, between 1 to 10 per cent.

2 $0.10 > p > 0.05$

3 $0.40 > p > 0.30$
Table 19. Values of t for differences between owner-operators, under age 45, and other tenure groups in marginal returns to resources

<table>
<thead>
<tr>
<th>Tenure groups compared</th>
<th>Values of t for differences in marginal returns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land</td>
</tr>
<tr>
<td>Owner-operators, age under 45 vs. age over 54 years</td>
<td>0.50</td>
</tr>
<tr>
<td>Owner-operators, age under 45 vs. part-owners</td>
<td>0.70</td>
</tr>
<tr>
<td>Owner-operators, age under 45 vs. livestock-share renters</td>
<td>1.31&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Owner-operators, age under 45 vs. livestock-share renters</td>
<td>1.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Significant at a probability level of 10 to 20 per cent.
<sup>b</sup> Significant at a probability level of 20 to 30 per cent.

Other values of t are non-significant at probability levels of 30 per cent or less.

Use for owner-operators, age under 45 years, are in the same direction as those for owner-operators as a group; but they would not be in the same magnitudes since the levels of marginal returns are different.

Marginal returns as affected by resource combinations

It was indicated previously that differences in marginal returns due to differences in resource combination could be "washed-out" by differences
in production elasticities. Consequently, figures on marginal returns obtained with a common set of elasticities for the two lease types are submitted below (Table 20).

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 combination (resource ratios) are not great enough to cause different patterns of marginal returns. As suggested in a previous analysis, the consistently higher levels of returns under livestock-share are due to other factors, presumably (1) management, (2) product combination or (3) both.

The foregoing inferences are drawn although the marginal returns to land are significantly different (Table 20), whereas the difference between the estimates using the individual elasticities was not. Only a part of the difference can be attributed to differences in resource combinations. On the one part, the higher land/labor ratio of livestock-share ($596.0/week versus $546.0/week) suggests a lower marginal return to land for livestock-share renters; while on the other part, the lower land/capital ratio for livestock-share ($4.6/dollar versus $6.4/dollar) suggests a higher land return. Thus, the difference in these resource (combinations) operate forces going in opposite directions. In the final analysis, it may be concluded that capital restriction on the crop-share-cash farms
Table 20. Marginal returns using common production elasticities for two lease types at their own geometric means, and values of t for their differences

<table>
<thead>
<tr>
<th>Lease type</th>
<th>Land</th>
<th>Labor</th>
<th>Capital services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$/b</td>
<td>$/wk</td>
<td>$/b</td>
</tr>
<tr>
<td>Marginal returns using common elasticities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>0.135</td>
<td>66.42</td>
<td>1.205</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>0.099</td>
<td>44.32</td>
<td>1.165</td>
</tr>
</tbody>
</table>

| Livestock-share renters  | 0.116| 54.79 | 1.278            |
| Crop-share-cash renters  | 0.107| 48.98 | 1.108            |

<table>
<thead>
<tr>
<th>Item</th>
<th>Values of t for differences in marginal returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal returns using common elasticities</td>
<td>1.90&lt;sup&gt;a&lt;/sup&gt; 0.96&lt;sup&gt;b&lt;/sup&gt; 0.22&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Marginal returns using individual elasticities</td>
<td>0.34&lt;sup&gt;c&lt;/sup&gt; 0.18&lt;sup&gt;c&lt;/sup&gt; 0.61&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant at probability level of 5 to 10 per cent.
<sup>b</sup>Significant only at probability level of 30 to 40 per cent.
<sup>c</sup>Non-significant at probability levels less than 50 per cent.
(higher land/capital or 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 capital rationing or imperfections in leasing arrangements 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 have also influenced the differences in marginal returns. When the effect of the regression constant (intercept) is removed, the marginal return to land for livestock-share leases reduces to 11.1 per cent as compared to 13.5 per cent (Table 20). If the 11.1 per cent is compared with the marginal return of 9.9 per cent for crop-share-cash the difference is not significant at probability levels less than 30 per cent. Further, since 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 differences in resource combination under the two lease types.
INEFFICIENCIES OBSERVED IN TERMS OF DEVIATIONS FROM
OPTIMUM RESOURCE COMBINATIONS

The preceding analysis on marginal returns was concerned primarily with departures from the optimum quantities of resources that would be associated with increases or decreases in the levels of production. In other words, departures from the condition where marginal returns would equal (or approach) the opportunity costs of the respective resources, were analyzed qualitatively. For reasons already stated, no indication was given of the quantities of resource excesses or deficits to achieve the optimum level of production. Thus efforts are directed toward quantitative optimum solutions where production is held fixed at the geometric means of production for each tenure and lease type.

In this analysis, production is held fixed and resources are substituted until the ratios of marginal return to the opportunity cost of the respective resource are equal—costs of production are accordingly minimized. The optimum resource combinations (or minimum cost combination) are determined under the "cost" assumptions as before: 6.0 per cent for land, $40.00 per week for labor and 10.0 per cent for capital services.\(^1\)

Thus, the calculated resource quantities at the optimum combinations are,

---

\(^1\)A possible limitation in the solution is that all the resources are not measured similarly. Thus, while \(\$0.06\) is actually used for land in the calculations, the amount of \(\$1.10\) is used for capital services. The extra (1) dollar for capital services represents the resource services "used up", while land remains for future uses.
more accurately, what the mean resource inputs should have been in order
to achieve the minimum cost attainable at the mean values of production,
granting the basic estimating equations used and the "cost" assumptions.

In determining the optimum resource combination owner-operators, as
a whole, are dropped for two reasons: (1) as noted before, there are,
supposedly, more biases in the production elasticities for this tenure
class and (2) the opportunity cost assumption of $40.00 per week for labor
is logically inapplicable. Since this group is constituted of a high
proportion of older operators the opportunity cost would be, most likely,
lower than $40.00, if the assumption of $40.00 for the other groups has
any validity. Consequently, only the younger age group of owner-operators
is considered in this section of the analysis.

