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A STUDY OF COSTS AND RETURNS FOR DRY-LAND FARMS IN THE TRIANGLE AREA OF MONTANA WITH EMPHASIS ON OPERATOR'S LABOR, MACHINERY, AND LAND

by

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ABSTRACT

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It is generally conceded that returns to resources used in agriculture are lower than returns to similar resources used in the non-farm sector of the economy. This is the general problem situation which led to the development of this study.

The study was concerned with an investigation of the cost structures of dry-land farms in the triangle area of Montana. The main objectives of the study were fourfold: (1) to develop an estimate of the long-run average cost curve for dry-land farms in the area, (2) to measure machinery capacity on a sample of dry-land farms and estimate the impact of the operator's risk-security preference schedule on optimum farm size, (3) to examine the returns to dry-land farms under the assumption that acquisition prices and salvage values are equal at a given point in time and, alternately to examine returns after recognizing that acquisition prices and salvage values are different at a given point in time, and (4) to develop recommendations for farmers, extension leaders, and research workers based on the findings of the study.

Budget models were constructed for four sizes of farms using survey data plus secondary information obtained from engineering studies. Selected costs were taken from the budget models, classified into fixed

and variable categories, and used to construct short-run and long-run cost curves. These cost curves, derived within the assumptions of traditional neo-classical price theory, suggested that farms in the area studied achieve some cost economies throughout the range of size represented by the budget models. However, most of the cost economies are achieved with the model designed to produce 900 acres of crop per year. For larger farms cost economies related to size are small and are not likely important in determining farm size.

A survey of farms indicated that farmers own approximately 25 percent more machinery than they believe to be optimum, considered in combination with the other resources they use. An additional conclusion from this survey is that tractor power requirements relative to farm size are the same for both spring and winter wheat areas. An implication of the findings, relative to tractor power, is that unit costs are higher than could be achieved under better resource allocation.

A decision-making method using game theory was illustrated for choosing land and machinery allocations under conditions of weather uncertainty. This procedure, using partial budgets to develop payoff matrices, offers promise as an improvement over usual decision making procedures used by farmers.

The cost-return structure of each budget model was examined under the theoretical framework of fixed asset theory. Estimates were made of the magnitude of the differences between acquisition costs and salvage values for land, machinery, and the operator's labor. These differences gave rise to substantially different conclusions regarding the returns to dry-land farms.

Returns to the operator's labor were negative for the three smallest models and very low for the largest model when land and machinery were valued at acquisition prices. When these same assets were valued at salvage prices, labor returns were positive for each of the four sizes of farm.

The process through which resources get committed to farming was examined. The consequences of making mistakes in resource commitment are serious. Since these mistakes most often occur at the time one enters farming, it would seem appropriate to step up educational efforts directed toward potential beginning farmers. Fewer mistakes of resource allocation would ease the problem of low returns to resources used in agriculture.

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Of course any errors remaining in the thesis are entirely my responsibility.

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CHAPTER I

INTRODUCTION

Maximizing farm income depends on the right combination of land, labor, and capital. In a dynamic economy the optimum combination of resources is constantly changing in response to changing prices, technology, and institutions. The major problem of the farm manager is to make the proper adjustments, i.e., the adjustments which will maximize his pecuniary and non-pecuniary returns. This is the so-called economizing process of minimizing resources and maximizing ends.

This problem is especially acute for farmers in Montana's Triangle, a dry-land grain-producing area serviced by Great Falls, Havre, and Shelby. This area is experiencing rapid technological innovations, a changing price structure for both factors of production and products, and changing government policies relative to price supports, taxation, services, and conservation subsidies. These are some of the many forces behind the changing Triangle grain production economy.

Recent studies indicate the cost of producing wheat and barley in the Triangle averages approximately $43 per acre. This cost includes $1.21 per hour for all labor, a 7 percent return on working capital and a 6 percent return on machinery and real estate capital based on current market prices for factors.[1] Normal yields in the area studied

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[1]LeRoy C. Rude, Land Use Alternative for Dryland Cash-Grain Operators-North Central Montana, Agricultural Economics Research Report No. 9, Department of Agricultural Economics and Rural Sociology, Montana Agricultural Experiment Station, Bozeman, Montana in cooperation with United States Department of Agriculture, Agricultural Research Service, Farm Economics Research Division, November, 1959.

by Rude are 25.6 and 30.4 bushels per acre for wheat and barley respectively. The prices for these crops would have to be $1.68 and $1.41 per bushel to cover total costs of all factors of production as determined above. Current returns for wheat and barley, including government payments, are averaging approximately $1.50 and $.80 per bushel respectively for those farmers participating in the USDA wheat and feed grain programs.

A comparison of these price relationships leads one to conclude that farmers in the Triangle are receiving less than $1.21 per hour for their labor and/or 6-7 percent return on their investment, using the cost price structure from Rude's study and ignoring capital gains on land. Farmers who have recently entered farming under a cost structure assumed by Rude are often hard pressed to meet farm financial obligations and family living expenses. They are anxious to make adjustments which show reasonable promise of increasing their net farm income.

Machinery as a factor of production, has increased in importance steadily during the past half century. Recent studies in Illinois indicate that the costs associated with the machinery input comprise nearly 36 percent of total farm costs.[1] These costs are the highest single yearly farm expenditure. Following this cost item is interest on the non-machinery capital investment which is primarily land. This item amounted to 26 percent for Illinois farms. There have been no studies in the Triangle specifically oriented toward obtaining similar cost data. However, Rude's work[2] and unpublished budgets of individual

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[1]Donnell Hunt, Farm Power and Machinery Management, Fourth Edition, Ames, Iowa: Iowa State University Press, 1964. p.i.

[2]Rude, op. cit., p. 9.

farms in the Triangle, seem to indicate that farms in the area follow this pattern, with respect to machinery and land costs, very closely.

It would appear that even slight economic improvement in the ratio of machinery to land or in the management of these factors of production could be very important in increasing farm income. Farmers in the area apparently recognize this situation as attested to by their interest and participation in educational programs which emphasize land-machinery balance and management.

The Hypotheses

General hypotheses are involved in this research project. Rather than stating them as formal "null" and "alternate" hypotheses or "if---then" relationships they will be discussed as questions relative to the Triangle dry-land wheat-producing industry.

1. Within the present technological structure and under present operating conditions are economies of scale present?

2. Do farms in this industry have excess machinery capacity?

3. Do current rates of return to farms in this industry tend to encourage surplus capital and labor to remain employed in the industry?

The Objectives

The objectives of this research effort may be classified into four general categories. The first is to develop a long-run planning curve (long-run average cost curve) for farms in the Triangle dry-land wheat producing industry.

The second objective is to measure machinery capacity on a sample of farms and to determine the impact on optimum farm size of the individual farmer's risk-security preference schedule.

A third objective is to examine the returns to Triangle dry-land farms, (1) under the assumption that the acquisition price of land is equal to its salvage value at a given point in time and (2) after recognizing that the acquisition price is different from the salvage value at a given point in time. A sub-part of this objective is to analyze the role of fixed assets in restricting resource mobility on dry-land farms.

The fourth objective is to develop conclusions and recommendations for farmers, research personnel, and extension workers, with respect to the area involved, based on the analyses of the first three objectives.

The Area

The Triangle in Montana consists of a loosely defined trading area of Shelby, Havre, and Great Falls (see Figure 1) which is known as an important dry-land grain-producing region. Soils vary from extremely heavy to sandy and both winter and spring grains are produced. Since such heterogeneity almost surely effects cost return structures for grain farms it was decided to select an area of more or less homogeneous soil types within the Triangle for the selection of cost-return data. The area selected is designated as "Community G" by the Agriculture Stabilization and Conservation Service classifications and consists of 95 farms. Nearly all of these farms are cash-grain farms. The few farms with livestock enterprises were excluded from the sample.

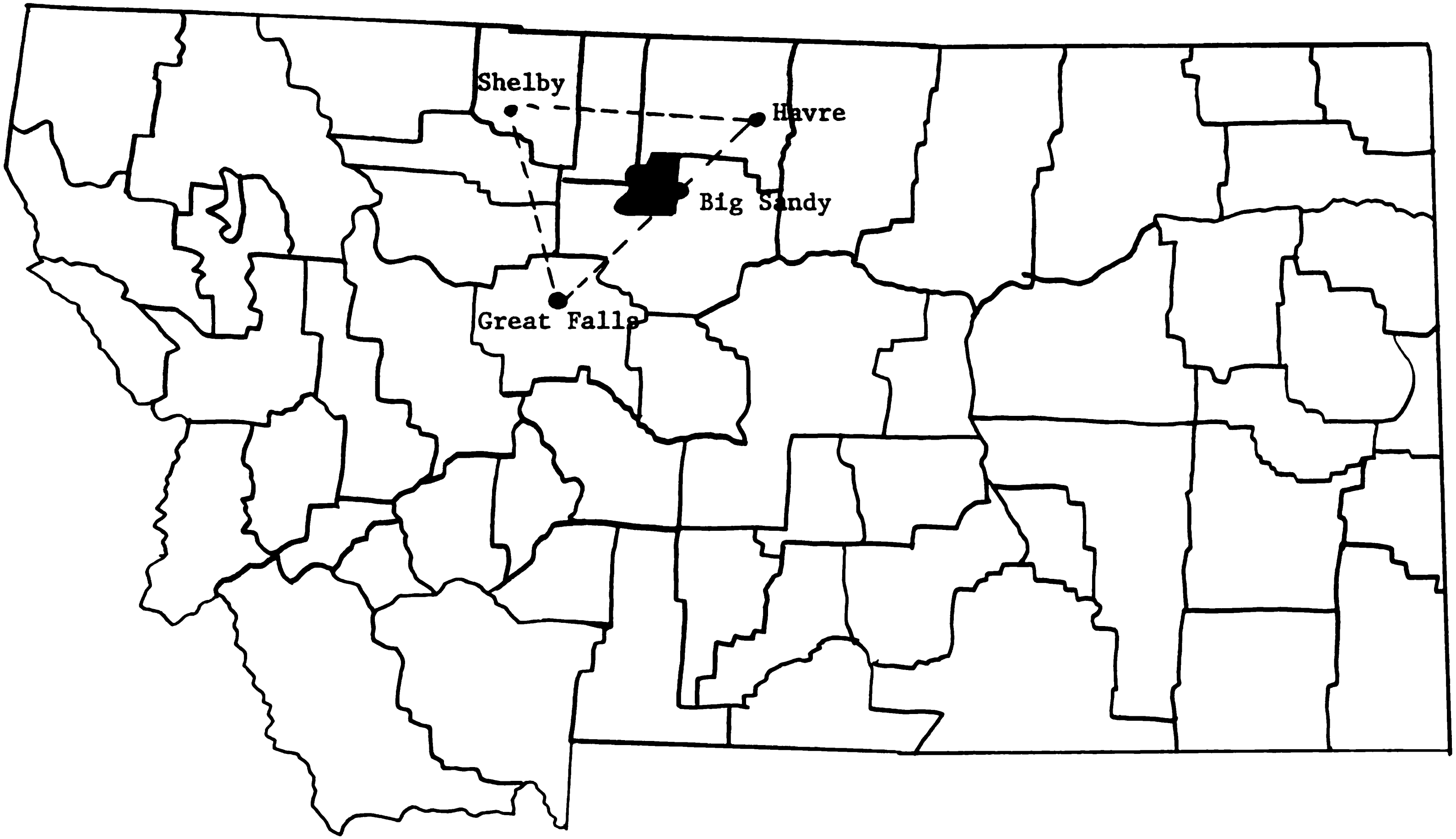

Fig. 1.--The "Triangle" Area of Montana and Community "G".

Soils

The soil of the area from which the study farms were selected is predominately the lighter-colored phase of the Scobey loams and Scobey sandy loams with a gently undulating relief. The Scobey loams are among the more important soils in the Triangle.[1] The soils generally have good tilth and water-holding capacity. However the lighter-colored phase particularly is greatly influenced by the amount and distribution of seasonal rainfall. The Scobey loams were homesteaded in tracts of 160 and 320 acres during the dry-land settlement era and most of the tillable land was broken prior to 1915. Many failures occurred during dry years and the prolonged drought of the 1930's caused considerable abandonment of farms in these soil areas. However with the return of wetter years, considerable consolidation of farms, and the adoption of new technology, these soils have proven to be profitable for the production of wheat and other small grains.

Soils of lesser importance in the area are Joplin loams and Phillips loams. These soils are slightly less productive than the Scobey soils but occur in only small amounts in the study area and have about the same topography i.e., gently undulating. In general the soils in the study area are considerably more homogeneous than other areas of similar size in the Triangle, which is one of the primary reasons it was selected.

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[1]L. F. Gieseker, Soils of Choteau County, Montana State College Agricultural Experiment Station Bulletin 252, Bozeman, Montana, 1931, p. 33.

Climatic Data

The 1941 Yearbook of Agriculture lists annual rainfall of 12.11 and 12.0 inches for Big Sandy and Kenilworth respectively.[1] These reporting stations are on the east-west edges of community "G". On the average two-thirds of this precipitation falls during the growing season. Although the winters are sometimes severe, the adoption of deep furrow drills and winter hardy varieties of wheat has made the area a very consistent and dependable winter wheat producer within the limitation imposed by the amount and seasonal distribution of rainfall.

The Research Techniques Used

Several methods were used in this study for obtaining and analyzing data.

Methods of Obtaining Data

The method of obtaining data relative to the cost-returns structures of different sized farms in the Triangle for this study was essentially the purposive sample. The procedure followed was to (1) select an area of uniform soils, topography, and yields, (2) stratify the population of farms found in this area according to acres of crop produced per farm, and (3) select three farms in each size grouping that were operated by a local resident with records available for the past three years which were open for detailed inspection and study, and that had no livestock.

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[1]U. S. Department of Agriculture, Climate and Man, Yearbook of Agriculture, Washington, D. C., United States Government Printing Office, 1941, pp. 955-966.

It was not intended that such a procedure would yield a random sample of Triangle wheat farms. It was believed, however, that such an approach would provide data useful in achieving the objectives of this study. The farms ultimately selected for the study were operated by men who were interested in such a study and willing to give freely of their time in providing data. As a result sixteen records were obtained for farms varying in size from 345 to 2460 acres of crop produced per year. The records obtained were quite detailed, each requiring several days of tabulation time.

A complete inventory of machinery and equipment was obtained. The farmer supplied the initial cost of each item, indicated the life of the machine and salvage value based on his method of operation, maintenance, and trading. After reviewing several years of operation, an expense statement was prepared which the farmer believed would most nearly typify the expenses associated with the production of a normal crop. Normal crop yields based on farmer records were obtained. When possible, the cost of machinery repairs and the fuel consumption rate for major machines and power units was obtained. However less than half the farms studied had records which were adequate for supplying such information.

Other samples were drawn from areas of the Triangle for obtaining information specifically on machinery capacity, both actual and desired. Interviews were conducted by telephone. Details regarding the selection of these samples and the interviewing process is included in Chapter V.

Methods of Analysis

The budget method, which is discussed in detail with theoretical and methodological considerations in Chapter II, was used to synthesize data collected from the sample of farms in the study area. Budget models representing least cost combinations of resources, designed to produce normal yields under existing technology, were developed for four sizes of farms. The budgets were reviewed by farmers and agricultural engineers, familiar with grain production in the area studied, to obtain the benefit of their judgment on the many technological relationships involved. The budget models were used as the basis for calculating average cost curves, total cost curves, payoff matrices for different strategies under various weather conditions, and returns under different assumptions regarding asset values.

Conventional marginal analysis was used in the construction of cost curves and in the consideration of economies associated with size of farms. This was later modified to include fixed asset theory for the analysis of returns to farms in the Triangle.

Alternative decision criteria in the form of mathematical algorithms were used to illustrate the selection of alternative land-machinery ratios. Payoff matrices were constructed from the budget models by the use of partial budgets.

A measure of machinery capacity from spring wheat farms in the Triangle was obtained and the sample was subjected to a statistical regression analysis. A similar procedure was used for a sample of winter wheat farms drawn from another area. Analysis of variance was used to make further statistical tests in comparing the spring wheat and winter wheat areas.

CHAPTER II

THEORETICAL AND METHODOLOGICAL PERSPECTIVE

The important theoretical underpinnings of this study include neo-classical marginal analysis, with special emphasis on cost curves, and a recent addition to neo-classical marginal analysis, fixed asset theory. While not in the same category as a theory, the budget or synthetic method was used to manipulate data in this thesis and is discussed in some detail in this chapter.

Budgeting or synthesis is used to combine data from various sources into units which can be later used for analytical purposes. In this thesis reference is made to these units as "budget models." Neo-classical marginal analysis is then used to construct cost curves, based on the budget models, for the purpose of evaluating returns to size. Fixed asset theory is then utilized in an analysis of returns to operator's labor and management for farms of different size in the Triangle. Each of these methodological and theoretical considerations is discussed in order in this chapter.

The Synthetic or Budget Method

The literal meaning of synthesis is to combine the relevant component parts into a whole. This is also the meaning of budgeting which involves planning a system for using or combining resources in order to produce economic goods and services. Synthesis, in a sense, is the opposite of analysis. According to the dictionary, analysis involves "a break-down of anything into constituent elements to distinguish its component parts separately or in relation to the whole." In another sense synthesis and analysis are complementary. As used in this thesis, synthesis provides a means of combining data into a model which represents the important input-output relationships of a farm. The model can then be subjected to analysis by delineating parts of the model which could not be identified from the original data.

Roth, an economist for the Bureau of Agricultural Economics in 1929, identified writings on budgeting in German literature dating back to 1663.[1] The rudiments of budgeting or synthesis were developed for use in the commutation of feudal tithes and dues from payments in kind to money payments. Writings on budgeting or "advance estimating" as it was called appeared in German literature through the years following 1663 in connection with valuation, appraisal, sale, leasing, and kindred subjects. Late in the 19th Century Von der Goltz and Aereboe, famous German economists, wrote extensively on budgeting and insisted on its use in advance of all management questions.[2]

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[1]Walter J. Roth, "Farm Budgeting in Germany", Journal of Farm Economics, Vol. XI, October, 1929, p. 623.

[2]Ibid., pp. 625-626.

The first writings in American agricultural economics literature on the subject of budgeting appear in Henry C. Taylor's book "Agricultural Economics" published in 1919.[1] In dealing with the question of securing information on which to base judgment on economic problems Taylor reviews farm bookkeeping, cost accounts, and statistical methods of obtaining information. He states that:

> "After all other methods have been exhausted the experimental method may have to be resorted to in order to secure some of the results desired. . ."[2]

However Taylor recognizes the limitations of the experimental method as he continues,

> "Experiments with a series of plots with varying treatment are valuable for ascertaining physical and biological truths, but it is doubtful if they are of use in the field of economics for the simple reason that while the laws of economics which determine the proper degree of intensity of culture are of general application, the conditions are so variable that the proper degree of intensity on one farm is not necessarily the proper degree on another.....It is highly desirable that a method of ascertaining the proper degree of intensity be taught but any attempt at teaching more than the principles involved and the methods of their application is folly. . . ."[3]

In his section on farm accounts[4] Taylor then discusses the analysis of accounts, including problems of valuation, opportunity costs and prorating fixed asset costs, which is essentially the synthetic or budgeting process although he never refers to it by either of these labels in this particular work.

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[1]Henry C. Taylor, Agricultural Economics, New York, The MacMillan Company, 1919, p. 405.

[2]Ibid., p. 407.

[3]Ibid., pp. 432-433.

[4]Ibid., p. 408

The synthetic method was discussed in Black's Production Economics, (1926) in which he called it the "method of substitution".[1] He defines the method as "estimating in advance the effect on total net income of the business of substituting possible new combinations of enterprises for the present combination."[2] Black points out that the substitution method requires cost data such as quantities of materials and supplies used and their prices, hours of man labor, machine labor used, time of year when operations are performed, yields, and selling prices and he suggests these data may come, at least partially, from cost accounts.

Holmes writes about the synthetic method (1928) calling it "the estimate method of cost analysis".[3] He states that the "estimate method" is designed to be put into operation by the farmer himself using data supplied by his records and professional investigators. He defines

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[1]John D. Black, Introduction to Production Economics, New York, Henry Holt and Company, 1926, p. 236.

[2]Ibid., p. 237.

[3]C. Holmes, Economics of Farm Organization and Management, New York City, New York, D. C. Heath and Company, 1928.

the process as:

> "a method which consists of the farmer's planning a production program in the light of his knowledge of productive resources and their possibilities in the productive processes, and in light of his knowledge of the alternative opportunities for the use of these factors in the various lines of production open to him. . . Instead of using figures obtained from some specific record, either from his own farm or another, which details the performance of a past period and possibly of a different set of circumstances, the farmer forms in his own mind an estimate of the results that he may obtain under a new set of circumstances involving his own production plant. . . ."[1]

In further discussion of the estimate method Holmes points out its requirements for application, its advantages, and he introduces the terminology "budget".[2]

He suggests that for any successful application the farmer needs: (1) technical knowledge of factor requirements of the various commodities which he may have in mind to produce, (2) a basis for forecasting purely physical results; that is the amount and kind of product which he may expect from the various alternative uses of his resources, (3) a well grounded forecast of prices of products and (4) a system of projecting the program "in a definite form in what we may call a farm budget." The advantages of this method, Holmes explains, are: (1) it is forward looking and dynamic, (2) it is motivated by economy, the maximum utilization of resources, and (3) it issues from the exercise of the functions of real entrepreneurship; that is, it is part and parcel with the art of productive farm organization.

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[1] *Ibid.*, p. 335.

[2] *Ibid.*, p. 336.

With this background of development over many years, the synthetic method has been applied to economic engineering data by later economic analysts in various types of cost studies. Some of the more important of these studies, which are related to economies of size, are reported in the next section.

Cost Curves

Any modern economic textbook may be referred to for background on the theoretical aspects of neo-classical marginal analysis.[1] However, the theoretical derivation of cost curves based on concepts of neo-classical marginal analysis, will be reviewed because of the special importance of cost curves in analyzing economies of size.

The traditional theoretical basis for analyzing cost economies is illustrated in Figure 2, using the average cost curves of the firm.[2] The short-run average cost curves (SAC) assume one or more resources to be fixed (a fixed "plant"), while other resources are variable; the long-run average cost curve (LAC) assumes all resources are variable (including those designated as "fixed" in the short-run).[3] In this study the

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[1]H. H. Liebhafsky, The Nature of Price Theory, Homewood, Illinois: The Dorsey Press, Inc., 1963 or George J. Stigler, The Theory of Price, New York: The MacMillan Company, 1962.

[2]Concepts of cost economies and economies of scale are discussed in detail in all modern textbooks on price theory. A monumental work on cost curves is Jacob Viner, "Cost Curves and Supply Curves", Zeitschrift für Nationalokonomies, Vol. III, 1932, pp. 23-46. Reprinted in Readings in Price Theory, eds., Kenneth Boulding and George Stigler, Homewood, Illinois, Richard D. Irwin, Inc., 1952, pp. 198-232.

[3]Although this is the usual textbook definition of the relationship between short-run and long-run average cost curves, there is a question of whether all factors can, in fact, be variable. This is discussed on pp.19-20 of this thesis.

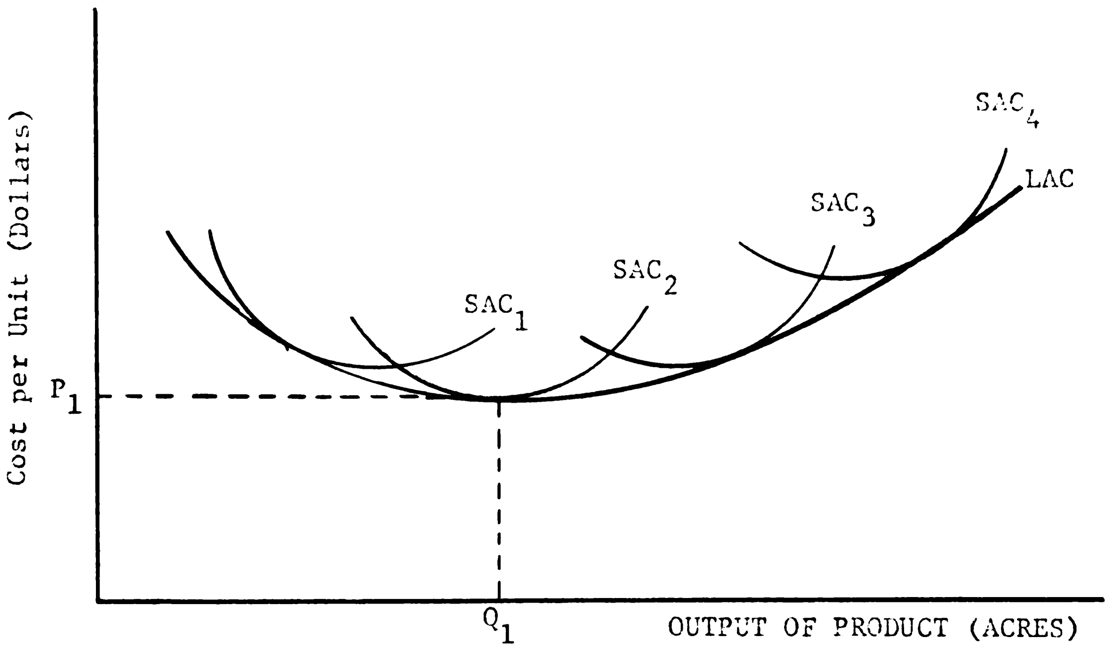

Fig.2.--Hypothetical Short-run and Long-run Average Cost Curves.

machinery component will be considered as the fixed factor for the short-run while land and other resources are variable. Thus SAC_1 represents a short-run average cost curve for a farm organized around a specified machinery component. The curve SAC_2 illustrates a short-run cost curve for a machinery component made up of larger and more pieces of equipment. Curves SAC_3 and SAC_4 have similar interpretations for still larger fixed machinery components. The short-run average cost curves have the typical "u" shape. Average costs decline with an initial expansion of output as fixed costs are spread over more units, eventually level off, and then begin to rise as other inputs must be added in increasing proportions to the fixed machinery component in order to achieve increasing output levels.

The LAC curve is an "envelope" formed as a tangency to the short-run cost curves. Thus it can be seen that the LAC curve theoretically represents the lowest cost per unit of production that can be achieved at any output. This assumes, of course, that machinery components can be supplied in indiscrete units, i. e., the machinery components are infinitely divisable. If this assumption is not met the LAC curve will not be a continuous locus of points.

In the long-run a farmer with sufficient funds could select any point on the LAC curve. From this standpoint the LAC curve is a planning curve and is important in explaining farm size and farm business survival.

It is important to note that once a position is selected on the LAC curve, i. e., a fixed machinery component is selected, the curve is no longer relevant for decision-making. The farmer is then restricted to the SAC curve which represents his given machinery component and expansion or contraction in output will follow the short-run curve. Figure 2 shows that SAC_2 results in the lowest cost per unit of production since this curve is tangent to the low point on the LAC curve. A farm organized with any other fixed machinery component will have higher costs.

In a competitive situation where returns per unit are forced to P_1, only farms operating with the optimum machinery component (represented by SAC_2), producing an output of Q_1 would stay in business, since all others have costs which exceed revenue and would be operating at losses. Of course if average unit returns are greater than P_1, farms with both larger and smaller machinery components than optimum could still operate profitably.

The short-run and long-run curves of Figure 2 represent the classical "textbook" relationships. Whether curves developed empirically for any industry or group of firms have this particular shape is subject to debate. Some argue that the LAC curve does not have a "u" shape because all inputs are variable in the long-run and therefore no reason exists for these curves to eventually turn up. Others argue that communications and organizational costs associated with large businesses are alone enough to explain eventually rising long-run average costs.

In approaching this problem and ultimately establishing a theoretical frame of reference for this thesis, assume the production function is homogeneous of the first degree. This means that a given production function has the property such that multiplying the quantities of all factors by a constant, will multiply output by the same constant. In other words doubling all factors will double output.

In this special case constant returns to scale and the traditional envelope curve would be a straight line parallel to the horizontal axis. If this case is thought of as a truism, it cannot, of course, be contradicted. However in the real world there are too many obvious contradictions to this assumption to make it valid. Friedman points out the parable of the fly, which, it is said, if the fly were reproduced accurately on a larger scale it would not be able to fly.[1] The problem is that it is not possible in reality to increase to scale all factors, which in the case of the fly includes the atmosphere, the strength of his body structure, velocity; and the force of gravity. By the same token firms operate within an environment of external factors which are impossible to reproduce to any given scale e.g., management, geography, and both product and factor markets.

As a result of not being able to reproduce all factors to scale, increasing or decreasing average costs may be found to exist in comparing sizes of firms even though most factors, the ones over which the firm has some control, are used in constant proportions. Increasing and decreasing costs resulting from the influence of factors over which the firm has only limited control gives rise to "economies of scale" and can be explained by the law of variable proportions.

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[1]Milton Friedman, Price Theory, A Provisional Text, Chicago: Aldine Publishing Company, 1962, p. 137.

In general economists agree that the expression "economies of scale" refers to changes in average cost per unit of production that are related to changes in the scale or size of the firm--and because of certain indivisibilities of factors it is plausible to expect decreasing costs for small levels of output which ultimately reach a minimum and then begin to increase as some factors become limiting in quantity or limiting because of technical inefficiencies. Friedman classifies those things which may affect cost conditions into three parts: (1) those that operate through explicit changes in the proportions among factors of production, the chief of which are prices (or conditions of supply) of factors of production; (2) those that operate through limiting the quantities of some factors of production available to the firm, and (3) those that produce indivisibilities.[1]

Although agreement on the general concept of economies of scale is perhaps not impossible it is much more difficult to achieve agreement on methods of measurement and the application of this concept in economic analysis.

One problem often encountered is confusion between economies of scale and economies of variable proportions. Although some economists insist economies of scale arise from changing firm size while holding input mixes constant, it has been shown that this is an unrealistic restriction. However at the other extreme if the input mix is allowed to change without any restriction while changing size, it may be argued

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[1] Ibid., p. 137.

that one is only comparing different firms rather than measuring differences associated with sizes of firms. It is doubtful, however, if this latter objection, which is largely academic, seriously impairs the validity of a long-run average cost curve which is constructed by letting factors vary in such a way that "minimum" unit costs are achieved for each level of output. Only if the type of product produced is allowed to change could the charge be supported that different firms are being compared.

A more important problem is in defining "minimum costs." Friedman points out that if one defines "minimum cost" in such a way that it is the firm's own interest to achieve it, then one would expect each firm to be organized in a minimum cost position.[1] The trouble with this approach is two-fold: (1) past mistakes can result in a firm being in a position where costs are not minimized, yet the firm is not able to correct the situation[2] and (2) non-monetary values associated with operating a firm oftentimes result in the entrepreneur consciously organizing production at unit cost levels which he knows are higher than necessary.[3] These difficulties may be met, in part, by rigidly specifying goals and objectives of entrepreneurs with regard to each set of cost data.

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[1]Ibid., p. 146.

[2]The theoretical aspects of this situation are discussed on p. 51.

[3]The problem of normative considerations on cost structure will be pointed out as the need arises throughout this thesis.

Following Friedman it is hypothesized that the best size of firm is really not one size at all but a distribution of sizes and that in general these sizes are distributed in an optimum way given the resources, alternatives, and ends of the individual entrepreneurs. The analysis of farm size in this study, then, will not be for the purpose of determining whether existing farms make mistakes in pursuing their own interests, but rather to determine why certain farms achieve specified sizes and resource allocations. This will be useful in predicting the response of farms to changes in circumstances relevant to the entrepreneur's interest and in guiding farm adjustments to meet specified ends. Although mistakes may have been made in the past by individual operators, the emphasis will be on explaining present resource allocation.

A long-run average cost curve suggests the levels of costs that may be expected from operating farms of various sizes when the farms are organized and operated as efficiently as possible. More technically it represents the locus of lowest average cost curves which may be achieved with various farm sizes. Such a curve is needed for intelligent planning for it shows the advantage or disadvantage for different sizes of farms.

Several methods have been used by research workers to estimate the economy of scale curve for specific types of plants and farms. R. G. Bressler has pointed out strengths and weaknesses of each of these methods which are summarized in the following paragraphs.[1]

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[1] R. G. Bressler, Jr., "Research Determination of Economies of Scale", Journal of Farm Economics, Vol. XXVII, May, 1945, pp. 526-539.

One method involves using a stratified random sampling technique. Average cost data are obtained from each firm which can be plotted on a scatter diagram. A regression line can be fitted to this scatter diagram which shows the average relationship between cost and size of firm. The main disadvantage of this method is that it confuses cost changes that result from the more complete utilization of a plant or farm of a given size with the cost changes that accompany changes in size. Each cost and volume point refers to a firm of some particular size and also with some portion of unused capacity. One would expect this problem to be especially serious in deriving an economy of scale curve for Triangle wheat farms. It is hypothesized that wide variations in excess capacity exist because of differences in farm entrepreneurs' willingness and financial ability to assume risk, and financial ability to operate with excess capacity because of personal preference and lack of knowledge.

Another possibility would be to derive an economy of scale curve based on a locus of lowest cost points (See Figure 3).

This approach would suffer from lack of observations and would undoubtedly produce results that had very limited statistical significance. This curve would lie below an average regression curve and would be a closer approximation to the true economy of scale curve than the average regression curve unless a heroic assumption is made that each firm in the sample is efficiently organized and operating at capacity.[1]

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[1]See page 32 of this thesis for further discussion of the so-called "regression fallacy."

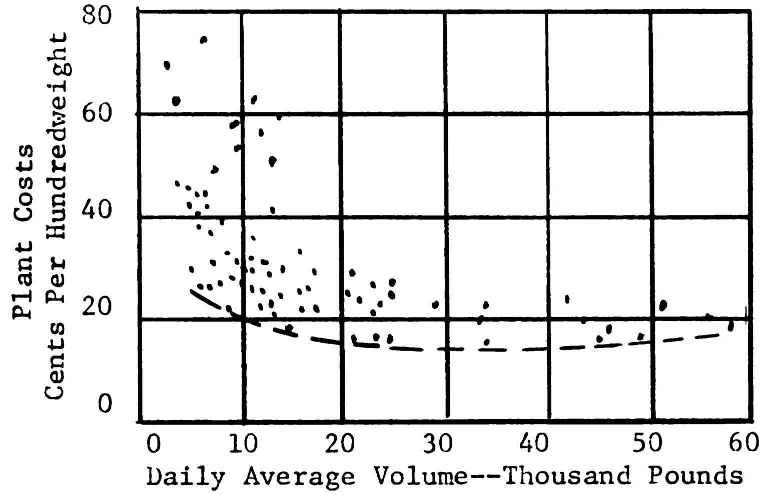

Fig. 3.--Scale Line Based on Locus of Lowest Cost Points.[a]

[a]Source: R. G. Bressler, Jr., "Research Determination of Economies of Scale", Journal of Farm Economics, Vol. XXVII, May, 1945, p. 528.

A third possibility of deriving an economy of scale curve from random data would be to separate out the excess capacity factor by adjusting each observation so as to represent full capacity. Assuming it is possible to define full capacity, average costs would be divided into fixed and variable costs and average cost would then be determined at full capacity. In Figure 4, output V represents some output less than full capacity whereas C represents full capacity. To make this transformation it is necessary to assume that variable costs remain constant as output is increased. This assumption is not implausible, at least for a given production range, and should result in a close estimate of the economy of scale curve. If variable costs per unit of output increase as size increases (marginal costs increase), as received theory generally suggests, then the economy of scale curve estimated by this method will be lower than the true economy of scale curve.

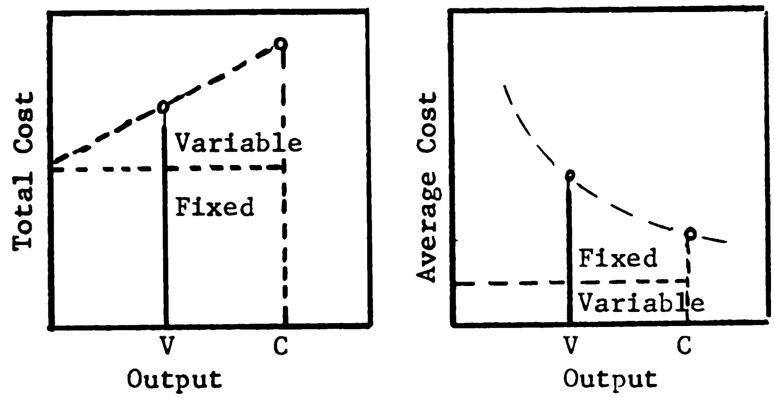

Fig. 4.--Projections of a Cost and Volume Situation to an Estimate of Costs at Full Capacity.[a]

[a]Source: R. G. Bressler, Jr., "Research Determination of Economies of Scale", Journal of Farm Economics, Vol. XXVII, May, 1945, p. 531.

The alternative to using random sampling and regression analysis is to use various forms of the synthetic approach. Fixed and variable costs are projected for various sizes of farm or plant based on known cost data and principles of physics and engineering. The chief disadvantage of this approach is that certain costs may be overlooked and changing cost structures, for example increasing or decreasing variable costs, may be ignored. This disadvantage can be at least partially overcome by careful work and by review of the work by persons thoroughly familiar with the technical operations. This approach has been used for many years in such fields as construction and is used as the basis for developing comparative farm budgets and the disposal activities for use in linear programming.

Bressler concludes the most direct approach to developing long-run average cost curves is to select a sample of plants or farms that are well organized and efficiently operated without excess capacity (other than that made unavoidable by seasonal factors). If this approach cannot be used he suggests using detailed analyses of cost-volume relationships for each of a small group of firms. Curves for each of these observations may be extended up to capacity volume through detailed analyses of the various items of cost and the effect of volume changes on these costs. As a last resort approximations to these curves may be synthesized completely following methods used by architects, engineers and contractors in projecting costs of construction, equipping, and operation of plants.

Positive and Normative Approaches

An estimate of cost curves can be made from the point of view of "what farmers do" or "what farmers ought to do". Heady has referred to this question as one of selecting the positive or the normative approach.[1] He argues that the two approaches provide major directions from which empirical estimates are approached. Whether one or the other approach is used should depend on the nature and purpose of the estimates. Each has its limitations and advantages for particular purposes and in respect to particular estimational objectives.

Heady points out that positive analysis has come to mean prediction of quantitative relationships among variables as they actually do exist at a point in time, or have existed over a period of time. Within the

[1]Earl O. Heady, "Uses and Concepts in Supply Analysis", Agricultural Supply Functions, Estimating Techniques and Interpretations, eds., Earl O. Heady, C. B. Baker, Howard G. Diesslin, Earl Kehrberg, and Sydney Staniforth; Ames, Iowa, Iowa State University Press, 1961, pp. 16-18.

limitations of technique, the positive analysis describes structure as it actually exists. In contrast, normative analysis refers to what ought to exist given certain restrictions and assumptions. As a predictive device it indicates what might be expected to happen if decision-makers possess certain goals and knowledge and are free from certain resource and institutional restraints. The major tools of positive analysis are regression procedures and projections which attempt to make predictions based on empirical data. The major tools for normative analysis are budgeting, linear programming, and judgment.[1]

From this it follows that one can, at least theoretically, derive short-run and long-run average cost curves normatively or positively. As discussed later (see page 33) the problem of deriving cost curves from the positive approach is that all firms are probably not operating at a point on their average short-run cost curve where it is tangent to the long-run average cost curve. Thus a strictly empirical estimate of LAC is unlikely to correctly estimate the parameter of a cost curve.

G. L. Johnson supports the case for "normative" estimates as follows:

> "The term 'normative'. . . . has unfortunately tended to become an approbrious epithet reserved in certain circles for <u>inaccurate</u> supply estimates while accurate estimates are labelled 'predictive' or 'positive'. This unfortunate distinction arises from the desire of positivists to avoid purposes or ends as being animistic, teleological and, hence, non-scientific (in their opinion). The use of this distinction implies that the behavior of producers can be accurately predicted without reference to desire for profit, liquidity

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[1] *Ibid.*, p. 16.

preference, desires for security as reflected in risk discounts, and the desires for income as reflected in willingness to make long chance investments which conditions the behavior of producers. . . It seems obvious that more accurate predictions of facts about supply decisions and responses must, generally speaking, be obtained in studies which take both values and beliefs into account than by non-normative studies."[1]

In the same article Johnson argues that the behavior of producers is in part a social phenomenon and that any serious analysis requires a complicated pluralism including, but not limited to, positivism. It is within this philosophic frame of reference that this study approaches the derivation of cost curves for Triangle wheat farms.

Review of Other Studies

At this point it should be helpful to review some important work by other research workers regarding the use of the synthetic method in estimating cost curves within the framework of neo-classical marginal analysis. In the following review of literature, problems reported by other researchers will be discussed and certain points mentioned in the previous theoretical discussion will be elaborated.

Reference has already been made to work by R. G. Bressler using economic-engineering synthesis methods relative to the development of

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[1] Glenn L. Johnson, "Budgeting and Engineering Analysis of Normative Supply Functions", Agricultural Supply Functions, Estimating Techniques and Interpretation, eds., Earl O. Heady, C. B. Baker, Howard G. Diesslin, Earl Kehrberg, and Sydney Staniforth, Ames, Iowa, Iowa State University Press, 1961, p. 170.

economy of scale curves for milk plants in the New England states.[1] This was followed by a study in which Fellows, et al., made application of techniques similar to those outlined by Bressler, to New England dairy farms.[2] Here the primary purpose was to determine the relationship between size of farm business and long-run costs where size of farm business was measured in terms of discrete units of labor input. Starting with the full-time owner-operator, quantities of land, equipment, buildings, livestock, supplies, and hired labor were combined under specified production practices and management skills to give full employment. Levels of production and unit costs were then calculated for this size of operation. Labor was added in full-time man increments to develop other sizes of dairy farms. One, two and three-man farm models were developed to appraise the influence of farm size on unit costs. Alternative combinations of resources were considered for each size of farm and a least-cost-point was determined for each farm size. A unit cost curve was estimated for each farm size and from this an envelope curve was derived.

Fellow's study concluded that one-man farms could achieve a unit cost level approximately equal to the level on farms of larger size

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[1]Bressler, op. cit.

[2]Irving F. Fellows, G. E. Frick, and S. B. Weeks, Production Efficiency on New England Dairy Farms, Storrs, Connecticut, Storrs Agricultural Experiment Station Bulletin 285, February, 1952.

when similar management efficiency is achieved. The farms on which the labor requirement was less than a full man-equivalent could not achieve a unit cost level similar to the larger farms unless labor and management returns to the operator and/or return to other owned resources were substantially below such returns to operators of larger farms. However scale economies were very small for farms larger than one man-equivalent under existing conditions of technology.

A later study in Michigan, however, suggests moderately increasing returns to size for units employing up to nine full-time man-equivalents.[1] In this study, size was measured in terms of cows milked with a range from 30 to 360.

B. C. French, et al., made a very comprehensive study of pear packing plants in California in 1956 in which techniques from the field of economics, accounting, and engineering were used.[2] In connection with this study a theoretical framework for studies of plant costs and efficiency was developed. Elaboration and modification of conventional theory, which is of special importance to this study, stresses the discontinuity of cost functions rather than continuous functions. This condition arises primarily due to the discrete nature of many inputs and leads to contradictions of the profit-maximizing conditions (marginal

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[1]Earl I. Fuller,"Some Michigan Dairy Farm Organizations Designed to Use Labor Efficiently", Unpublished Master's Thesis, Michigan State University, 1957.

[2]B. C. French, L. L. Sammet, and R. G. Bressler, "Economic Efficiency In Plant Operations With Special Reference to the Marketing of California Pears", Hilgardia, 24:663, Berkeley, California, California Agricultural Experiment Station, July, 1956.

cost equal to marginal revenue) of conventional theory.

Carter and Dean made a study of cost-size relationships for cash crop farms in California in 1960 and estimated long-run planning curves by budgeting, linear programming, and regression analysis.[1] In evaluating the three methods the authors place most confidence in the scale curve developed via linear programming. They placed very little confidence in the curve derived by regression analysis which was considerably higher than the other curves. Factors such as inefficient technology, inefficient input combinations, risk considerations, and managerial capacity were believed to be important in causing many farms to operate above minimum cost positions. They noted also that the regression curve was quite volatile, depending importantly on the deletion or inclusion of a single "questionable" farm observation and lack of enough large farm observations prevented improvement of reliability in the regression analysis. These problems lead to what is generally referred to as the "regression fallacy".[2] That is, because of the above consideration and others, farmers operate at points above minimum average cost and a regression line fitted to a scatter of average cost observations passes through these points and gives a cost curve which lies above the "true" envelope curve.

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[1]H. O. Carter and G. W. Dean, "Cost-Size Relationships for Cash Crop Farms in a Highly Commercialized Agriculture", Journal of Farm Economics, Vol. XLIII, May, 1961, pp. 264-277.

[2]George J. Stigler, The Theory of Price, New York, MacMillan Company, rev. ed., 1952, pp. 143-144.

This situation is depicted graphically in Figure 5. The dotted line REC, represents the regression-estimated long-run cost curve. The curves SAC, short-run average cost, and LAC, long-run average cost, represent parameters of an industry's cost structure. That REC does not adequately estimate LAC is explained by the fact that individual firms are not necessarily operating at points where SAC curves are tangent to the LAC curve for reasons mentioned previously. The scale curve derived from budgeting is very similar to the one derived from the linear programming. The advantage of using linear programming over budgeting is that it may achieve optimum cropping systems at each level of output if the proper data and tableau are used. The authors contend this would result in a scale curve which would most nearly estimate that particular cost parameter. The results of this study clearly indicate that unit costs decline as farm size increases and that cost economies, therefore, are one reason for the present trend toward consolidation and expansion of farms. However the analysis does not indicate any strong cost incentive for expansion to extremely large size. Farms of about 750-900 acres appear able to compete on a unit cost basis with much larger farms.

In a paper prepared for the North Central Farm Management Research Committee, Earl O. Heady reviewed budgeting and linear programming as methods of estimating cost relationships.[1] Several methods of using

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[1]Earl O. Heady, Glenn L. Johnson, Lowell S. Hardin, eds., Resource Productivity, Returns to Scale, and Farm Size, Ames, Iowa: Iowa State University Press, 1956, pp. 65-81.

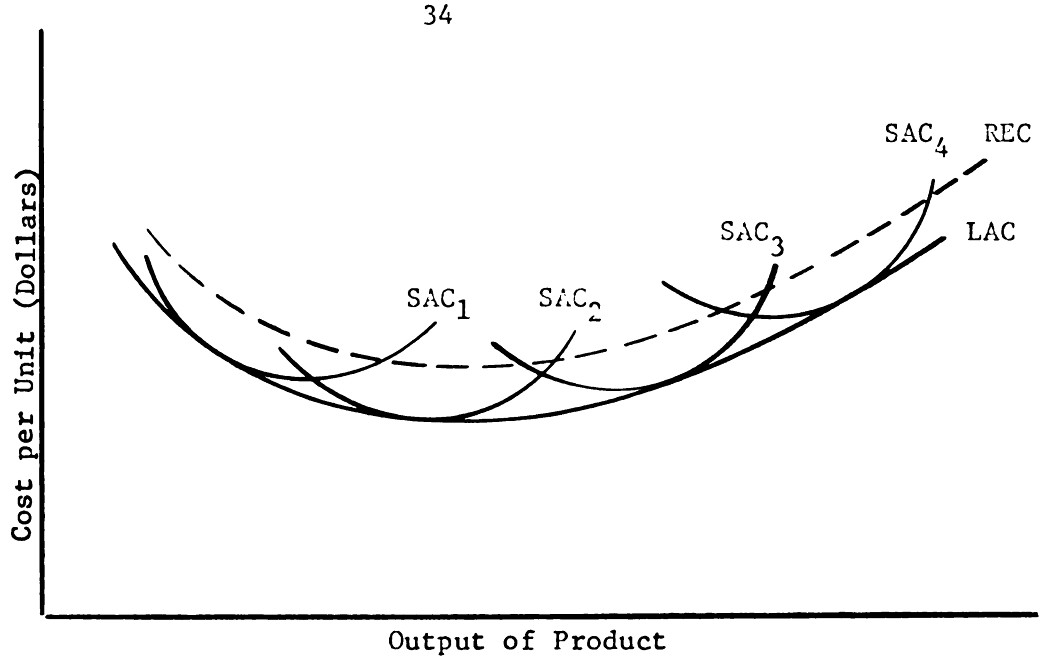

Fig. 5.—Relationship Between Regression Estimated Long-run Average Cost Curve and True Long-run Average Cost Curve.

budgets and budget equations are summarized and compared with methods of regression analysis. Heady concludes that even though regression-estimated long-run average cost curves lie above the true long-run cost curve the slopes are likely to be the same and the minimum points, although at different levels, will both indicate the same output of product.

A section of the American Farm Economics Association Annual Meeting in 1961 was devoted to a series of papers on various aspects of economies of scale in agricultural production. In the lead-off paper J. Edwin Faris discussed the types of economies that may be encountered in crop farming, i.e., (1) those arising from technical relationships, (2) those arising from the acquisition of inputs, and (3) those arising from vertical integration of the farming operation.[1] The effect of these three

[1]J. Edwin Faris, "Economies of Scale in Crop Production", Journal of Farm Economics, Vol. XLIII, December, 1961, pp. 1219-1226.

types of economies on the long-run average cost curve are summarized in Figure 6.

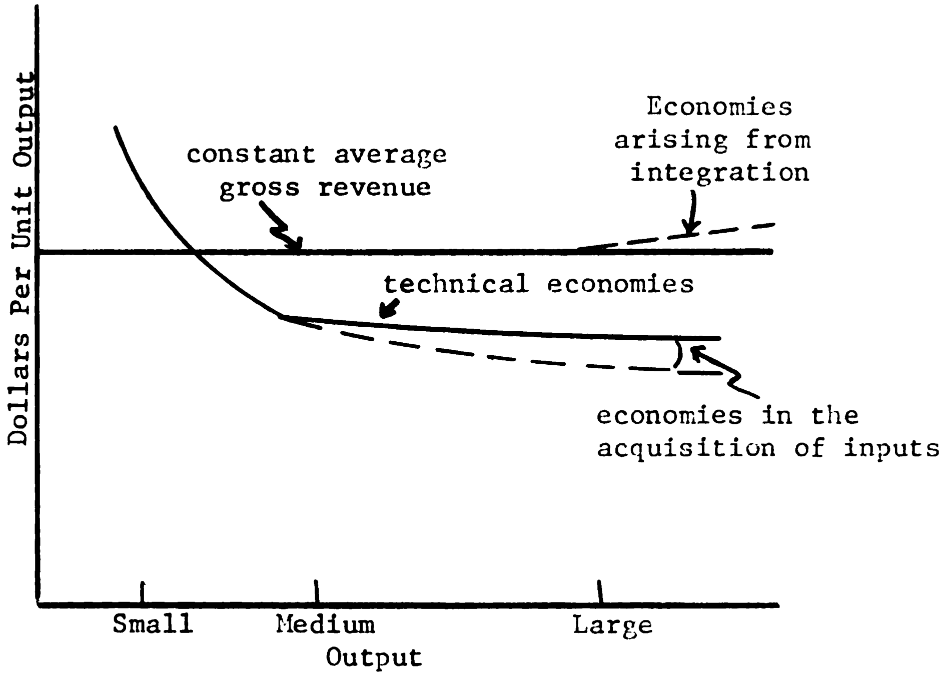

Fig. 6.—Possible Economies Associated with Size.[a]

[a]Source: J. Edwin Faris, "Economies of Scale in Crop Production", Journal of Farm Economics, Vol. XLIII, December, 1961, p. 1225.

As Faris points out, Figure 6 has been hypothetically constructed to show the relevant relationships that might exist as the farm operation increases in size. Technical economies are assumed to reduce the cost curve very little after medium-sized farms are achieved. It is hypothesized, however, that additional economies can be gained by larger farms in the acquisition of inputs. Special volume rates for fuel, chemicals, seed and other supplies, along with lower interest rates for borrowed capital and lower custom rates for large acreages, are known to exist in the agricultural industry and consequently provide strong support for this hypothesis. Economies arising from integration are likewise assumed to accrue to large farms. This may result in average revenue curve sloping upward to the right as increasing opportunities for integrated marketing activities of farm products are accrued.

A 1962 study by Heady and Krenz tested the hypothesis that recent machine technology, viz., the development of four and six-row corn planting and cultivating equipment and picker-sheller harvesting machines, would cause important increases in farm size.[1] Cost functions were estimated by budgeting methods and cost curves were derived as a function of acreage per farm. Losses in crop production resulting from untimely field operations were considered as costs for different acreages. The results, assuming normal weather and current cropping methods, indicated that cost advantages for the large equipment were small relative to the more standard sizes, so small that the savings alone were unlikely to cause the establishment of larger farms. This study concluded that minimum per-unit production costs (per dollar of product) are obtained on farms from 600 to 680 acres in the area investigated and under a given set of assumptions relative to cropping practices. However, the reduction in per-unit cost was found to be very small as acreage was extended from 400 to 800 crop acres. The results of this study conform with others, which indicate an extensive relatively flat segment of the long-run average cost curve exists after initial scale economies are accounted for. Cost functions in this study were calculated on the basis of a charge for all labor, whether hired or provided

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[1]Earl O. Heady and Ronald D. Krenz, Farm Size and Cost Relationships in Relation to Recent Machine Technology, Ames, Iowa, Iowa State University Research Bulletin 504, May, 1962.

by the family. It was pointed out that on small farms most of the labor is supplied by the family which, in many cases, has a low opportunity cost. Also in this study several game theoretic criteria were applied in the examination of optimum farm size under uncertainty. When these techniques were applied to decision-making it was found that a larger machinery investment proved optimal.

Armstrong and Faris used an economic engineering technique to synthesize costs of crop-farm production in the Southern San Joaquin Valley of California.[1] Special emphasis was given to investigating the machinery input for various sizes of farms as it relates to economies of size. It presents basic data on machinery performance, rates, costs and combinations. Data were reported in such a manner that adjustments could be made for use in other areas with a minimum of effort. Curves were constructed which indicated the technical economies associated with machinery. These curves were based on least-cost machinery combinations selected through the use of linear programming models. The annual machinery costs per acre for 80-acre farms were more than double the annual costs for the 3,200-acre farm units. However, the authors point out, most of the technical economies associated with machinery are obtained by 1,280-acre farm units. Technical economies, for all practical purposes, were found to be virtually non-existant beyond this farm size.

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[1]David S. Armstrong and J. Edwin Faris, Farm Machinery--Costs, Performance Rates, and Combinations--Southern San Joaquin Valley, California Berkeley, California, Giannini Foundation Research Report No. 273, March, 1964.

Another recent Iowa study shows rapidly declining per unit costs as acreage is increased, reaching a minimum at approximately 320-crop acres.[1] This study also indicated most of the economies were achieved by farms of 196 to 232 crop acres. A special feature of this study was to consider the place of custom operations on small farms which, it was found, reduced per unit costs significantly below similar sized farms owning a complete line of machinery.

Conceptual Problems Relative To Cost Analysis

In addition to problems of measurement there are conceptual difficulties associated with cost analysis. The discussion which follows points out some of these difficulties and explains the methods used in this thesis for handling them.

Many different procedures have been used to classify costs. In general two alternatives appear to be useful. Looking forward one can conceive of defining total costs for various levels of output as the summation of the costs of all resources used, based on the highest alternative use of each resource. Conceived in this way total costs do not need to be equal to either anticipated total revenue (ex ante) or actual total revenue (ex post).

In considering ex post costs and ex post receipts, the other alternative, it may be better to define costs and receipts as being equal.

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[1] Loren Ihnen and Earl O. Heady, Cost Functions in Relation to Farm Size and Machinery Technology in Southern Iowa, Ames, Iowa, Iowa State University Research Bulletin 527, May, 1964.

Such definition insures that the total value of production is allocated to some factor of production. Following such a definition costs can be classified as contractual and non-contractual.[1] Contractual costs depend on what the firm does but not on how its actions turn out. They represent hired resources that can be used in production or sold or leased to other firms. Non-contractual costs are payments to the other factors of production, i. e., resources which are unique to the specified firm such as fixed assets, entrepreneurial capacity, and good will. Non-contractual costs can never be known in advance. They are determined by the outcome of the actions of the firm and are subject to mistakes, windfall gains, and other uncertainties. They can, however, be further classified as expected and unexpected returns. Expected non-contractual costs or returns are frequently called "rent" or "quasi-rent" which is also defined as a price determined cost resulting from the inelasticity of supply of certain inputs.[2] The difference between expected and actual non-contractual costs, according to Friedman, is "profit" or "pure profit" which is an unanticipated residual arising out of uncertainty.

Other research workers have struggled with conceptual problems of cost analysis in different ways. In a recent journal article M. L. Upchurch discusses certain difficulties in assembling cost data.[3] He points out that operator and family labor, including management and

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[1]Friedman, op. cit., p. 144.

[2]H. H. Liebhafsky, The Nature of Price Theory, Homewood, Illinois, The Dorsey Press, Inc., 1963, p. 356.

[3]M. L. Upchurch, "Implications of Economies of Scale", Journal of Farm Economics, Vol. XLIII, December, 1961, pp. 1239-46.

entrepreneurial capacity, is often handled in one of three ways:

1. It is left as a residual claimant after distributing gross income to all other factors. According to Upchurch, this biases our notions of economies of scale toward the size of enterprise which maximizes the use of operator labor.

2. It is calculated as a fixed cost against the business which makes unit costs look high for small businesses. This, Upchurch argues, results in an excessive charge against production when the labor of the farm operator is underemployed.

3. Occasionally operator labor is charged as a variable cost to the business. In other words, the business is charged at some predetermined rate only with the operator labor actually used in production.

Upchurch correctly concludes that such variability in handling costs results in poor information for national studies and planning purposes. He continues with the statement:

> "In addition to the problem of handling returns to operators for labor, capital, and management, we have experienced difficulty with pricing the relatively fixed capital investments in the farm business. Investment in machinery looms large on most farms. . . How do we price it in our accounting techniques to reflect truly the economies of scale?"[1]

In summarizing his paper, Upchurch concludes studies should be coordinated so uniform procedures could be used for "costing" in order that we may learn more about the implication of economies of scale in

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[1]*Ibid.*, p. 1240.

studying national agricultural adjustment.[1]

Upchurch recognizes the need for uniform procedures but falls short of suggesting what they should be. In this respect, it would appear a recent extension to traditional marginal analysis may help to bridge the gap. The next section briefly examines this new extension of theory.

Review of Fixed Asset Theory[2]

Fixed asset theory is based on the premise that the acquisition cost of a production factor differs from the salvage value of that production factor. The acquisition price for an input is that price which the firm has paid or would have to pay to get a unit of the input, including transportation and delivery costs, to the location of the firm. Salvage value is the price the firm receives or could receive if it sold the unit or input to the highest bidder rather than use it in production.

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[1] Ibid., p. 1246.

[2] Fixed asset theory is basically an addition to neo-classical marginal analysis in which the assumption that acquisition costs and salvage values of production factors are equal is relaxed. The theory was utilized originally in a publication by Glenn L. Johnson and Lowell S. Hardin, Economics of Forage Evaluation, Lafayette, Indiana, Agricultural Experiment Station Bulletin 623, April, 1955. Mathematical exposition of the theory is contained in Clark Edwards, "Resource Fixity, Credit Availability and Agricultural Organization", Unpublished Ph.D Thesis, Michigan State University, 1958. Clark Edwards, "Resource Fixity and Farm Organization", Journal of Farm Economics, Vol. XLI, November, 1959, pp. 747-759. Other publications on asset fixity include Glenn L. Johnson, "Some Basic Problems for Economists and Statisticians Arising from U. S. Agricultural Policies", Manchester Statistical Society, November, 1959, pp. 1f; Glenn L. Johnson, "Implications of the IMS for Study of Responses to Price", A Study of Managerial Processes of Midwestern Farmers, edited by Glenn L. Johnson, et al., Ames, Iowa, Iowa State University Press, 1961, pp. 151-169. Bob F. Jones, "Farm-Nonfarm Labor Flows, 1917-62, with Emphasis on Recent Manpower and Credit Programs", Unpublished Ph.D Thesis, Michigan State University, 1964; and Dale E. Hathaway, Government and Agriculture, New York, The MacMillan Company, 1963.

The essential contribution of fixed asset theory to neo-classical marginal analysis is illustrated in Figure 7. Neo-classical theory assumed the entrepreneur could buy or sell units of input at acquisition price. Thus a drop in the price of the product, which would cause the marginal value product to shift from MVP_1 to MVP_2, would result in cutting back the use of the input to x_2. According to fixed asset theory, which recognizes a difference between acquisition and salvage prices of inputs, such as shift in marginal value productivity of an input may lead to a different conclusion regarding the use of the input. In fact according to the illustration in Figure 7, such a decline in marginal value productivity would lead to no change in input use.

The concept of a fixed asset is also illustrated in Figure 7. An asset is defined as fixed when it does not pay to acquire more of the asset or to dispose of the asset. A shift in marginal productivity of the factor from MVP_1 to MVP_2 does not change the use of the factor since, at the quantity x_1, the marginal value product of the factor exceeds its salvage value. Therefore it does not pay to sell the factor nor does it pay to acquire more of it. The price of the product would have to decline enough to shift the marginal value productivity curve below that indicated by MVP_3 before the firm would find it profitable to start selling units of the input at salvage value.

A more useful model involves the use of several inputs. Such a model will also have greater predictive power for Triangle dry-land farms. The model is constructed as follows:

$$y = f\ (x_1,x_2,x_3)$$

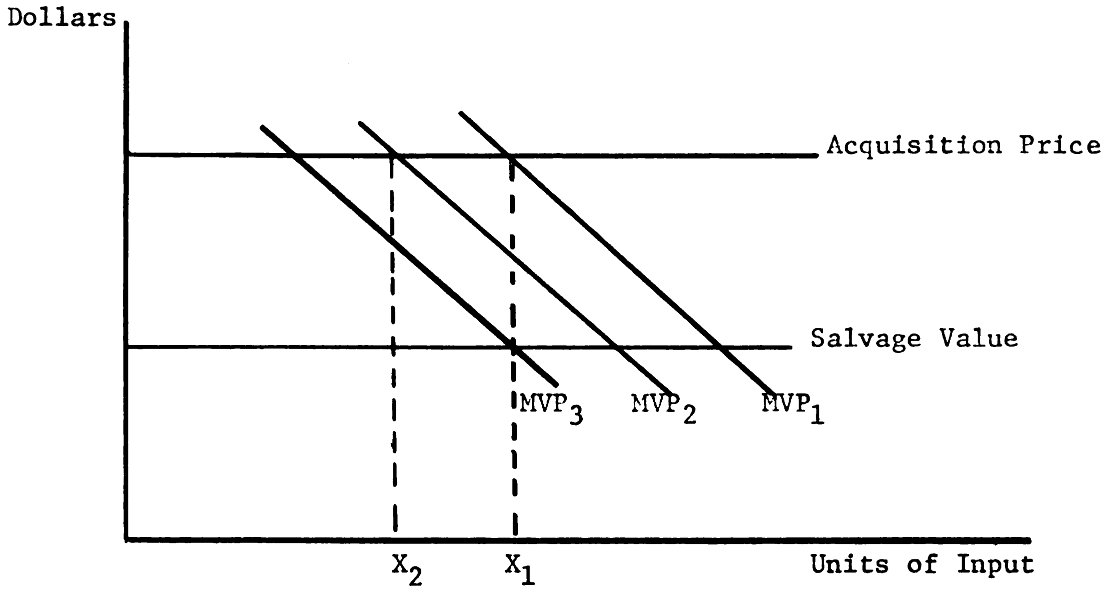

Fig. 7.--Change in Input Use Resulting from a Change in Product Price.

Where: y is production of undifferentiated small grain.

x_1 is undifferentiated dry farm land.

x_2 is undifferentiated machinery investment.

x_3 is a fixed commitment of the entrepreneur's labor and management.[1] It is assumed the marginal value productivity of x_3 exceeds its salvage value and is less than the acquisition cost of another laborer-manager. Therefore it fits the previous definition of a fixed resource. By specifying that x_3 is fixed we may be assured of the working of the law of diminishing returns and production functions with traditionally formed curves for x_1 and x_2.

This model is concerned with resource flow into and out of a single product firm. Wheat and barley can be treated as a single product since the costs of production for the two crops are virtually equal and the combinations in which they are grown are specified by government policy.

If it is assumed the parameters of the production functions for x_1 and x_2 are known and the quantity of x_3 is given, one can employ another analytical tool, a value-product map, for the two inputs. A value-product map is illustrated in Figure 8 for x_1 and x_2.

The curves y_1 and y_2 are iso-value-product curves each of which represent different levels of production. Each curve represents a locus of points which indicate various combinations of x_1 and x_2 required to produce a specified level of output, given a fixed amount of x_3.

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[1]The cost of this human factor to the farm has been defined by Chennareddy Venkareddy as the present value of the expected future income stream of the individual. The present value of income streams for the remaining years of life for persons in farming, manufacturing, construction, laundries, and retail trade were constructed for both 25 and 45-year old workers. See Chennareddy Venkareddy, "Present Values of Expected Future Income Streams and Their Relevance to Mobility of Farm Workers to the Non-farm Sector in the United States, 1917-62", East Lansing, Michigan, Unpublished Ph.D Thesis, Michigan State University, pp. 22, 170 and 181.

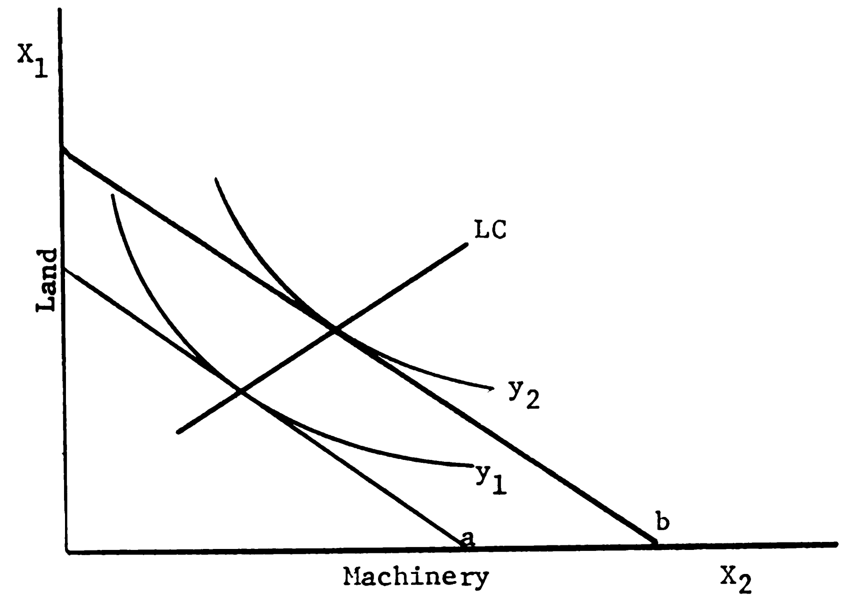

Fig. 8.--Illustration of Iso-Cost Curves, Iso-Value-Product Curves and Line of Least-Cost-Combinations.

The line LC represents a locus of least cost points for various levels of output and is derived from the equation:

$$\frac{MVP_{x_1}}{P_{x_1}} = \frac{MVP_{x_2}}{P_{x_2}} \qquad (1)$$

Where: MVP_{x_1} is the marginal value product of x_1.

MVP_{x_2} is the marginal value product of x_2.

P_{x_1} is the price of x_1.

P_{x_2} is the price of x_2.

Lines a and b in Figure 8 are iso-cost lines which represent different cost outlays given a specified relationship between P_{x_1} and P_{x_2}. The tangency of iso-cost lines, a and b, and iso-value-product lines, y_1 and y_2, is a graphic method of presenting equation (1) above.

A unique point on the line LC, Figure 8, can be obtained by setting equation (1) equal to 1 and solving. This point is generally referred to as the "high profit point" and insures maximum returns from using variable factors x_1 and x_2.

It should be noted that the slope of lines a and b depend on the ratio of prices for factors x_1 and x_2. As previously discussed, fixed asset theory is based on the premise that acquisition prices and salvage values for certain assets are not equal.

If the usual assumption is made, that salvage prices are less than acquisition prices, it follows that a given capital outlay will purchase more x_1 and x_2 at salvage prices than at acquisition prices. Line a, Figure 9, represents an iso-cost curve for x_1 and x_2 valued at acquisition prices and line b represents an iso-cost curve for x_1 and x_2

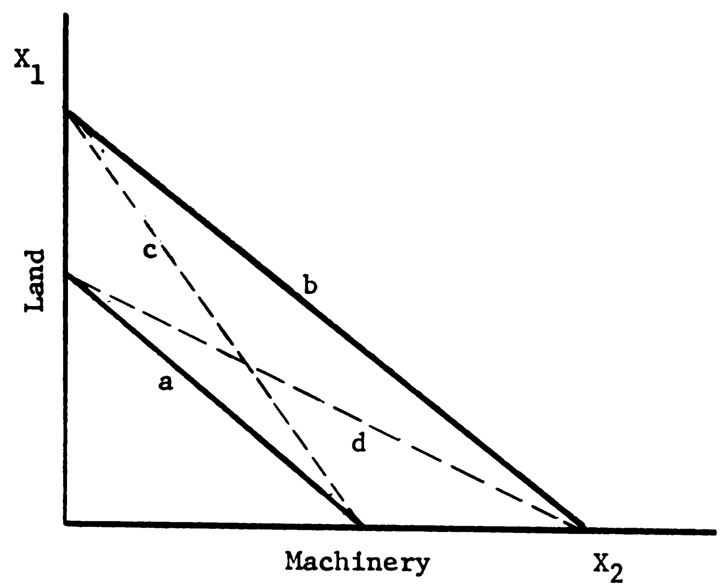

Fig. 9.—Iso-Cost Curves Representing a Constant Capital Outlay for Land and Machinery Using Different Assumptions Regarding Acquisition Prices and/or Salvage Values.

valued at salvage. The fact that these lines are parallel suggests salvage value and acquisition price ratios are equal, a condition which is not necessary to the argument.

Line c, Figure 9, represents an iso-cost curve for x_1 priced at salvage value and x_2 priced at acquisition cost. Line d is an iso-cost curve with these relationships reversed. Iso-cost curves now represent three different slopes and it becomes clear that the use of such iso-cost curves, given a certain value-product map, will yield three different least-cost-combination lines. Normally four least-cost-combination lines are shown in explanations of fixed asset theory but this presupposes the ratio for costs of x_1 and x_2 at acquisition prices is different from the ratio for costs of x_1 and x_2 at salvage values. If there is a difference between land and machinery price ratios at salvage and acquisition, it is not known whether the difference is positive or negative. Therefore it seems better to assume there will be no difference and that the iso-cost curves have the same slope for either asset pricing alternative.

We can now consider the three least-cost-combination lines, derived in the same manner as suggested in Figure 8. By using iso-cost curves of three different slopes on a given value-product map we would expect to derive three unique least-cost-combination lines as illustrated in Figure 10. The exact shape of these lines will depend on the shape of the value-product surface and the slope of each respective iso-cost line.

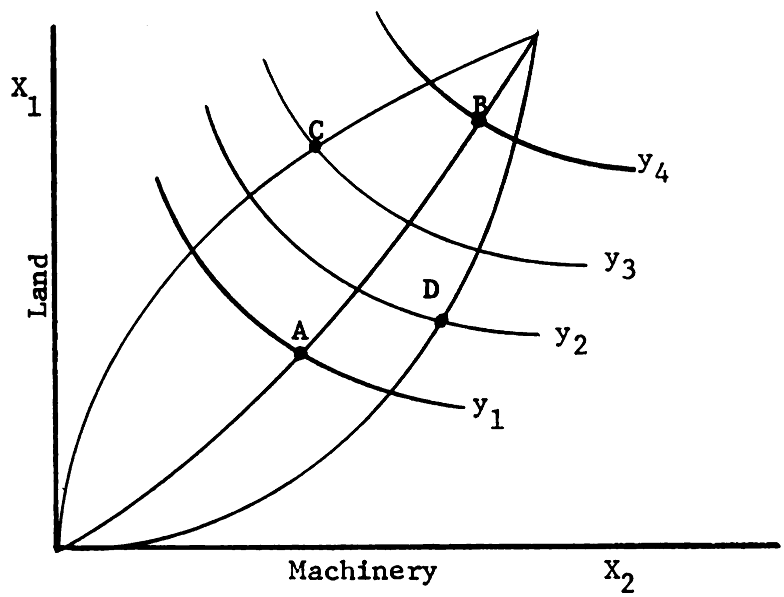

Fig. 10.—Least-Cost-Combination Lines and High-Profit Points, for a given Value-Product Map assuming Acquisition Cost Exceeds Salvage Value.

As mentioned earlier high profit points can be derived for each least-cost-combination line. The high profit point will be lower when assets are priced at acquisition cost, point A, than when they are priced at salvage value, point B, if salvage values are less than acquisition prices.[1] This is a result of lower factor prices leading to greater use of those factors and consequently greater production. It also follows that when one factor is priced at salvage value and the other is priced at acquisition cost the resulting high profit points will lie between the production level implied when both assets are valued at salvage and when both assets are priced at acquisition. Production levels are designated by iso-value-product curves y_1, y_2, y_3, and y_4 in Figure 10.

By joining points A, B, C, and D as shown in Figure 11 it is possible to illustrate profitable use of these resources under specified conditions. In order to minimize confusion the least-cost-combination lines and iso-value-product curves, except for y_1, have been omitted from Figure 11.

Line e, in Figure 11, can be explained as a locus of points where the marginal value product of x_1 is equal to the salvage value of x_1. Recall that high profit points are derived by setting equation (1), page 45, equal to 1 and solving. This procedure results in equating the

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[1]It may be argued that only point A, Figure 10, is a high profit point since assets are acquired only at acquisition cost. The other points B, C, and D would then be considered loss minimization points since each of these positions imply valuing at least one factor at salvage price. See page 51 for further elaboration.