Deviations from Optimum Resource Combinations by Tenure
and Lease Type

From the findings (Table 21), the younger owner-operators are the
most efficient, when compared with the other tenure and lease types—the
average deviation from minimum cost being $325 or 2.5 per cent. On the
other extreme, crop-share-cash renters are shown to be the least efficient
with the corresponding deviation amounting to $508 or 4.7 per cent. Of
course, while crop-share-cash renters show the greatest deviation from
minimum cost percentagewise, part-owners show the greatest deviation in
absolute terms of $546. As might have been expected, livestock-share
renters are more similar to owner-operators; their average deviation is
$474 or 3.3 per cent. It is doubtful, however, that the seeming
Table 21. "Optimum" resource combination, and deviations of actual resource combination from the "optimum" at the geometric means of production for each tenure and lease type

<table>
<thead>
<tr>
<th>Item</th>
<th>Resource combinations</th>
<th>Average deviation of actual from &quot;optimum&quot; combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual (geometric means)</td>
<td>&quot;Optimum&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner-operators: age under 45 with production at $17,714</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land (§)</td>
<td>27,551</td>
<td>22,893</td>
</tr>
<tr>
<td>Labor (wk)</td>
<td>91</td>
<td>63</td>
</tr>
<tr>
<td>Capital services (§)</td>
<td>8,794</td>
<td>9,799</td>
</tr>
<tr>
<td>Total value of services (§)²</td>
<td>13,674</td>
<td>13,349</td>
</tr>
<tr>
<td>Part-owners with production at $16,467</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land (§)</td>
<td>45,594</td>
<td>54,760</td>
</tr>
<tr>
<td>Labor (wk)</td>
<td>83</td>
<td>50</td>
</tr>
<tr>
<td>Capital services (§)</td>
<td>7,816</td>
<td>8,177</td>
</tr>
<tr>
<td>Total value of services (§)²</td>
<td>13,187</td>
<td>12,941</td>
</tr>
<tr>
<td>Livestock-share renters with production at $22,936</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land (§)</td>
<td>45,884</td>
<td>65,236</td>
</tr>
<tr>
<td>Labor (wk)</td>
<td>77</td>
<td>78</td>
</tr>
<tr>
<td>Capital services (§)</td>
<td>9,566</td>
<td>8,181</td>
</tr>
<tr>
<td>Total value of services (§)²</td>
<td>14,711</td>
<td>14,237</td>
</tr>
</tbody>
</table>

²Land services are valued as 4.5 per cent of the total market value of land and labor services at $40.00 per week.
Table 21. Continued

<table>
<thead>
<tr>
<th>Item</th>
<th>Resource combinations</th>
<th>Average deviation of actual from &quot;optimum&quot; combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual (geometric means)</td>
<td>&quot;Optimum&quot;</td>
</tr>
<tr>
<td>Crop-share-cash renters with production at $15,105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land (§)</td>
<td>41,506</td>
<td>59,375</td>
</tr>
<tr>
<td>Labor (wk)</td>
<td>76</td>
<td>75</td>
</tr>
<tr>
<td>Capital services (§)</td>
<td>6,517</td>
<td>5,845</td>
</tr>
<tr>
<td>Total value of services (§)*</td>
<td>11,425</td>
<td>10,917</td>
</tr>
</tbody>
</table>

Differences in average deviations or levels of efficiency are significant in a probability sense. More pronounced differences are observed by examination of the deviations with respect to specific resource categories.

Deviations under owner-operatorship

For owner-operators (younger age group) the indications are deficit in capital services and excesses in both land and labor. It is the only group that shows an excess of $4,658 in the quantity of land needed to

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1 Interpreted in a different way: owner-operators, age under 45 years, are 97.4 per cent efficient; livestock-share renters 96.7 per cent; part-owners 95.7 per cent; and crop-share-cash renters 95.3 per cent. The differences between these "efficiency indices" are most likely non-significant. The tenure and lease types are "equally" inefficient.
achieve the optimum combination. At the same time, the group shows an excess of labor of 28 weeks. Thus, in order to improve resource allocation, land and labor should be substituted with capital services of $1,005 (10.3 per cent) the greatest deficit in capital of all the tenure groups.

As outlined in the theoretical analysis, one can expect owner-operators, on the average to be limited in land, capital services or both in relation to labor due to capital rationing. So, prior commitments in land purchases have presumably caused a restriction in the amount of capital needed to operate the given quantity of labor (not necessarily land) more efficiently. The excess land of $4,658 is only approximately 24 acres. Therefore, the greatest substitution under owner-operatorship is the displacement of labor by 144.4 per cent. While the excess labor and capital deficit may be crucial, the excess of 24 acres is intuitively not so, since the maladjustment in acres employed could be in part temporary.

Deviations under part-ownership

In the previous analysis on marginal returns (as related to optimum production levels) under part-ownership, it was suggested that land was more limitational than capital services. Coincident with that suggestion are observations where production is held fixed and the resource services

1 The excess labor for owner-operators (and part-owners) can be identified, perhaps, with the general belief that "there is too much labor in agriculture". So it should be noted that, on the average, between 20 and 25 per cent of the total labor reported is from the operator's family. Hence only a part of the excesses observed could really be attributed "underemployment".
are substituted: to achieve a superior resource combination, an increase
in land of 16.7 per cent (9,166 or 45 acres) is indicated as against an
increase in capital services of only 4.4 per cent (96). Both land and
capital services are substituted for labor, resulting in 33 weeks of
"displaced" labor, an amount that is 66 per cent greater than the optimum
quantity required for the observed production.

Generalizations on the reasons for the deviations from optimum under
part-ownership are made difficult since part-owners as a group constitute
an admixture of tenure arrangements. But, the pattern of resource
organization is most likely influenced more by the tenure relationships
that are more "predominant" within the group. So, since 50.0 per cent of
the part-owners analyzed are under share contracts while only 20.0 per cent
have cash leases, there are reasons to believe that share leasing being
predominant has exerted more influence. In addition, the part-owners
analyzed are more like full owner-operators than they are full tenant-
operators. Therefore, to the extent that capital rationing is operative,
ownership it is evidenced by restrictions placed on the capital services
in relation to labor, similar to owner-operators, age under 45 years. In
spite of the limitations in trying to generalize on part-owners as a tenure

1 Of the 76 part-owners analyzed, 41 (or 54 per cent) own most of the
land operated (i.e., each owns more than 50 per cent); while 31 (or 41 per
cent) rent most of the land operated (i.e., each rents more than 50 per
cent). (The other 4 part-owners or 5 per cent own and rent equal quantities
of land). Thus, using the proportion of land owned and rented as a
criterion, the majority of part-owners (41) are more like "full owners"
(owning on the average 69 per cent of the land operated and a minority (31)
are more like "full tenants" (renting on the average 64 per cent of the
land operated).
group, the deficits in capital and land were not expected since part-
owners are usually regarded as being among the better managers, and in a more favorable capital position with credit available. But again, a part of the malallocations could be temporary.

**Deviations under livestock-share leasing**

Livestock-share renters like part-owners are also short on land. But the deficit of $19,354 (76 acres) or 29.7 per cent is greater. In further contrast to part-owners (and owners also), livestock-share renters show an excess of capital services—12.0 per cent of the optimum quantity. Hence, most of the readjustment of resources that is suggested for livestock-share leases is substitution of land in favor of capital services. This is so since the deficit of 1 week labor 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. It is likely that "undervaluation" of land productivity (due to "imperfect knowledge") could have caused restrictions in the use of land, thus resulting in the substitution of capital services for land. But as suggested before, the restriction observed here in the amount of land could also be related to the "low" estimates given (by the tenants) for the values of the land inputs.

If the malallocations observed were in terms of land-labor or labor-capital substitutions more plausible explanations could be advanced. For example, if the reorganization needed were 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, since more land and labor (to a small degree) and less capital services should have been used such an hypothesis would be denied. Then too, both landlords and tenants (under livestock-share leases) make contributions to the quantity of capital services used. Therefore, the landlord would be defeating his personal ends by making contributions in capital to the extent that the marginal return to labor is not minimized and that capital is excessive.

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 require an additional 1 week (or 1.3 per cent) of labor while livestock-share renters ought to have used 1

1Also, if most of the substitution had taken place by labor in favor of capital services, the conclusion could be that a premium is placed on minimizing irksome farm operations or leisure time.

2The hypothesis probably could be tested also by holding capital fixed at the geometric mean and then observe the pattern of needed readjustments. From inspection of the marginal return-opportunity cost ratios (Table 14) it appears that land would be substituted for labor: the marginal returns to land are 93.0 per cent above the opportunity cost and that for labor only 36.0 per cent. To obtain equality of these percentages land would have to be substituted for labor. But as discussed before, the high marginal return to land is due in part to the "high" capital/land ratio ("low" land/capital). Landlords' contributions also account for the size of this ratio. But the ratio can also be affected by the value placed on the land input.
week less. As suggested in the analysis on livestock-share renters, this difference of a week (plus or minus) is negligible. Hence, the needed reorganization of resources, as in livestock-share, is predominantly land in favor of capital services. The quantity of land used should be $17,869 (79 acres) more—a deviation from optimum of -30.1 per cent while capital services should be increased by $1,272 or 24.3 per cent.

The inferences drawn on the possible causes for deviations under livestock-share leases are equally as applicable to crop-share-cash, since the pattern of deviations is similar. However, further to that analysis (on livestock-share), one could have predicted that capital services would be limited in relation to land on the premise that "imperfections" in cost sharing and exogenous rationing faced by crop-share-cash renters should cause restrictions in the amount of capital used. The improvements in resource use (toward the optimum) would then be in favor of capital services instead of land. Therefore the findings would lead one to suspect that exogenous rationing of capital and leasing imperfections are relatively unimportant for reasons advanced before—the joint contribution of landlords and tenants to the total farm assets dampens the adverse effects of leasing "imperfections". But no definite conclusion can be drawn on the effects of imperfections in the sharing of costs between landlords and tenants: (1) the kind of restrictions in resource use that are likely to emerge are in connection with more specific capital items that are covered up in the aggregation of capital services and (2) the reorganization suggested by the findings may be biased due to the value placed on land.
Significance of Differences in Deviations and Marginal Returns at the Optima

At the present time no direct test for the differences between tenure and lease types in average deviations from minimum costs is available. As an alternative to a direct test of significance, the "consistency" of the difference in deviations is tested for two lease types only. More precisely, the deviations from optimum resource combinations are calculated for livestock-share and crop-share-cash renters using the coefficients of the pooled regression. Then the resulting estimates are compared with those using the individual coefficients.

Surprisingly, with a slight (non-significant) change in the estimating equations, the net deviation (average reduction in costs) under crop-share-cash leasing is 2.4 per cent and smaller than that for livestock-share of 6.1 per cent (Table 22). With such a shift in the deviation values obtained, it is doubtful that the difference 4.7 (livestock-share) versus 3.3 per cent (crop-share-cash) obtained previously by using individual coefficients is significant. By implications, the other differences in the deviations are likewise presumed to be non-significant, in a probability sense, since a slight change in the equation may reverse the positions of the tenure and lease types in terms of relative efficiency.

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1By "consistency" is meant: whether the differences in average deviations from minimum costs remain in the same relation (algebraically), and not necessarily in the same magnitude.

2While the directions (or patterns) of substitution with respect to the individual resource categories remain the same, it is noticeable (Table 21 and Table 22) that the magnitudes of the changes differ.
Table 22. "Optimum" resource combination and deviations of actual resource combination from the "optimum" at the geometric mean of production for two lease types, using common elasticities

<table>
<thead>
<tr>
<th>Item</th>
<th>Resource combinations</th>
<th>Average deviation of actual from &quot;optimum&quot; combination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual (geometric mean)</td>
<td>&quot;Optimum&quot;</td>
</tr>
<tr>
<td>Livestock-share renters with production at $22,936</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land ($)</td>
<td>45,664</td>
<td>70,877</td>
</tr>
<tr>
<td>Labor (wk)</td>
<td>77</td>
<td>88</td>
</tr>
<tr>
<td>Capital services ($)</td>
<td>9,566</td>
<td>7,153</td>
</tr>
<tr>
<td>Total value of services ($)$a</td>
<td>14,711</td>
<td>13,362</td>
</tr>
<tr>
<td>Crop-share-cash renters with production at $15,105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land ($)</td>
<td>41,506</td>
<td>56,700</td>
</tr>
<tr>
<td>Labor (wk)</td>
<td>76</td>
<td>70</td>
</tr>
<tr>
<td>Capital services ($)</td>
<td>6,517</td>
<td>5,720</td>
</tr>
<tr>
<td>Total value of services ($)$a</td>
<td>11,425</td>
<td>11,151</td>
</tr>
</tbody>
</table>

Land services are valued at 4.5 per cent of the total market value of land and labor services at $40.00 per week.
To gain some idea of the significance of the deviations of the actual resource inputs (geometric means) from their optimum quantities, marginal returns at the optimum combination are compared with marginal returns observed at the geometric means. It is assumed that if the difference in marginal returns of at least one resource is significant, then the deviations are significant.