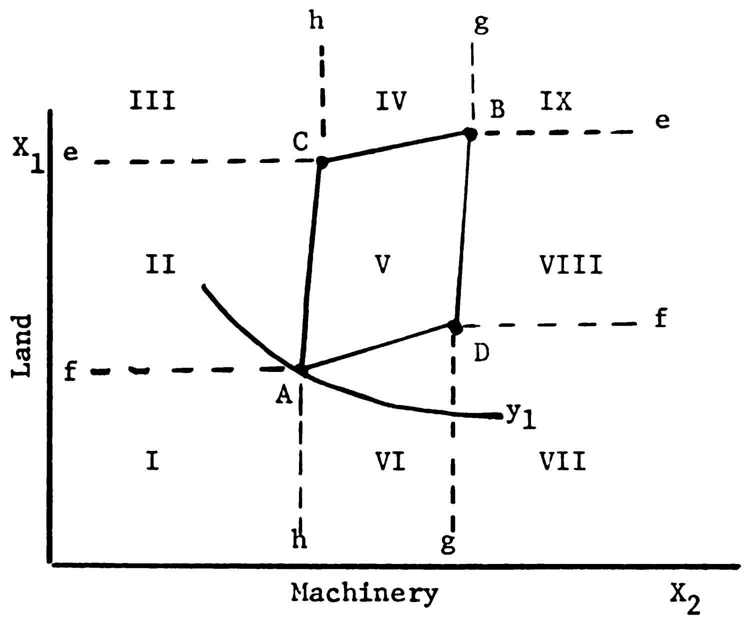

Fig. 11.--Most Profitable Level of Input Use When Acquisition Cost Exceeds Salvage Value.

marginal value product of each factor with its respective price. A line, such as the solid portion of e, joining two high profit points in which salvage value for x_1 is used, approximates this equality for other points on the value-product map. The broken lines are simply extensions of the solid line which approximate the equality of marginal value product to factor price across the value-product map. Line f can be explained in a similar manner. It represents a locus of points where the marginal value product of x_1 is equal to the acquisition price of x_1. Lines g and h bear the same respective relationship to x_2 with regard to the marginal value product of x_2 and salvage and acquisition prices of x_2.

The usefulness of the model for explaining actions of farm entrepreneurs, organized at different positions on the value-product map, now becomes apparent. For example, a farm organized in region I, but not at point A, would find it advantageous to acquire more of both land and machinery since the marginal value product of both factors exceed their acquisition prices. In the ex-ante sense, assuming perfect knowledge, the entrepreneur would acquire x_1 and x_2 until he achieved the position, with respect to these resources, designated in Figure 11 as point A. In this position it would not pay him to acquire more of x_1 or x_2 nor would it be profitable for him to sell any of these factors. By moving to point A, production would be increased, assuming constant price levels, since a higher iso-value-product curve would be achieved.

Point A in Figure 11 has another special significance. If it is assumed the rest of the economy is organized so that the effective prices of all resources are equal to their respective marginal value productivities, then it follows that the agricultural resources x_1 and x_2 are earning a return equal to similar resources elsewhere. At any other point on the value-product map the marginal value product of either x_1 or x_2 or both will differ from the acquisition price for these inputs. The significance of these differences can be illustrated by briefly discussing areas designed I through IX.

The economic pressures on a farm organized in Area I have already been discussed. In the attempt to maximize returns such a farm would try to move to point A by acquiring more x_1 and x_2.

For a farm organized in area II, the profit motivated economic solution would be different. The marginal value product for x_1 for such a firm would be between the acquisition and salvage price. In other words it would not pay to acquire more of the resource nor would it pay to sell any of it. It would be "fixed" to the firm and not subject to any adjustment. It would, however, pay such a firm to acquire more of factor x_2 since, in this area, the marginal value product of x_2 is greater than the acquisition price of the factor. The best adjustment in this case would be horizontally to the solid portion of line h. At this point no further adjustment could improve the economic position of the firm.

Similar analysis suggests a farm organized in area III would sell units of factor x_1 until the marginal value product of x_1 became equal to the salvage value of x_1. Meanwhile such a farm would acquire additional units of x_2 bringing it into equilibrium at point C, Figure 11. Farms organized in area IV would attempt to dispose of x_1 while holding x_2 constant. Only in area IX would it be profitable to dispose of both

x_1 and x_2.

It is of special interest that firms organized in area V would find no adjustment of x_1 and x_2 profitable. At any point in area V it is unprofitable to acquire more of either x_1, or x_2 nor is it profitable to dispose of either factor. This situation leads to an equilibrium <u>area</u>, with respect to x_1 and x_2, rather than an equilibrium <u>point</u>. This phenomenon can be attributed to the fact that a difference exists between acquisition cost and salvage value for inputs x_1 and x_2.

The iso-value-product curve y_1, Figure 11, is of interest because it indicates that many agricultural adjustments of an individual firm may lead to greater output than would be considered desirable from the standpoint of factor, product, price adjustment using acquisition prices. For example, a farm may be organized at a point on curve y_1 in area II. This would be the equilibrium level of output for all firms, in the ex-ante sense, using acquisition prices for x_1 and x_2. However, because of a prior mistake in resource allocation, inheritance of x_1 or other reasons, this firm finds it advantageous to acquire more x_2 and consequently increase production (move to a higher iso-value-product curve). This is the situation, according to authors previously cited, which helps explain chronic overproduction in the agricultural industry. It explains why some farms find it profitable to expand and consequently increase output even though some assets used by the firm are not making a return comparable to similar assets used elsewhere in the economy.

In summary, the previous discussion and Figure 11, suggests that there is only one point where the resources x_1 and x_2 will earn a return comparable to similar resources used in other segments of the economy when these resources are priced at acquisition cost. However there are many points, area V, where these resources will be receiving low earnings and yet will be trapped into agricultural production. Furthermore there are many potential positions where it will be to the firm's advantage to acquire more of certain assets, which consequently increases production, even though other assets used by the firm are earning a low return.

CHAPTER III

BUDGET MODELS

This chapter explains the assumptions, definitions and procedures used in developing the budget models for four sizes of dry-land wheat farms. The complete budgets including annual income and expense statements, equipment inventories, machinery capacity computations, investment requirements, and computations of imputed returns are included in the Appendices.

Application of The Synthetic Method

The first step in the development of the budget models was to determine the operations required to produce a crop in the area studied. These operations are as follows:

1. Five summer fallowing operations on an acreage equal to the total acres of crop for each farm plus 15 percent. This restriction is consistent with the general pattern of cropping 50 percent of the land and fallowing the other 50 percent. The additional 15 percent is to account for acreage restrictions and the "soil conserving base" as required to be in compliance with the U. S. Department of Agriculture's farm program.

2. One fall seeding operation on 65 percent of the acres of crop for each farm. This represents the wheat allotment which is seeded to winter wheat.

3. One combining operation on an acreage equal to the acreage of crops produced annually. It is assumed that harvesting a normal crop of wheat and a normal crop of barley has equal costs and technical requirements.

4. One tillage operation on 35 percent of the crop acres per farm in preparation for seeding a spring barley crop.

5. One seeding operation in the spring on 35 percent of the crop acres per farm.

The second step was to determine time limitations within which critical operations must be performed. Based upon interviews with farmers in the area it was determined that three operations were especially critical, viz. the first summer-fallow operation, combining, and seeding. Total field time is not critical since tractors are seldom used more than 500 hours per year and combines rarely exceed 140 hours of annual use. However the timeliness of these operations is important.

When interviewing farmers a chart similar to that depicted in Figure 1 was shown to them. They were reminded that, because of spreading fixed costs over more acres, machinery costs per unit declined as total acreage increased. However as total acreage increased, timeliness of operations decreased. Since operational timeliness is positively correlated with crop yields (although the author is not aware of studies which specifically measure this relationship) it is apparent that two forces are working simultaneously on unit costs. Spreading equipment use over more volume reduces per unit cost while the reduction in yields and the greater than proportional use of other factors causes the opposite effect. After discussing these concepts with the farmer he was asked to indicate the optimum operational timeliness, i. e., the machinery capacity, which would allow him to achieve minimum average total costs per unit of production for his farm taking into account weather variation.

These capacities were estimated rather consistently as follows:

1. Combining: 10 days. There was a general concensus among growers interviewed that a 14-day harvest was optimum in terms of minimizing per unit costs. This would allow four days out for bad weather, breakdowns, etc. It is necessary to keep in mind that custom combine operators are usually available and can be called upon if for any reason a farmer gets behind in his work. Also certain varieties of grain require more stringent timeliness of operation restrictions for harvesting than others. As a general rule, however, farmers feel that tooling up to take off a crop in less than ten operating days costs more than is gained through increased operational timeliness.

2. Fallowing: 7 days. There is some flexibility in this restriction. It is based on 10-hour days and running time can actually be increased to twenty or more hours per day by adding additional hired labor. The major problem here is in hiring labor to achieve such flexibility. During wet years all farmers in the area may get behind with their summer-fallow work in which case available labor to operate equipment is in very short supply. Although some farmers do achieve additional machine economy by using double labor shifts the practice is not general. A more usual pattern for increasing operating capacity on the larger farms is for the owner-operator or general manager to put in perhaps a half-day shift thereby increasing running time to fourteen hours per day rather than ten hours per day.

3. Seeding: 7 days. The critical period for seeding is in the fall when 65 percent of total crop acreage is seeded to winter wheat. Larger farms seem to get more service out of given span of drills, perhaps because of more labor and equipment available to fill drills, deliver seed, and move and service equipment. It is generally not feasible for the small operator to hire a man to help with this operation yet it is somewhat awkward and time consuming to do it alone.

The third step in the procedure was to use economic and engineering data and reasoning to derive budget models for various sizes of farms.

Farm Survey Data

Sixteen farms were studied to provide data for building the budget models. By careful interviewing it was possible to make judgments about which data represented unique circumstances. For example one farm hired more labor and operated with more machinery because the owner-operator was suffering from a heart condition which commenced three years ago. Only farmers in a strong equity capital position could operate under the cost structure associated with this farm. In another case the farm showed higher than normal fuel, license, and repair costs because the owner-operator commuted to his farm by airplane and charged these expenses to the business. Again only a strong equity capital position made such an operation possible.

Data gathered from interviews which represented minimum cost operations were used in conjunction with engineering data to construct the budget models for various sizes of farms. In many instances it was apparent that the equity position of the owner-operator was an important factor in dictating the pattern of cost structure. In each instance, judgment was used to establish a model cost structure believed to be consistent with assumptions of this study and optimum in terms of minimizing per unit costs for a given size of farm.

Engineering Data

Each annual edition of the Agricultural Engineers Yearbook contains a section on "Farm Machinery Costs and Use."[1] Up-to-date data are

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[1]American Society of Agricultural Engineers, 1965 Agricultural Engineers Yearbook, St. Joseph, Michigan, 1965, p. 248.

provided for the purpose of estimating each of the factors involved in determining the overall cost of performing a field operation. Current literature is surveyed and reported in this publication, with respect to depreciation rates, repair costs and machine reliability.

In developing budget models considerable use was made of "field efficiency" and "field capacity" coefficients. The American Society of Agricultural Engineers (ASAE) defines field capacity as the actual average rate of coverage (usually expressed in terms of acres per hour) based on total time in the field. Field efficiency is the percentage ratio of effective field capacity to the theoretical rate of coverage that would be obtained if the machine were performing its function 100 percent of the time at the rated forward speed and always covered 100 percent of its rated width.

Field efficiency includes the effects of overlap (failure to utilize the full rated width of the machine) and time lost in the field as a result of turning, filling drills, clogging of equipment, unloading combine hoppers, field lubrication and minor repairs, and other interruptions. It does not include traveling to and from fields, regular lubrication and maintenance of machines, or major breakdowns. (See Table 1).

Effective field capacity of any machine may be computed as follows:

$$C = \frac{SWE}{825} \qquad (1)$$

Where: C = effective field capacity, in acres per hour.

S = Speed of travel, in miles per hour.

W = rated width of machine action, in feet.

E = field efficiency, in percent.

If field efficiency is assumed to be 82.5 percent, a rate which is especially applicable to tillage or summer fallowing operations, then E may be eliminated from equation (1) providing the amount ten is substituted in place of 825. Given this assumption, equation (1) can be rewritten as follows:

$$C = \frac{SW}{10} \qquad (2)$$

Other engineering data useful for making adjustments in budget models include estimates of machine life in terms of "wear-out-life" and "number of years until obsolete." With these estimates one can determine whether to treat depreciation as a fixed or variable cost. If the annual use of the machine times the estimated years until it is obsolete exceeds the estimated wear-out-life, then depreciation should be treated as a variable cost. If the product of these two factors is less than the estimated wear-out-life, which is the usual situation on Montana's dry-land grain farms, depreciation should be treated as a fixed factor of production. (See Appendix F. Table 1).

TABLE 1.—Typical Field Efficiencies[a]

Operation	Field Efficiency Percent
Summer Fallowing	75-90
Drilling Grain	60-80
Combining	65-80

[a]Source: American Society of Agricultural Engineers, The Agricultural Engineers Yearbook, St. Joseph, Michigan, 1965, p. 251.

Repair and maintenance cost estimates are based on various studies and machinery company reports. They are reported in terms of percent of new cost per hundred hours of use. The assumption is made that the machine will be used for its entire wear-out-life and the cost coefficients reflect average costs for the life of the machine. Consequently there will be a tendency to over-estimate repair and maintenance costs during the early years of the machines life and under-estimate them during the later years. In the development of the budget models, repair costs were taken directly from the sixteen farms studied. Data from the sixteen farms studied were rejected if the machinery and equipment trading pattern for a particular farm differed from that assumed for the budget model or if peculiar mechanical abilities and interests existed on the part of the operator of the farm. It was found that the ASAE machinery and equipment repair coefficients tended to over-estimate costs as compared to the costs reported by farmers in this study. This is apparently due to several factors. Equipment is not ordinarily kept in service for the "wear-out-life" estimated by ASAE. Consequently annual repair costs tend to be lower. The second reason is that ASAE coefficients do not apply to the four-wheel drive tractors which have come into widespread use during the past three or four years. It is likely to be several years before enough experience with the newer models is available to develop reliable repair and maintenance cost coefficients. Preliminary information based on machinery dealer data indicates that .33 percent of the new cost per 100 hours of use results in a closer estimate of repair costs than the 1 percent coefficient suggested by ASAE.

Another reason the repair coefficients suggested by ASAE are less than completely reliable for estimating repair costs stems from the type of original pricing policies of manufacturers and dealers. For example a popular four-wheel drive tractor is sold with an arrangement by a tire company to keep the unit on good rubber at a cost of $50 per year per tire. Such a plan makes tires a fixed cost and destroys the validity of cost coefficients related to hours of use.

Particularly valuable engineering data are provided by the Agricultural Engineering Department, University of Nebraska, in the form of reports on tests conducted for nearly all models and types of tractors commonly used on American farms.[1] These reports were utilized in conjunction with the development of the budget models in this study.

In measuring power requirements for farms, the general terminology used is "maximum drawbar horsepower" as reported in the Nebraska tractor tests. Agricultural engineers, however, point out that "drawbar horsepower at 75 percent of pull at maximum power", a coefficient also reported in the Nebraska tractor tests, is a more useful measure. The following example will illustrate this point.

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[1]A summary of these tests and details of current tests are reported each year in the January issue of the Farm Equipment Redbook. See Farm Equipment Redbook, Kansas City, Missouri, Implement and Tractor Publications, Inc., 1965.

A conversion formula commonly used by agricultural engineers to calculate drawbar horsepower (dhp) required for field operations is given as follows:[1]

$$\text{dhp} = \frac{\text{(draft, in pounds)(speed, in mph)}}{375} \qquad (3)$$

Using equation (3) we can estimate the drawbar horsepower required to pull, for example, a 20-foot duckfoot, four inches deep, at a speed of 4.5 miles per hour. By making use of the data from Tables 2 and 3, the calculation

$$\text{dhp} = \frac{(35)(4)(20)(4.5)}{375} = 33.6$$

indicates that the necessary drawbar horsepower is 33.6. Rather than selecting a tractor with maximum drawbar horsepower as close as possible to 33.6, it would be more appropriate to select a tractor as close as possible in size to 33.6 drawbar horsepower at 75 percent of pull at maximum power. Drawbar horsepower at 75 percent of pull at maximum power more nearly measures the power needed to pull a given load under field conditions.

The example above is oversimplified since it does not consider "rolling resistance" and slippage. Rolling resistance is a form of draft that becomes appreciable when heavy loads are involved, particularly on loose soils. Rolling resistance and slippage reduce the useful draw-

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[1]American Society of Agricultural Engineers, op. cit., p. 248.

bar horsepower available from a tractor. In order to account for these factors Table 4 is presented. Traction-and-transmission coefficients are provided to convert drawbar horsepower values for tractors with different types of drive mechanisms to a common value. As reported in the Agricultural Engineers Yearbook the traction-and-transmission coefficient includes an estimated 3 percent loss in power between the power outlet and the axle.[1] In view of the rather crude estimates involved in arriving at the coefficients for Table 4, the 3 percent correction to take out the effect of transmission power loss is probably

TABLE 2.--Draft and Power Requirements[a]

Machine	Typical Draft or Power Requirements
Duckfoot with sweeps or chisels	25-45 lb./ft. per inch depth[b]
Disk - tandem	100-180 lb./ft.
Disk - offset (22-24 inch blades, 9 inch spacing)	200-250 lb./ft., or 90% of weight
One-way, 3-5 inch depth	180-400 lb./ft.
Rod weeder	60-120 lb./ft.
Spike tooth harrow	20-60 lb./ft.
Grain drill	30-80 lb./ft.

[a]Source: American Society of Agricultural Engineers, The Agricultural Engineers Yearbook, St. Joseph, Michigan, 1965, p. 251.

[b]lb./ft., indicates pounds of draft per foot of width. Under extreme conditions draft requirements may be greater than the ranges indicated, particularly for the first summer fallow operation. Ranges are shown for light, medium, and heavy soils, respectively.

[1]Ibid., p. 253.

TABLE 3.--Typical Speeds or Performance Rates[a]

Machine	Rate
Duckfoot	3-5 mph
Disk	3 1/2-6 mph
Spike tooth harrow	3-6 mph
Grain Drill	2 1/2-3 1/2 mph
Combine	2-3 1/2 mph

[a]Source: American Society of Agricultural Engineers, The Agricultural Engineers Yearbook, St. Joseph, Michigan, 1965, p. 252.

TABLE 4.--Traction-and-Transmission Coefficients for Tilled, Reasonably Firm Soil, Normal Field Drawbar Load[a]

Type of Tractor	Traction and Transmission Coefficients
Crawler	.80
Two-wheel drive rubber tire	.65
Four-wheel drive rubber tire of equal size	.80
Four-wheel drive rubber tires-smaller wheels in front	.72

[a]Source: American Society of Agricultural Engineers, The Agricultural Engineers Yearbook, St. Josph, Michigan, 1965, p. 253. This source states "No data on track rolling resistance or slippage in loose soils are available to serve as a basis for predicting performance . . . However as a rough approximation one might assume a coefficient of 0.75 to 0.8 for medium or heavy loads under most soil conditions" (see page 249). Similar data for four-wheel drive tractors are also unavailable. The coefficients provided above are based on estimates by agricultural engineers at Montana State University.

not justified.[1]

Therefore, returning to the example, to select a two-wheel drive tractor to pull the 20-foot duckfoot, use the coefficient of .65 from Table 4 to make a further adjustment for rolling resistance and slippage. A tractor with a rating of 51.7 drawbar horsepower at 75 percent of pull at maximum power (33.6 ÷ .65 = 51.7) is indicated. Such a tractor would have a maximum drawbar horsepower rating of approximately 68.9.

A Wyoming study of machinery costs was used considerably in making judgments relevant to machinery requirements for the budget models.[2] This study was based on data obtained from interviews of 92 farmers in Wyoming's primary dry-land wheat producing area. Total costs, including a classification of fixed and variable costs, were obtained for all major items of equipment found on each farm. Various mathematical functions, e. g., exponential, Cobb-Douglas, linear, were used to produce

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[1]From an engineering standpoint it is possible to compute power required to overcome slippage and rolling resistance. However it is necessary to know tire size, inflation pressure, tread design, weight on each tire, soil type and physical structure, soil moisture, type of soil cover if any, and drawbar load. Since these factors are quite variable for actual field performance it is of questionable value to attempt the achievement of more refined methods with the data presently available.

[3]Delwin M. Stevens and Allen H. Fehr, Jr., Cost of Owning and Operating Farm Power and Machinery on Dry-land Farms in Wyoming, Laramie, Wyoming, Wyoming Agricultural Experiment Station Bulletin 420, 1964.

regression lines describing the relationship between acres or hours of use and total cost per unit. The function yielding the highest correlation coefficient was used to construct cost diagrams for each major power unit or machine. Such cost diagrams are particularly useful for estimating machine costs for various acreages and in determining whether ownership or leasing is a better alternative for a particular situation.

Especially useful in determining truck costs is a study by Capstick.[1] Data for the study of truck costs were obtained from a sample survey of 61 farms in Arkansas. The study classified and reported various types of costs on a per mile basis for one-half ton and one-half ton trucks.

Another study of machinery costs for wheat farms, which are similar in size and organization to the farms involved in this study, was done by H. G. Sitler of Colorado.[2] The Colorado study was based on a sample of dry-land farms from eastern Colorado and it reports fixed and variable costs for typical machines.

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[1]Daniel F. Capstick, Cost of Owning and Operating Farm Trucks In Eastern Arkansas, Fayetteville, Arkansas, Arkansas Agricultural Experiment Station, Bulletin 639, 1961.

[2]Harry G. Sitler, Costs of Selected Sizes and Types of Farm Machinery on Colorado Wheat Farms, Fort Collins, Colorado, Cooperative Extension Service and Farm Production Economics Division, Economic Research Service, USDA, 1964.

Other publications relative to machinery costs used in developing model budgets came from Kansas and North Dakota.[1] In general these publications are based on studies of samples of farms and they allocate costs into typical fixed and variable classifications.

Assumptions and Definitions

The budget models have meaning only if assumptions and definitions of terms regarding the budgets are made specific. Such specifications and certain explanations of procedures are outlined in the following sections.

Dating of Coefficients, Prices, and Programs

The data collected from farms in this study are used to construct cost curves for farms of different size. To be useful in constructing a long-run average cost curve it is necessary that the data be consistent with respect to price levels, government programs, yields, and other factors which change over time. Therefore, the assumption made with

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[1]See: Laurel D. Loftsgard, Dale O. Anderson and Marvin T. Nordbo, Owning and Operating Costs for Farm Machinery, Fargo, North Dakota, Agricultural Experiment Station Bulletin No. 436, 1961. LeRoy W. Schaffner, Laurel D. Loftsgard and Wayne W. Owens, Economics of Leasing Farm Machinery and Buildings, Fargo, North Dakota, Agricultural Experiment Station Bulletin No. 450, 1964. Marvin T. Nordbo, LeRoy Schaffner and Sigurd Strangeland, Decision-Making Processes in Farm Machinery Selections, Fargo, North Dakota, Agricultural Experiment Station Bulletin No. 410, 1957. G. H. Larson, G. E. Fairbanks and F. C. Fenton, What It Costs to Use Farm Machinery, Manhattan, Kansas, Kansas Agricultural Experiment Station Bulletin 417, 1960.

respect to time is that all data reflect the situation existing for the current year, 1966.

In this regard a special problem exists for capital assets. The value of capital assets reported by farmers often reflects the price level that existed at the time they purchased the asset. To remove this effect from the farm data collected, the following procedure was used to establish a uniform investment value for machinery, equipment, and improvements.

Farm inventories of machinery, equipment and improvements were adjusted to reflect the current price level. Then "average investment" was calculated as follows:

$$\text{Average investment} = \frac{\text{1966 Cost + Salvage}}{2} \qquad (4)$$

Where: 1966 Cost for new equipment is as listed in Appendix F, Table 1.

Salvage value is based on the actual trading pattern salvage or 10 percent of new value.

Prices for factors of production, other than machinery, also reflect current 1966 levels. Prices of products were based on current expectations for the 1966 crop.

In using data from the farms surveyed it must be concluded that some pecuniary economies (quantity discounts and special prices to large scale operators) were included in the cost structure. No attempt was made to exclude the effect of pecuniary economies except that the initial cost of all machinery components, adjusted to the current price level, was used uniformly for all sizes of farms budgeted.

Input-output coefficients were based on current technology. A few farmers in the area studied were starting to use commercial fertilizers but the value of this practice had not been proven to the satisfaction of farmers in the area and fertilizer costs were not included in the budget models for the different sizes of farms.

Wheat allotments and feed grain base acreages for 1966 were used. Compliance with wheat allotments, for the budget models was assumed. This entitled a farmer to a basic Commodity Credit Corporation loan price of $1.05 per bushel for all wheat grown on the alloted acres plus an estimated $1.31 per bushel for 45 percent of a normal crop (a normal crop was defined as "normal yield", specified by the Agricultural Stabilization and Conservation Service, times alloted acres). It was further assumed that the entire feed grain base would be used to produce barley and sold at market price of $.80 per bushel. On the average 65 percent of each farm's grain acreage was planted to wheat; the remaining 35 percent was used for barley production. With this ratio of crops the average gross revenue per acre for a normal crop was $35.88 (See page 93 for calculation of gross revenue per acre).

The prices and yields for products are the same for each of the four budget models developed, starting on page 76. The price assumption is not at all implausible since a very highly developed market exists for wheat and barley. There might be some question about the assumption regarding equal yields, yet there is no evidence to support making any other.

In order to maintain farm price support program eligibility it was generally necessary to have a soil conserving base which exceeded the total crop acreage by 15 percent. Although this acreage could be planted to designated soil conserving crops, a more general practice was to double-summer-fallow which was also considered to be a soil conserving use of land. Therefore, the budget models were constructed on the basis of summer-fallow acreage which exceeded total crop acres by 15 percent.

It was assumed capital was available to secure resources needed to achieve each size situation. In other words, the problem of how entrepreneurs secure control over resources was ignored. Although full ownership of all resources was assumed, conclusions regarding optimum farm size will not likely differ from rental situations if it is assumed, further, that rent approaches ownership costs in the long run.[1] When this condition holds, the resources needed for any specified level of gross income are approximately the same irrespective of whether operators are owners or tenants. Therefore, for simplicity, unlimited capital and full ownership of all resources was assumed.

Another important assumption regarding the acquisition and salvage value of resources was made at this point. The budget models and cost curves were derived within the framework of traditional neo-classical theory (see pp. 16-54). Therefore, an implicit assumption was that acquisition costs and salvage values for assets, at a given point in time, are equal. The importance of the limitations growing out of this assumption will become clear in chapters VI and VII of this thesis.

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[1]E. O. Heady, Economics of Agricultural Production and Resource Use, New York, Prentice Hall, Inc., 1952, Chapter 20 and 21.

Labor

An assumption was required relative to the labor situation for each farm size. For the area studied, it seemed that the most realistic assumption to make about the operator's labor was that it was fixed in the sense that the discounted marginal value productivity of the farmer's labor used on the farm, promised to be higher than the discounted future income from non-farm occupations in which he could likely find employment.[1] Although some farmers in the area had non-farm employment they were in the minority. There is little industry in the Triangle and opportunities for part time non-farm employment are extremely limited. All labor other than that provided by the operator was considered as hired labor at a uniform price of $1.50 per hour. This price was assumed to include any allowances made for board and room. Therefore, labor houses were excluded from capital inventory. Hired labor was assumed to work 250 hours per month, per man.

Management

As noted above each budget model in this study includes the full time services of the owner-operator who contributes labor and management to the farm business. As traditionally defined management involves supervision, coordination and uncertainty-bearing. Supervision involves

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[1]For estimates of the present value of expected future income streams for farmers in non-farm employment. See Chennareddy Venkareddy op. cit., pp. 22, 42, and 177f.

day-to-day instruction and leadership in the operator's relationship with hired help and in directing his own labor. Coordination involves higher level decisions such as resource combination, determining operational sequence, timeliness and methods of operations, and solving problems of logistics. Bearing uncertainty is a unique function of the entrepreneur for which the return, if any, if often referred to as pure profits.

In general the managerial function was considered as a separate enterprise in the farm business, which was devoted to solving problems, carrying out the decisions, and bearing responsibility for these decisions and subsequent actions.[1] Viewed in this way management, becomes a controlling agent rather than a factor of production.

A common procedure in cost analysis is to designate management as the residual claimant of income.[2] In other words management gets what is left of gross income after all resources have been paid at a specified rate based on acquisition cost, salvage value, value in use, or a combination of these. Obviously the magnitude of the residual claimant

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[1]The merits of this position have been presented by Glenn L. Johnson in the proceedings of a workshop devoted to discussions of the managerial input. See: Farm Foundation, The Management Input in Agriculture, Chicago, Illinois, Agricultural Policy Institute, Southern Farm Management Research Committee, Farm Foundation, 1963, p. 12.

[2]For example see Bob Davis and J. Patrick Madden, Theory and Procedures for Studying Economies of Size on Irrigated Cotton Farms of the Texas High Plains, College Station, Texas, Texas A & M University in cooperation with the U. S. Department of Agriculture, MP-780, 1965, p.16.

changes depending on the method used to price factors of production.

Values, Objectives, and Capabilities of The Entrepreneur

It has been pointed out previously that the cost structure for a given farm often depends on the values, objectives, and capabilities of the owner-operator. Therefore, it is necessary to specify that the budget models were based on the following conditions relative to the owner-operator: (1) he lives on the farm, i.e., he does not commute daily from city residence to farm, (2) he is in normal health, (3) he has average mechanical skills such as may be learned in a high school vo-agricultural course, (4) he has the average managerial ability of a high school graduate, (5) he is willing to work long days (up to 14 hours) when necessary but not average over 8 hours per day or 40 hours per week, and (6) he is interested in maximizing income within the framework of the assumptions and restrictions previously discussed and consistent with the definitions of income which follow.

Definitions and Procedures for Computing Income

The definitions and procedures outlined below were used to compute the cost-return structure of the budget models.

1. Gross income is total production from alloted acres times effective product prices as explained previously.

2. Net cash income is gross income minus cash costs.

3. Cash costs include utilities, insurance, property taxes, license fees, dues, bank charges, miscellaneous supplies, seed, chemicals, machinery repairs, fuel, oil, grease, and hired labor. These costs occur annually and will be costed at acquisition price. Specifically excluded from the budget models are crop and hail insurance costs and interest paid. Crop and hail insurance costs reflect

3. only the willingness or lack of willingness to accept risk. These costs are highly variable among farms in the study area. Liability and fire insurance is included, however, because variability among farms is small and such insurance is generally considered as a necessary cost of doing business. The total insurance cost is higher for large farms which reflects cost of protection for a greater value of insurable assets. Actual interest paid usually reflects the equity position of the operator which is outside the scope of this study.

4. Net farm income is net cash income less depreciation. If this quantity is positive and if all assets are owned without any obligations against them, the farm can continue to operate indefinitely assuming personal expenditures are ignored. All cash costs are being paid and depreciation reserves will maintain the machinery and equipment investment.

5. Depreciation is based on the current price level for machinery and equipment and straight line depreciation. In general the following formula is applied to arrive at annual depreciation costs.

$$\text{Annual depreciation} = \frac{\text{acquisition cost less salvage value}}{\text{number of years of useful life}}$$

   The salvage value and the number of years of life placed on each machine or item of equipment is related to the hours of use given the machine and the frequency of replacement. Replacement occurs more often on larger farms since it is not possible for the owner-operator to give machines as much personal attention as on small farms.

6. Return to operator is net farm income less interest on investment. This quantity is what is left for the operator for his labor and management without making any division between the two.

7. Interest on investment is the opporunity cost to the entrepreneur of using capital in the farm business. It is computed by multiplying the opportunity rate of interest times the cost of assets used in the business. The opportunity rate of interest reflects the highest return the entrepreneur could get for capital invested in assets of similar risk, liquidity, and appreciation potential. The rate used in the budget models is 5 percent.

The problem of valuing fixed assets has been previously discussed. To avoid unnecessary confusion, the procedures used in developing the cost structure in Chapters III and IV arbitrarily specified $5,000 per year for the operator's labor and management, average investment value (as explained on page 69 of this thesis) for machinery and improvements, and two different levels, $100 and $158.47, for land. The effect of alternately using either acquisition prices or salvage values of assets on cost structure is discussed in Chapter VI and VII.

Budget Models

The budget models, summarized in Table 5 and reported in detail in Appendices A, B, C, and D, are based on the previously mentioned definitions and assumptions. Data from the sixteen farms studied were used as a point of departure and were adjusted with various engineering data and coefficients when judgment dictated that adjustment was needed. Detailed coefficients of yield, price, and cost are given in Appendix F, Tables 1-6.

Four Hundred Acre Model

This model represents the smallest farm size studied. It is essentially a one-man farm but since some jobs cannot be done alone, e.g., harvesting, a small amount of labor is hired each year. Operator labor is underemployed on farms of this size. Operators on farms producing 400 acres of crop are fully employed for only six months of the year. Less than half-time employment is required for the remaining six months.

In order to stay in business on a farm of this size it is usually necessary to operate with mostly used equipment and to make it last for many years The fact that the operators on these farms are underemployed and that most of their unemployed labor has a salvage value which approaches zero, means that considerable time is available to repair machinery and shop for used equipment. Also small operators are able to get by with older equipment because they operate it themselves. They learn to protect the equipment in a way not possible when using hired help.

TABLE 5.--Budget Model Summaries for Four Sizes of Farms with Land Valued at $100 per Acre.

Items of Income and Cost	Acres of Crop Produced Per Year 400	900	1500	2400
	dollars	dollars	dollars	dollars
Gross Income	14,353	32,293	53,823	86,117
Less cash costs	4,692	9,994	16,695	26,904
Net cash income	9,661	22,299	37,128	59,213
Less depreciation	2,066	4,758	7,369	9,383
Net farm income	7,595	17,541	29,759	49,830
Less 5% return on total investment	5,240	12,088	20,281	30,984
Return to operator for labor and management	2,355	5,453	9,478	18,846

The reader may question the ownership of a combine on a farm of this size. However a study of combine costs for dry-land farms in Wyoming shows a total cost of approximately $2.05 per acre for 14-foot combines used on 400 acres of crop per year.[1] This cost, based on a survey of 46 machines, includes taxes, interest on investment, depreciation, repairs, lubricants and fuel. If $.50 per acre is added to cover the cost of a combine operator, the total cost per acre is $2.55 which is at least $1.00 less than the usual cost of employing a custom operator.[2] Furthermore if the farmer on this small farm operates the combine himself and hires less expensive labor to drive trucks he is able to increase his labor returns.

A weed sprayer is not included in this model because the size of unit does not justify it's ownership. Weather conditions in the study area are such that crop spraying must be done about every alternate year, with airplanes, in order to achieve optimum timeliness of application. This results in an acreage much too small to justify ownership of a ground sprayer. The cost of custom spraying is appropriately charged as a cash expense.

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[1]Delwin M. Stevens and Allen H. Fehr, Jr., op. cit., p. 37.

[2]S. J. Tietema, Rates for Custom Work in Montana, Bozeman, Montana, Cooperative Extension Service, Circular 242, 1965, p. 2.

Grain storage capacity is provided in the model to adequately store a normal crop for one year. Some farms in the study area have considerably more storage capacity but this is a result of various past government programs which virtually made grain storage another enterprise in itself. In years of above average crop yields it is usually possible to get excess grain into commercial storage. In emergencies it can be piled on the ground for periods of several weeks with little storage loss. The cost of storage in this model is $.32 per bushel capacity. This is approximately the cost of new 2250 bushel capacity round steel bins.[1] Larger farms can reduce this cost per unit by using larger capacity storage. However it is necessary to have a minimum of four bins which results in higher costs for small farms. Layton Thompson reported a range from $.31 to $.57 per bushel capacity, associated with size, for similar type storage in a 1955 study.[2]

Farms, in this size category, often use diesel tractors which, in most cases, increase total per unit costs. The budget model assumes the use of a used sixty drawbar horsepower gasoline burning tractor. Although fuel costs are higher for gasoline tractors this is usually more than offset, on farms of this size, by lower overhead costs and

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[1]Robert L. Sargent,"Alternatives for Developing Land on the Hardin Unit, Montana," Bozeman, Montana, Unpublished Ph.D. Thesis, Montana State University, 1965, p. 174.

[2]Layton S. Thompson, Economics of Grain Storage on Montana Farms, Bozeman, Montana, Agricultural Experiment Station Bulletin 511, 1955, pp. 50-51.

lower maintenance costs. Overhead costs (taxes, depreciation, interest on investment, and insurance) are lower because the initial cost of gasoline tractors is less than for diesel tractors of comparable size and resale or salvage value is higher for gasoline tractors. Maintenance costs for gasoline tractors is usually lower, particularly on small farms, because less equipment and less technical ability is required to overhaul gasoline engines. In general, operators of small farms are not trained in diesel mechanics. The following example is an appropriate analysis for comparing diesel and gasoline tractors for the 400-acre budget model. It is based on local fuel prices, a $500 differential in initial cost, and assumes the farmer is capable of doing most of his overhaul and repair work on gasoline engines but is incapable of doing the same on diesel engines.[1]

Gasoline Tractor Annual Cost:	
Overhead ($3500 x .13)	$455
Fuel (4.5 gal. x 407 hrs. x $.185)	339
Maintenance	150
Total	$944
Diesel Tractor Annual Cost:	
Overhead ($4,000 x .13)	$520
Fuel (3.2 gal. x 407 hrs. x $.175)	228
Maintenance	350
Total	$1098

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[1]For further detail in comparing tractor types for various sizes of farms see Eric Wilson and M. E. Quenemoen, Gasoline, Diesel, or LP Gas for Tractor Power, Bozeman, Montana, Cooperative Extension Service Management Guide 349, July, 1965.