The results (Table 23) reveal that the more significant differences are in the marginal returns to land for the two lease types. Again one could be suspicious of the value reported by the tenants for the land inputs. Although resource deficits and excesses are observed for owner-operators and part-owners, at probability levels less than 30 per cent of the differences in the levels of marginal returns are not significant. The low significance levels for owner-operators probably coincide with the observation that owner-operators are the least inefficient of the tenure groups. But the significance of the differences for part-owners is perhaps in conflict with the observations on the magnitudes of the deviations. The test of significance applied would suggest that part-owners on balance are closer to the optimum than livestock-share renters although their reduction in costs is greater. But as pointed out before, the differences in reduction in costs are most probably not significant.

As observed, the extent of resource reallocation under each tenure class is evidently unimportant—it is not "substantially" different from zero. In the first place, the average reductions in cost especially percentage-wise are "small". In the second place, marginal returns at
Table 23. Marginal returns at the optimum resource combinations and values of \( t \) for the differences with marginal returns at the geometric means

<table>
<thead>
<tr>
<th>Tenure and lease type</th>
<th>Land</th>
<th>Labor</th>
<th>Capital services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$/$</td>
<td>$/\text{wk}$</td>
<td>$/$</td>
</tr>
<tr>
<td>Owner-operators: age under 45</td>
<td>0.072</td>
<td>46.22</td>
<td>1.329</td>
</tr>
<tr>
<td>Part-owners</td>
<td>0.073</td>
<td>49.07</td>
<td>1.350</td>
</tr>
<tr>
<td>Livestock-share renters</td>
<td>0.081</td>
<td>54.29</td>
<td>1.494</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
<td>0.075</td>
<td>49.63</td>
<td>1.377</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Values of ( t ) for differences with the marginal returns at the geometric means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner-operators: age under 45</td>
</tr>
<tr>
<td>Part-owners</td>
</tr>
<tr>
<td>Livestock-share renters</td>
</tr>
<tr>
<td>Crop-share-cash renters</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant at a probability level of 5 to 10 per cent.
<sup>b</sup>Significant at a probability level of 10 to 20 per cent.
<sup>c</sup>Significant at a probability level of 30 to 40 per cent.
<sup>d</sup>Non-significant at probability levels less than 50 per cent.
the optima are, by and large, not significantly different from those observed. This situation then raises the question: that either no real economic problems exist for the broad tenure classes or the methods and data used are inadequate for detecting the inefficiencies present. As emphasized before, there are crudities in the analytical models used and thus room for improvements. On the other hand, within the broad tenure classes the heterogeneity of tenure characteristics could have cancelled the inefficiencies (if any) present. However, the differences in the patterns of deviations (by tenure classes) in terms of resource excesses and deficits should imply that the broad tenure classes represent different "problem situations" for future inquiry.
SUMMARY AND CONCLUSIONS

The problems delimited for this study involve the effects of the tenure status of farm operators upon efficient resource allocation within an agricultural firm. The effects were examined under owner-operators, part-owners and full tenants as tenure types, and under livestock-share and crop-share-cash renters as lease types.

With the use of 1954 data obtained from a sample of farms, the immediate objectives of the study were twofold: (1) to further explore single equation models as means for estimating and comparing efficiency in resource use within farms operated under different tenure classifications; and conjointly, (2) to gain further insights into the relationships between the tenure status of farm operators and the use and productivities of resources employed in Iowa and northern Illinois, the area from which data were obtained.

Hypotheses Tested and to be Tested Further

It was posed as a central hypothesis that if production decisions are conditioned to any significant extent by tenure classes analyzed then there should be differences between these classes (as populations) in the patterns of resource allocation. More specifically, three major operational hypotheses were used to direct the empirical phases of the investigation. Briefly, the hypotheses formulated were these:
1. Output-input functions relating gross production to gross resource services "used up" within a production year are affected by tenure status, therefore they should differ between agricultural firms according to the tenure of the operator.

2. If resource organization is conditioned by the tenure status of farm operators, there should be differences reflected in the patterns of marginal returns to resources employed.

3. Tenure status theoretically impedes the achievement of optimum resource allocation; hence, it can be predicted that there are corresponding differences in deviations of actual resource combination, within the farm, from the optimum combination of resources for given levels of production.

To test the foregoing hypotheses, estimating equations were derived from the data for each tenure and lease type through weighted least squares. The first hypothesis was tested through a simple regression model,

\[ Y = \mu + \beta X + \epsilon \]

where \( Y \) refers to the gross production in dollars, and \( X \) refers to gross resource services, also in dollars. The second and third hypotheses were tested through a multiple regression model,

\[ \log Y = \log \mu + \sum_{i=1}^{3} \beta_i \log X_i + \log \epsilon \]

yielding functions of the Cobb-Douglas type.

The three resource categories \((X_{1-3})\) were land in dollars, labor in weeks and capital services in dollars. As in the simple regression model, \( Y \) denotes gross production in dollars.
Test of hypothesis No. 1, about average gross output-input relationships

From the analysis dealing with this hypothesis, it was observed that there are no significant differences in the estimated gross average output-input (regression) coefficient for the tenure types—owner-operators, part-owners and full tenants. The difference between the two lease types—livestock share and crop-share-cash renters—is significant but the relationships appear to be unstable. It was in a sense surprising to observe that livestock-share had an output-input coefficient (of 1.2230) which is smaller than that of crop-share-cash renters (of 1.4401); but one possible explanation may be found in the larger average scale of operations under livestock share leasing.

Results show, further, that at two different levels of gross resource inputs owner-operators (the least efficient) are 91.1 and 91.5 per cent as efficient as full tenants who are the most efficient. But again, when the "indices of comparative efficiency" are tested, their differences are not significant at probability levels ordinarily considered as acceptable.

The findings pose the following hypotheses for further testing: (1) that in output-input relationships there are greater intra-tenure class variations than there are between the tenure classes analyzed; (2) that stratification of the observations by an appropriate criterion of scale operations should yield more meaningful results. However, it is recognized that, amongst other factors, the aggregation of production as well as the valuation of resource services could have affected the comparability of the
functions obtained.