It is apparent from the example above that lower costs are achieved for a farm of this size with a gasoline tractor rather than a diesel tractor under assumptions that fit typical small farms. The general case for such analysis is illustrated in Figure 12. Point A on the vertical axis represents the annual fixed cost for a diesel tractor which is invariably higher than for a gasoline tractor, point B. The slope of the two lines depends on fuel and maintenance costs. Higher fuel costs for the gasoline tractors usually exceeds higher maintenance cost for diesel tractors, both of which vary directly and in a linear way with hours of use. This gives a greater slope to the gasoline tractor cost line. The point at which the two lines cross, C, is the breakeven or indifference point which indicates the number of hours of use required to make the annual cost of the two types of power units equal.

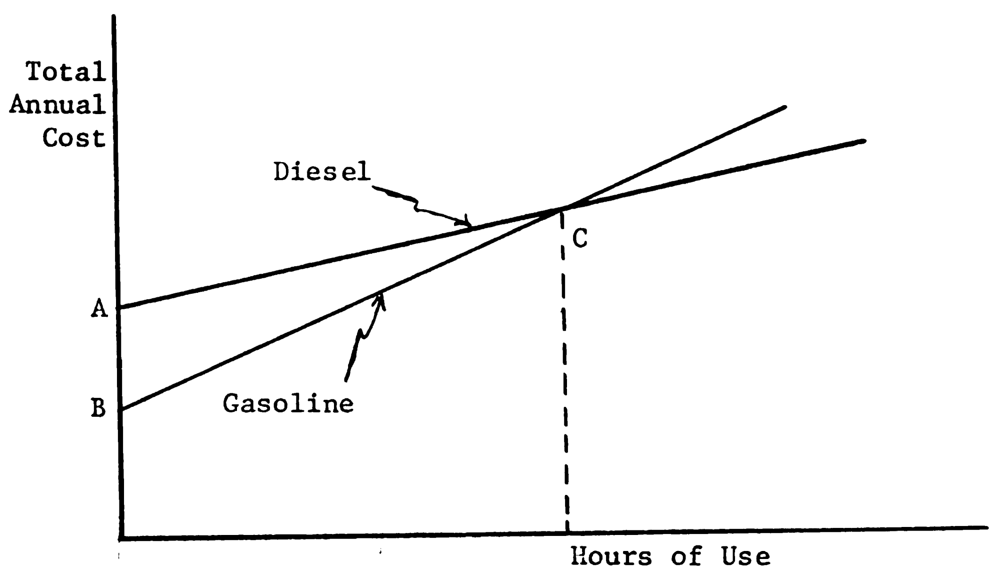

Fig. 12.--Hypothetical Diagram to Illustrate Economies Associated with Diesel and Gasoline Tractors.

In constructing the 400 acre budget model each item of equipment and each item of cash cost was subjected to the following question:

> "In view of all the choices available, does this particular choice represent the least-cost alternative consistent with the operator labor available, typical management, operational timeliness restrictions, and production of a normal crop?"

Assuming the choices were made correctly, the unit cost associated with this budget, at the specified output (400 acres x $35.83), will be the lowest point on the short-run average cost curve for that particular level of output.

Nine Hundred Acre Model

The 900-acre model is constructed with the same underlying assumptions as the previous model. However since the managerial services must still come from one man, somewhat newer equipment is used resulting in slightly higher per unit depreciation costs. With over four months of hired labor required in the 900-acre model, less personal attention to machinery and equipment is possible than on the 400-acre model.

A second tractor is included in the 900-acre model. When both tractors are operating full 10-hour days, the overall capacity to complete the summer fallow tillage operation is somewhat greater than for the 400-acre model. However the general practice is to operate the large power unit for more than ten hours per day. The owner-operator may contribute four hours running time plus time for servicing equipment. This, coupled with ten hours of hired labor, may result in fourteen hours of operating time per day. Under this system the owner-operator has more free time to perform his managerial function and the extra power unit is used only when weather and growing conditions require more tillage capacity.

Additional labor saving equipment has been added to this model such as the 22-foot grain loader. This equipment is used for loading trucks from grain bins and eliminates the need for handling the larger and less efficient loaders when hauling grain from storage bins to delivering points.

Also a utility tractor has been added to the machinery and equipment inventory which is used for power on grain loaders, cutting weeds around buildings, snow removal, and other miscellaneous jobs. Such equipment adds greatly to convenience but is not economically feasible on small farms.

The other major equipment item added to the 900-acre model is a weed sprayer. When conditions are favorable, considerable acreage can be sprayed with such a machine. The budget assumes half the weed spraying will be done with the ground sprayer.

Operators of 900-acre farms feel they are nearly fully employed for the entire year. Compared to the 400-acre model, the additional machinery and equipment to repair, grain to haul, and managerial functions to engage ones mind, provide a man of average capabilities with a full time job. With this size of unit, however, it is possible for a person with superior managerial capacity, i.e., capacity to organize, supervise and coordinate activities, and with superior mechanical abilities, to operate at lower per unit costs than the budget model implies.

Fifteen Hundred Acre Model

In this budget model, we shift to the large crawler or four-wheel drive tractors. Also a second tractor is included in the capital inventory but the tendency for farms equipped in this manner is to operate the big equipment longer hours and use the second unit only when needed because of work delays caused by weather. A special problem in estimating costs for this model is caused by the fact that the use of large four-wheel drive tractors in dry-land farming is a recent innovation and cost data are inadequate. Two units which have been in operation for nine years in other parts of the Triangle formed the basis for cost estimates. Preliminary evidence indicates that these tractors, built for construction and industrial use, may have a lower cost of maintenance than is obtained by using the ASAE estimating coefficients for two-wheel drive tractors.

Two combines of medium capacity are included in capital inventory. This is necessary in order to stay within the restriction of ten days combining time. Another alternative, frequently used by farms of this size, is to use one large capacity combine and relax the timeliness restriction to thirteen days. This reduces combine overhead costs approximately 25 percent and reduces the labor cost by one combine operator. The savings thus derived can be used to pay custom costs in years when unfavorable weather makes the use of custom operators necessary.

A relatively important economy associated with this size of farm exists for grain storage. Large capacity grain bins cost less per unit of storage capacity. For this model an original cost of $.30 per bushel capacity was used. This is a $.02 reduction from the storage cost used in the 400-acre budget.[1]

In order to handle large equipment the size of the shop was increased to 1,000 square feet in this model. Allowance was also made for additional shop equipment necessary for handling larger and heavier machinery.

Approximately eight months of hired labor are used on a farm this size with the machinery and equipment specified. It is difficult to obtain workers skilled in operating big equipment on a part-of-the year basis. Some farmers hire one man on an annual basis for farms of this size. This results in an "underemployed" labor situation but it is often felt to be a better solution than hiring seasonal workers. On a 1500-acre farm the owner-operator of average ability is fully employed, particularly if he depends on seasonal employees for hired labor.

Twenty-Four Hundred Acre Model

The 2400-acre model features a large four-wheel drive tractor plus a large two-wheel drive unit. A third smaller tractor is listed in capital inventory for standby use. Another alternative for farms of this size is to use the largest four-wheel drive tractor (180 max. dhp). However these units require up to sixty feet of tillage equipment to be properly loaded and many farms are not adapted to this size equipment because of topography and field layout.

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[1]This cost reduction is based on data provided by Thompson, _op. cit._, p. 51

The 2400-acre farm is well adapted to the use of two large capacity combines. The acreage is great enough to reduce overhead costs per acre to reasonable levels and the operation of these machines in "pairs" facilitates maintenance of parts inventories as well as making repairs.

Except for larger and generally new equipment the composition of capital inventory is not greatly changed from the 1500-acre model. An additional significant cost economy is achieved in grain storage in that the initial cost is reduced to $.27 per bushel capacity.[1] This is consistent with the lower costs associated with large capacity storage facilities.

The 2400-acre model, with specified equipment and system of operation, requires thirteen months of hired labor per year plus the usual full time self-employment of the owner-operator. However most of this labor is required during a six-month season. Thus the problem of obtaining experienced large equipment operators is virtually the same on this farm as for the smaller farms. Hiring year around help, while desirable from some points of view, results in some underemployment of labor. However on a farm of this size there is an opportunity to substitute labor for repair costs if a qualified employee can be obtained. In other words, the opportunity for overhauling equipment, hard surfacing cultivator shovels and other similar work is great enough to raise the marginal value productivity of winter labor to at least near its acquisition cost. Add to this the convenience of having experienced

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[1]This cost reduction is based on data provided by Thompson, op. cit., p. 51.

help available plus savings in less equipment breakage, and the added cost of a full time year around employee may be justified.

CHAPTER IV

ECONOMIES ASSOCIATED WITH SIZE FOR SELECTED FIXED AND VARIABLE COSTS

Budgets for farms of four different sizes have been presented in Chapter III. The next task is to derive cost curves from these budgets. Budget equations and partial budgets are employed in this chapter, to derive average cost curves. The data from the budget models are then used to derive total costs for each size of farm.

Short-run Average Selected (Fixed and Variable) Cost Curves (SASC)

From the data contained in the budget models, certain costs are selected to construct short-run cost curves. The primary interest is to derive cost curves that will give some indication of cost economies related to size. In this analysis it is assumed that acquisition costs and salvage values are equal. The return to capital investment in land is excluded because, under the assumptions, as the size of farm changes this charge will accrue in a linear fashion. The return to the entrepreneur is also excluded from consideration in constructing these curves, to avoid, at this point, the problem of determining an appropriate charge for these services. The combined cost of return to capital investment and earnings of the entrepreneur is a large component of total cost. It is important to keep this in mind in interpreting the cost curves illustrated in this section.

Short-run average selected cost (SASC) curves, composed of both fixed and variable costs, are derived under two sets of assumptions, viz. (1) gross revenue and variable costs per acre farmed and fixed costs per farm are held constant and (2) gross revenue and variable costs per acre farmed and fixed, costs per farm are permitted to change as the size of farm is changed.

Constant Gross Revenue per Acre, Variable Cost per Acre, and Fixed Cost per Farm

The implication of constant gross revenue per acre is that yields, prices, and acreage ratios for wheat and barley are held constant as farm size is varied for each budget model.[1] Similarly, variable costs per acre are constant, i.e., they do not change in magnitude as acreage is changed for each budget model. In other words, revenue and variable costs are linear functions of size (acreage) in the construction of SASC curves for each budget model. Average fixed cost is a hyperbolic function of size. The magnitude of fixed costs per acre changes each time acreage is changed for a specified budget model.

To derive SASC curves, selected cost data from the budget models are reclassified into selected fixed cost and selected variable cost categories. The budget models, reclassified according to whether selected costs are fixed or variable, are shown in Table 6.

It is assumed that buildings and equipment are not variable in the short run, once a particular size of farm is decided upon. Therefore

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[1]Computations for deriving gross revenue per acre are given on page 93.

TABLE 6.--Budget Models with Selected Costs Classified as Fixed and Variable.[a]

Item	400 Acre Model	900 Acre Model	1500 Acre Model	2400 Acre Model
	(dollars)	(dollars)	(dollars)	(dollars)
Selected Variable Costs:				
Fuel and oil	960.00	1,440.00	2,325.00	3,720.00
Weed and insect control	300.00	405.00	825.00	1,800.00
Labor hired	280.00	1,485.00	2,925.00	4,920.00
Machinery repairs	640.00	1,395.00	2,325.00	3,600.00
Seed	644.00	1,444.00	2,400.00	3,840.00
Taxes on land	602.00	1,355.00	2,258.00	3,612.00
Supplies	160.00	225.00	300.00	720.00
Total Selected Variable Costs	3,586.00	7,749.00	13,358.00	22,212.00
Average Selected Variable Costs per Acre	8.97	8.61	8.91	9.25
Selected Fixed Costs:				
Machinery depreciation	1,933.00	4,524.00	6,999.00	8,908.00
Building depreciation	133.00	234.00	370.00	475.00
Taxes on machinery and buildings	398.00	1,030.00	1,792.00	2,388.00
Utilities	160.00	315.00	375.00	504.00
Auto expense	88.00	180.00	270.00	384.00
Building repairs	100.00	180.00	300.00	456.00
Insurance	360.00	540.00	600.00	960.00
Total Selected Fixed Costs	3,172.00	7,003.00	10,706.00	14,075.00

[a]These costs are "selected" from the total costs presented in the budget models. The basis for excluding certain costs is explained on page 87.

depreciation and taxes are treated as fixed for both items. However this study and others have indicated a linear relationship exists between hours of use and machinery repairs; therefore machinery repairs are considered as variable.[1] Taxes are separated into taxes on land, which are considered variable, and taxes on machinery and buildings, which are considered as fixed. Auto expense, insurance and utilities are classified as fixed costs although these items, it may be argued, are to some degree variable (related directly to acres farmed). However small changes in acreage, about the specified size category, would change these much less than proportionately. One might say these costs are "predominately" fixed. Other selected costs are similarly difficult to classify in a precise way. The cost of fuel and oil is "predominately" variable, yet this cost is higher per acre on small farms, which indicates part of the cost is not directly correlated with number of acres farmed. However, in spite of small inconsistencies which accounting procedures make impossible to eliminate, the classification presented in Table 6 represents a reasonable estimate of fixed and variable costs for computation of short-run average selected cost functions.

Budget equations are developed for the data presented in Table 6 to facilitate the construction of cost curves. A general form of the total selected cost function is:

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[1] David S. Armstrong and J. Edwin Faris, op. cit., p. 11.

$$T = K + VQ \qquad (1)$$

Where: T = total selected fixed and variable costs.
K = selected fixed costs.
V = selected variable costs.
Q = quantity of output.

Since Table 6 shows selected variable cost (V) in terms of per acre units rather than output it is necessary to revise the general equation slightly. Under the assumption of constant product per acre, regardless of the number of acres farmed, it is possible to substitute number of acres for quantity of output. Then T will indicate the selected total cost for a given number of acres. To derive selected average cost per acre it is necessary only to divide the left side of the equation by Q_a.

$$A_a = \frac{K + V_a Q_a}{Q_a} \qquad (2)$$

Where: A_a = average selected fixed and variable costs per acre
K = selected fixed costs
V_a = selected variable costs per acre
Q_a = number of acres farmed

This equation will yield average selected fixed and variable costs per acre. However, if another assumption is introduced, viz. that perfect competition exists in the product market, acres can be multiplied times yields times price and a gross revenue value can be derived which can also be substituted for Q_a in the denominator of the budget equation. By following this procedure average selected fixed and variable costs will be in terms of per dollar of gross revenue rather than per acre.

$$A_{gr} = \frac{K + V_a Q_a}{GR} \qquad (3)$$

Where: A_{gr} = average selected fixed and variable cost per one dollar of gross revenue
K = selected fixed costs
V_a = selected variable costs per acre
Q_a = number of acres farmed
GR = gross revenue (Q_a X gross revenue per acre)

Gross revenue must be further defined since the budget models represent multiple product farms. The problem of definition is simplified since crops are grown in constant proportions because of acreage allotment programs for all sizes of farms, i.e., 65 percent wheat, 35 percent barley. Thus for each acre of crop produced a gross revenue coefficient can be computed which is constant for all acreages and all sizes of farms. The following example will illustrate.

If Q_a = 1 then actual crop distribution will be .65 acres of wheat and .35 acres of barley. Assuming a normal crop (25 bushels per acre) there will be 16.25 bushels of wheat available for the basic government supported price of $1.05 per bushel. Forty-five percent of the normal crop will be eligible for certificate payments of approximately $1.31 per bushel. Assume a normal crop of barley which is sold for $.80 per bushel.[1] Gross revenue for one acre will be:

Wheat:	.65 acres X 25 bu. X $1.05	=	$17.06
	.65 acres X 25 bu. X $1.31 X .45	=	9.58
Barley:	.35 acres X 33 bu. X $ .80	=	9.24
	Gross Revenue per acre		$35.88

[1]The source of information for support prices, certificate payments, barley prices, and the provisions of the 1966 government program is the Montana Agricultural Stabilization and Conservation Service. At the time of this writing the certificate payments for 1966 were not definitely known since they are contingent on parity price on July 1, and export prices throughout the year.

The term GR in equation (3) is the product of O_a and \$35.88. Equation (3) is used to construct the cost curves shown in Figures 13, 14, 15, and 16, using the data from Table 6 for each respective size of farm.

The broken vertical line in each figure indicates the acreage for which each respective budget model was constructed. Recall it was the objective in each model to represent an input mix, including the machinery complement, which would achieve minimum average unit costs at a specified acreage. At each of these acreages the average of specified selected fixed and variable costs per unit of gross revenue, point S, is 47, 45, 44, and 42 cents respectively. These costs, it is again emphasized, are not <u>total</u> average costs since capital costs (interest on investment) or a return to the operator for labor and management have not been included. Total costs will be considered later in this chapter.

That point S in each cost curve does not represent a minimum can be explained by the assumptions made relative to V_a and GR, viz. that they both change at a constant rate relative to changes in acreage (size) about the specified acreage for each budget. In fact these curves do not reach a minimum but rather approach a limit which is V_a for each respective curve.

The individual average selected cost curves are combined in Figure 17 for comparative purposes. In all cases the curves drop sharply due to reductions in selected fixed costs for the first few acres. Then the curves tend to flatten out for sufficiently large acreages. The decline over a larger acreage range for the farms with large machinery complements is due to the fact that their fixed costs are high and a low

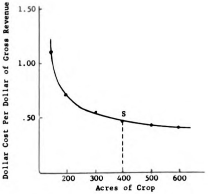

Fig. 13.--Selected Fixed and Variable Costs Per Dollar of Gross Revenue for a 400-Acre Farm.[a]

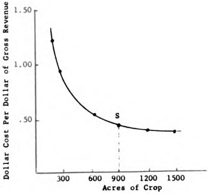

Fig. 14.--Selected Fixed and Variable Costs per Dollar of Gross Revenue for a 900-Acre Farm.[a]

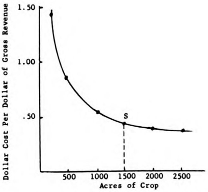

Fig. 15.--Selected Fixed and Variable Costs per Dollar of Gross Revenue for a 1500-Acre Farm.[a]

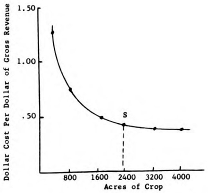

Fig. 16.--Selected Fixed and Variable Costs per Dollar of Gross Revenue for a 2400-Acre Farm.[a]

[a] The construction of each of these curves is based on the assumptions stated on page 89 with regard to gross revenue per acre, variable costs per acre, and fixed costs per farm.

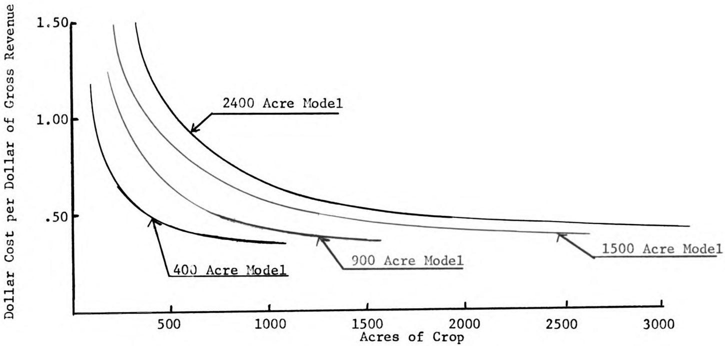

Fig. 17.--Selected Fixed and Variable Costs per Dollar of Gross Revenue for Four Sizes of Farms and Respective Machinery Complements.[a]

[a]The contruction of these curves is based on the assumptions stated on page 89 with regard to gross revenue per acre, variable costs per acre and fixed costs per farm.

per unit cost can be obtained only by large-scale operations. The curves begin to flatten out rapidly when selected fixed costs per unit become less than selected variable costs per unit. Conversely, per unit costs for small acreages are less with the small machinery complement because fixed costs are less relative to variable costs.

Relax Assumptions About Constant Gross Revenue Variable Costs, and Fixed Costs

This section deals with selected per-unit costs when weather, biological and other forces (1) cause changes in yield as each budget model and respective machinery complement is retracted or extended over different acreages of land farmed and (2) selected variable costs per acre change because of technical economies. Recall that the capacity for doing summer fallow tillage operations has been identified as the limiting factor which determines the basic size of the machinery complement. Seeding requires less power than summer fallowing and consequently capacity can be expanded with relatively small outlay by increasing the number of drills used. Also total acres of summer fallow for each farm represents 115 percent of acres cropped per year while the acreage of wheat, planted in the fall, represents only 65 percent of acres cropped per year. Barley seeding on the remaining 35 percent of acres cropped is a spring operation. Combining is dismissed as a critical operation on the basis that it does not involve the use of basic farm power equipment and custom combine operators are available at costs competitive with the farmer's costs of owning and operating combines. In other words there is little economic justification for suffering reduction in yield or quality because of insufficient seeding or combining capacity. The situation relative to harvesting capacity could change if custom combine operators became scarce but presently, large numbers of custom operators move into the Triangle each fall, from southern grain-producing regions, giving the area ample harvest capacity for all but the most perverse weather conditions.

On Triangle wheat farms, summer fallow tillage accomplishes four objectives, viz. (1) moisture conservation, (2) weed control, (3) seedbed preparation and (4) nitrate fixation.[1] The combined effect of these factors influence yields considerably in the semi-arid region in which this study is geographically located. However the exact relationship between summer fallow tillage capacity or operational timeliness and yield has apparently never been determined (at least a careful search of the literature failed to produce any report of such investigation). Several studies provide information on the relationship between yields and the time of the initial summer fallowing operation.[2]

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[1]For a comprehensive discussion of the role of summer fallow in dry-land farming regions see: O. R. Mathews and John S. Cole, "Special Dry-Farming Problems", Soils and Men, Washington, D. C., USDA Yearbook, 1938, p. 679.

[2]M. A. Bell, The Effect of Tillage Method, Crop Sequence, and Date of Seeding Upon the Yield and Quality of Cereals and Other Crops Grown Under Dry-Land Conditions in North Central Montana, Bozeman, Montana, Montana Agricultural Experiment Station Bulletin 336, 1937, p. 39 and J. E. Krall, T. J. Army, A. H. Post, and A. E. Seamans, A Summary of Dry-land Rotations and Tillage Experiments at Havre, Huntley, and Moccasin, Montana, Bozeman, Montana, Montana Agricultural Experiment Station Bulletin 599, 1965, p. 27.

A report by Bell involving a sixteen year study of winter wheat indicates a 37 percent reduction in yield from delaying the first tillage operation from May to July. Another report by Krall, et al., covering a 34-year period suggests a 25 percent reduction attributed to delaying the first fallow operation from May to June.

One approach to estimating yield reduction caused by untimely tillage operation is to use the range suggested by the studies cited. For example set 7-day capacity equal to zero loss and 28-day capacity equal to a 30 percent loss. Then by interpolation, 14-day capacity results in 10 percent loss, and 21-day capacity results in 20 percent loss. The points thus derived, using the budget equation (3) and appropriately adjusting GR to reflect lower gross revenue per acre, may then be used to estimate a short-run average selected cost curve.

The accuracy of this machinery capacity-loss ratio could be empirically verified but data are currently very sketchy. For example, there are no known records of the average number of working days available during April, May and June. Such information would be very helpful in at least estimating a capacity-loss ratio. It is known that the number of days when field conditions will permit seeding and tillage during these months are sometimes very limited. For example in the spring of 1965 a late snow storm drifted in coulees and ditches causing considerable delay in field work. This was followed by rains and light snow during the month of May. The Montana Statistical Reporting Service reported for the week ending June 8, "By the end of this week more than 95 percent of the oats and barley had been seeded."[1] Since seeding precedes summer fallow operations, it is apparent that some farmers did not do their first tillage operation until well into June. Considering the fact that on the average nearly one-third of the rainfall during the growing season (April through September) comes during June, it is apparent that the first tillage operation, may, under perverse weather conditions, readily approach the July 1 date and consequent yield reductions mentioned earlier.

Assumptions with regard to V_a need to be modified in proportion to the extent to which farm size is changed from the size specified for each model. Several items may be affected to a large degree. Each item listed as a selected variable cost in Table 6 is discussed below relative to its behavior as size changes.

First, consider those items that are generally linear functions of size. Fuel and oil, seed, taxes on land, and supplies probably fit this category very closely. There is little reason to expect these costs, on a per acre basis, to change with farm size.[2]

Weed and insect control costs are likely to increase as acreage is increased since more acres will need to be sprayed by custom operators due to lack of capacity of farm-owned sprayers. All spraying

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[1]U. S. Department of Agriculture, Montana Weekly Weather, Crop and Livestock Bulletin, Helena, Montana, Statistical Reporting Service, June 8, 1965.

[2]Pecuniary economies may affect variable costs between budget models of different size but there is little reason to expect them to be important for small changes in output within each budget model.

on the 400-acre model is done by custom operators but not all acres are sprayed. This is accounted for by the fact that close managerial attention can eliminate weed-free fields from treatment. As acreage is increased, the close attention necessary to make such decisions is not feasible and consequently spraying costs increase.

Hired labor costs per acre will increase for all budget models as acreage is increased, particularly for the smaller sizes. This situation arises because labor supplied by the owner-operator has not been included as a selected variable cost. Consequently the labor cost per acre will go up relatively faster on the small farms than on the large farms as acreage is increased.

Machinery repairs per acre will increase with increased size of farm, or depreciation, which is treated as a selected fixed cost in Table 6, will move into the category of a variable cost. If hours of machine use reaches or exceeds wear-out-life, then depreciation becomes a variable factor. It is customary in cost studies to treat depreciation as a fixed cost if "time" depreciation exceeds "use" depreciation.[1] This is the normal case on Triangle wheat farms. However, if acreage is extended considerably beyond the size specifications for the model budgets this relationship will change and depreciation will enter the production function as a variable cost.

As acreage is increased considerably beyond the budget model optimum size, other selected fixed costs become restricting and must

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[1]For example see Earl O. Heady, Dean E. McKee, and C. B. Haver, Farm Size Adjustments in Iowa and Cost Economies in Crop Production for Farms of Different Sizes, Ames, Iowa, Iowa Agricultural Experiment Station Bulletin 428, 1955, p. 428.

eventually enter the function as variable costs or if not supplied they will cause reduced returns. For example, costs associated with grain storage capacity, insurance, and utilities, treated as selected fixed costs for small changes in size, become restricting and either add to costs if expanded or reduce returns if held fixed.

In order to determine the precise change of the selected cost factors discussed in this section, an analysis using production function studies would be necessary. However it would be difficult to obtain a sample for such a study, since farms organized as specified in the budget models tend to cluster about the specified optimum size. Consequently, values for production function coefficients would most likely be subject to large statistical error.

To summarize this discussion refer to the budget equation (3) used to construct the curves in Figures 13, 14, 15, 16 and 17.

$$A_{gr} = \frac{K + V_a Q_a}{GR = Q_a \ \$35.88} \qquad (3)$$

Note that GR is not linear with respect to Q_a because yield changes as Q_a changes and this causes gross revenue per acre to change (recall: GR is the product of Q_a times gross revenue per acre). In analyzing the components of V_a it has also been revealed that it is unrealistic to expect V_a to remain constant over all ranges of Q_a. And finally, it was recognized that K would not likely remain constant as machine "use" depreciation exceeded "time" depreciation and storage capacity for grain became limiting. The latter phenomenon caused K to decrease as items previously considered fixed were transferred to the selected variable cost category.[1]

Partial Budget Analysis

One method of deriving an average selected cost curve which takes account of changing values of K, V_a, and GR for each value of Q_a is to use partial budgets. The chief advantage of using a partial budget rather than simply estimating values for equation (3) is that it represents a method commonly used in farm management analysis with which many farm managers are familiar. The following partial budget illustrates the use of this method to determine the average selected cost per dollar of gross revenue for the 400-acre budget model expanded to farm 800 acres. In making this shift in size the following changes in cost structure are anticipated:[2]

1. Timeliness in tillage is changed from 7 to 14 days.
2. Yields are reduced 10 percent.
3. Selected variable costs per acre increase $3.50 per acre.
4. Selected fixed costs decrease $600.

The partial budget analysis (Table 7) indicates that the average selected cost per dollar of gross revenue is $.58 (see point "p" Figure 18) when the budget model, organized for producing 400 acres of crop per year, is expanded to 800 acres without changing the composition

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[1]An alternative way of viewing this relationship is that K remains constant or fixed for the farm and that additional machine depreciation, taxes, and insurance and additional costs associated with storage and insurance are added to the V_a coefficient as acreage is expanded beyond the optimum specified for each budget.

[2]These changes are estimates based on deduction and general knowledge of the production process. Although production function studies would be valuable they are not available. Farmers base their planning on judgment or estimates of cost structure in much the same way that we are forced to do here. In the absence of experimental data, there appears to be no alternative to estimating these values.

TABLE 7.-- Partial Budget Depicting the Shift in Structure of Returns and Selected Costs from Increasing the Number of Acres Cropped from 400 to 800 for the 400 Acre Budget Model.

Added costs:		
(V_a) (400 acres) or ($8.97) (400)	$3588	
(ΔV_a) (800 acres) or ($3.50) (800)	2800	
Total Added Cost		$6,388
Reduced returns:		
(.10) (gross returns per acre) (400) or (.10) ($35.88) (400)		1,436
Reduced cost:		
ΔK		600
Added return:		
(.90) (gross return per acre) (400) or (.90) ($35.88) (400)		12,917

$$\frac{\text{Added costs + reduced returns}}{\text{Reduced cost + added return}} = \frac{6388 + 1436}{600 + 12,917} = \frac{\$\ 7824}{13517} = \underline{\underline{\$.58}}$$

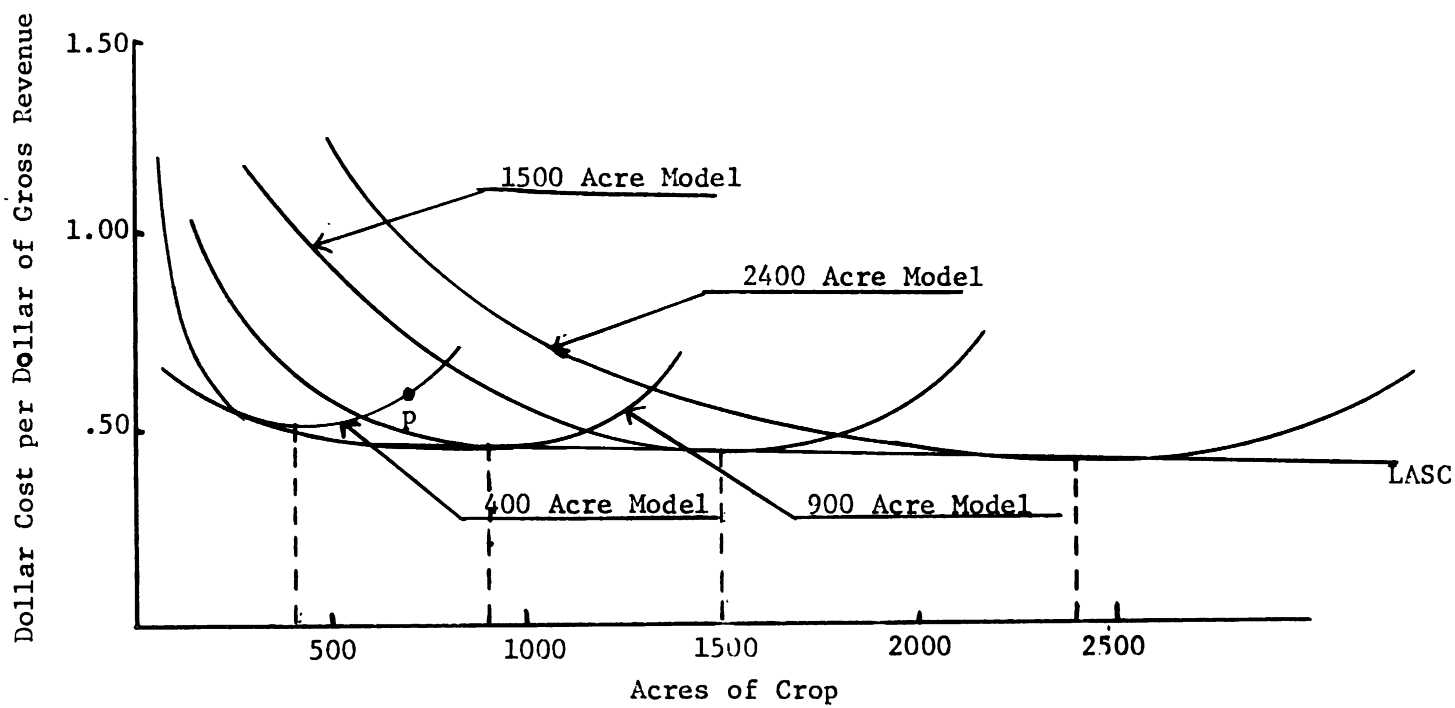

Fig. 18.--Average Selected Costs per Dollar of Gross Revenue for Four Sizes of Farms and Respective Machinery Complements.[a]

[a]The construction of these curves depends on relaxing assumptions previously held regarding gross revenue per acre, variable cost per acre, and fixed cost per farm. (See page 97).

of the basic power and machinery factors. This procedure can be repeated for any magnitude of departure from the specified size for each budget model. A curve fitted to the points obtained by this method for each budget model will result in a family of curves which have U shapes typical of short-run average cost curves.

Long-Run Average Selected (Fixed and Variable) Costs,(LASC)

The long-run average cost (LASC) curve for selected fixed and variable costs can be derived directly from a family of short-run average selected cost (SASC) curves by connecting them with a so-called envelope curve. The SASC cost curves will each be tangent to the LASC cost curve. In a sense the LASC curve is a "planning" curve since it represents a locus of minimum cost points which are technically possible to achieve for different levels of output.

Figure 18 depicts SASC curves for each budget model representing farms of 400, 900, 1500, and 2400 acres. SASC curves differ from LASC curves in that more factors are held fixed as output is expanded. Factors held constant for the SASC curves represented in Figure 18 are the basic power and equipment complement and the hours of time available from the farm entrepreneur. Although the entrepreneur's time is fixed, it was assumed he had the managerial capacity to expand operations along each respective SASC curve.

The low points on each SASC cost curve are 47, 45, 44, and 42 cents for the 400, 900, 1500 and 2400 acre models respectively. This indicates that increasing returns to size exist for dry-land wheat farms in the area studied, but they are modest and probably not large enough to explain the existance of particular sizes of farm. This conclusion, it should be recognized, is not supported by statistical analysis in this study but rather depends on human judgment in preparing the budget models and manipulating costs curves. If farms were actually operated at the point where SASC curves are tangent to the LASC curve (LASC in Figure 18) a sample of farm observations would allow regression estimates of selected costs which would describe the LASC curve. However farmers actually operate at many points within the SASC structure which is available to them because of limited capital, personal preferences, discounts growing out of risk and uncertainty, and lack of knowledge and ability. Also some farmers expand or decrease size of operation without changing equipment size, which causes them to shift along the SASC curve without moving to a new curve. As a result regression analysis and statistical inference about LASC structure is subject to serious limitations.[1] The normal situation is for regression estimated cost curves to be higher than LASC cost parameters as illustrated in Figure 5.

The only production function study of dry-land wheat farms in the Triangle was made in 1952 by Fienup.[2] In this study a crop function was expressed as: $Y = \alpha X_1^{\beta_1}, X_2^{\beta_2}, X_3^{\beta_3}, X_4^{\beta_4}, X_5^{\beta_5}$

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[1]For further discussion see Earl O. Heady, Dean E. McKee, and C. B. Haver, op. cit., p.424.

[2]Darrell F. Fienup, Resource Productivity on Montana Dry-land Crop Farms, Montana Agricultural Experiment Station Circular 66, Bozeman, Montana, 1952.

where: Y is the value of crops and crop products.
X_1 is total crop acres.
X_2 is total acres in hay and pasture.
X_3 is the total man months of labor attributed to crops.
X_4 is the total value of machine services including custom work hired, fuel, annual cost of machinery plus repairs, annual cost of buildings for crops.
X_5 is total cash expenses including value of home produced seed sown, purchased seed, and spray.

Expressed in logarithms, the crop function was found to be:

$\text{Log } Y = .929689 + .224196 \log X_1 - .006735X_2 + .065263X_3 + .338398X_4 + .468972X_5$.[1] Because of its logarithmic form, this equation expresses directly the production elasticities indicative of returns to size. Increasing returns to size are indicated by a sum of the β values which exceeds one; constant returns are indicated by a sum equal to one; and decreasing returns are indicated by a sum which is less than one. In the case of Fienup's study $\sum_{1}^{n=5}\beta = 1.09$ which indicates increasing returns to size. In this study all values were significant at the five percent significance level except β_2 and β_3. As other authors have pointed out, even though regression-estimated long-run average cost curves may not represent the "true" cost curve, the slopes of the regression-estimated cost curves should provide reliable estimates of the slopes of the actual long-run curve.[2] To this extent it may be concluded that Fienup's study supports this study which, based on the budget models, suggests moderately increasing returns to size.

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[1] _Ibid._, p. 47.

[2] This point is discussed on page 34.

Total Cost Structures

Thus far the discussion of cost structure has been limited to a selected group of costs which are sensitive to changes in firm size within the framework of traditional neo-classical marginal analysis theory. Certain important costs, i.e., costs associated with returns to capital investment and costs of labor and management provided by the entrepreneur, were omitted for reasons previously explained.[1] In turning to a discussion of total costs it is now necessary to include these costs.

The problems of handling fixed assets in calculating costs has been previously documented. Staying more or less within the vaguely defined framework of traditional neo-classical theory, it was implicitly assumed that the salvage value of these assets was equal to acquisition price. When it is recognized that acquisition cost exceeds salvage value, the important question, then, is at what level should they be priced? At this point, the principle of opportunity cost and the concept of quasi rent enter the computations.

Acquisition Price of Land

It is often argued that the acquisition price is the most appropriate value to place on the real estate investment. The acquisition price may be regarded as the market price plus closing costs, if any, borne by the buyer. Thus, studies of market price, assuming they include all closing costs, can be used to establish such a value.

According to a study done by Thompson, of actual Montana land sales in 1959, land capable of producing an average of 25 bushels

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[1]See page 88.

of wheat on summer fallow had an average sale value of $127.80.[1] Sales of dry-land wheat farms with normal yields ranging from eight bushels per acre to 30.5 were included in the market price investigation. A linear regression analysis using the method of least squares yielded an estimated value of $130.45 per acre for land capable of producing 25 bushels per acre of wheat on summer fallow.[2]

The prices paid for non-irrigated cropland in Montana increased 24 percent from March 1, 1959 to March 1, 1965 according to U. S. Department of Agriculture sources.[3] If the actual average sale value of 25 bushel capacity land, as found in Thompson's study, is raised by 24 percent, it results in a current market value of $158.47.[4] This value may be used to represent the acquisition cost of land for farms in the area studied.

Value of Other Capital Items

Other capital items i.e., machinery, buildings, and operating capital, are arbitrarily valued without reference to acquisition or salvage prices. Tables 4 and 5 of Appendices A, B, C, and D summarize these values for each budget model.

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[1]Layton S. Thompson, Sale Prices of Montana Agricultural Land by Class and Grade, Bozeman, Montana, Montana Agricultural Experiment Station Bulletin 583, December, 1963, p. 9.

[2] Ibid., p. 10.

[3]U. S. Department of Agriculture, Farm Real Estate Market Developments, Washington, D. C., Economic Research Service, CD-67, August, 1965, p. 9.

[4]1959 price of $127.80 x 1.24 = $158.47.

Value of The Entrepreneur's Labor and Management

An arbitrary value of $5,000 per year is placed on labor and management services provided by the entrepreneur. This amount is the same for each budget model, which, from some points of view is not an adequate method of valuing this resource. This point is discussed more fully in Chapter VI.[1]

Opportunity Rate of Return on Capital

The opportunity rate of return on capital, or to put it differently the opportunity cost of using capital, varies among individuals depending on each individual's knowledge of and access to investment alternatives. Also there are different categories of investment in a farm business such as cash reserves, working capital, and real-estate capital. It may be argued that since each of these categories vary in their degree of liquidity and possible risk, they should each have different opportunity rates of return.

While an individual farmer may well decide to incorporate such refinements into a cost analysis for his personal circumstances it may be satisfactory, as a generalization, to use one rate for all types of capital used on a farm. Also because of the subjective nature of opportunity rates of return, greater refinement seems unwarranted.

According to recent studies, farm real estate in Montana has experienced a growth in value of 5.7 percent from 1940 to 1964 as compared to 7.1 percent for common stock (Standard and Poor Index of 500 common

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[1] See page 188.

stocks adjusted for stock splits and changes in capitalization).[1] In view of this relationship, it would seem conservative to use the current rate of earnings on common stock as the opportunity rate of return for farm real estate, which since 1961 has been very close to 5 percent.[2] It is recognized that some people may be willing to accept a lower return on real estate because of income tax situations or personal reasons such as sentiment, desire for tangible property, recreational value of farm real estate, and prestige.

Discussion of Total Cost

Without the refinements of fixed asset theory, total cost can be discussed mainly in terms of different arbitrary alternatives regarding the value of assets used in production. The total cost structures for the budget models are depicted in Figures 19 and 20 for two alternative asset values. Land is valued at $158.47 per acre in Figure 19 and $100 per acre in Figure 20.

As indicated in Figure 19, returns of $35.88 per acre are not adequate to pay the specified costs of all factors of production. All four

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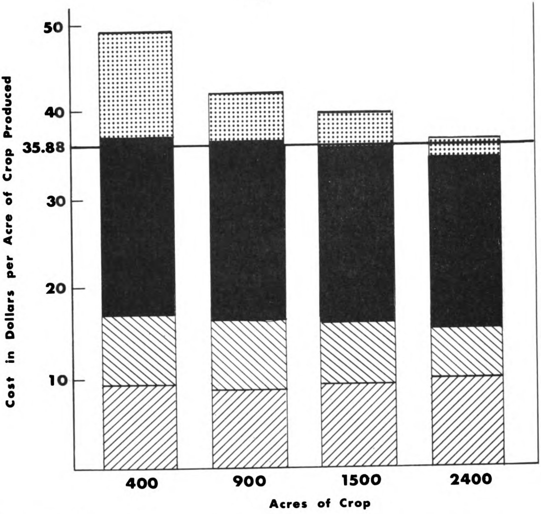
[1] M. E. Quenemoen and Layton S. Thompson, How to Estimate Land Value, Bozeman, Montana, Montana Agricultural Experiment Station and Cooperative Extension Service Bulletin #327, December, 1965, p. 24.

[2] William H. Scofield, "Land Returns and Farm Income", Farm Real Estate Market Developments, Washington, D. C., Economic Research Service, CD-67, August, 1965, p. 48.



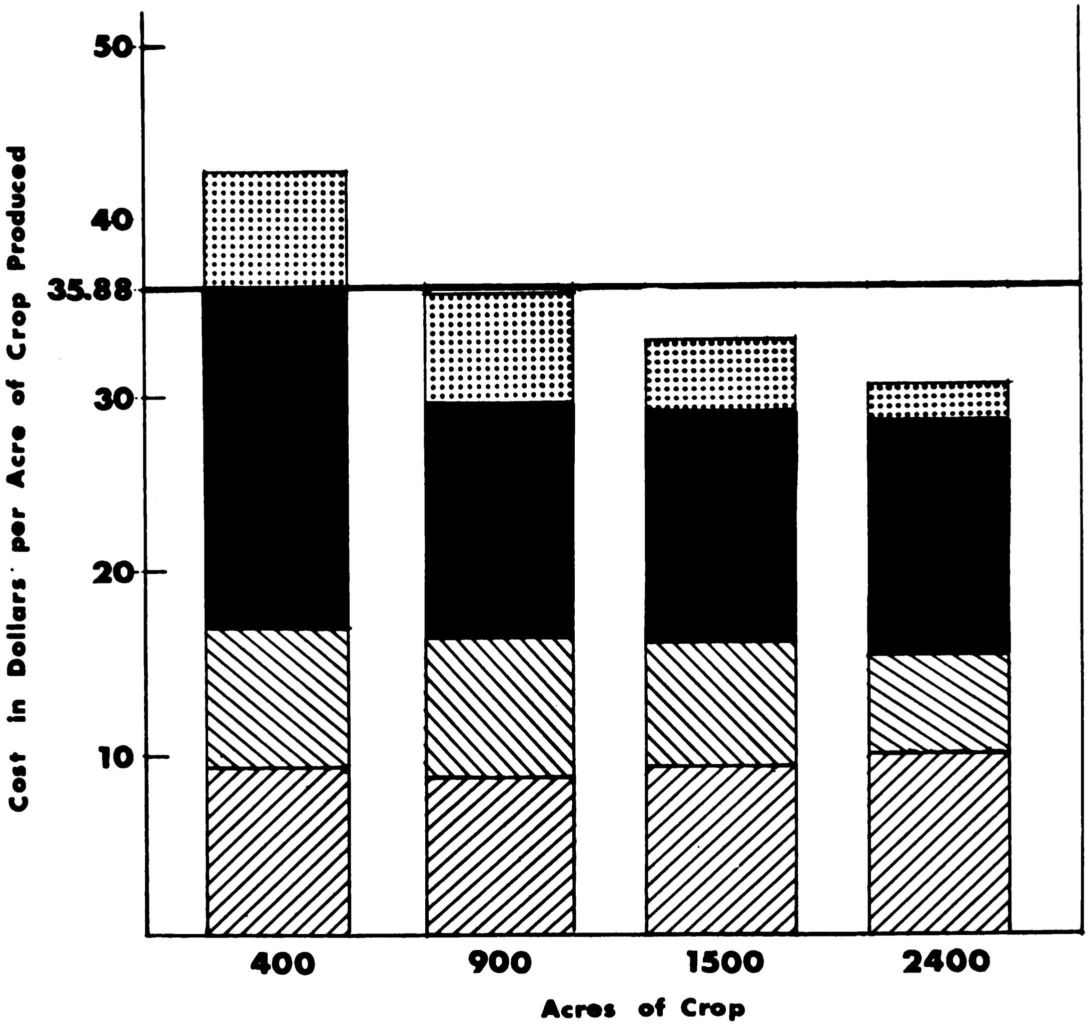
Return to operator for his labor and management is $5,000.

Interest rate is 5 percent and land is valued at $158.47 per acre.

Selected fixed operating costs include machinery depreciation, building depreciation, taxes on machinery and buildings, utilities, auto expense, building repairs, and insurance.

Selected variable operating costs include fuel and oil, weed and insect control, hired labor, machinery repairs, seed, taxes on land and supplies.

Fig. 19.--Total Cost Structure per Acre for Dry-land Wheat Farms Based on Budget Models for Four Sizes of Farms; Land Valued at $158.47 per Acre



Return to Operator for his labor and management is $5,000.

Interest rate is 5 percent and land is valued at $100 per acre.

Selected fixed operating costs include machinery depreciation, building depreciation, taxes on machinery and buildings, utilities, auto expense, building repairs, and insurance.

Selected variable operating costs include fuel and oil, weed and insect control, hired labor, machinery repairs, seed, taxes on land, and supplies

Fig. 20--Total Cost Structure per Acre for Dry-land Wheat Farms Based on Budget Models for Four Sizes of Farms; Land Valued at $100 per Acre.

sizes of farms pay, or very nearly pay, all operating costs plus a 5 percent return on investment. However, none of the farms pay $5000 return to the operator for his labor and management when a gross return of $35.88 per acre is used and when a 5 percent charge is made for the capital investment (land valued at $158.47 per acre).

When land is valued at $100 per acre, as in Figure 20, the 900 acre farm provides sufficient income to pay a 5 percent charge for capital at its assumed value and $5000 to the operator for his labor and management. For the farms larger than 900 acres, additional profits exist which might be termed "pure profits" as defined earlier in this thesis.[1]

Dispersion of Observed Cost Data

The fact that farmers do not operate at the point where short-run average cost curves are tangent to long-run average cost curves has been pointed out previously. Figure 21 suggests that a similar situation exists for farms observed in this study. The scattered points indicate actual selected costs (selected fixed and selected variable costs as previously defined) for each of the farms observed. These costs were taken from farm records using acquisition costs to each farmer. The costs reflect the price level at the time factors were purchased. They have not been adjusted to a constant price level.

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[1]See discussion on page 39.

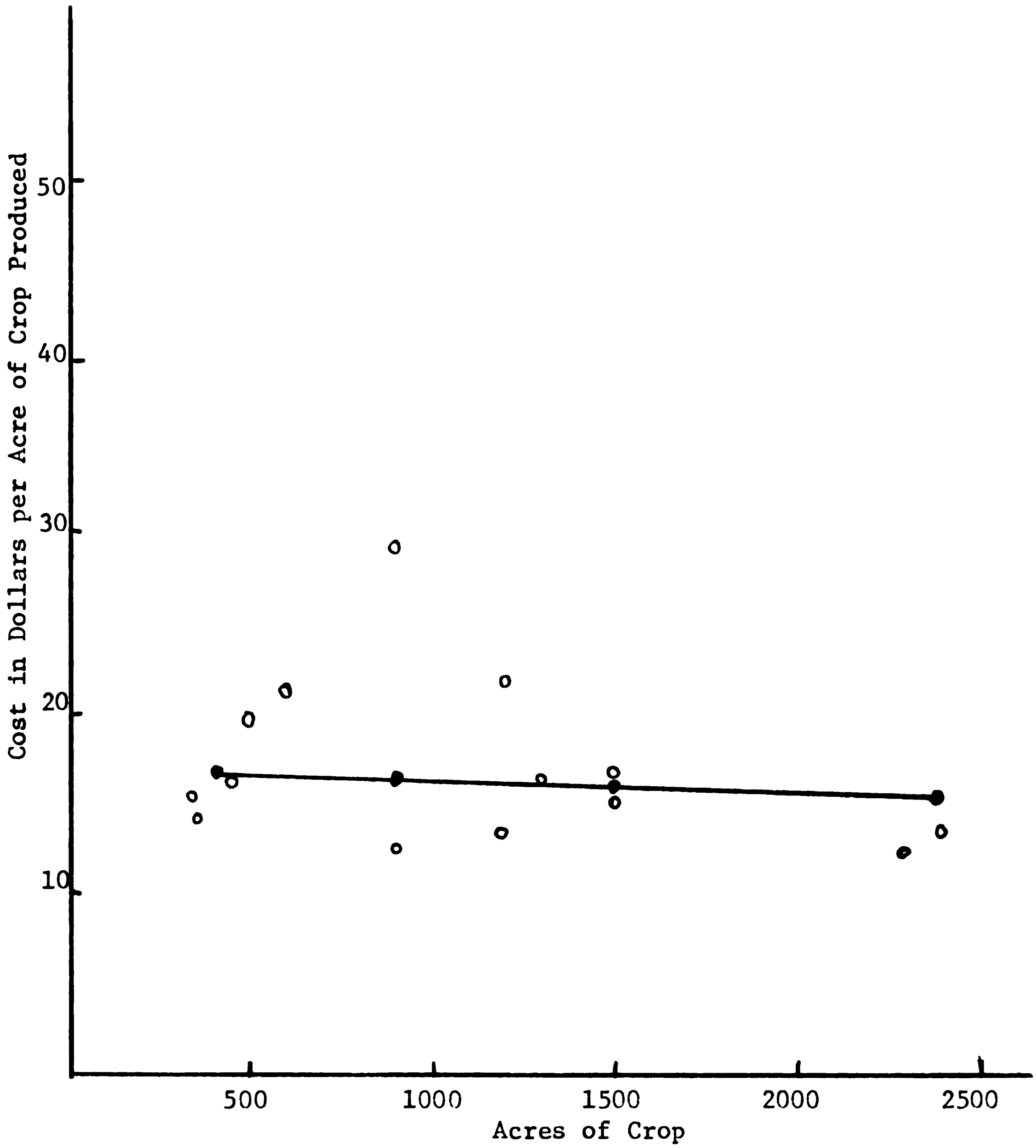

Fig. 21.—Average Cost Structure Comparing Actual Observations with Budget Models for Four Sizes of Farm.[a]

[a]The circles represent the sum of selected fixed and selected variable costs, as defined in the text, for farms observed in this study. The line connects points representing corresponding selected costs for the budget models of four sizes of farms.

The points connected by the solid line represent the total selected fixed and variable costs calculated for each budget model. In arriving at these costs, prices have been adjusted to a constant level and adjustments have been made in resource organization to achieve an optimum position under the assumptions stated in Chapter III.

The wide dispersion in the observed costs can be attributed to several factors. One reason for dispersion is suggested by fixed asset theory. It may be argued with reference to Figure 11, page 50, that because of past mistakes and other reasons to be discussed in Chapter VI, farmers are operating at different positions in area V. Consequently they have different cost structures, which, from their point of view may be economically rational. The size of area V, Figure 11, depends on the magnitude of the divergence between acquisition costs and salvage values for land and machinery. This is estimated in Chapter VI. If the size of area V is large, this suggests that potential differences in cost structure for optimally organized farms are great. The position in area V occupied by an individual farmer depends on past organizational decisions, or perhaps mistakes, and the present marginal value productivity of resources.

It is also possible that some farms may be organized in a position which is outside of area V, Figure 11. From the standpoint of maximizing net farm income, such a position would be considered irrational. However, a farmer could be in such a position for several reasons.

Certainly lack of knowledge is one plausible explanation. However considering the many judgments involved in the organization of farms, this is difficult to prove.

Other causes of variance in observed data can be broadly classified as "problems of accounting". For example, it is sometimes difficult to separate personal expenditures from the farm business accounts. Similarly, farmers with off-farm jobs sometimes combine farm income and expenditures with non-farm income and expenditures in such a way that they are difficult to separate.

Community or social values were also observed to be an apparent cause of cost variability between farms. For example, the owner of one of the largest farms observed, refused a cost savings of over $400 per year on fuel because it involved taking tanker deliveries and by-passing a local dealer. Not all farmers will pass up cost savings of this magnitude to save the rural community. This example serves to illustrate that short-run profit maximization is not the only criterion used by farmers for organizing farms.

CHAPTER V

CHOOSING LAND-MACHINERY COMBINATIONS UNDER UNCERTAINTY

The budgets developed in Chapter III and the cost curves derived in Chapter IV are based on average yields and subject to all weather conditions. They are also based on specified restrictions regarding operational timeliness (see page 57).

This chapter is addressed to two major objectives. First, it attempts to evaluate alternative resource combinations under different weather conditions. Secondly, it describes and reports the results of an investigation of machinery capacity on dry-land wheat farms in two sub-areas of the Triangle.

Relationships Between Farm Size and Machinery Capacity

Other researchers have observed two important conditions about the relationships between farm size and machinery capacity. Machinery capacity, measured in terms of horsepower per acre, is highly variable even among farms of similar type and organization. Secondly, there is a tendency for machinery capacity per acre to be greater on small farms than on large farms.[1] For example in a study of corn-hog farms in Nebraska,

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[1]For example see J. Edwin Faris, op. cit., p. 1221 and Gerald W. Dean and Harold O. Carter, Cost-Size Relationship for Cash Crop Farms in Yolo County, California, California Agricultural Experiment Station, Giannini Mimeo Report No. 238, Berkeley, December, 1960, p. 24.

found that small farms (120 acres) had almost twice as much horsepower per acre as did large farms (200 acres).[1]

Carter and Dean also observe that a considerable portion of the change in average unit costs, as farm size varies, can be attributed to the use, type, or size of farm machinery.[2]

Variance In Machinery Capacity per Acre

The variance in machinery capacity per acre may be attributed to a number of factors, some of which have already been discussed. The reason most frequently given by farmers for having excess capacity is that they wish to have insurance against those years when unfavorable weather would cause serious losses if they were equipped for "average" years.

The use of hired custom operators could reduce machinery requirements on some farms but, except for harvesting and weed spraying, it does not appear that this is a significant factor accounting for machinery capacity variability in the Triangle. The difficulty associated with moving heavy tillage equipment, timeliness requirements, and low profit margins combine to eliminate custom tillage as an important source of variance.

Scoville notes that some farmers, laying plans for larger operations, buy equipment in excess of the amount they think they need for their

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[1] O. J. Scoville, Relationship Between Size of Farm and Utilization of Machinery and Labor on Nebraska Corn-Livestock Farms, Washington, D. C., USDA Technical Bulletin 1037, 1951. p. 21.

[2] Gerald W. Dean and Harold O. Carter, op. cit., p. 28.

current operations.[1] Also tenants, equipped for a given size of farm sometimes move to one of a different size.

The problem of separating economics of consumption and economics of production has been alluded to earlier in this report. Greater machinery capacity may mean more leisure time for the owner-operator. Therefore, if the owner-operator is in a financial position to operate with machine capacity in excess of that required to otherwise maximize returns, he may choose to do so. In effect he sacrifices monetary returns for leisure time.

Another closely related factor is the value which owner-operators place on satisfactions associated with operating big equipment. Although difficult, if not impossible to measure, it is apparent that such values are interwoven with profit maximizing consideration in the decision-making process relative to machinery selection.

The labor situation on farms is believed to be a factor which causes variation in machinery capacity to land ratio. Some farms have a higher family labor supply than others and can rationally operate with less machine capacity. However this item appears to be getting less important with time. Farm operators are shifting to the position that training and education of youth has a higher priority than utilizing child labor on the farm. They are becoming reluctant to keep children out of school for intermittent farm work and this greatly reduces the importance of farm youth as a labor source for farms. An additional labor factor is the attitude of the owner-operator toward hired labor. Some

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[1]Scoville, op. cit., p.22

farmers are willing and able to pay the higher costs associated with excess machine capacity in order to avoid the disutility of having to contend with hired labor. Farm labor is not particularly expensive in terms of monetary outlay (it is readily available at $1.50 per hour, the price used in this study) but many farmers are willing to sacrifice considerable income to avoid the above-mentioned disutility. From an economic standpoint, using only monetary costs of labor, it would appear that many farms were not adequately adjusted.[1] This anomally may also be regarded as a problem of separating consumption economics from production economics since the disutility of personal relations with hired labor can logically be considered as an item related to the owner-operator as a consumer.

Other factors occasionally affect the ratio between machinery capacity and land for any given farm. The health of the operator is important in that operators in poor health tend to substitute machinery for labor. Off-farm employment by the farm operator obviously relates to a farmer's need for extra machinery capacity and in addition restricts his opportunity to shop for machinery, particularly used machinery. Another factor closely related to the financial position and desire to purchase leisure time is the investment credit provision of the federal income tax laws. This provision, which allows the purchaser of farm machinery

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[1]In static equilibrium the relationship between labor and machinery should be such that:

$$\frac{MVP_L}{MFC_L} = \frac{MVP_M}{MFC_M}$$

Where:

MVP_L = marginal value product of labor
MFC_L = marginal factor cost of labor
MVP_M = marginal value product of machinery
MFC_M = marginal factor cost of machinery

and certain other depreciable capital assets to deduct an amount from the income tax which he would otherwise pay, makes the cost of excess capacity less than it would be without the tax credit.[1]

Costs Associated With Excess Machinery Capacity

The costs associated with more or less machinery capacity for farms of a given size are difficult to assess in a general way. Three different assumptions or situations may prevail with regard to obtaining and using additional machinery capacity for any given farm.

Changes in capacity may be accomplished by changing numbers of units of existing machines. For example, if it were desired to double the tillage capacity for a given farm another complete set of power and equipment identical with the first set could be provided.

Secondly, capacity could be changed by increasing the size of existing equipment through replacement. For example, a tractor with twice as much horsepower, pulling twice as many feet of equipment, would approximately double the tillage capacity for a given farm.

A third method of changing capacity could involve the use of "standby" equipment. In this case total capacity could be changed by adding a unit of older equipment which would be used only in emergency situations. This case differs from the first two in that capacity could be <u>changed</u>

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[1]The investment credit is 7 percent for depreciable tangible personal property and certain types of real property which has a life of six years or more. This amount is deducted from the taxpayer's tax liability in the year the purchase was made. See U. S. Treasury Department, <u>Farmer's Tax Guide</u>, Washington, 1966 Edition Internal Revenue Service Publication #225, 1966, p. 13.

but not necessarily <u>used</u> in each yearly operation. The first two cases assume amounts of equipment of comparable age and conditions are adjusted to achieve different levels of capacity for the total farm.

The cost consequences of each alternative method of adjusting capacity are likely to be quite different. This can be illustrated by referring to a partial budget form (Table 8) which shows the appropriate items in cost and return structure which need to be considered for any of the three situations outlined above for changing machinery tillage capacity. Decreases in tillage capacity could similarly be analyzed with partial budgets but the actual entries in the partial budget form would be changed.

The "added costs" depend on the actual use for which the additional equipment is intended. For example if it is for stand-by use in emergencies the estimated years of life until obsolete would probably be appropriate for calculating depreciation. Its intended use would also be reflected in the other "added costs" since it would affect "average value" which is used in the calculation of interest, taxes, and insurance. Also the additional labor for stand-by equipment would be only that amount used in emergency situations pro-rated over the life of the investment. Obviously the cost coefficients used in this part of the partial budget would be different for alternative assumptions regarding methods of obtaining additional capacity and plans for using this capacity.

Assuming that capital is available to finance additional machinery without curtailing other parts of the total business enterprise, it is not likely that an increase in machinery capacity will "reduce returns"

TABLE 8.--Partial Budget Form Indicating the Changes in Cost and Return Structure Associated with Increasing Machinery Tillage Capacity for a Farm of Specified Size.

Added Costs:

Use or obsolescence depreciation on additional equipment.
Interest on average investment in additional equipment.
Taxes on additional equipment.
Insurance on additional equipment.
Labor hired to operate additional equipment.
Fuel, oil, and repairs for additional equipment.

Reduced Returns:

None.

Added Returns:

Increased revenue resulting from increased timeliness and release of owner-operator's time for managerial functions.

Reduced Costs:

Use and/or obsolescence depreciation on primary equipment.[a]
Interest on investment in primary equipment.
Taxes on primary equipment.
Insurance on primary equipment.
Labor hired to operate primary equipment.
Fuel, oil, and repairs for primary equipment.

(added returns + reduced costs) - (added costs + reduced returns) = Change in return to operator's labor and management.

[a]"Primary equipment" refers to the equipment on the farm before introducing a proposed change in tillage capacity.

in any way. This part of the total business structure should always be considered, however, in making any analysis of a proposed change. A reduction in machinery capacity would be expected to result in "reduced returns" to the business because of less timeliness in tillage operations, and, assuming the owner-operator would spend more time operating the smaller equipment, loss of over-all efficiency due to less managerial time being expended.[1]

The "reduced cost" entries are especially dependent on how the changes in capacity are made. If, for example, capacity is increased by duplicating the existing machinery component and both units are actually used simultaneously, in effect, doubling tillage capacity for the farm, the "reduced cost" items will largely reflect a longer life of the primary machinery component. Since the annual use of this equipment will be cut in half, its depreciation will be reduced unless the original depreciation rate was initially based on the machinery's obsolescence life. In this case there would be no reduction in the depreciation cost. In this example insurance and the annual interest cost would not change since the average value of the investment is constant even though total life may be lengthened. Taxes on an annual basis would probably decrease since assessment schedules would not change to reflect longer life of the asset. If labor is variable, its cost should be reduced since the primary equipment component will be used only half as

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[1]In analyzing a proposed change in a farm business with the partial budget, the actual entries, and ultimately the results of the analysis, depend on assumptions made about input-output relationships. For example if we assume the owner-operator's time distribution between management, leisure, and labor is fixed, then any additional labor required to operate machines will be listed as an "added cost" and the only factor causing changes in revenue will be that of operational timeliness.

much as formerly. However this will depend on individual circumstances. The reduced cost of fuel, oil, and repairs for primary equipment in this example will be just offset by the added cost of fuel, oil, and repairs for the added equipment. Thus, for this example, it could be ignored.

An alternative example could be pointed out in which the primary equipment is replaced by a machinery component having twice the capacity of the former. Then the entire ownership costs, i.e., depreciation, taxes, insurance, and interest on investment, plus the variable costs, i.e., fuel, oil and repairs, should be listed as "reduced costs". The same type of costs should be listed as "added costs" for the added equipment component. What happens to labor in this case is again a matter of individual circumstances. Whether or not the business is able to vary such costs depends on the source of the labor input and the alternative opportunities for the use of labor in off-farm employment.

Cost Structure for 1500-Acre Model with Various Machine Capacities

It has been pointed out that the actual cost structure associated with different machinery capacity depends on how changes in capacity are made, individual circumstances relative to the labor supply, and whether stand-by capacity is considered. In order to examine the cost structure of the 1500-acre model as tillage capacity is changed by altering size of power and equipment, the following assumptions will be used:

1. Existing equipment will be replaced if necessary, in order to accommodate the most efficient machinery combinations to achieve specified capacities.

2. The owner-operator is fully employed; his labor and management time has zero salvage value; hired labor can be obtained in any quantity for $1.50 per hour.

3. Machinery capacity will be used fully, i.e., stand-by capacity will not be considered.

The 1500-acre model contains two tractors, a 155 drawbar horsepower crawler or four-wheel drive unit and a 90 drawbar horsepower two-wheel drive unit which permits the first seasonal fallowing operation to be completed in seven ten-hour days. This machinery complement is now changed to permit tillage operational timeliness of 3.5, 5.25, 10.5 and 14, 10-hour days (See page 57 for discussion and computation of operational timeliness). Partial budgets, which include only cost components (revenue components have been excluded) are shown in Tables 9, 10, 11, and 12 for each respective change in machinery capacity.

In developing these budgets, machinery and labor components were used which appeared to be feasible from the standpoint of cost and technical applicability within the framework of average managerial capacity, average mechanical ability, and fixed allocation of labor, leisure, and management time of the owner-operator. Other alternatives are available and possible economies could be achieved by utilizing other machinery components. However the method illustrated by use of partial budgets could be used by any owner-operator to estimate changes in cost structure associated with changes in capacity or combinations of machinery.

Relationships Between Machinery Capacity and Net Farm Income

The cost structure associated with changes in machinery capacity is significant only if related to net farm income. It is obvious that net farm income could be maximized by changing the machinery component as suggested in Table 9, if revenue increased or remained constant. This occurence, however, is probable only if more favorable than normal weather conditions are specified.

TABLE 9.--Changes in Total Cost Structure on an Annual Basis for the 1500 Acre Budget Model with the Tillage Machinery Component Changed from 7 to 14 Day Operational Timeliness.

Added Costs:	dollars
110 dhp. two-wheel drive tractor[a]	4,361
26 ft. duckfoot and rod[b]	1,497
Labor 595 hours @ $1.50	893
	6,751
Reduced Costs:	
155 dhp four-wheel drive or crawler tractor[c]	4,660
90 dhp two-wheel drive tractor[d]	1,762
48 ft. duckfoot and rod[e]	1,428
Labor 405 hours @ $1.50	608
	8,458
Net Change in Costs from Shifting to Less Capacity	-1,707

[a]Requires 1,000 hours of tractor time per year.

[b]Fixed cost $433 per year plus $1.16 per hour of use.

[c]Requires 405 hours of tractor time per year.

[d]Requires 405 hours of tractor time per year.

[e]Fixed cost $800 per year plus $1.96 per hour of use.

The cost curve for selected fixed and variable costs, presented in Chapter IV, are of a static type and do not consider decision-making with respect to weather variability. The short-run average selected cost curves depicted in Figure 18 on page 105 show increasing costs after a minimum cost is reached, which, in part, is caused by decreasing yields associated with changing the land to machinery capacity ratio under the assumption of all weather conditions. If this assumption is changed and

TABLE 10.--Changes in Total Cost Structure on an Annual Basis for the 1500 Acre Budget Model with the Tillage Machinery Component Changed from 7 to 10.5 Day Operational Timeliness.

Added Costs:	dollars
228 hrs. operating time on 155 dhp tractor[a]	736
Use depreciation on 155 dhp tractor	200
145 hrs. operating time on 36' of duckfoot & rod[b]	233
Labor 228 hrs. @ $1.50	343
	1,511
Reduced Costs:	
90 dhp two-wheel drive tractor[c]	1,762
22 ft. duckfoot and rod[d]	655
Labor, 405 hrs. @ $1.50	608
	3,025
Net Change in Costs from Shifting to Less Capacity	-1,514

[a]Requires total of 633 hours tractor time.

[b]Variable cost rate of $1.61 per hour of use.

[c]In this alternative the smaller tractor and equipment component is eliminated from the operation.

[d]Fixed cost $311 per year plus $.98 per hour of use.

TABLE 11.--Changes in Total Cost Structure on an Annual Basis for the 1500 Acre Budget Model with the Tillage Machinery Component Changed from 7 to 5.25 Day Operational Timeliness.

Added Costs:	dollars
155 dhp four-wheel drive or crawler tractor[a]	4,273
36 ft. of duckfoot and rod[b]	1,029
Labor 285 hrs. @ $1.50	428
	5,730
Reduced Costs:	
90 dhp two-wheel drive tractor[c]	1,762
22 ft. of duckfoot and rod[d]	655
37 hrs. operating time on 155 dhp @ $3.24	120
Labor 405 hrs. @ $1.50	608
	3,145
Net Change in Costs from Shifting to More Capacity	+2,585

[a]Requires 285 hours of tractor time per year.

[b]Fixed cost $600 per year plus $1.61 per hour of use.

[c]Requires 405 hours of tractor time per year.

[d]Fixed cost $311 per year plus $.98 per hour of use.

TABLE 12.--Changes in Total Cost Structure on An Annual Basis for the 1500 Acre Budget Model with the Tillage Machinery Component Changed from 7 to 3.5 Day Operational Timeliness.

Added Costs:	dollars
Two 180 dhp. four-wheel drive crawler tractors[a]	10,320
110 ft. of duckfoot and rod[b]	2,694
Labor 185 hours @ $1.50	278
	13,292
Reduced Costs:	
155 dhp. four-wheel drive or crawler tractor[c]	4,660
90 dhp. two-wheel drive tractor[d]	1,762
58 ft. of duckfoot and rod[e]	1,428
Labor 405 hours @ $1.50	608
	8,458
Net Change in Costs from Shifting to More Capacity	+4,834

[a]Requires 226 hours of tractor time per year for each tractor.

[b]Fixed cost $1800 per year plus $4.83 per hour of use.

[c]Requires 405 hours of tractor time per year.

[d]Requires 405 hours of tractor time per year.

[e]Fixed cost $800 per year plus $1.96 per hour of use.

cost curves are constructed for a given machinery component under specified weather situations a family of cost curves is obtained; in fact a cost curve for each given weather condition is derived.

The family of cost curves in Figure 22 illustrates the effect of alternative annual weather conditions on the cost structure of the 1500 acre model farm and its' specified machinery component. Curve A represents the cost structure, for the given machinery component, in a year when weather conditions are better than average.[1] In such a year minimum costs per dollar of revenue could be achieved with a larger acreage than the 1500 acres which minimizes average costs for the average year. Curve C depicts the average unit costs for a given machinery component in a year in which weather is considerably more adverse than average. During such a year, unit costs would be minimized with smaller acreage

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[1]Adverse weather, as discussed in this section, actually affects two years production on dry-land grain farms since it requires two years to produce one crop on a given tract of land. The first year the land is summer fallowed (tilled) and the second year it is cropped. Late or untimely tillage results in reduced yields the following year. However late or untimely tillage due to adverse weather is often also accompanied by untimely spraying, harvesting and seeding of the current crop which also reduces yields. It is perhaps helpful to think of the affect of adverse weather on a current year's production plus the potential accrued affect on the following year's crop. The combination of these two factors may be accounted for in the particular year for which weather conditions are being considered.