Test of hypothesis No. 2, about patterns of marginal returns

The analysis with respect to this hypothesis was primarily concerned with examination of the levels of marginal returns and their comparisons with the opportunity cost of the respective resources as clues to inefficient resource use. The assumed opportunity costs of 6.0 per cent for land, $40.00 per week for labor and 10.0 per cent for capital services set the limits to which resources should be extended (or contracted) to obtain optimum levels of production.

In relation to the opportunity costs assumed, the marginal return labor ($17.96 per week) is low, and the marginal return to capital services (70.6 per cent) is high for the owner-operators. The marginal value product of land (14.9 per cent) is not significantly below the opportunity costs. The findings would support the hypothesis that rationing of capital, on the average, causes resource malallocation under owner-operatorship. Thus, resource allocation could be improved with the use of more capital services. Accordingly, the productivities of both land and labor would be increased. However, other findings suggest that part of the lower productivity of labor under owner-operatorship might be attributed to the inferior quality of labor, to the extent that age is negatively correlated with labor quality: younger owner-operators show a marginal return to labor of $33.50 per week as compared to $2.50 per week for older owners. But the evidence obtained is not conclusive since the difference is not significant and other factors can confound the analysis.
With respect to part-owners, only the marginal return to labor ($29.70 per week) is relatively low, suggesting excess labor as in the case of owner-operators. But, unlike the return for owner-operators, the level of marginal return for part-owners is not significantly below the opportunity cost assumed. However, to absorb the excess labor either land or capital services (or both) could be extended in use, with priority given to land. But, any suggestions attempting to explain the pattern of marginal returns under part-ownership would be hazardous, since the group constitutes a conglomeration of tenure arrangements.

Unlike the inferences drawn for owner-operators and part-owners, no evidence of resource excesses is given from the level of marginal returns for livestock-share renters. All resources here may be profitably extended in use. But, neither the marginal return to labor ($54.79 per week) nor the marginal return to capital services (27.8 per cent) is significantly above the assumed resource "prices". Only the marginal return to land (11.6 per cent) is significantly different. The foregoing resource productivity estimates under livestock-share leases could be reasonably expected. The greater quantity of capital services employed results in a "low" marginal return to capital. Further, the higher marginal return to both land and labor could be due to the high land/capital and labor/capital ratios observed for this lease type. But it is suspected that the estimates for livestock-share as well as crop-share-cash renters are not comparable with those of the tenure types because of "errors" possible in measurement of the land inputs.
Under crop-share-cash leases the pattern of resource productivities is most analogous to that under livestock-share leases. That is, only the marginal return to land (10.7 per cent) is relatively high. But the levels of marginal returns for crop-share-cash leases are consistently lower than those under livestock-share. It is proposed as a further hypothesis, that this consistent differential stems from one or a combination of (1) inferior management and (2) different combination of enterprises (products) for crop-share-cash renters.

On the other hand, the marginal returns to labor ($46.96 per week) and to capital services (10.5 per cent) for crop-share-cash renters are in closer correspondence with the opportunity costs assumed than are the estimates of any other tenure classes. One might then pose the hypothesis that the "imperfections" generated by leasing arrangements are, on the average, negated by the sharing of uncertainties, and that capital rationing is circumvented by the joint contribution of landlords and tenants to the total farm assets.

Contrary to expectations, the significant differences between tenure and lease types in the levels of marginal value products are few. These are in (1) the marginal returns to land and (2) the marginal returns to capital services for owner-operators versus the two lease types. But, for one or more reasons, one would suspect that there are "biases" in the coefficients of the basic estimating equation for owner-operators and the valuation of resources. If these biases are reduced, the differences observed would probably disappear. As deduced under the previous hypothesis
(No.1) non-significant differences could be due to too great a variation in resource use within the tenure classes.

Test of hypothesis No. 3, about deviations from optimum resource combinations

In the analysis guided by this hypothesis, an attempt was made to estimate the degree to which optimum resource combination was achieved by each tenure class at its own mean value of production. Deviations from the optima (minimum-cost combinations) were obtained for each tenure and lease type under the same cost assumptions as in hypothesis No. 2. Consequently, owner-operators as a whole were dropped, partly because the opportunity cost of $40.00 per week was considered inapplicable. Instead, only the younger age group of owner-operators was analyzed.

According to the findings, the younger owners are the most efficient when compared with the other tenure classes—the average deviation from minimum cost being $325 or 2.5 per cent. On the other extreme, crop-share-cash renters are shown to be the least efficient with the corresponding deviation amounting to $508 or 4.7 per cent. As it might have been expected livestock-share renters are more similar to owner-operators: their average deviation is $379 or 3.3 per cent. It is doubtful, however, that the differences in deviations—levels of efficiency—are significant. Again, the findings invite doubts that the traditional classification of tenure groups by owner-operatorship and methods of rental payment, are different (in the aggregate) in achieving agricultural efficiency.

With regard to deviations from the optima in the quantities of
resource, only the owner-operator class is in excess of land. As expected
from the analysis under hypothesis No. 2, both part-owners and owner-
operators ought to have used less labor and more capital to achieve the
optimum quantities. Owner-operators show the greatest deficit of all
tenure classes in capital services and this further supports to an extent,
the hypothesis on capital restrictions under owner-operatorship. The two
lease types are the most efficient in the use of labor services, but are
excessive in capital services. Although it is recognized that these
estimates could have been effected by the values used for the land imputes,
the findings under the two lease types cast further doubts that leasing
"imperfections", on the average, cause restrictions in the use of capital
services.

Evaluation of the Analytical Models and Data Used

Admittedly, both the analytical models and the data used in this
study have weaknesses and could be more refined. For example, separate
functions for crops and livestock would probably yield more fruitful
results. Also, the resource categories could be expanded since lumping
of capital services conceals the way in which more specific capital items
are used. Then, too, labor services should be more accurately measured
in terms of weeks of man equivalents and land in terms of "homogeneous"
acres. Further, for the simple regression model, stratification of
farms by an appropriate criterion on scale of operations as well as
an improved valuation of resource services would quite likely reduce the
unstable character of the relationships observed in this study. Finally, the data used do not represent a true random sample of farms within the selected tenue classes. These classes are also "groups of farms" that follow geographic clusters. Thus transitory phenomena such as weather and initial conservation decisions that are likely to interfere with the estimates might have distorted the true comparisons. In essence, a more homogeneous area of analysis is necessary in order to minimize the possible effects of the foregoing factors.

Recognizing possible errors in the specification of the models and data used, evidences from the three hypotheses tested still suggest that, in terms of resource use, the intra-tenure class variations are probably greater than those variations between classes. Even with refinements of the models and the data, as suggested, it is suspected that further analysis of the traditional tenue classes would not show significant differences in resource use. In addition, the small values (not "significantly" different from zero) obtained for the deviations from optimum resource combinations, suggest that the inefficiencies are probably washed out within the broad tenue classes. These conclusions are not unreasonable in light of the heterogeneity of tenue characteristics and arrangements within a tenue class that can affect production decisions in different ways. Such a situation points towards orienting analytical models designed to isolate the specific characteristics and arrangements of tenue that are conducive to or impede efficiency in resource allocation.
Simple regression model and the data

The results from this model appear to be unreliable. But, part of the weaknesses could possibly be removed if the suggestions made previously are followed. If the results obtained from such functions are plausible, the regression lines could be assumed to represent "normal" returns for each tenure group. Further, individual residual observations (cases), say around the mean values of production and resource services, could be examined to observe if specific tenure characteristics (or arrangements) could account for any part of the deviations from normal returns. These negative individual observations could then be reprogrammed—improve resource organization.

The above extension of the model would require a homogeneous type of farming area. Then, too, as suggested before, stratification of observations on the basis of size of business with individual equations for each stratum should improve the estimates. It is recognized that comparisons of gross average output-input coefficients and the indices of comparative efficiency are rough indicators of relative efficiency. But with extension of the model, incorporating the case study approach, the model might serve in detecting tenure-oriented reasons (if any) for deviations from maximum production for given levels of gross resource inputs.

Multiple regression model and the data

In spite of the weaknesses of this model it is presumed that its use can be extended subject to refinements like those already mentioned.
Evidence points toward the need for removing the effects of factors that are not associated with tenure per se. 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 with the age of farm operators. Although not concrete, the findings indicate that adjustments for "age effects" are important. In this connection a multiple covariance model would quite likely be fitting for the analysis. Or an analysis of variance model using a two criteria 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, since 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 an unencumbered. Also the effects of non-optimum cost-sharing arrangements may be offset by the sharing of uncertainties under share contracts. Thus the results may still be confounded. It is then suggested that further analysis attempting to isolate the effects of tenure arrangements should focus attention on specific tenure arrangements and characteristics themselves, using the conventional tenure classification only as an initial device. If estimating equations are used for this purpose, it would of necessity entail a relatively large sample of a tenure or lease type that could be broken down into "cells" of adequate sizes, based upon the tenure
characteristics or arrangements to be controlled.

In making such analyses, attention should be focused also on the
effects of tenure arrangements upon (1) resource combinations and intensity
of resource use, and (2) combination of enterprises or products. It must
be recognised, however, that the effects of resource combination on the
levels of marginal returns cannot be analysed specifically with this model—
the Cobb-Douglas type function using separate estimating equations for each
tenure class—unless the coefficients are identical. Marginal returns are
affected not only by resource combinations (ratios) but also by the basic
estimating equations used. Further, it is doubtful that the effects of
tenure arrangements on product combination can be treated adequately with
the Cobb-Douglas function. ¹ A certain level of aggregation of production
is necessary.

Evidently, a rigorous analysis of farm tenure efficiency is beset
with many unsolved difficulties. In addition to the above mentioned
analytical problems, a question to be resolved concerns the identification
of the tenure-oriented part of the deviations from optimum even under more
"well defined" tenure classes. Resource readjustments do not actually take
place in continuous changes, but instead by lumpy as step-by-step changes.
Therefore, part of the resource excesses and deficits observed in this
study could have been "transitory". Coupled with this question are the

¹ Possibly "budgeting" of some form would be more appropriate, recog-
nizing that as a model it does not estimate existing relationships (explains
or predicts); it is a planning device, For the usefulness of linear pro-
gramming, see: W. D. Troussaint. Two empirical techniques applicable to
land tenure research: linear programming and single equation models. Jour.
aspects of intertemporal resource allocation (over two or more production years or intervals) that were indicated in the theoretical analysis but remain to be investigated further.
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The author is especially indebted to Professor John F. Timmons not only for the guidance he gave to this study but also for the inspiration and personal encouragements that he gave during graduate training.

If the study deserves any merits, they are for a great part reflections of discussions with the persons acknowledged and other colleagues particularly those with Drs. Ross Baumann, Lester Telser and Frank Oakes. The weaknesses contained are due solely to the author.

Appreciation is expressed to the Chicago Stock Yard and Transit Company through whom the data were made available.
APPENDICES
APPENDIX A

Prices Used and the Weighting of Regressions

Prices used

All values were obtained directly from the respondents except for crop production and livestock inventory. The prices used to estimate the value of the physical quantities reported are given below.

Prices used to value crop production

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Iowa $</td>
</tr>
<tr>
<td>Corn</td>
<td>bus.</td>
<td>1.32</td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td>0.65</td>
</tr>
<tr>
<td>Soybeans</td>
<td></td>
<td>2.45</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Buckwheat</td>
<td></td>
<td>0.60</td>
</tr>
<tr>
<td>Flax</td>
<td></td>
<td>3.10</td>
</tr>
<tr>
<td>Corn silage</td>
<td>tons</td>
<td>11.00</td>
</tr>
<tr>
<td>Corn hogged</td>
<td>bus.</td>
<td>1.00</td>
</tr>
<tr>
<td>Hay</td>
<td>tons</td>
<td>11.00</td>
</tr>
<tr>
<td>Timothy seed</td>
<td>lbs.</td>
<td>0.20</td>
</tr>
<tr>
<td>Clover and alfalfa seeds</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Brome seed</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Clover</td>
<td></td>
<td>0.57</td>
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</table>

Prices used to value livestock inventories

<table>
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<tr>
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<th>Head</th>
<th>155.00</th>
<th>162.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows, 2 years and over</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle and calves</td>
<td></td>
<td>95.00</td>
<td>104.00</td>
</tr>
<tr>
<td>Sheep and lambs</td>
<td></td>
<td>12.70</td>
<td>14.70</td>
</tr>
<tr>
<td>Laying hens</td>
<td></td>
<td>1.50</td>
<td>1.35</td>
</tr>
<tr>
<td>Hogs</td>
<td></td>
<td>44.20</td>
<td>39.30</td>
</tr>
</tbody>
</table>

Weighting of regressions

Since the data used are from observations stratified by "farm size"—classes 1, 2, and 3—with different sampling proportions 1/5, 1/4 and 1, respectively, applied to each class, to obtain unbiased estimates of the regression constants and coefficients the moments used are weighted.