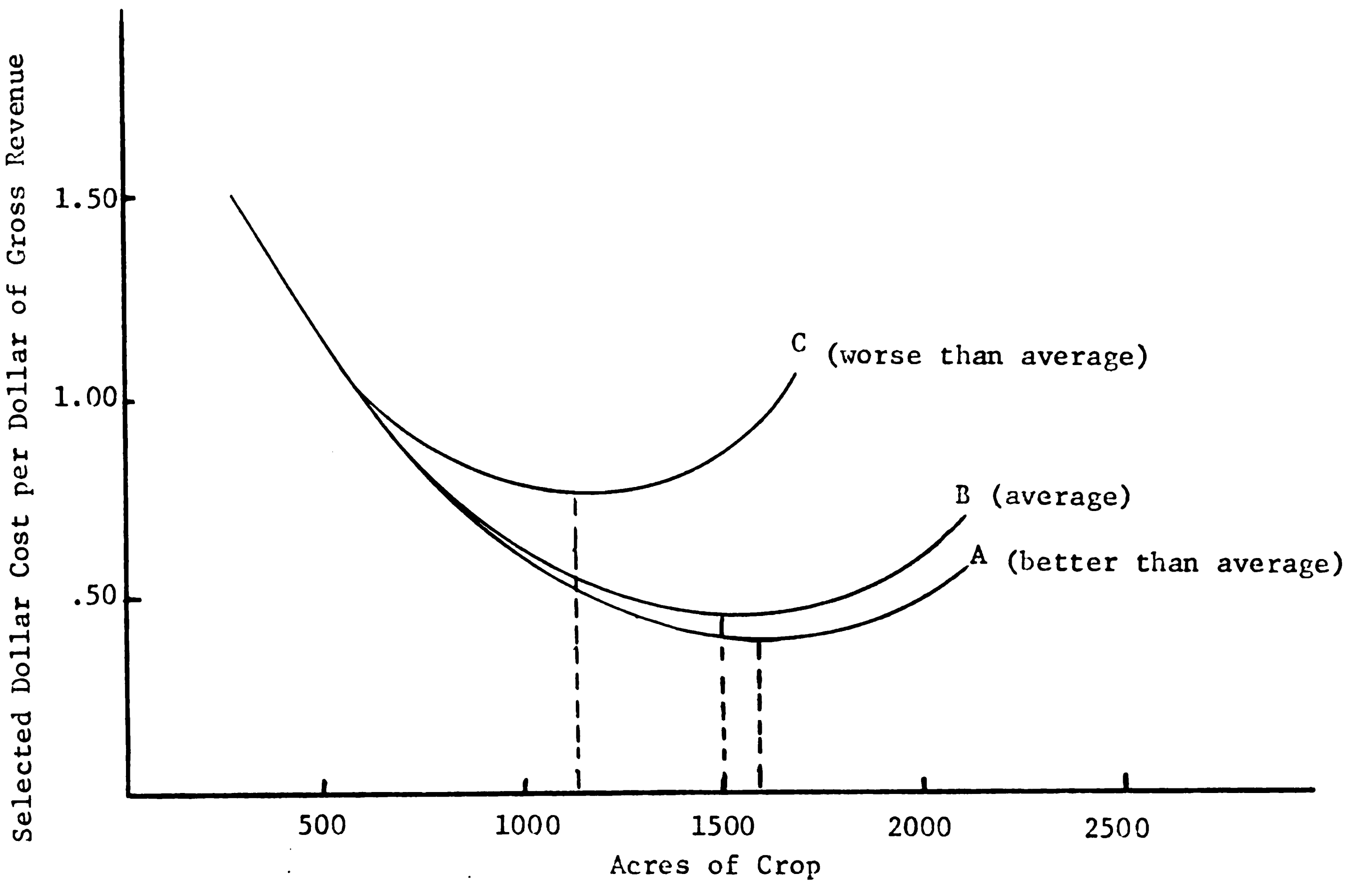

Fig. 22.--Short-Run Average Selected Costs per Dollar of Gross Revenue for the 1500 Acre Budget Model Under Better Than Average, Average, and Worse Than Average Weather Conditions.

than that which is optimum for average weather. Curve B represents short-run average selected costs for the 1500 acre budget model, given a specified machinery component, designed to minimize selected fixed and variable costs, assuming average weather conditions.

The rationale for investing more in equipment than is justified for an "average" or "normal" year has been pointed out by Dean and Carter.[1] In a study of Yolo County farms in California they compared actual performance of 37 farms in 1958 (a year of late spring rains which hampered field operations) with their projected performance when adjusted for normal weather conditions. Farms normally utilizing their machinery at less than 25 percent of capacity experienced an increase of 4 percent in average total costs per dollar of total revenue in 1958 compared to a normal year; farms normally operating equipment from 25-75 percent of capacity experience a 12 percent increase in average total costs in 1958; and those normally operating at 75-100 percent capacity experienced a 17 percent increase in average total costs in 1958. This study indicates that in spite of other factors, such as using machinery more hours when time is limited and using custom operators, farms with little excess machinery capacity suffer more under adverse weather conditions than farms with greater machinery capacity.

A series of average cost curves could be constructed for each machinery component alternative suggested by Tables 9, 10, 11, and 12. In the years following the worst weather conditions, serious losses would

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[1]Dean and Carter, op. cit., p. 38.

be sustained when operating with the reduced machinery components. On the other hand the reduced machinery component alternative would be most profitable in years of more favorable than average weather.

Optimum Ratio Between Machinery Capacity and Acreage

In analyzing the ratio between machinery and crop acreage two alternatives are possible. Machinery can be held constant and acreage adjusted until an optimum is reached. The other procedure is to hold acreage constant and adjust machinery components as suggested by Tables 9-12.

The selection of an optimum resource position under uncertainty can be implemented by the use of a game-theory framework which is developed in this section.[1] A similar analysis was made by Heady and Krenz for various machinery components and farm sizes for corn belt farms.[2]

A careful search failed to reveal any historical data on the number of days during which summer fallow tillage operations have been feasible during the growing season for the study area or any area of similar climatic and soil conditions. Therefore a hypothetical frequency distribution of weather conditions is assumed. Weather conditions are classified into five different groups designated as A, B, C, D, and E,

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[1]The theoretical basis for the game-theory framework is presented in Herman Chernoff and Lincoln Moses, Elementary Decision Theory, New York, John Wiley and Sons, Inc., 1959, pp.1-16.

[2]Heady and Krenz, op. cit., p. 461.

(See Table 13). Group A is the best possible weather condition, B is next,C is average, D is worse than average, and E is the least favorable.

As indicated, six out of 18 years are classified as normal.

TABLE 13.--Hypothetical Weather Categories and Frequency Distributions

	Weather Categories				
	A	B	C	D	E
No. of Years Occurrence in 18 Years	2	4	6	4	2
Probability of Occurrence	0.11	0.22	0.33	0.22	0.11

Optimum Acreage Under Weather Variation

An assumption underlying the budget models is that they are organized to achieve maximum net returns, on the average, for all weather conditions. This is equivalent to what Heady and Krenz call "maximizing the expected value of net return".[1] This expected value is calculated by multiplying the estimated net return for each acreage and weather condition, given a specified machinery component, by the probability of occurrence for each weather condition and summing the products.

The returns to labor and management for the 1500-acre model dryland farm have been budgeted for different acreages, holding the machinery component constant. The results of these budgeted returns are

[1] *Ibid.*, p. 461.

summarized in Table 14. The returns are based on land values of $100 per acre and 5 percent interest charged for total capital investment under the assumption that acquisition prices and salvage values are equal. If this assumption was relaxed, acquisition prices might be used for expanding size beyond 1500 acres and salvage values might be used for contraction. Thus the makeup of the payoff matrix would be changed.

It should be pointed out that the budgeted returns are based on the author's judgment regarding changes in cost and return structure associated with changes in acreage. The empirical data necessary for construction of such a table which could eliminate much of the judgment, are not available. Carefully controlled experimental work over a long period of time could provide information on the relationship between operational timeliness and crop production. However the possibility of getting information on changes in cost structure is remote. For such information the experimental technique is not feasible. Nor are farms available for observation at the extremes (where the ratio of machinery to acreage is very small or very large) which limits the usefulness of the survey technique.

In spite of the arbitrary determination of costs and returns, several useful principles are suggested for allocating resources under weather variability. The net return to labor and management in the 1500-acre model budget is $9,478.00 per year given certain technology, restrictions, weather probability and assumptions. However this value represents only one position in Table 14, viz., the expected return at

TABLE 14.--Net Return to Operator's Labor and Management for Various Acreages of Dry-land Farms with Five Categories of Weather and a Given Component of Summer Fallow Tillage Machinery (Land Valued at $100 per Acre).

Crop Acres		Annual Return to the Operator's Labor & Management Under Five Categories of Weather A	B	C	D	E	Expected Value of Return[a]
	acres	dollars	dollars	dollars	dollars	dollars	dollars
A_1	750	-2,261	-2,309	-2,479	-2,488	-2,509	-2,398
A_2	1,125	2,793	2,412	2,154	1,988	1,816	2,186
A_3	1,500	10,597	10,090	9,603	9,086	8,403	9,478
A_4	2,250	19,449	12,051	10,582	322	-3,891	7,926
A_5	3,000	23,088	12,543	10,981	-3,453	-61,432	1,406

[a]Expected value of return is computed by assigning probabilities for each state of nature as given in Table 13. Each estimated net return (payoff) is multiplied by the frequency of occurrence for the type of weather appropriate to that payoff. Each row is summed to get the average expected value of return for all types of weather.

the 1500-acre level. Any of the other four acreage level alternatives could equally as well be selected as "best" by a given decision-maker, depending on his particular risk-security preference schedule.[1] Income variability is lowest with 750 crop acres. If the owner-operator is

[1]The term "risk-security" preference schedule refers to the individuals desire for or aversion to risk. It is not inferred that this schedule can be quantiatively measured.

willing and financially able to accept a negative return for his labor and management, in order to avoid income variability, he might rationally select the resource combination implied by the 750 acre level. Similarly an owner-operator who is willing and able to withstand extreme income variation may elect the resource combination implied by the 3,000 acre level in Table 14 since the potential gains with better than average weather are greater than for the other four alternatives.

Decision Criteria

In recent years several game theoretic criteria have been developed for use in making decisions under uncertainty. Strictly speaking, decision making under uncertainty assumes the decision maker has no knowledge of the probabilities or frequency distribution of the alternative states of nature.[1] The payoff matrix presented in Table 14 has been analyzed using an assumed frequency distribution of states of nature, in this case weather conditions, but this does not destroy its value for illustrating various decision criteria under uncertainty, a task to which attention is now turned.

Five criteria which have been offered to resolve the decision problem under uncertainty will be described and illustrated. Although the number of such criteria are virtually infinite, these particular criteria are most frequently referred to in the literature and appear to be relevant for farmer decision-making. In each case it is assumed

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[1]R. Duncan Luce and Howard Raiffa, Games and Decisions, New York, John Wiley and Sons, Inc., 1957, pp. 275-277.

the problem can be reduced to certain acts, states of nature, and payoffs. In general the form will follow that illustrated in Table 14 where the acts A_1, A_2. . . A_m, are the acreage levels, the states of nature S_1, S_2, . . . S_n are the weather conditions, and the payoffs u_{ij}, $i = 1, \ldots,$ m and $j = 1, \ldots, n$, are the returns to labor and management. It should be pointed out that decision criteria are not general theories. Each provides a mathematical algorithm for selecting the best act or choice which are tautologically termed "optimal" according to the criterion.[1] There are no a priori theoretical grounds for selecting one criterion over another. Only the psychological makeup of the decision-maker is relevant in selecting a particular decision criterion.

1. The maximin or Wald criterion prescribes that the act which maximizes the minimum payoff is "best". Thus each act is appraised by looking at the worst payoff for that act and then selecting the act which has the best worst payoff.[2]

Under this criterion the optimum act from Table 14 would be A_3 or 1500 acres of cropland. This alternative yields the best worst payoff of the five possible acts. The worst possible return to labor and management under this act is $8,403.00.

2. The minimax regret or Savage criterion considers the regret that might be felt after the true state of nature is known and it is

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[1] _Ibid._, p. 278.

[2] _Ibid._, p. 279.

realized by the decision-maker that a larger payoff could have been achieved by selecting an alternative act. The general procedure for this criterion is:

(a) To each decision problem under uncertainty with payoff entries u_{ij}, develop a new table with payoffs r_{ij}, where r_{ij} is defined as the amount that has to be added to u_{ij} to equal the maximum payoff in the jth column.

(b) Choose that act which minimizes the maximum regret for each act.[1]

To illustrate this criterion first subtract each payoff in each state of nature column in Table 14 from the highest payoff in each column. The results of this computation are:

	A	B	C	D	E
A_1:	25,349	14,852	13,460	11,574	10,912
A_2:	20,295	10,131	8,827	7,098	6,587
A_3:	12,491	2,453	1,378	000	000
A_4:	3,639	492	399	8,764	12,294
A_5:	000	000	000	12,539	69,835

Following this criterion the optimum solution would be 2,250 acres, A_4, since the maximum regret of $12,294 is smaller than that for any other act (row).

3. The pessimism-optimism index criterion of Hurwicz considers both the best and the worst payoffs for each act and gives a solution only after the individual making the decision selects a specific pessimism-optimism index. The Hurwicz criterion is more optimistic than the two previously considered in that it looks at a weighted combination of

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[1] *Ibid.*, p. 280.

the best and worst payoff rather than just the worst consequence. In essence the Hurwicz criterion is as follows:

"For act A_i, let m_i be the minimum and M_i the maximum of the payoff numbers $u_{i_1}, u_{i_2}, \ldots, u_{i_n}$. Let a fixed number between 0 and 1, called the pessimism-optimism index, be given. To each A_i associate the index $\alpha m_i + (1 - \alpha) M_i$, which we shall term the α index of A_i. Of two acts the one with the higher α index is preferred."[1]

To illustrate this method we shall first select the maximum and minimum payoff for each act or row in the payoff matrix, Table 14:

A_1:	-2,509,	-2,261,
A_2:	1,816,	2,793
A_3:	8,403,	10,597
A_4:	-3,891,	19,449
A_5:	-61,432,	23,083

It can be seen that A_3 dominates A_1 and A_2, i.e., A_3 has better outcomes and none worse than A_1 and A_2. Therefore the choice is between A_3, A_4 and A_5. The decision-maker's pessimism-optimism index will determine which act should be selected. This index is specified as some number α between 0 and 1. The weight given to the worst outcome is α, and the weight given to the best outcome is $1 - \alpha$.

For a decision-maker with a pessimism-optimism index of .3 (moderately optimistic) the computations for acts A_3, A_4 and A_5 are:

A_3: .3(8,403) + .7 (10,597) = 9,939
A_4: .3(-3,891)+ .7 (19,449) = 12,447
A_5: .3(-61,432) + .7 (23,083) =-2,268

Therefore with a pessimism-optimism index of .3, A_4 would be selected. These computations have been made for various levels of α and

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[1] *Ibid.*, p.282.

the appropriate choice of acreage for each level of α is given in Table 15. Note that with complete optimism ($\alpha = 0$) the large acreage, A_5, has been selected. On the other hand the completely pessimistic decision-maker ($\alpha = 1$) would choose the 1500 acre size, A_3. When $\alpha = 1$, the Hurwicz criterion becomes the same as the maximin or Wald criterion. Thus the maximin criterion may be considered as a special case of the Hurwicz pessimism-optimism index criterion.

TABLE 15.--Optimum Acreage for a Given Component of Machinery (1500 Acre Model) for Various Levels of the Hurwicz Pessimism-Optimism Index.

Level of α	Optimum Acreage as Indicated by Maximum α Index
0.0	3,000
0.1-0.4	2,250
0.5-1.0	1,500

4. The criterion based on the "principle of insufficient reason" asserts that if one is absolutely ignorant about the frequency distribution of the states of nature he should assign them equal probabilities. This is equivalent to treating the problem as one of risk with a uniform a priori probability distribution over all states of nature. An expected payoff index, anolagous to the expected return to the operator's labor

and management in Table 14 can be computed as

$$\frac{U_{i_1} + U_{i_2} + \ldots + U_{i_n}}{n}$$

for each A_i and the A_i having the highest index value will be chosen.[1]

The results of applying this decision criterion to the payoff matrix from Table 14 are summarized below:

A_1:	-2,409
A_2:	2,232
A_3:	9,556
A_4:	7,703
A_5:	-3,655

The obvious choice in this example is the 1500 acre level, A_3, which coincidentally, is the same solution arrived at earlier in the risk situation by assigning different probabilities to each state of nature.

5. Shackle's theory of potential surprise and focus outcomes involves pairing the best and worst payoff for each act. The pair selected depends on the decision-maker's gambling indifference system. If he is disposed to gamble he chooses the act with the highest possible payoff; if he is less disposed to gamble he may select an act which has a lower potential payoff but also has a more favorable worst payoff.[2]

For example the best and worst payoff for each act in Table 14 are paired as follows:

A_1:	-2,261	-2,509
A_2:	2,793	1,816
A_3:	10,597	8,403
A_4:	19,449	-3,891
A_5:	23,088	-61,432

[1]Ibid., p. 284.

[2]John L. Dillon and Earl O. Heady, Theories of Choice in Relation to Farmer Decisions, Ames, Iowa, Agriculture and Home Economics Experiment Station, Research Bulletin 485,1960, p. 906.

As in the Hurwicz criterion, act A_3 dominates acts A_1 and A_2. Act A_3 has a higher maximum payoff and none worse than A_1 and A_2. Therefore the decision must be between acts A_3, A_4, and A_5. Shackle's criterion suggests that a decision-maker having a high propensity to gamble would select act A_5 since this act offers the greatest possible payoff. In view of the potential loss for act A_5 however, it might be more appropriate to say the decision-maker who selected this act would have to have a pathological desire to gamble. Following this criterion the most conservative position would be act A_3 which is the 1500 acre level.

In summary it has been demonstrated that different alternatives should be selected depending on the decision-maker's psychological make-up and goals. It must be assumed that the acts or alternatives considered are open to the decision-maker, i.e., they are not blocked due to capital rationing, institutional factors, or other restrictions. According to the various criteria the optimum decision with respect to the payoff matrix, Table 14, would be A_3 for the Wald maximin, A_4 for the Savage minimax regret, A_3 for Hurwicz pessimism-optimism with α = .5 to 1.0, A_4 with α = .1 to .4, and A_3 with α = 0, A_3 for the principle of insufficient reason and A_3, A_4 or A_5 for the Shackle approach depending on the decision-maker's disposition to gamble.

Optimum Machinery Capacity for a Given Acreage

The problem of selecting an appropriate crop acreage to combine with a given complement of machinery in order to achieve certain satisfactions and objectives of a decision-maker has been studied. It is now desirable to apply various decision criteria to the selection of machinery complements for a given acreage.

Earlier in this chapter cost changes associated with changing machinery complements for a 1500 acre farm were analyzed. Utilizing these data a payoff matrix is now constructed in which the alternative acts are considered as different machinery components for a 1500 acre farm under five states of nature (weather categories). As before, the matrix rests on the assumption acquisition prices and salvage values are equal. This matrix is summarized in Table 16.

The variance in net return to the operator's labor and management is not as great as in the previous payoff matrix (Table 14). This is because the alternatives under consideration, A_1, A_2, . . . A_5, do not affect returns as much as the alternatives in Table 14. In the present case only changes in tillage capacity are considered, whereas in the former, the total relationship between all machinery and acreage was considered.

The net return estimates which make up the payoff matrix in Table 16 are based on the same prices, costs and technology used in constructing the budget models. As with the payoff matrix developed for different levels of acreage, this matrix is subject to error resulting from lack of empirical data. However, as an illustration of a method of decision making, it is useful. Each decision-maker may supply his own estimates of net income related to alternative strategies (acts) and states of nature.

The criteria used previously have been applied to analyzing the optimum machinery capacity for the 1500 acre farm. The results obtained from applying those criteria are summarized in Table 17. As would be expected there is a tendency to choose more machinery as the degree of

TABLE 16.--Net Return to Operator's Labor and Management for Alternative Summer Fallow Tillage Machinery Components of 1500 Acre Dry-land Farm Under Five Weather Categories.

Machinery Component		Annual Return to the Operator's Labor & Management Under Five Categories of Weather A	B	C	D	E	Expected Value of Return[a]
	days[b]	dollars	dollars	dollars	dollars	dollars	dollars
A_1	3.5	4,925	4,925	4,925	4,925	4,925	4,875
A_2	5.25	7,175	7,175	7,175	7,175	6,975	7,081
A_3	7	9,759	9,759	9,759	9,270	9,070	9,478
A_4	10.5	11,275	10,240	9,260	8,845	8,004	9,375
A_5	14	11,400	10,200	8,850	8,200	6,500	8,938

[a]Expected value of return is computed by assigning probabilities for each state of nature as given in Table 13. Each estimated net return (payoff) is multiplied by the probability of occurrence for the type of weather appropriate to that payoff. Each row is summed to get the average expected value of return for all types of weather.

[b]The machinery component is measured in terms of ten-hour-days required to complete the first summer fallow tillage operation each year. The basic machinery component is given in detail for a 1500 acre farm in Appendix C, Table 2. Adjustments for acts A_1, A_2, A_4, and A_5 above are shown in detail in Tables 9-12.

pessimism increases.

From observation of the payoff matrix in Table 16 it appears that all strategy alternatives are superior to A_1 since they all have higher maximum payoffs and none lower than A_1. Based on the data, it is difficult to imagine why any decision-maker would choose the A_1 alternative. Perhaps a pathological desire for income stability could be a reason justifying such a position. Other forms of utility, achieved by choosing such a position, may be related to personal satisfactions associated with such things as pride in property ownership and getting work done ahead of neighbors.

TABLE 17.--Optimum Machinery Components According to Various Decision Criteria for 1500 Acre Dry-land Farm.

Criterion	Decision on Machinery Component Alternative
Risk (expected value of return as explained on page 127)	$A_3 > A_4 > A_5 > A_2 > A_1$[a]
Uncertainty:	
Maximin (Wald)	$A_3 > A_4 > A_2 > A_5 > A_1$
Minimax regret (Savage)	$A_4 > A_3 > A_5 > A_2 > A_1$
Pessimism-optimism index (Hurwicz)	
$\alpha = 0$	$A_5 > A_4 > A_3 > A_2 > A_1$
$\alpha = .2$	$A_4 > A_5 > A_3 > A_2 > A_1$
$\alpha = .4$	$A_4 > A_3 > A_5 > A_2 > A_1$
$\alpha = .6$	$A_3 > A_4 > A_5 > A_2 > A_1$
$\alpha = .8$	$A_3 > A_4 > A_5 > A_2 > A_1$
$\alpha = 1.0$	$A_3 > A_4 > A_2 > A_5 > A_1$
Principle of insufficient reason	$A_4 > A_3 > A_5 > A_2 > A_1$

[a]The symbol $>$ means "preferred to".

According to the pessimism-optimism index, only the most optimistic decision-maker (α = 0.0) would try to operate a 1500 acre farm with machinery which would require 14 days of actual operating time for each tillage operation. The most pessimistic decision-maker, according to this criterion, would select A_3 where the possibilities of large losses are minimized.

Machinery Capacity In The Triangle

This section of Chapter V has two major objectives: (1) to estimate the actual and desired tractor power capacity on various sizes of dry-land cash grain farms in the Triangle and (2) to determine the difference, if any, between tractor power capacity on farms producing predominately spring grain and those farms producing predominately winter wheat. No known source of data relative to these objectives is available for the Triangle.

Since tractor power capacity is the crucial factor limiting tillage and seeding capacity, such an estimate will provide a basis for estimating operational timeliness. The importance of operational timeliness in the construction of budget models for various sizes of farms has been observed. Therefore an empirical estimate of tractor power and operational timeliness would be valuable.

Sampling Procedure

The farm observations, from which the budget models were derived, were made in an area of the Triangle designed as Community "G" (see page 5), which produces winter wheat as the major cash crop. To the north of this area is a continuation of the winter wheat area designated officially as Communities "H" and "C" of Hill and Liberty counties respectively, by the Montana Agricultural Stabilization and Conservation Service of the United States Department of Agriculture. Only the south half of Community "H" was used since the northern part of this Community extended into the spring wheat area. The spring wheat area selected for

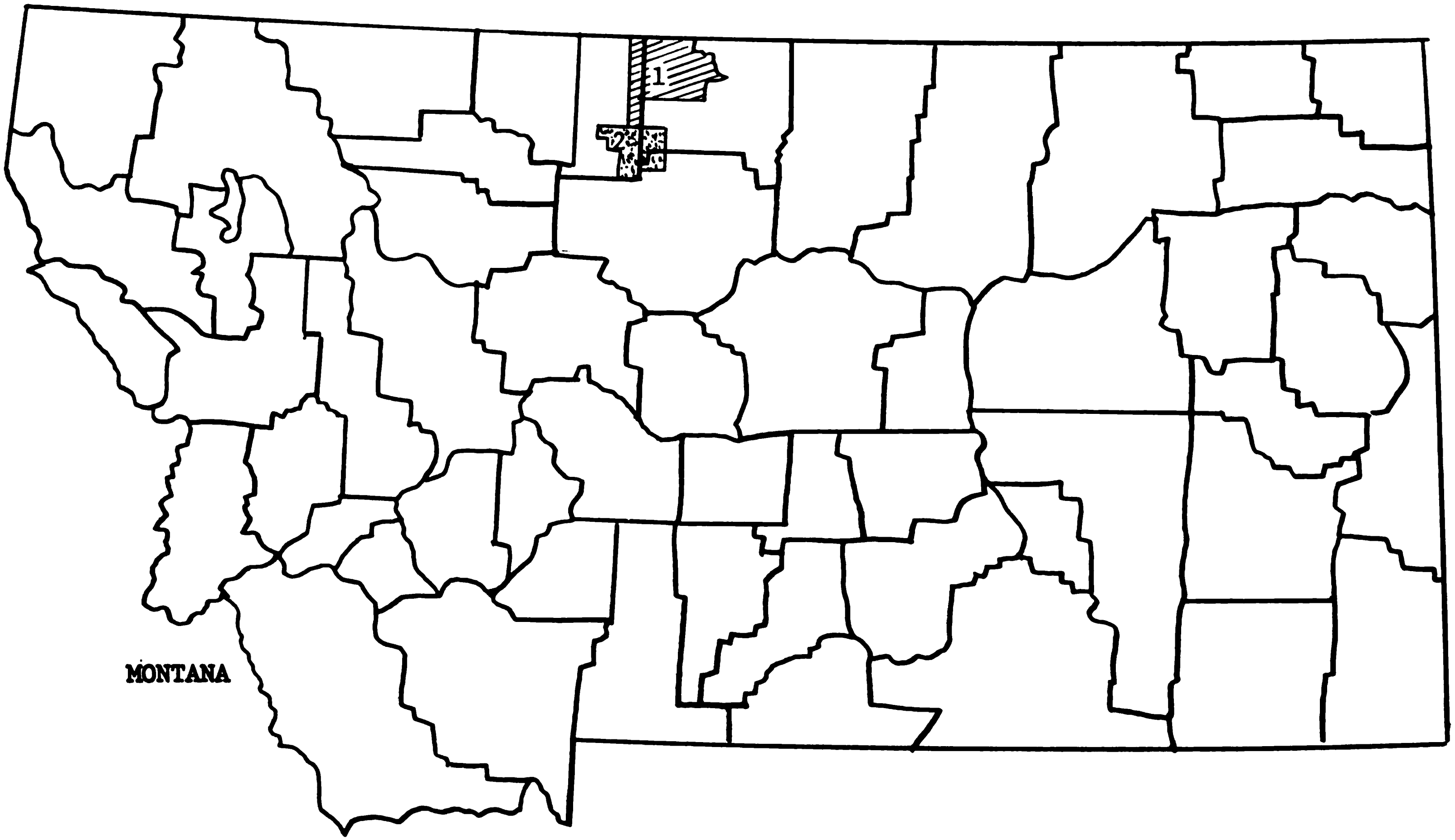

Fig. 23.--Spring Wheat and Winter Wheat Areas Selected for Machinery Capacity Sampling.

sampling was comprised of Communities "I" and "A" from Hill and Liberty counties respectively. This is shown in Figure 23 as the shaded area (1). Area (2) corresponds to the geographical location used for drawing the sample of winter wheat farms.

The spring wheat area selected for sampling contained approximately 125 farms and the winter wheat area contained approximately 60 farms. With the aid of county office managers of the Agricultural Stabilization and Conservation Service, all farms were removed from the two populations which were known to have more than 25 head of beef cattle or any other substantial livestock enterprise. The reason for this was that it was desired to remove the effect of livestock on machinery-land relationships from the population sampled. After making this adjustment the two populations contained 106 and 48 farms respectively.

The wheat acreage allotment and the feed grain base for each farm was obtained from the Agricultural Stabilization and Conservation Service. The sum of these two acreages was used as a measure of farm size. The farms in each population were then arrayed from the smallest to the largest size. Observation of farm sizes arrayed in such a manner revealed that the distribution of farms were skewed to the left or toward the small size of farms.

Since one of the purposes of sampling these populations was to determine the relationship between tractor power capacity and farm size, it was decided to use a special sampling procedure other than selecting a purely random sample. Thus for the spring wheat population of farms the three that came closest to acreages of 300, 600, 900, 1200 and 1500 were selected to be interviewed. For the winter wheat population the three farms nearest to each size of 300, 600, 900 and 1,200 acres were selected. Thus the anticipated sample size was 15 and 12 for each respective population. Actually 17 usable observations from the spring wheat area and 14 from the winter wheat area were ultimately obtained.

One of the anticipated advantages of this sampling procedure was that in the event the relationship between tractor power and farm size was not linear, analysis of variance could be used to determine differences in tractor power capacity related to farm size. By selecting farms which cluster about a given size, within treatment variance could be minimized. The experimental design, is summarized below. Notice that each farm size is considered as a different treatment with three replications.

Spring Wheat Population

	T_{300}	T_{600}	T_{900}	T_{1200}	T_{1500}
Rep 1					
Rep 2					
Rep 3					

Winter Wheat Population

	T_{300}	T_{600}	T_{900}	T_{1200}
Rep 1				
Rep 2				
Rep 3				

The survey was conducted by telephone. In one case there was some reluctance to provide information but when it was suggested that the respondent could check the authenticity of the survey with his local County Extension Agent before answering the questions, consent was given and the interview proceeded. The questionnaire is included in this report as Appendix E.

Measurement of Horsepower

The telephone survey revealed that tractor make and model numbers were readily available from farmers. Often respondents also volunteered information about the manufacturer's rated horsepower for their tractor. Such information is believed to be unacceptable because of the variety of ways in which horsepower can be stated, e. g., motor, drawbar, power-take-off, belt, maximum capacity, less than maximum capacity, etc. Therefore, with information on make, model and year, the Nebraska tractor tests were relied on for horsepower data. Drawbar horsepower at 75 percent of pull at maximum power was selected as the standard for rating all tractors.[1]

The type of tractors reported by farmers sampled included both two wheel drive and four-wheel drive rubber tired units as well as crawlers. Since the Nebraska tractor tests are made on concrete for

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[1]For an explanation of the conditions under which drawbar horsepower at 75 percent of pull at maximum power is calculated see Implement and Tractor Publications, Inc., Farm Equipment Red Book, Volume 81, No. 3, Kansas City 5, Mo., January, 1966, p. A-225.

rubber tired units and firmly packed soil for crawlers,[1] it was necessary to derive a standardized coefficient of horsepower for each type of tractor, when used under field conditions, in order to have a uniform measure of effective field horsepower. In other words a two-wheel drive rubber tired tractor of x drawbar horsepower, based on tests made on concrete, is not equivalent to a crawler tractor of the same horsepower based on tests made on firm soil, when both are used under typical field conditions.

The reason such comparisons are invalid is that the coefficient of traction[2] changes when the two different types of driving mechanisms, the wheel and the track, are placed in an environment different from that in which the tests were made. Barger, et. al., reports that some of the factors affecting the coefficient of traction are: type of traction device, tire inflation pressure, soil type and state, soil moisture content, lug design, dimensions of traction device, and soil pressure distribution.[3]

In view of these variables, each tending to increase or decrease the effective horsepower available from a given tractor under field conditions, it is apparent that refined estimates of differences between

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[1]Ibid., p. A-224.

[2]Defined as the ratio of the drawbar pull to the dynamic load on the traction device according to Barger et. al., (see footnote 3 of this page.)

[3]E. L. Barger, J. B. Liljedahl, W. M. Carleton, and E. G. McKibben, Tractors and Their Power Units, New York, John Wiley and Sons, Inc., Second Edition, 1963, p. 272.

types of traction devices are impossible. Barger et. al., indicated that the state of the arts relative to making such measurements are crude:

> "Because of the complex and variable nature of soil, its properties have not been classified with the degree of precision normally associated with most engineering materials. As a result, the experimental rather than the analytical approach has generally been used in the design of traction members for tractors. . . ."[1]

It appears that precise engineering data which show the relationships needed to compare horsepower for various types of tractors in the Triangle are not available.[2] Therefore it is necessary to use the estimated data referred to in Table 4 (page 65) for coefficients with which to reduce drawbar horsepower for different types of tractors to an approximated common denominator. It has already been pointed out that the coefficients reported in Table 4 reflect reductions in power due to transmission losses (from power outlet to axle), slippage and rolling resistance. While it would be desirable to have coefficients which reflect only slippage and rolling resistance, the affect of transmission loss on the coefficient is small and thus may be ignored.[3]

To summarize, the coefficients used to provide a common horsepower value for tractors reported in this study are:

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[1]*Ibid.*, p. 273.

[2]This point has previously been discussed relative to selecting tractor power for the budget models (see pages 62-66).

[3]See discussion on page 64.

Crawlers	.80
Four-wheel drive, equal tire size	.80
Four-wheel drive, smaller front tires	.72
Two-wheel drive	.65

The product of the drawbar horsepower (75 percent of pull at maximum power) for a given make, model, and year tractor and the appropriate coefficient from those listed above results in a horsepower rating for each tractor that can be compared and related to farm size.[1]

For example if a farm reports using a 1965, Model M670 Diesel, Minneapolis Moline tractor, a coefficient of effective field horsepower would be calculated as follows. The maximum drawbar horsepower for such a tractor is 64.08 according to tests performed by the University of Nebraska Agricultural Experiment Station.[2] This is the horsepower rating usually mentioned by dealers and most often reported by farmers when responding to a question about tractor horsepower. However the Nebraska tests also report drawbar horsepower at 75 percent of pull at maximum power for a ten-hour test which more nearly represents usable horsepower at the drawbar on concrete. For the Model M670 Diesel this value is 50.46. Since this tractor has a standard chassis, two-wheel drive, a value of .65 will be used to derive a coefficient of effective field horsepower (.65 X 50.46 = 32.80). The horsepower value of each

[1]After making the adjustments outlined here and comparing the results with machinery loads and speeds reported by farmers interviewed it appears that the capacity of crawler tractors and four-wheel drive equal size tire units is being slightly underestimated by this procedure. However farmer information on loads, speeds traveled and acres covered per hour or per day are too variable and indefinite to use as a basis for making valid inferences.

[2]Implement and Tractor Publications, Inc., op. cit., p. A-223.

tractor reported in this study, which corresponds to the value 32.80 in the example, is used in the statistical analyses which follow.

Estimates of Tractor Power

Upon completion of the interviews in the spring wheat and winter wheat areas scatter diagrams were prepared which show the relationship between farm size and tractor power (see Figures 24 and 25). These diagrams revealed that the anticipated cluster of points about specified acreages was not achieved and that there was a generally linear relationship between acreage and tractor power. The anticipated grouping of points, with respect to specified sizes of farms, did not materialize because many farms were not participating in acreage allotment programs or were farming land which was listed in another ownership. However, this did not present a problem since the relationship between farm size and tractor power was obviously linear. This eliminated the need to employ analysis of variance to estimate differences in tractor power between treatment groups and consequently the desirability of having treatment groups of equal size.

The linear regression equation

$$\mu_{y \cdot x} = \alpha + \beta(x - \bar{x}) \qquad (1)$$

is constructed according to the usual assumptions that each x-array of y is normally distributed and all x-arrays of y have the same variance. It has two parameters α and β.[1] If these parameters are known the values of y can be determined for any given value of x. If the population is not known these parameters must be estimated from a sample. In this study these parameters were estimated from two samples, one of 17 spring wheat farms and the other of 14 winter wheat farms. In the analysis which follows y designates effective drawbar horsepower and x designates acres of summer fallow. The sample estimates of α, β, and $\mu_{y \cdot x}$ are denoted by a, b, and $\bar{y}_x$ respectively. Then the estimated regression equation is

$$\bar{y}_x = a + b\,(x - \bar{x}), \qquad (2)$$

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[1] Statistical notations and terminology are from Jerome C. R. Li, Statistical Inference I, Ann Arbor, Michigan, Edward Bros., Inc., 1964, pp. 279-349. For purposes of this discussion the following notations and definitions are listed:

$\mu_{y \cdot x}$ is the mean of a sub-population or an array of y with respect to a given x.

α is the mean of the array of y where the x value is equal to the mean of all x values, $x = \bar{x}$.

β is the rate of change of the mean of y with respect to x and is called the regression coefficient.

When the estimates a and b are obtained from the sample, $\bar{y}_x$ can be obtained for any value of x. For simplification and to facilitate graphic exposition this equation is generally written

$$\bar{y}_x = a + bx. \qquad (3)$$

The value, $b\bar{x}$, has been subtracted from a. When the equation is written as in (3) the value of a represents the estimated mean of the array of y when x = 0. In other words it indicates the point on the y axis or perpendicular coordinate of a two dimension diagram which is intersected by the regression line.

A scatter diagram and a regression line, fitted by the method of least squares, for the sample of spring wheat farms is depicted in Figure 24. The estimated regression equation for the regression line shown as a solid line in Figure 24 is

$$\bar{y}_x = 21.3 + .049x.$$

From this equation drawbar horsepower requirements can be estimated ($\bar{y}_x$) for a farm if acreage (x) is known. A test of the hypothesis that β = 0 yields an F value of 65.349 with 1 and 15 degrees of freedom which leads to the rejection of the hypothesis at the 1 percent level of significance. The correlation coefficient for the data depicted in Figure 24 is .902 and the estimated variance, with respect to the regression line, is 363.4. The resulting standard deviation, shown by the broken lines in Figure 24, is 19.06.

A similar analysis was made of the 14 farms included in the winter wheat sample and is depicted in Figure 25. A comparison of the statistics calculated for each sample is provided in Table 18. The estimated β coefficients in both samples are significant at the 1 percent level.