The moments of variation and covariation (corrected sums of squares and cross products of the variables) are calculated separately for the 3 classes of farms around the individual class means. These values are then follows: class 1 farms -- \( W_1 = 5/13 \), class 2 farms -- \( W_2 = 4/13 \) and class 1 farms -- \( W_1 = 1/13 \). That is, denoting \( W_h \) as the weight for the \( h \)-th class, \( h = 1, 2, \) and 3, the weights are such that

\[
\sum_{h=1}^{3} W_h = 1.
\]

However, to simplify the computations, i.e., to avoid weighting (multiplying) by fractions the plain integers of 5, 4 and 1 are used as weights to arrive at the same solution. Thus,

---

(1) the weighted corrected sums of squares

\[ \sum_{h=1}^{3} w_h \sum_{i=1}^{n_h} x_{ih}^2 \]

(2) the weighted corrected sums of cross products

\[ \sum_{h=1}^{3} w_h \sum_{i=1}^{n_h} (x_{ih} x_{ij})_h , \text{ and} \]

(3) the weighted means of the variables

\[ \frac{\sum_{h=1}^{3} w_h \sum_{i=1}^{3} x_{ih}}{\sum_{h=1}^{3} w_h n_h} \]

In effect, the sums of squares and products are weighted to make the data representative of the population. That is, if the sample were completely random, there would have been 3 times as many class 1 observations and 4 times as many class 2 observations in relation to the number of observations on class 3 farms.
APPENDIX B

Marginal Value Product Equation and Solution Used for Optimum Resource Combination

Derivation of marginal value product equation

Given the basic estimating equation

\[ \hat{y} = a x_1^{b_1} x_2^{b_2} x_3^{b_3}, \quad (1) \]

the marginal return to resource \( x_1 \), for instance, is equal to

\[ \frac{\partial \hat{y}}{\partial x_1} = b_1 a x_1^{b_1-1} x_2^{b_2} x_3^{b_3} \]

\[ = \frac{b_1 a x_1^{b_1} x_2^{b_2} x_3^{b_3}}{x_1} \quad (2) \]

Substituting equation (1) into (2)

\[ \frac{\partial \hat{y}}{\partial x_1} = b_1 \frac{\hat{y}}{x_1} \]

Hence the general equation for marginal value product becomes

\[ \frac{\partial \hat{y}}{\partial x_1} = b_1 \frac{\hat{y}}{x_1} \quad (3) \]
In the present study, since all the marginal returns are estimated at the geometric means, $\hat{Y} = \bar{Y}$ and the $X_{i} = \bar{X}_{i}$. That is, at the geometric means

$$\frac{\partial Y}{\partial X_{i}} = b_{i} \frac{\bar{Y}}{\bar{X}_{i}}$$

(4)

Solution used for optimum resource combination

To obtain the optimum combination of resources for each tenure class the goal is to achieve the equality:

$$\frac{NWP_{d}}{P_{d}} = \frac{NWP_{1}}{P_{1}} = \frac{NWP_{c}}{P_{c}}$$

where production is held fixed at the geometric mean. That is, the marginal value product (return)--opportunity cost ratios are made equal for the resources--land (d), labor (l) and capital services (c). In the computations, the actual values used for the "opportunity costs" are $P_{d} = $0.06, $P_{l} = $40.00 and $P_{c} = $1.10. (as indicated in the text the "extra" 1 dollar for the "opportunity costs" of capital represents resources "used up" of sunk).

Therefore, given the basic estimating equation,

$$\hat{Y} = aX_{1}^{b_{1}} X_{2}^{b_{2}} X_{3}^{b_{3}}$$

(1)
the equality to be achieved, in other terms, is

$$\frac{\partial \hat{y}/\partial x_1}{p_1} = \frac{\partial \hat{y}/\partial x_2}{p_2} = \frac{\partial \hat{y}/\partial x_3}{p_3}$$

where $\hat{y} = y$. Or, from the preceding equation (4) and the assumed resource "prices",

$$\frac{b_1 \hat{y}/x_1}{p_1} = \frac{b_2 \hat{y}/x_2}{p_2} = \frac{b_3 \hat{y}/x_3}{p_3} = x_1; \quad (2)$$

the unknowns being the values to be determined for $x_{1-s}$ that represent the "optimum" quantities ($x_{1-s}^+$).

From equation (2), derive $\partial x_1/\partial x_j = p_j/p_1$. Hence

$$\partial x_2/\partial x_1 = \frac{p_1}{p_2} = \frac{b_1}{b_2} x_1 = x_2 = x_1^*; \quad \text{(3a)}$$

$$\partial x_3/\partial x_1 = \frac{p_1}{p_3} = \frac{b_1}{b_3} x_1 = x_3 = x_1^* \quad \text{(3b)}$$

Substituting equations (3a) and (3b) into equation (1), holding $\hat{y}$ at $y$, expresses the basic estimating equation in terms of $x_1$. That is,

$$y = a x_1^{b_1} (x_1^*)^{b_2} (x_1^*)^{b_3}$$

and solve for $x_1^*$ (the optimum quantity) in logarithms as
\[
\ln X^+ = \frac{\ln Y - \ln a - b_2 \ln(p_1/p_2 + b_2/b_1) - b_3 \ln(p_1/p_3 + b_3/b_1)}{b_1 + b_2 + b_3} \quad (5)
\]

Substitute \(X^+_1\) into the basic equation \(\hat{Y} = Y\) and it can be seen that

\[
x_2 = (\frac{\hat{Y}}{ax_1^{+ \frac{b_1}{b_2}}} \frac{1}{b_2}) \frac{1}{b_2} \frac{1}{b_2} X_3 \quad (6)
\]

Let \((\frac{\hat{Y}}{ax_1^{+ \frac{b_1}{b_2}}} \frac{1}{b_2}) = X\)

\[
.\quad \ln X^+ = (1/b_2)(\ln Y - \ln a) - (b_2/b_2) \ln X_1^+ \quad (7)
\]

From (6) and the respective opportunity costs assumed:

\[
\frac{\partial x_2}{\partial x_3} = -\frac{b_3}{b_2} X^+ \frac{1}{b_2} \frac{1}{b_2} X_3 = \frac{P_3}{P_2} \quad (8)
\]

\[
.\quad X^+_j = \left(\frac{P_2 b_j}{P_3 b_2}ight) X^+ \quad (9)
\]

or \(\ln X^+_j = \frac{1}{1 + b_j/b_2} \ln\left(\frac{P_2 b_j}{P_3 b_2} X^+\right)\), and

\[
\ln X^+_2 = \ln X^+ - (b_3/b_2) \ln X^+_1 \quad (9)
\]

The computational procedure involves the use of equations (5), (7), (8)

and (9) in sequence. The deviations from the optimum resource quantities
are \(X^+_1 - a - X^+_1\). The marginal return-opportunity costs ratio, at the
optimum, corresponds to the constant, \(X\), indicated in equation (2). The

\[1\text{Recall that since } \ln Y - \ln a = \sum b_2 \ln Y, \text{ the computations are}
\]

slightly reduced given the latter.
computations are checked accordingly, and also by substituting the "optimum" values \( X^+_i \) back into the original equation to obtain \( Y \).
APPENDIX C

Statistics Used for Testing Differences

Estimates from the simple regression model

Test for differences in regression coefficients. The statistics used is

\[ t = \frac{b_j - b_k}{s_{b_j - b_k}} \]

where the subscripts \( j \) and \( k \) denote the two tenure classes compared. The standard error of the difference, \( s_{b_j - b_k} \), is equal to

\[ s_p \sqrt{f_j + f_k} \]

where

\[ s_p = \sqrt{\frac{\sum_{t=1}^{T} \left[ \sum_{h=1}^{3} \left( \frac{\sum_{y} - (\sum_{x})^2}{\sum_x^2} \right) \right]}{\sum_{t=1}^{T} n_t - 6 T}} \]

standard error of the regression estimate. In the equation, \( T \) = the number of tenure classes compared (pooled), \( n_t \) = the number of observations in the \( t \)-th tenure class, \( b \) = the number of variables times the number of farm classes (\( \text{a.e., } 2 \times 3 \)). The values for \( f \) (factor) are
obtained as
\[ f = \frac{\sum_{h=1}^{3} \frac{v_h^2}{x_h} + \sum_{i=1}^{x_h} x_h^2}{\left( \sum_{h=1}^{3} \frac{v_h}{x_h} \sum_{i=1}^{x_h} x_h \right)^2} \]

This factor is calculated for each tenure class. The \( v_h \) values are 8, 4 and 1 for the three classes (sizes) of farms and \( n_h \) represents the number of observations in the \( h \)-th farm class.

Test for differences in the "indices of comparative efficiency." Similarly, the statistic used is
\[ t = \frac{\hat{y}_j - \hat{y}_k}{\sqrt{s_{y_j}^2/x_0 + s_{y_k}^2/x_0}} \]
where the subscripts \( j \) and \( k \) are as before—the tenure classes. The standard error is
\[ \sqrt{s_{y_j}^2/x_0 + s_{y_k}^2/x_0} \]
where, \( s_{y_j}^2/x_0 = \frac{s^2}{n_j} \left( \frac{1}{n_j} \sum_{j} \frac{y_j - x_0}{x_j^2} \right) \), and
\[ f = \frac{3}{3} = \frac{13}{3} \]

The value for \( x_0 \) is the gross resource input from which predictions...
are made. As indicated in the text, the tenure class with the largest predicted value of production ($\hat{Y}_{\text{max}}$) that was full tenants in this analysis, is assumed to be "100 per cent" efficient.

Estimates from the multiple regression model

Test for differences in regression coefficients. As in the simple model,

$$t = \frac{b_{ij} - b_{ik}}{s_{b_{ij}}/b_{ik}}$$

except that $b_i$ represents the estimated coefficient of the $i$-th resource category. The standard error of the difference is equal to

$$\sqrt{s_{b_{ij}}^2 + s_{b_{ik}}^2}$$

The estimates of the individual variances, $s_{b_i}^2$, remain the same as in a completely random sample\(^1\), except that $3$ times the number of degrees of freedom are lost due to the "stratification" (into sizes of farms).

Test for differences in marginal value products. As before,

$$t = \frac{Y_{ij} - Y_{ik}}{s_{M_{ij}}/M_{ik}}$$

But now, $M$ represents the estimated marginal value product or return and

$$s_{M_{ij}}/M_{ik} = \sqrt{s_{M_{ij}}^2 + s_{M_{ik}}^2}$$

\(^1\)Consult Ostle, op. cit., p. 216.
\[ \frac{e^2}{m_1} = \Lambda^2 \left( \frac{s^2}{n_1} \frac{b_1^2}{n} \right) + \left( \frac{s^2}{n_1} \frac{c_{ii}}{b_1} \right) \]

The factor \( \Lambda^2 = 2.302 \) is the adjustment for logarithms taken to the base 10. \( s^2 \) is the standard error of the estimate, \( b_1 \) the associated regression coefficient and \( c_{ii} \) denotes the related diagonal element of the variance-covariance matrix, \( \{0\} \). \( Y \) and \( X \) are geometric means.

**Test for differences between resource marginal returns and the respective "opportunity costs".** The statistics used, as in the previous tests, are

\[ t = \frac{M_1 - P_1}{s_{m_1}} \]

where \( M_1 \) is the estimated marginal return (at the geometric means) and \( P_1 \) the opportunity cost assumed for the related resource. The estimate, \( s_{m_1} \), is square root of the variance \( s^2_{m_1} \) obtained by the formula just indicated.

**Test for differences between resource marginal returns at the geometric means and at the "optimum" resource combination.** The procedure used is analogous to the immediately preceding test, except that

\[ t = \frac{M_1(g) - M_1(opt)}{s_{m_1}} \]

where $M_i(g)$ is the marginal return at the geometric mean and $M_i(\text{opt})$ is the marginal return at the calculated optimum. $s_{M_i}$ is the standard error of marginal return at the geometric mean—the same as in the previous test. Essentially, these last two tests are based upon the null hypothesis, $H^0: M_i - P_i = 0$ and $M_i(g) - M_i(\text{opt}) = 0$. 