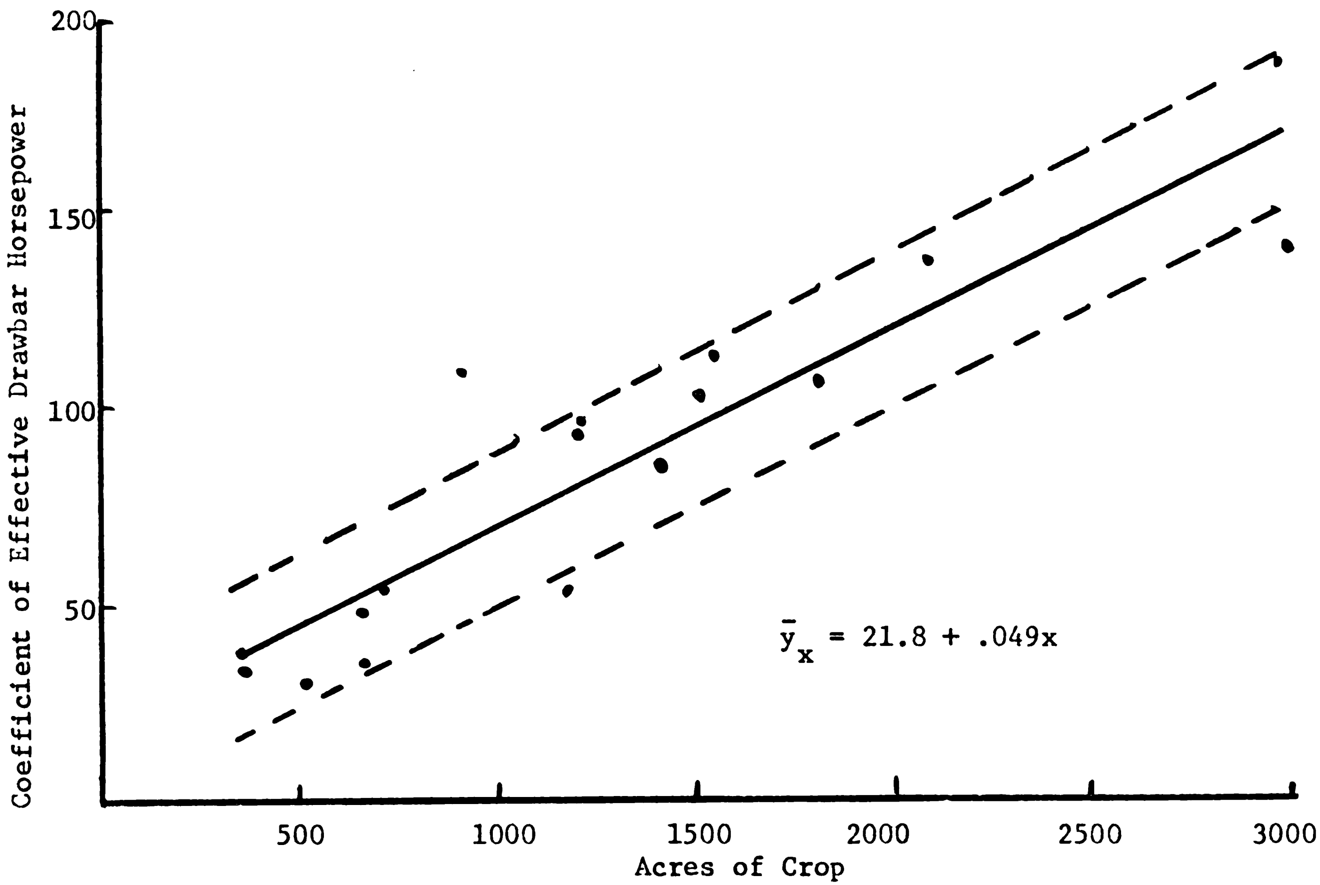

Fig. 24.--The Relationship Between Actual Acreage and Tractor Power for Dry-land Spring Wheat Farms in Selected Areas of Hill and Liberty Counties, Montana.

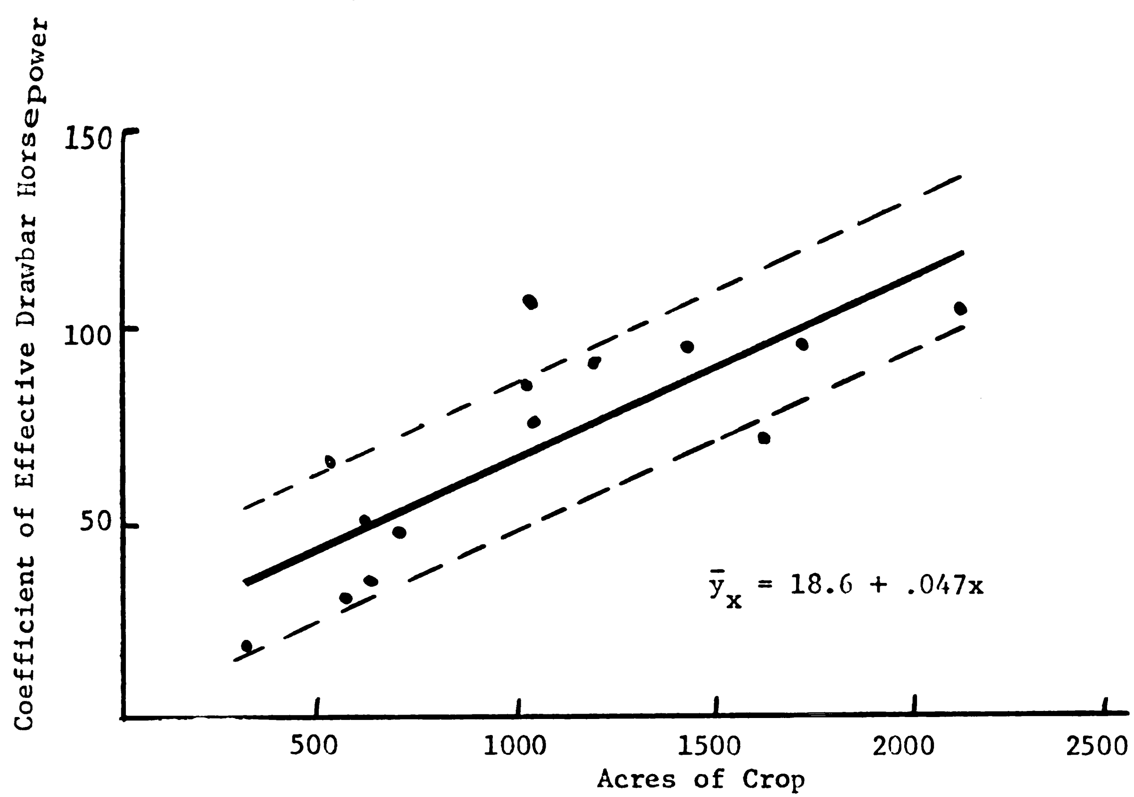

Fig. 25.--The Relationship Between Actual Acreage and Tractor Power for Dry-land Winter Wheat Farms in Selected Areas of Hill and Liberty Counties, Montana.

Visual appraisal of the data shown in Figures 24 and 25 as well as comparison of the data in Table 18 indicates considerable similarity between the two samples.

Therefore the hypothesis $b_1 = b_2$ was tested to determine if the regression coefficients from the two samples could be considered as

TABLE 18.--Summary of Statistics of the Relationships Between Tractor Power and Actual Acreage for Spring Wheat and Winter Wheat Samples.

Statistic	Spring Wheat Sample	Winter Wheat Sample	Combined Samples
Number in sample (n)	17	14	31
Regression coefficient (b)	.049	.047	.049
F-ratio $\frac{\text{regression SS}}{s^2}$	65.349 (1, 15)	24.788 (1, 12)	100.527 (1,29)
Standard deviation (s)	19.06	18.20	18.22
Correlation coefficient (r)	.902	.821	.881
Mean of x/y	14.7[a]	15.6[a]	15.1[a]

[a]The mean of x/y is a measure of average acres per horsepower for all farms in each sample and is calculated $\frac{\sum(x/y)}{n}$.

estimates of a common β . For this test, t as in equation (4) is distributed as Student's t with $n_1 + n_2 - 4$ degrees of freedom,[1]

[1]Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics, New York, McGraw-Hill Book Co., 1960, p. 173.

$$t = \frac{b_1 - b_2}{\sqrt{s_p^2\ (1/\Sigma x_{1j}^2 + 1/\Sigma x_{2j}^2)}} \qquad (4)$$

where s_p^2 is the pooled variance from the two samples and the other notations are as explained above. This test yields a t-value of .260 with 27 degrees of freedom which justifies acceptance of the hypothesis using the two-tailed test and the 5 percent level of significance.

In addition the hypothesis that $\left[\frac{\Sigma (x/y)}{n}\right]_1 = \left[\frac{\Sigma (x/y)}{n}\right]_2$ was tested where subscripts 1 and 2 refer to the winter wheat area and spring wheat area respectively, to determine if the means of the ratio between acres and horsepower for each sample were estimates of a common parameter. For this test, based on analysis of variance, t as in equation (5) is distributed as Student's t with $n_1 + n_2 - 2$ degrees of freedom.[1]

$$t = \frac{\left[\frac{\Sigma (x/y)}{n}\right]_1 - \left[\frac{\Sigma (x/y)}{n}\right]_2}{\sqrt{s_p^2\ (\frac{1}{n_1} + \frac{1}{n_2})}} \qquad (5)$$

This test yields a t-value of .629 with 29 degrees of freedom which justifies accepting the hypothesis using the two-tailed test and 5 percent level of significance.

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[1]Jerome C. R. Li, op. cit., p. 146.

The results of these tests indicate there is no significant difference in the relationship of tractor power to farm size between the spring wheat and winter wheat areas.[1] This justifies pooling the observations from the two samples and deriving a regression equation common to both samples. The summary of statistics for the combined sample are included in Table 18. A scatter diagram and regression line for the combined samples are provided in Figure 26.

The interviews also obtained an estimate from farmers of their <u>desired</u> acreage considering their present tractor power capacity. They were asked to estimate the amount of land they could farm with their present line of machinery without working double shifts or increasing the days required per tillage operation to the point where yields were seriously reduced. Regression analyses were made using the <u>desired</u> acreage data in place of <u>actual</u> acreage data. As in the case of the actual data, statistical tests indicated there was no significant difference in the mean acreage to horsepower ratios or in the regression coefficients between the spring wheat and winter wheat areas. The various statistics for desired acreages on winter wheat farms, spring wheat farms and combined samples of farms are listed in Table 19. The correlation coefficient and the F-ratio are both higher for the desired acreages than for the actual acreages. The estimated standard deviation is lower for the desired acreage than for the actual acreage.

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[1] A more powerful test might have been used. For example see Richard J. Foote, <u>Analytical Tools for Studying Demand and Price Structures</u>, Washington, D. C., Agricultural Handbook No. 146, United States Department of Agriculture, 1958, pp. 181-82.

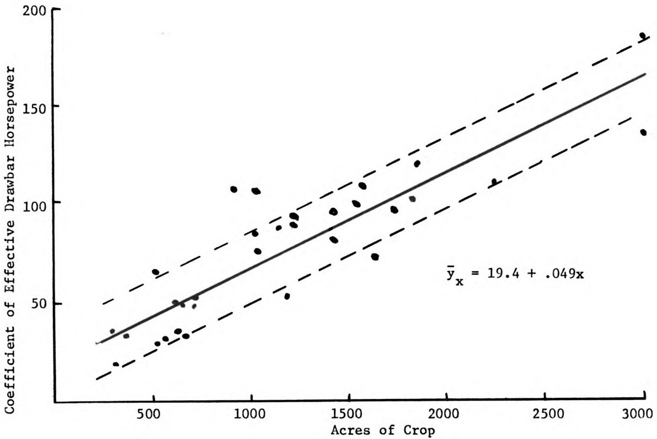

Fig. 26.--The Relationship Between Actual Acreage and Tractor Power for Combined Samples of Dry-land Winter Wheat Farms and Dry-land Spring Wheat Farms in Selected Areas of Hill and Liberty Counties, Montana.

The hypothesis that $\left[\frac{\Sigma (x/y)}{n}\right]_1 = \left[\frac{\Sigma (x/y)}{n}\right]_2$, where the subscripts 1 and 2 refer to the combined samples using actual acreage and desired acreage respectively, was tested to determine if the means of the ratio between acreage and horsepower for each sample were estimates of a common parameter. The t-value for this, a two-tailed test, is derived as in equation (5) with 60 degrees of freedom. A value of t = 3.958 with 60 degrees of freedom leads to the rejection of the null hypothesis at the 1 percent significance level and it is concluded that the mean of desired acreage to horsepower ratio is less than the mean of actual acreage to horsepower ratio.

TABLE 19.--Summary of Statistics of the Relationships Between Tractor Power and Desired Acreage for the Spring Wheat and Winter Wheat Samples.

	Spring Wheat Sample	Winter Wheat Sample	Combined Samples
Number in sample (n)	17	14	31
Regression coefficient (b)	.049	.052	.051
F-ratio $\frac{\text{regression SS}}{s^2}$	73.804 (1,15)	97.830 (1,12)	156.567 (1,29)
Standard deviation (s)	18.13	10.54	15.21
Correlation coefficient (r)	.912	.944	.918
Mean of x/y	17.8[a]	19.9[a]	18.8[a]

[a]The mean of x/y is a measure of average acres per horsepower for all farms in each sample and is calculated $\frac{\Sigma (x/y)}{n}$.

This evidence supports the general hypothesis that farmers operate with excess tractor capacity. In other words actual tractor capacity is greater than what farmers consider to be optimum. Expressed as a percentage, it appears that on the average farmers in the area studied operate with what they think is approximately 25 percent over-capacity.[1]

A scatter diagram and regression line for the combined samples using desired acreage is presented in Figure 27. This regression line represents the combined judgment of 31 farmers regarding the desired relationship between acreage and tractor power. The statistics corresponding to Figure 27 are listed in the third column of Table 19. Note the high F-ratio and correlation coefficient.

The regression equation shown in Figure 27 provides a good basis for estimating tractor requirements for farms in the population sampled. It eliminates known over-capacity due to mistakes and other reasons farmers may have for being in a less than optimum position regarding their actual acreage to tractor power ratio.

To facilitate the use of the regression equation shown in Figure 27 in selecting tractor capacity for different sizes of farms, Table 20 has been prepared. Drawbar horsepower requirements are shown for different types of tractors with ratings shown at 75 percent of pull at maximum power. This value, unfortunately is not commonly available to farmers and can be obtained only by reference to Nebraska tractor tests. An approximate conversion to the more common maximum drawbar horsepower value can be made by dividing the coefficients in Table 20 by .75.

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[1]This percentage is calculated as $\frac{(18.8-15.1)}{15.1} 100 = 24.5\%$ where 18.8 is the mean ratio of desired acreage to horsepower and 15.1 is the mean ratio of actual acreage to horsepower.

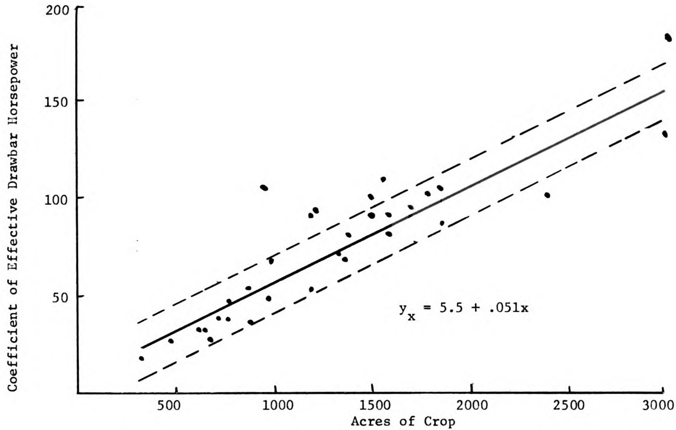

Fig. 27.--The Relationship Between Desired Acreage and Tractor Power for Combined Samples of Dry-land Winter Wheat Farms and Dry-land Spring Wheat Farms in Selected Areas of Hill and Liberty Counties, Montana.

TABLE 20.-- Drawbar Horsepower Requirements for Farms of Various Sizes Based on Survey of Spring Wheat and Winter Wheat Farms in Hill and Liberty Counties, Montana.

Acres of Fallow	Coefficient of Effective DHP	Drawbar Horsepower at 75 percent of Pull at Maximum Power[a]		
		2-Wheel Drive	4-Wheel Drive Smaller Front Tires	Crawlers and 4-Wheel Drive - Equal Size Tires
300	20.7	31.8	28.8	25.9
400	25.8	39.5	35.7	32.1
500	30.9	47.4	42.8	38.5
600	35.9	55.2	49.9	44.9
700	41.0	63.1	56.9	51.3
800	46.1	70.9	64.0	57.6
900	51.1	78.6	70.9	63.9
1000	56.2	86.5	78.1	70.3
1200	66.3	102.0	92.1	82.9
1400	76.5	117.7	106.3	95.6
1600	86.6	133.2	120.3	108.3
1800	96.8	148.9	134.4	121.0
2000	106.9	164.5	148.5	133.6
2200	117.0	180.0	162.5	146.3
2400	127.2	195.7	176.7	159.0
2600	137.3	211.1	190.6	171.5
2800	147.5	226.9	205.9	184.4
3000	157.6	242.5	218.9	197.0

[a]These values for most tractors are reported in the Nebraska tractor tests. If these reports are not available the coefficient may be estimated for any tractor by taking 75 percent of the more commonly known maximum drawbar horsepower.

The data provided in Table 20 can be used to estimate tractor requirements for a farm of a given size. However when tractor requirements are estimated by this method and the results are compared with actual farm situations, it appears that the coefficients in the table underestimate the effective power available from crawler and four-wheel drive equal size tire units. This suggests that the factor of .80 used to reduce drawbar horsepower at 75 percent pull at maximum power to effective horsepower under field conditions, is too low for these types of tractors. Engineering studies directed toward developing better coefficients of effective horsepower under field conditions for various types of traction mechanisms could greatly improve methods of estimating tractor requirements.

Field Tillage Capacity

If the estimate of horsepower relative to acreage accurately measures effective drawbar horsepower available under field conditions it should provide a relative measure of field tillage capacity. To check this relationship farmers interviewed were also asked to estimate their tillage capacity in terms of acres per hour or day, pulling chisels the first time over. In a few cases, in which they were unable to make this estimate, they provided information on the span of equipment pulled in feet and the gear used. A quick calculation, using the Tractor and Equipment Guide[1] to establish ground speed and equation (2) on page 60,

[1]National Farm and Power Equipment Dealers Association, Official Tractor and Farm Equipment Guide, St. Louis, Mo., NRFER Publications, Inc., 1966, pp. 34-43.

TABLE 21.--Tillage Capacity Reported by Farmers in Combined Samples of Spring Wheat and Winter Wheat Farms, Liberty and Hill Counties, Montana.

Tillage Capacity 1st Time Over	Actual		Desired	
	Acreage Fallowed	No. 10-hour Days Required	Acreage to Fallow	No. 10-hour Days Required
Acres/10-hr. day	Acres	Days	Acres	Days
70	350	5.0	670	9.6
76	350	4.8	750	9.9
56	500	8.9	500	8.9
90	640	7.1	640	7.1
100	640	6.4	800	8.0
130	650	5.0	1000	7.7
100	700	7.0	900	9.0
225	900	4.0	900	4.0
135	1200	8.9	1200	8.9
220	1200	5.5	1800	8.2
180	1200	6.7	1520	8.4
140	1400	10.0	1400	10.0
175	1520	8.7	1720	9.8
250	1550	6.2	2550	10.2
218	1800	8.3	1800	8.3
300	2920	9.7	2920	9.7
300	3000	10.0	3000	10.0
60	320	5.3	320	5.3
90	490	5.4	790	8.8
50	510	10.2	710	14.2
100	600	6.0	900	9.0
90	585	6.5	1000	11.1
80	663	8.3	823	10.3
120	1000	8.3	1600	13.3
245	1000	4.1	1850	7.6
100	1020	10.2	1350	13.5
182	1200	6.5	1500	8.2

TABLE 21.--Tillage Capacity Reported by Farmers in Combined Samples of Spring Wheat and Winter Wheat Farms, Liberty and Hill Counties, Montana. (Continued)

	Actual		Desired	
Tillage Capacity 1st Time Over	Acreage Fallowe	No. 10-hour Days Required	Acreage to Fallow	No. 10-hour Days Required
Acres/10-hr. day	Acres	Days	Acres	Days
176	1400	8.0	1600	9.1
150	1636	10.9	1376	9.2
230	1700	7.4	1700	7.4
275	2100	7.6	2420	8.8
Total		226.9		283.5
Average Per Farm		7.3		9.1

provided an estimate of field capacity which the farmer was asked to verify. These data are summarized in Table 21.

The number of ten-hour days required on the average, to do the first tillage operations is 25 percent greater based on the desired acreage than the number of ten-hour days required to do the same operation based on the actual acreage. Both methods of estimating capacity lead to the same conclusion, i.e., farmers in the areas sampled have approximately one-fourth greater machinery capacity for tillage operations than they consider optimum or ideal.

Summary

In this chapter the machinery and acreage relationships under conditions of risk and uncertainty have been studied. A conceptual framework was considered for decision-making. The importance of making specific assumptions regarding decision criteria when computing least cost resource combinations was noted. For example it was demonstrated that budgets designed with machinery components to accomodate farms of a given size under average weather will likely have too little capacity to be optimum when weather variation is introduced.

The use of partial budgets in estimating payoff matrices was illustrated. This device is especially useful for farmer decision-making. It provides a workable took requiring only imagination and the ability to make arithmatic calculations on the part of the decision-maker. Yet, if carefully used, it provides an analytical method for appraising alternatives which utilizes all the intricacies of production economic theory.

The significance of the psychological state of the decision-maker in selecting a position on a payoff matrix was stressed. Several decision criteria were considered and their uses in choosing among alternative courses of action were illustrated.

An investigation of tillage capacity for selected samples of farms in Hill and Liberty counties was described and the results were reported. It was concluded that no significant difference exists in machine capacity between the winter wheat and spring wheat farms. It was also concluded that farms have on the average, 25 percent more tillage capacity than is considered optimum by the farmer's own judgment.

A linear regression equation based on desired relationship between tractor power and acreage was derived from the combined samples of spring wheat and winter wheat farms. A method was illustrated for using this regression equation for estimating tractor requirements on various sizes of farms in the area studied. This method should be useful to lenders, farmers, farm managers, and others interested in farm planning.

CHAPTER VI

RETURNS FROM DRY-LAND FARMING IN THE TRIANGLE

It is generally conceded that returns to human effort in agriculture are low relative to the returns to human effort in most other types of economic endeavor in the United States. Economic reasoning indicates that national income would be higher if resources were shifted out of agriculture and into types of industry where the marginal returns are higher.

In equilibrium, resources devoted to agriculture should be earning, at the time of entry into the agricultural industry, a marginal return comparable to similar resources used in other parts of the economy. The highest return, from these resources in other parts of the economy becomes the opportunity cost of using these resources for agriculture. Comparable returns, of course, do not imply equal returns since different individuals have different occupational preferences. However most economists would agree that occupational preference alone is not sufficient to explain the low monetary returns to human effort in agriculture.

The literature in agricultural economics over the past several decades is replete with attempted explanations of disequilibrium in the agricultural sector of the economy. Dale E. Hathaway suggests five characteristics of the agricultural industry which, considered together, explain most of the persistent disequilibrium resulting in low returns for certain resources. These characteristics are: (1) a highly inelastic demand for agricultural products, (2) a low income elasticity of demand for products, (3) rapid rates of technological change which increase the physical productivity of certain inputs, (4) a competitive structure, and (5) a high degree of asset fixity which reduces resource mobility from the industry.[1] Hathaway points out that although other industries have some of these characteristics, agriculture is in the unique position of having the entire combination.

In this chapter the primary concern is to analyze the magnitude and consequences of asset fixity on the returns to dry-land farming in the Triangle. The approach will be to first examine the potential differences between acquisition price and salvage value for land, machinery, and the entrepreneur's input of human effort. Secondly, these differences will be applied to the total cost-return structure of dry-land farms as previously depicted in the budget models. Finally an hypothesis will be presented which suggests a sequence of events involving sociological variables and mistakes of resource commitment which lead to the "entrapment" of resources into agriculture.

The Potential Magnitude of the Difference Between Acquisition Cost and Salvage Value

Agricultural assets have been classified by Johnson into categories which are reasonably homogeneous with respect to the behavior of acquis-

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[1]Dale E. Hathaway, op. cit., p. 126.

ition costs, marginal value productivity, and salvage value.[1] These assets are classified as follows:

1. Nonfarm produced durables--tractors, combines, tiling, etc.
2. Unspecialized farm durables--fence posts, pasture seedings, soil improvements, etc.
3. Specialized farm durables--dairy cows, orchards, sows, ewes, beef breeding stock, etc.
4. Unspecialized farm expendables--corn, hay, etc.
5. Specialized farm expendables--seed corn, grass seeds, etc.
6. Nonfarm expendables--fuel, oil, commercial fertilizers, etc.
7. Hired labor.
8. Family and operator's labor.
9. Land.

Of these nine categories, numbers 1, 6, 7, 8, and 9 are of major importance in dry-land farming in the Triangle. Number 5 is of minor importance. From the point of view of considering assets which have a tendency to become fixed only numbers 1, 8, and 9 are important. The other categories of assets which are important to farms in this study are characteristically available in relatively small units and traded in relatively perfect markets. As a result there is little reason for any divergence between acquisition price and salvage value.

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[1]Glenn L. Johnson "Supply Function--Some Facts and Notions", Agricultural Adjustment Problems in a Growing Economy, Ames, Iowa, Iowa State University Press, 1956.

Agricultural assets can be further classified as: (1) fixed to an enterprise, (2) fixed to a farm but variable between enterprises or (3) fixed to the industry but variable between farms. This discussion is oriented towards the farmer's or the entrepreneur's point of view. Consequently, the major concern is with resources which become fixed to the farm. This includes land, machinery, and the labor and management services provided by the entrepreneur.

Land

Differences in acquisition cost and salvage value for land are usually attributed to real estate brokerage commissions, legal fees for providing title opinions and preparing deeds, title insurance, federal revenue stamps, and of particular importance, taxes on capital gains. The magnitude of these items is difficult to determine and may vary considerably between individual asset owners and between specified units of real property. However there is evidence that these items are important enough to cause real estate assets to be "fixed" to a farm according to the definition of a "fixed asset" described previously.

In the absence of carefully conducted empirical studies of the factors causing the differences between acquisition prices and salvage values, it will be necessary to use estimates. Consequently each factor and its estimated magnitude will be discussed and later applied to an analysis of the four sizes of farms represented by the budget models.

Selling commissions, charged by real estate brokers usually range from 0.5 percent to 6 percent of the selling price of the property. Several real estate dealers and former dealers suggested the following fee schedule as applicable for Montana:

1st	$100,000 selling price	6 percent
2nd	100,000 selling price	3 percent
3rd	100,000 selling price	2 percent
4th	100,000 selling price	2 percent
5th	100,000 selling price	1 percent
over	500,000 selling price	1/2 percent

Although it is not binding that real estate dealers adhere to this schedule, there is evidence that it at least approximates brokerage fees usually collected for selling farm property in Montana. Obviously the ability of the seller to bargain for special rates, along with other considerations such as dealer competition and geographic location of the property, affects the total amount of fees which are ultimately paid.

Title insurance has become almost a standard requirement in all real estate transfers. Typical costs for an owner-purchaser policy are as follows:[1]

Amount of insurance	Cost
$ 5,000	$ 50.00
25,000	150.00
50,000	250.00
100,000	400.00
1,000,000	1,950.00

The seller is generally expected to pay the cost of title insurance which must be purchased each time the asset changes ownership. Consequently,

[1]Information provided by the Gallatin Land Title Company, 19 South Willson, Bozeman, Montana.

this item becomes a factor in the divergence between acquisition price and salvage value for land.

Federal revenue stamps must be affixed to each new deed issued, at the rate of $.55 per $500, or a fraction. This is based on the full purchase price of the property. Although not large, this item also adds to the cost of property transfer.

Legal fees associated with property transfers may range from as little as $7.50 to prepare a simple deed to several hundred dollars to prepare a deed for a large unit with more complex tenure arrangements. Under normal circumstances this cost is not of much significance.

Another cost, usually minor, is the recording fee paid to the County Clerk and Recorder. This fee is usually $10 but may be as much as $50 for large complex farm units.

The most important item in this regard is the capital gains tax to which the seller may be subject. The maximum amount of capital gains tax would be 25 percent of the gain.[1] The gain itself depends on the cost basis of the property, improvements made, selling costs, and the gross return from the sale. Generally speaking the gain would be greater for an older farmer who had acquired the farm when real estate values were

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[1]See John C. O'Byrne, Farm Income Tax Manual, Indianapolis, Indiana, Third Edition, The Allen Smith Company.,1964, p. 150. An alternative tax on the Schedule "D" insures that long-term capital gains will not be taxed in excess of 25 percent of the gain regardless of the income tax bracket of the taxpayer. Consequently 25 percent of the capital gain represents the maximum capital gain tax cost for any land transfer.

lower than at the selling date. Under such circumstances his cost basis would be low. Higher selling costs tend to reduce the capital gain but the selling costs in themselves also contribute to the divergence of acquisition price and salvage values.

The assumption of unlimited capital in this study removes a potential cause for divergence of acquisition price and salvage value. Fees associated with closing loans and making appraisals often contribute to the divergence. Such fees depend on competition for load funds which are in turn closely related to the supply of money in the general economy. The fact that these fees are paid in a lump sum, at the time financing arrangements are made, set them apart from ordinary interest charges. Staying within the framework of the assumptions, these charges are not considered but they should not be overlooked as a potential cause of asset fixity.

The present acquisition value of land in the area studied has been defined as the market value, $158.47 per acre.[1] The determination of salvage value requires that relevant costs associated with disposing of land are deducted. Estimates of these costs are summarized in Table 22. The capital gains tax used in constructing the table, $25 per acre, would be appropriate for an individual who (1) bought the land shortly after World War II, 1946-47, (2) considers disposal of the land in a lump sum trans-

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[1]See discussion on page 110 of this thesis. Also note that this definition excludes the possibility that an individual might mistakenly acquire land at a price higher than market value.

action rather than on an installment sales basis[1], and (3) is in a tax bracket which could utilize the "alternative" capital gains computation.[2]

Table 22 represents typical salvage values for a farmer presently 45 years of age who purchased his farm shortly after World War II. At that time land was selling at a price of $40-60 per acre.[3] All fees and charges except capital gains were taken against both land and buildings.

TABLE 22.--Estimated Maximum Deductions Per Acre from the Current Selling Price of Land ($158.47 per acre) to Determine Salvage Value.

Item	Acres of Crop Produced Per Year 400	900	1500	2400
	Dollars per Acre			
Brokerage commission	8.35	5.81	4.37	3.00
Title Insurance	.56	.42	.37	.33
Federal revenue stamps	.18	.18	.18	.18
Legal fees	.01	.01	.01	.01
Recording fees	.01	.01	.01	.01
Capital gains tax	25.00	25.00	25.00	25.00
Total deductions	34.11	31.43	29.94	28.53
Net salvage value	124.36	127.04	128.53	129.94

It is assumed building depreciation reduces value enough to just offset gains associated with changes in price levels and consequently no capital

[1]Installment sales permit one to defer tax on capital gains to future years. See John C. O'Byrne, op. cit., p. 197.

[2]The alternative tax on the Schedule "D" insures that the taxes on capital gains do not exceed 25 percent of the gain.

[3]USDA, Farm Real Estate Market Developments, Economic Research Service, CO-66, Washington, D. C., Oct., 1964, p. 52. Data given are in index numbers which were converted to dollar values.

gains are involved.

Notice that the net salvage value is from $34.11 to $28.53 less than the acquisition price depending on farm size. It should be kept in mind that this difference is associated with one point in time. As an illustration a person owning and operating the 400-acre model and fitting the characteristics assumed in constructing the table, could sell his land and realize a net of $124.36 per acre or he could purchase additional land of similar quality for $158.47. The implications of this will become clearer later.

Machinery

The acquisition price of machinery is the price to the firm, including delivery costs, at a given point in time. The salvage value is what the firm could receive for that equipment at the same point in time. The divergence between these two values depends on delivery costs, buying and selling costs, and cost of gaining knowledge about the operation of the machine acquired.

Delivery costs, of course, depend on the location of the farm with respect to machinery distribution points and the methods of transportation available.

Buying and selling costs are probably the major items contributing to the divergence between acquisition price and salvage value. They depend on local custom, competition, and efficiency of markets.

The cost of obtaining knowledge about the operation of a new machine is especially difficult to evaluate. It may be very significant, for example, in the case of a complicated harvesting machine. In other situations this cost may be trivial. It should be recognized however that the salvage value of this knowledge may approach zero as the machine becomes obsolete.

It appears that the cost of buying and selling is of most importance. Therefore attention is given to this aspect.

The National Farm and Power Equipment Dealers Association compile descriptive statistics on the sales of used equipment.[1] The reports include actual sales prices of used equipment and the cost of reconditioning this equipment. After subtracting the cost of reconditioning the equipment, the National Association recommends subtracting an additional 20 percent in arriving at a price to the farmer to provide a margin for the retail dealer. Thus if a farmer had an item of equipment valued at $1,000 by the machinery retail trade (the farmer's salvage value), he could expect to pay $1,250 plus reconditioning costs to buy this machine from a dealer, or a 25 percent margin above his salvage value.[2] It could be assumed that the dealer handles transportation costs, that the reconditioning cost charged by the dealer is equivalent to the farmer's cost of doing similar reconditioning, and that the cost of acquiring knowledge is negligible. Under such assumptions it would seem reasonable to use 25 percent of the "as-is" value of a line of machinery as the differential between acquisition price and salvage value.

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[1]National Farm and Power Equipment Dealers Association, op. cit., See especially pp. 3-6.

[2]For example assume a used machine has a retail sales value of $1,500 and cost $250 to recondition. The difference $1,250 is subject to a 20 percent reduction for the dealer's margin, $250, which leaves $1,000 net as-is value to the farmer. This, in effect, becomes the farmer's salvage value for the particular item of equipment.

Unfortunately the divergence between the acquisition price and the salvage value of machinery is not constant over the life of a machine. This is illustrated in Table 23. The suggested retail price of new equipment was obtained for various types of tractors and combines normally found in the Triangle grain-producing area. Only one model, that of a track-type tractor, provided consecutive data for as many as 13 years. Because of frequent model changes, such a series of data was uncommon. Using straight line depreciation, with no allowance for scrap value and based on machine life recommended by the American Society of Agricultural Engineers, a depreciated value for each machine was computed. A further computation derived the ratio of this value to the average "as-is" value reported by dealers. Ignoring the effects of price level changes over time, one would expect this ratio to be exactly 1.00 if the salvage market for used machinery accurately reflected the remaining value of the machinery based on its useful life. In this analysis it must be assumed, of course, that use depreciation is less than obsolescence depreciation, a normal situation in the Triangle.

For machines having a long consecutive series of data, such as in the case of tractor number 5, Table 23, the ratio of the two values is greater than one. This suggests that changes in the general price level result in an inflated value for older machinery. Table 23 indicates that the most serious loss in value occurs during the first year of the assets useful life. At least in part, this may reflect an irrational discounting of one year old equipment by users of that equipment. Thus farmers themselves may help to create the situation where new equipment loses an unjustified amount of value during the first few years of its life.

TABLE 23.--Relationships Between Machinery Values Based on Straight-Line Depreciation and Trade-In Values Suggested by Machinery Dealers.[a]

Machine	New[b] Cost 1965 Models	1965 Average As-Is Value for Older Models[c] 1964	1963	1962	1961	1960	1959	1958	1957	1956	1955	1954	1953	Life Until Obsolete[d]	$\frac{NC}{L}$	$\frac{NC}{L}Y$	$NC\ \frac{NC}{L}$[e]	Av. As-Is Value Yth yr	Av. As-Is Value, Yth Yrs. $NC - \frac{NC}{L}Y$
	$	$	$	$	$	$	$	$	$	$	$	$	$	Yrs.	$	$	$	$	Ratio
Tractors (Diesel)																			
1 Wheel type	8,817	5,380	4,924	4,505	4,119									15	588	2,940	5,877	4,119	.70
2 Wheel type	5,485	3,176	2,925	2,725										15	366	1,464	4,024	2,725	.68
3 Wheel type	6,500	4,200	3,834	3,497	3,188									15	433	2,165	4,335	3,188	.74
4 Track type	16,165	9,736	8,906	8,144	7,443	6,799	6,208	5,664						15	1,078	8,624	7,541	5,664	.75
5 Track type	16,730	9,832	9,032	8,294	7,612	6,982	6,402	5,866	5,371	4,914	4,493	4,104	3,740	15	1,115	14,495	2,235	3,740	1.67
Combines																			
14 ft.	7,207	4,104	3,690	3,314	2,975	2,669	2,392	2,142	1,915					10	721	6,489	718	1,915	2.67
16 ft	8,919	5,100	4,575	4,102	3,674	3,290								10	892	5,352	3,567	3,290	.92
20 ft.	11,629	6,552	5,878	5,271	4,723									10	1,163	5,815	5,814	4,723	.81
14 ft.	7,207	4,104	3,690											10	721	2,163	5,044	3,690	.73
16 ft.	8,919	5,100	4,575											10	892	2,676	6,243	4,575	.73
20 ft.	11,629	6,552	5,878											10	1,163	3,489	8,140	5,878	.72

[a] Suggested retail prices and trade in values were obtained from National Farm Power and Equipment Dealers, Official Tractor and Farm Equipment Guide, St. Louis, Mo., 1965.

[b] New cost is the manufacturer's suggested retail price.

[c] Average as-is value is computed by subtracting average reconditioning cost from the average resale price and then subtracting 20 percent from that difference. Actual resale prices of used equipment and actual reconditioning costs are reported by retail dealers and compiled by the National Association.

[d] Based on American Society of Agricultural Engineers, Agricultural Engineers Yearbook, 420 Main Street, St. Joseph, Michigan, May, 1965, p. 252.

[e] NC is new cost, L is life until obsolete, and Y is years of reported data.

However, regardless of the reason for this loss of value the result is that the divergence between acquisition price and salvage value for machinery is even greater during the first years for equipment purchased as "new" than for equipment purchased as "used". This causes the relative fixity of resources to change over time, depending on recent purchases, if one considers the price of new equipment as the acquisition price and the "as-is" value one year later as the salvage value.

Some farm operators may have the time and ability to purchase machinery directly from other farmers or at farm auction sales. This will eliminate the dealer margins but will be all or partially offset by travel expense, fees charged by auctioneers, lack of warrantees on purchases, and the opportunity cost of using entrepreneurial time in this manner. This alternative is also dependent on adequate farm shop facilities for reconditioning machinery.

The implication of this discussion is that the divergence of acquisition price and salvage value, under usual circumstances, would be at least 25 percent of the salvage value using the National Farm Power and Equipment Dealers "as-is" price as a basis for determining farm salvage value. The divergence could be even greater for a farmer with a line of new machinery.

Operator's Labor and Managerial Ability[1]

The commitment to a life of farming usually involves the total commit-

[1]The combination of labor and management here does not imply that they represent a combined input to the farm business. The notion that ability to manage is not a factor of production has been previously discussed with reference to Johnson's article presented at a Southern Farm Management Research Committee meeting (see page 73 for reference). Labor and Management are combined in the present context to imply that the acquisition cost of a farmer to agriculture involves the return he could get in a nonfarm occupation for his total human service.

ment of the individual's capacity to perform manual labor and his ability to manage resources. This is particularly true in the Triangle where distances between farms and population centers usually make commuting to non-farm jobs impractical.

Venkareddy has defined the acquisition cost for an operator entering farming as the present value of the expected future income stream of the individual in the non-farm sector if he would enter for the remaining years of life.[1] A life-time salvage value is similarly defined. According to this definition it is clear that the salvage value declines as the farmer gets older. It is also obvious that illness or disability can reduce a farmer's salvage value to zero.

This line of reasoning provides a frame of reference for analyzing individual decisions relative to entering or leaving farming as an occupation. First consider the case of a 20-year old person, in good health, with a potential of 40 productive years. Taking into consideration his abilities, values and alternative opportunities for training and education he might construct a 40-year projected stream of income. This stream of income should be net after deducting educational and training costs.

Projecting a lifetime stream of income is a matter of extreme difficulty. If it is assumed that a worker is paid a wage equal to his marginal value productivity, then anything that affects his marginal value productivity will affect his lifetime earnings. Such things as changes in consumer taste, population, the development of substitute products, and general consumer income levels have a potential effect on commodity prices and consequently on the workers marginal value productivity. Similarly, technological changes may cause shifts in the marginal productivity of

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[1]Chennareddy Venkareddy, op. cit., p. 22. Also see Bob F. Jones, op cit., p. 51.

certain kinds of labor which will change the level of earnings. Changes in technology also may require job retraining which adds to the worker's costs and consequently, reduces the net value of his income stream.

In projecting a 40-year income stream, a 20-year old person might anticipate some years when net income would be negative, e.g., in the early years when training and educational costs exceed income. Also income may peak and then, say after the 30th year, decline. This, of course, will depend on the type of occupation involved in the projection.

Still another factor which needs to be considered is the probability of being unemployed due to seasonality of work or due to business cycles. This notion implies fluctuation in incomes. Therefore income taxes need to be considered, since the impact of income taxes is greater on fluctuating incomes than on incomes which are more stable over time.

The projection should also consider opportunities within the occupation which may be peculiar to the individual and his relationships with the firm with whom he is employed. For example a prospective construction worker may anticipate working up into supervisory or other positions which yield a higher value of lifetime earnings than would be obtained by simply taking only the average of all construction workers.

Figure 28 illustrates three hypothetical 40-year earnings curves for alternative occupations. These curves are relevant assuming a 20-year old person had the capacity to work in these occupations and was not barred from them because of lack of capital, race, religion, etc. Curve A, for example, might represent a clerical occupation where starting wages were relatively low but earnings could be expected to be maintained during the later years of a person's working life. Curve B might represent

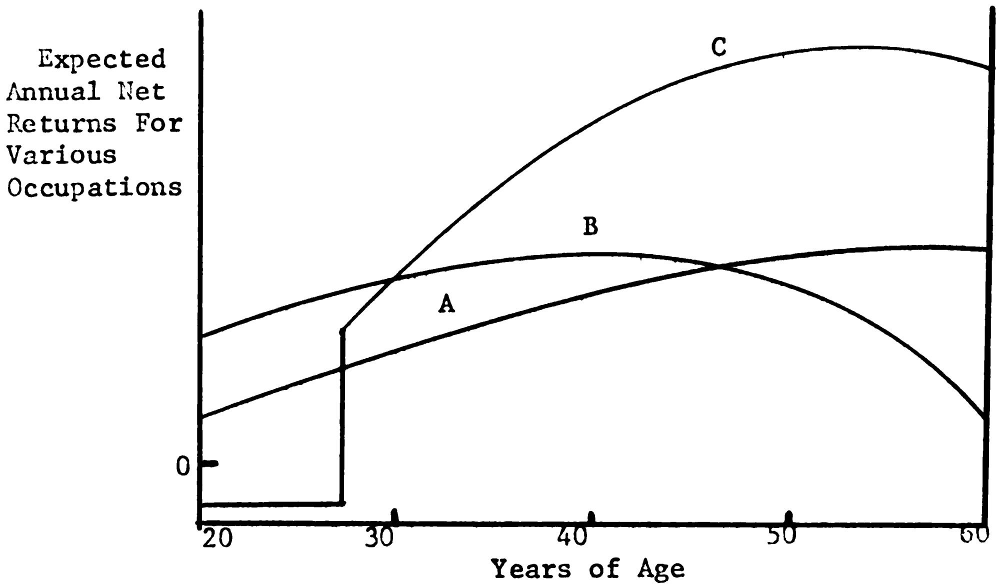

Fig. 28.—Hypothetical Expected Annual Net Returns for Various Occupations Which Might be Chosen by a Person Twenty Years of Age.

construction work with higher wages during the earlier years of a person's working life and lower earnings later. Curve C might represent earnings from a professional occupation which require several years of training past the age of twenty and consequently negative earnings during this time.

Thus it is conceptually possible to derive an anticipated lifetime earnings flow for an individual. Ideally it should reflect the aforementioned considerations. This income stream can then be discounted, by use of the following equation, to arrive at the present value:

$$PV = \frac{A_1}{(1+r)^1} + \frac{A_2}{(1+r)^2} + . . . + \frac{A_{40}}{(1+r)^{40}}$$

Where: PV is present value.

A is the amount of net income expected per year.

r is the rate of interest.

If it is assumed that this stream of income is the best one available to the individual and that he has made adjustments for occupational preference in deriving the A values between this occupation and farming, then the present value can be considered as the acquisition cost of this person to the farm. Present value of the income stream based on such computations represents the opportunity cost of committing the individual's labor and managerial capacity to a lifetime of farming.

Once a commitment has been made to enter farming, however, the opportunity cost of the operator's labor and managerial talents is the salvage value which at a given point in time, reflects the acquisition cost less transfer costs. As the farm operator ages, the future income stream which he could receive in non-agricultural employment diminishes. After several years of farming and the normal growth of obligations associated with a family, many farm operators find it impossible to pursue occupations which require costly education or training.

Several studies support this hypothesis. Perkins found that four industries employed over three-fourths of all farm workers who transferred to non-farm employment, viz. construction, manufacturing, wholesale and retail trade, and government. Of these, manufacturing and wholesale and retail trade were most important.[1] Schnittker and Owens reported construction labor, machine shop and mechanical work, factory work, and retail and wholesale trade as primary sources of employment, listed in order, for farmers transferring to non-farm employment.[2] These occupations are obviously not types of employment that require higher education and extensive training, nor do they provide particularly high returns when compared to professional and semi-professional occupations.

However, even when only non-professional occupations are considered, the annual salvage value of labor appears to decrease as the age of the farm operator increases. Farm experience is apparently not valued highly by most non-farm employers and older farmers leaving agriculture are required to start at the same wage, or even less, than young workers without any experience. Support for this argument is provided by two studies.

Perkins found that income differentials decrease with age for farm

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[1] Brian B. Perkins, "The Mobility of Labor Between the Farm and Non-Farm Sector", East Lansing, Michigan, 1964, Unpublished Ph.D thesis, Michigan State University, p. 95.

[2] John A. Schnittker and Gerald P. Owens, <u>Farm to City Migration: Perspective and Problems</u>, Kansas Agricultural Experiment Station, Ag. Ec. Report No. 84, 1959, p. 28. As reported by Bob F. Jones, <u>op. cit.</u>, pp.142-43.

operators who shift to non-farm employment.[1] His study of persons shifting out of agriculture reported farm earnings the year in which the shift was made and non-farm earnings, the following year. During a four year period from 1955 to 1959 earning differentials were as high as $565 per year for persons under age 25. For persons over age 55 differentials were negative in each of the four years.

Venkareddy's study of farm to non-farm employment mobility provides empirical evidence which indicates that shifts from farm to non-farm occupations are made at higher wage levels for younger farmers than for older farmers.[2] He found that young farm workers are more attracted to higher paid non-farm jobs, such as manufacturing, while older people are likely to have the alternative of transferring out of farming only at the equivalent of laundry workers wages.

Also of special interest in Venkareddy's study is the computation of present value of wages for workers in farming, manufacturing, construction, laundries, and retail trade.[3] Present values were computed for both 25 and 45 year old workers, taking into account anticipated unemployment and anticipated wage increases to the year 2007. These computations are especially applicable for establishing salvage values for 45 year old farmers since these four non-farm occupations represent the usual alternatives for such persons.

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[1]Brian B. Perkins, op. cit., Table D, 6, p. 175.

[2]Chennareddy Venkareddy, op. cit., pp. 115-118.

[3]Ibid., pp. 177-184.

This discussion has pointed out the factors relevant to the question, what cost should be ascribed to the labor and management services provided by the entrepreneur? For one who is entering farming, acquisition cost is appropriate. For one now in farming, salvage value is appropriate. In both cases the following items must be taken into consideration, (1) age of the individual, (2) location with respect to non-farm jobs, (3) net annual wages in non-farm occupations, (4) training costs, (5) occupational preference of the individual, (6) family obligations, (7) personal abilities, and (8) personal aspirations.

The appropriate acquisition cost or salvage value can be computed as the present value of the individual's projected income stream, for the most suitable non-farm occupation, for the expected remaining years of his working life.

Cost and Return Structures for Persons Entering Dry-Land Farming in the Triangle

Cost and return structures are dependent on the values assigned to assets. In this analysis we shall assume assets are acquired at market price even though it is recognized that many people enter farming with some assets which have been inherited, leased, borrowed or otherwise obtained. Acquisition of assets at market price should represent the maximum value of the assets for purposes of assigning annual costs.

The acquisition cost of land has been defined as market value, assuming this value includes all closing costs except for those associated with financing or refinancing. This value, $158.47 per acre, has previously been determined.

The average investment in machinery, equipment, and buildings, as listed in Appendices A, B, C, and D, represents a simple average between beginning and ending value of each item. As indicated in Table 23, this method of value determination tends to place asset value high, relative to "as-is" retail dealer prices for used equipment. However assuming the items are adequately maintained under farm conditions, they may have a value reasonably close to the actual retail sales prices as quoted by dealers. An adjustment of 10 percent increase in value over the "average investment" as shown in Table 2 of Appendices A, B, C, and D is estimated to account for transportation costs and costs of acquiring knowledge about new equipment. Buildings are excluded from this adjustment.

After making these adjustments, Table 24 is presented to summarize returns to land, machinery, and labor. The return to the operator is left as a residual and is a positive value only for the 2,400 acre model. With assets valued at acquisition cost and an assumed 5 percent opportunity cost of capital, the conclusion is that no one should enter farming at the 400, 900, and 1,500 acre level if he places any value on his labor. Only persons with an acquisition cost for their labor and management of less than $3,368 per year should enter farming at the 2,400 acre level.

The cost structure illustrated in Table 24 might suggest that three classes of operators would be available to enter farming: (1) individuals wealthy enough, from inheritance or past earnings, to virtually ignore returns to their own labor[1], (2) individuals with low salvage values for

[1]Another way of stating this situation is that such individuals have a low "reservation price" for their labor. Reservation price is defined as the minimum return for which an individual will provide his human services to a firm. Presumably he would rather have leisure time than to provide his human services for less than his reservation price.

their human services because they have a low level of capacity or ability, and (3) persons with relatively high personal capacity or ability but who have made mistaken appraisals of the potential value of their human services in non-farm employment.

TABLE 24.--Budget Model Summaries for Four Sizes of Farms With Land and Machinery Valued at Acquisition Prices.[a]

Items of Income and Cost	Acres of Crop Produced Per Year 400	900	1500	2400
	Dollars			
Gross income	14,353	32,293	53,823	86,117
Less Cash cost	4,692	9,994	16,695	26,904
Net cash income	9,661	22,299	37,128	59,213
Less depreciation	2,066	4,758	7,369	9,383
Net farm income	7,595	17,541	29,759	49,830
Less 5% return on total investment	7,820	17,933	30,038	46,462
Return to operator for labor & management	-225	-392	-279	3,368

[a]Acquisition prices, for this example, are equivalent to market prices.

The first category of individuals may put stresses and strains on the economy, e.g., by bidding up land prices to levels which cause total returns in agriculture to be lower than in the non-farm sector of the economy. However, this problem must be approached through methods which are outside the scope of this study.

If the second category of individuals gain control of agricultural resources, e.g., through inheritance, the returns they receive for their labor may be reasonably close to the salvage value of their labor. If the acquisition of resources by such individuals is defined as or leads to a national economic problem, it too must be approached by means outside the scope of this study.

Those individuals who enter agriculture on the basis of mistaken judgments about the value of their human services, however, represent a problem of resource allocation within the province of this study. Suggested methods of treating this problem will be discussed in Chapter VII.

Cost and Return Structures for Persons Already Established in Dry-land Farming in the Triangle

The cost and return structure for persons already established in farming is logically based on salvage value of assets rather than acquisition cost. It has been pointed out that salvage value for land varies among farms depending on location, size, financial position of the owner, and other factors. For illustrative purposes, the salvage values for land computed in Table 22, page 183, are used. As explained earlier, these values may be typical of land owned by a 45-year old farmer.

The salvage value of machinery is estimated by reducing "average investment" data from Table 2, Appendices A, B, C, and D by 15 percent for machinery and equipment. This makes a total of a 25 percent adjustment between acquisition cost and salvage value (recall "average investment" data were increased by 10 percent to estimate acquisition cost). This estimate is consistent with the differential suggested by the Equipment Dealers Association.[1]

The cost and return structure for each farm size using salvage values of land and machinery is summarized in Table 25. The residual return to

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[1]National Farm and Power Equipment Dealers Assoc., <u>op. cit</u>. pp. 3-4.

labor and management is positive for each farm size. From the standpoint of a 45-year old operator, it is appropriate for him to compare the residual returns with the salvage value of his human services which he contributes to the farm.

TABLE 25.--Budget Model Summaries for Four Sizes of Farms With Land and Machinery Valued at Salvage Value

Items of Income and Cost	Acres of Crop Produced Per Year 400	900	1500	2400
	Dollars			
Gross income	14,353	32,293	53,823	86,117
Less cash cost	4,692	9,994	16,695	26,904
Net cash income	9,661	22,299	37,128	59,213
Less depreciation	2,066	4,758	7,369	9,383
Net farm income	7,595	17,541	29,759	49,830
Less 5% return on total investment	6,188	14,423	24,389	38,119
Return to operator for labor and management	1,407	3,118	5,370	11,711

One might expect operators of 400-acre farms to be leaving farming since even laundry worker wages are likely to be more attractive than the $1,407 return from farming. Trends in size of farm and numbers of farms in the smaller size categories appear to substantiate this hypothesis. For the larger farms, however, the case is not so clear cut. The return of $3,118 for a farm operator on a 900-acre farm may well be equivalent to or greater than the salvage value of his labor and managerial services. This, of course, would help explain why such farmers stay in agriculture, even when the returns appear to be low based on the acquisition price of assets.

An Hypothesis About the Role of Sociological Variables, Asset Transfer Considerations, and Mistakes of Overcommitment

How do assets get trapped into agricultural production?[1] Several explanations are available. This section briefly reviews explanations based on price expectations and technology. An hypothesis is suggested which involves a sequence of events involving sociological variables, asset transfer considerations, and mistakes.

One explanation is that farm operators' price expectations are generally on the optimistic side. This hypothesis is in part, supported by Lerohl's study of price expectation models.[2] In his study, Lerohl computed expected prices based on mechanical estimates, modified where necessary, in the light of available outlook information. These prices were compared with actual prices. On the basis of a general commodity index, looking ahead one year, prices were overestimated 28 out of 46 years. On the basis of making 10-year price forecasts, which is probably more pertinent for making long-range resource allocation decisions, prices were over-

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[1]The concept of an asset being "trapped" into agricultural production implies that the marginal value product of the asset is greater than its salvage value but less than its acquisition price. Therefore it doesn't pay pay to acquire more units of the asset nor does it pay to dispose of any units of the asset. Thus the asset remains in agricultural production even though it has low relative earnings based on acquisition costs.

[2]Milburn L. Lerohl,"Expected Prices for U. S. Agricultural Commodities, 1917-62",Unpublished Ph.D thesis, Michigan State University, East Lansing, Michigan, 1965, p. 101.

estimated 42 out of 46 times. This supports the hypothesis that farmers tend to overcommit resources on the basis of overestimated product prices.

However the data on wheat price estimates, the product most important to Triangle dry-land agriculture, are less conclusive. Based on a one-year projection wheat prices were overestimated 22 out of 45 years; on a five-year basis they were overestimated 19 out of 41 years; and on a ten-year basis they were overestimated in only 15 out of 36 years. In all other years they were underestimated except for one year when expected prices exactly equaled actual prices.[1] The fact that wheat prices have been supported through government price support programs probably explains the tendency to underestimate wheat prices on the ten-year basis compared with the estimates of the general commodity index. However the data do not support the hypothesis that overoptimistic price expectations are important in causing overcommitment of capital for wheat farms.

Jones emphasizes the role of changing technology in keeping certain assets commited to agriculture at low rates of return. He reasons that most forms of new technology will likely increase the marginal value product of capital and lower the marginal value product of labor.[2] Unless technology causes the marginal value product of labor to fall below salvage value, it will be profitable to continue using this resource in agricultural production. Consequently the return to all

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[1]See Ibid., pp. 130, 157, and 184.

[2]Bob F. Jones, op. cit., pp. 42-43.

resources considered together at acquisition prices will be lower than the alternative returns from non-farm investments.

Another possible explanation of how human, land, and capital resources become drawn into the "fixed asset" trap, presented here as an hypothesis, involves social values, asset transfer considerations, and mistakes.

Young persons often experience a period of greater than usual uncertainty about the time they are in a process of selecting a career. They often make this decision with limited guidance and information relative to career opportunities. They have less than adequate information on projected incomes, unemployment rates, and educational requirements and costs. Because of lack of information an individual is very likely to underestimate the present value of potential lifetime earnings available to him in non-farm employment. At the same time social ties common to this age group may cause him to further discount future earnings if he is required to leave the community in order to achieve such earnings. With a distorted notion of the alternatives, and with his vision narrowed because of social ties, he is likely to accept local employment. If the local area happens to be economically depressed local wage rates will likely be low.

In these circumstances and with a farm background, the opportunity to acquire the use of farm assets is very likely to attract the individual. Often agricultural assets, especially land, are made available to young farmers through lease at rates based at or near the owner's salvage value. This may be done by the older farmer out of benevolence or simply to temporarily defer the payment of transfer costs and capital gains taxes. It has been noted that the salvage value of land for an older farmer can be significantly less than acquisition cost to a farm entrant. This makes an attractive opportunity for the prospective young farmer. He may even get access to the use of farm machinery on the basis of salvage value.

Under these circumstances the individual will probably choose to enter the occupation of farming. Note, however, that he has done so on the basis of (1) underestimating the value of his human resource, (2) discounting other alternatives because of social ties to the local community, and (3) temporarily acquiring the use of agricultural assets based on or near salvage values. The ultimate cost of the agricultural assets he temporarily controls is probably unknown to him.

Another explanation for a young person accepting a low return to his labor is his hope of inheriting resources which, he fears, may not occur if he accepts non-farm employment. This in effect puts an unknown acquisition price on assets and suggests the possibility of zero salvage value. Thus the prospect of inheritance may, of itself, place an individual some place on the value-product map (see Figure 11, page 50) such that he is virtually required to make further commitments in order to stay in business while awaiting his expected inheritance.

In either case valuable time is committed to a career in farming. Over time additional capital is probably committed by the young farmer to purchase other assets. In the Triangle this is likely to be machinery. The difference between acquisition cost and salvage value causes these assets to become fixed in agricultural production. At this point, with his own labor and with machinery trapped in farming (marginal value productivity between acquisition price and salvage value), the individual is likely to be in the position of finding it personally advantageous to stay in agriculture and minimize losses by purchasing or renting more land. Also at this point he may be forced to purchase land which he has previously been renting.

The further the individual follows through this chain of events, the more difficult transferring out of farming becomes. Over time the salvage value of his labor declines, his social ties to the community probably strengthen and it is likely that family obligations become greater. This tends to increase retraining and transfer costs. By the time the individual reaches middle age the salvage value of his human resource, in the absence of any retraining, is predictably very low compared to non-farm returns. Yet in order to make the best of the situation the individual is virtually forced to continue buying machinery and land even though this action improves his labor returns very little.

From observations in the Triangle it appears that social considerations, introduced in this hypothesis, play an important part in trapping resources into agricultural production. It also appears that "favors" provided by retiring farmers to beginning farmers, sometimes inspired by humanitarian desires and sometimes to avoid selling assets at salvage values, may do more harm than good.

Conclusions for Farms Organized in Area V of Figure 11

This chapter has considered the magnitude of the differences between acquisition cost and salvage value for land, machinery, and the entrepreneur's input of labor and management. Returns to dry-land farms have been computed for assets valued at acquisition price and for assets valued at salvage price. An hypothesis has been suggested which attempts to extend explanations made by other research workers of why resources get "trapped" into agriculture.

The empirical data from this study indicate that returns are low when assets are valued at acquisition price. An examination of the facts based on the theoretical model used in the study at least partially explains why these returns are low and will probably remain low.

First, there is a tendency for the salvage value of the entrepreneur's labor and management contributions to decline through time. This discourages the individual from leaving agriculture even if the marginal value productivity of his labor in agriculture is declining. Such a decline in the marginal value productivity of labor may occur from changes in technology, declines in product prices, or a combination of these factors.

Secondly, there is a tendency for the divergence between the acquisition price and the salvage value of land to increase over time. This is caused primarily by the capital gains taxes associated with appreciation in land values. The result is that a sizable amount of land is held by owners who are willing to compute returns on land which they value at less than acquisition cost.

The difference between the acquisition price and the salvage value of an all-age line of machinery may be rather constant with respect to time. At least there is no evidence to the contrary. However, this study provides data (see Table 23, page 187)which indicate the difference is greater for new or relatively new machinery than for older equipment. This suggests that if young farmers acquire new machinery they may be more completely trapped into farming than would be indicated by the fixity of their land and human resources. Although the divergence of acquisition cost and salvage value for new machinery may decline somewhat over time, this tends to be offset by declining salvage values for the operator's labor and increasing divergence between acquisition and salvage values for land.

It appears that the combination of these changes through time tends to keep area V (Figure 11, page 50) rather large for an individual farmer. Thus the range in economically optimum positions (in many cases loss minimizing positions for persons and assets trapped as a result of earlier mistakes) for a given sample of farmers could be quite large.

To summarize the main points of the argument presented in this chapter it may be helpful to consider a hypothetical example. For a starting point, consider the 400-acre model, Table 25, page 199, in which the return to labor and management is $1,407 with land and machinery valued at salvage prices. Assume that the returns imputed to capital investment represent realistically the opportunity cost to the individual of using this capital in farming.

Now assume that because of transfer costs, social ties, and other reasons, the salvage value of this operator's labor is less than $1,407 and declining each year as he gets older. Further assume that this farm is typical of farms in the area studied with respect to machinery, i.e., it has 25 percent excess capacity.

In order to improve his income position, the individual logically will consider expansion. However, expansion must take place within the framework of the situation described above which suggests the following conditions: (1) the marginal value productivity of the individual's labor exceeds the salvage value, (2) the marginal value productivity of machinery is less than the acquisition cost and (3) the marginal value productivity of land is less than the acquisition cost. In an attempt to expand output under these conditions, one would predict the individual would try to use his labor and possibly machinery more fully. To the individual viewing the situation within the context of his farm unit, this would have the effect of at least appearing to increase the marginal value productivity of land, which is a complementary factor relative to labor and machinery. If the marginal value productivity appeared to rise above the acquisition price it would seem profitable to acquire more land through renting or leasing. However such action by farmers collectively, will put increasing upward pressure on land prices. At the same time more intensive use of labor and machinery will predictably increase aggregate output. In view of the low price elasticity of demand for wheat and barley, such an increase in output will likely depress prices more than proportionately with output change. A decline in product price tends to negate the effect of the rise in the marginal physical productivity of land causing the marginal value productivity to decline. After making the adjustment to more intensive use of labor and machinery plus the acquisition of more land, and given time for market forces to work, the individual is likely to be in the position of operating on a larger scale but with marginal value productivities of land, machinery, and labor significantly below their acquisition prices.

The consequences of being "trapped" in agriculture, then, implies a choice between two poor alternatives relative to returns for the operator's labor. The salvage value associated with getting out is not attractive. Similarly there are strong economic forces at work which make the improvement in labor earnings very remote for farmers collectively who remain in agriculture.

CHAPTER VII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was concerned with an investigation of the cost structure of dry-land farms in the Triangle area of Montana. The major objectives of the study were fourfold: (1) to develop an estimate of the long-run planning curve for dry-land farms in the area, (2) to measure machinery capacity on a sample of dry-land farms and estimate the impact of the operator's risk-security preference schedule on optimum farm size, and (3) to examine the returns to dry-land farms under the assumption that acquisition prices and salvage values are equal at a given point in time and, alternatively, to examine returns after recognizing that acquisition prices and salvage values are different at a given point in time, and (4) to develop recommendations for farmers, extension leaders, and research workers based on the findings of the study.

Sixteen farmers were interviewed in the area delineated for the study. Data were classified and summarized for each farm. These data, plus coefficients derived from engineering studies, were used to construct farm budget models. Within the framework of explicit assumptions these budget models were constructed to represent four different sizes of farms each having minimum unit costs for a farm of that size.

Selected costs were taken from the budget models, classified into fixed and variable categories, and used to construct selected short-run average cost curves. Estimates were made of changes in average unit cost structure as the size of farm was changed. A method of deriving selected average cost curves with the use of partial budgets was illustrated. A selected long-run average cost curve was then developed which was used to indicate economies to size. These selected cost curves were derived largely within the assumptions of traditional neo-classical price theory.

Total selected costs were then computed for each budget model using the same theoretical assumptions. Two different levels were used for valuing assets. Returns for each level of asset value were compared. Dispersion of data collected from the farm observations was considered and possible reasons for the observed variance were set forth.

A method of using partial budgets to prepare payoff matrices for different combinations of weather and land-machinery ratios was illustrated. Various decision criteria were then used to select the "best" position from the matrices. The role of the decision maker's risk-security preference schedule in choosing alternatives under uncertainty was considered.

Empirical data were obtained relative to land-tractor power ratios for farms in two areas of the Triangle. One sample was drawn from a spring wheat producing area. The other sample was taken from an area that produces predominately winter wheat. Regression equations were estimated by the method of least squares for each area. Separate equations were developed for desired land-tractor power ratios as well as actual land-tractor power ratios as reported by farmers. Statistical analysis indicated there were no significant differences between the mean of the ratios or the regression coefficients for samples drawn from the spring wheat and winter wheat areas. Consequently the observations were pooled and a regression equation was computed for the combined samples. From this equation a table of coefficients was prepared which is useful in estimating tractor power requirements for dry-land farms in the Triangle.

Finally, returns to dry-land farming were examined under the theoretical framework of fixed asset theory. Estimates were made of the magnitude of the differences between acquisition costs and salvage values for the services of the entrepreneur, for machinery, and for land. The estimated limits of these values were used in a further analysis of returns and in a concluding discussion on the implications of asset fixity to dry-land farming in the Triangle.

Conclusions

Economies Associated With Size

The analysis of average cost curves, using selected fixed and variable costs and the general assumptions of traditional neo-classical theory, suggests that dry-land farms in the Triangle achieve modest cost economies throughout the range of the sizes studied. However, after the size of 900 acres of annual production is reached, cost economies appear to be small and are probably not important in explaining why farms achieve a given size. This finding is consistent with numerous other studies of farm size for other areas and regions.

It would be interesting, for future investigations, to approach the problem of constructing average cost curves within the framework of fixed asset theory. In this study, the problems presented by arbitrarily allocating returns to capital and to the operator's labor were handled by simply excluding such costs from consideration. It is recognized that this procedure has led to somewhat imperfect estimates of average cost curves. The problem of determining the allocation of returns to capital and to the operator's labor could be made a function of the analysis rather than making arbitrary allocations or leaving them out. This would result in discontinuous functions, depending on whether size was being expanded or contracted and the differences in the acquisition and salvage values of durable assets including the operator's labor.

Total cost, as conceived in Chapter IV of this study, is an unsatisfactory measure for determining economies associated with size. This is because durable assets are given arbitrary values and the value of the operator's labor is held constant for all four farm sizes. Under these conditions one is impressed by the reduction in total cost per unit of output as farm size increases (see for example Figure 19, page 113). However when it is recognized that asset values must be a function of the analysis, i.e., they must be valued according to circumstances peculiar to an individual entrepreneur at a given point in time, then the meaning of total costs, such as represented in Figure 19, becomes ambiguous.

Optimum Land and Machinery Combinations

The lack of empirical data relating operational timeliness to yields is a serious obstacle for anyone attempting to determine optimum land and machinery combinations. Also problems of measuring effective tractor power make such an analysis difficult. Additional research, in cooperation with agronomists and agricultural engineers, could provide the necessary data and measurement techniques to permit further fruitful analytical work in this area.

The method illustrated in this thesis for selecting land-machinery combinations under risk and uncertainty can improve farmer decision-making, however, even with crude existing data and measurement techniques. Costs associated with extra machinery capacity need to be considered in terms of the insurance such capacity provides. The use of specific decision criteria increases the precision and rigor of making such choices as well as forcing the decision maker to look introspectively at his own risk-security preference schedule.

The study of decision-making under risk and uncertainty in this thesis followed the assumption that acquisition costs and salvage values for land are equal. The procedure would be considerably improved by relaxing this assumption. Using appropriate acquisition and salvage values, depending on whether the amount of land was being increased or reduced, would result in a different payoff matrix and most likely different conclusions for each decision criterion.

Included in this study was an empirical analysis of tractor power as related to farm size which permits drawing two conclusions. First, there is no difference in power requirements between the spring and winter wheat areas. Secondly, on the average, farmers have 25 percent more tractor capacity than considered optimum by their own judgment. It can be hypothesized that farmers have this excess capacity because of past mistakes, loss of acreage from various causes, unavailability of equipment of the size which fits their needs (indivisibilities), pride of ownership and other reasons. Regardless of the cause, an important conclusion is that costs are higher than would be necessary if farmers operated with the amount of power equipment which, in their own judgment, is optimum.

The technique devised for measuring effective tractor power, and the regression equations relating acreage and effective horsepower, should be of special interest to anyone involved with farm planning in the Triangle. This includes teachers, county extension agents, lenders, and rural appraisers as well as, of course, farmers. The technique for measuring effective tractor power provides a needed method for converting conventional measures of drawbar horsepower for crawlers, 2-wheel drive, and 4-wheel drive tractors to a common measure of effective drawbar horsepower under field conditions. The regression equations provide a means of estimating power needs for a farm of a given size. The two items together (see Table 20, page 170) provide a guide for selecting power size from among different types of tractors for a specified acreage.

Returns From Dry-Land Farming

Returns for the four budget models used in this study were computed on the basis of acquisition costs for all factors of production except for the operator's labor. Based on acquisition values, the returns to operator's labor were negative except for the 2400 acre model. From this, one would conclude persons who place a positive value on their own labor resource should not enter farming except on the largest scale studied (2400 acres).

Similarly returns were computed for each size of farm based on salvage values. This yielded positive returns to the operator's labor for each size of farm although they were quite low for the small farms. Accordingly it might be concluded that dry-land farms in the area studied are well adjusted.

Unfortunately assets do not enter farm businesses at salvage value. They enter at acquisition prices and on this basis seldom make returns that are comparable with non-farm returns. This is illustrated by the negative returns shown in Table 24, page 197. If mistakes, financing costs, or other reasons cause actual acquisition prices to be higher than assumed in Table 24, returns would be even more unfavorable.

The implications for farmers in the Triangle are varied. For older, established farmers having relatively low salvage values for their labor, land, machinery, and other assets, the situation permits little change. Based on salvage values, the returns to such farmers, particularly those producing 900 acres or more of crop per year, are probably more than competitive with non-farm returns. It should also be noted that even though salvage values for land may be substantially below acquisition prices, the absolute value has been rising almost every year for the past quarter century. These increases can eventually be turned into cash. Only the loss of government price subsidies or rapid increases in factor prices present really serious potential difficulties for such individuals.

At the other end of the spectrum is the young man who is uncommitted to a career. If he has enough assets even to consider commercial farming, he also has enough assets to obtain training for non-farm occupations. Assuming the individual has at least normal abilities, the present value of his future income stream from non-farm occupations, at usual rates of interest, make his labor a high cost input to the farm. It would appear that if he does discount non-farm earnings sufficiently to make a career of farming attractive (or conversely attaches high non-monetary values to farming as a way of life), he should try to get established on a large farm. Even with constant returns to size, large farms provide more net income than small farms.

However in looking at the area as a whole, this is not a perfect solution. If farms in the Triangle increased in size to 2400 acres of crop produced per year, the number of farms would be reduced to less than one fourth of the present number. The problem of isolation and the cost of supplying services for such a sparce population would certainly detract from monetary gains which such action makes possible.

Arguments based on economic theory have been employed in this thesis (see pp. 206-208)which indicate that a major cause of high market prices for land may be attributed to the low salvage values for farm operator's labor. It has been shown that under conditions of low salvage values for the labor of farm operators, attempts to increase farm returns through acquisition of more machinery and land lead to higher land prices. Since the amount of land available for agricultural purposes is relatively fixed, the price of land is very sensitive to changes in demand. Furthermore the tendency, noted in this study, for farmers to own excess machine capacity, in part because they have overcommitted themselves to farms, encourages further pressure on land prices. Thus attempts to improve farm income by farmers, acting individually, have the effect of driving up land prices which result in little improvement of labor returns.

Farmers apparently recognize, at least implicitly, that salvage values for the labor of persons who have been employed in farming for a number of years are generally low. They tend to make adjustments, which in fact, consider the operator's labor as being worth little. Consequently it should not be surprising to find, ex post, that returns to those resources are low.

Such pressure on land prices is likely to continue as long as agriculture is supplied with an overabundance of human resources having a low salvage value. As a result, returns to resources used in agriculture will continue to be lower than returns to similar resources used in the non-farm economy. In other words, it does not appear likely that all assets used on dry-land farms in the Triangle, under present conditions can simultaneously each receive returns competitive with non-farm alternatives.

A process was suggested in Chapter VI in which young men gradually get drawn into agriculture through a series of social circumstances and mistakes. This process seems to insure that the farming sector of the economy is provided with excess human resources. Agriculture appears to have a "built in" apparatus for keeping the industry supplied with labor which has only low non-farm value and consequently only limited alternatives for moving out.

From this it is concluded that low salvage values of farm operator's labor is a major cause of low returns to agriculture. Any plans or policies to improve conditions in agriculture should give this situation high consideration.

Recommendations

To Farmers

The results of this study indicate small farmers should increase the size of their farms or transfer to non-farm employment. It appears that economies associated with size are important at least up to 900 acres of crop production per year. It is not possible to specify exactly what size is best. This depends on characteristics unique to an individual entrepreneur, such as his cost-return structure based on appropriate asset values, his past mistakes, his risk-security preference schedule, and his reservation price for his personal services.[1]

This recommendation is consistent with the theoretical underpinnings of the study which imply that maximum returns are achieved when the ratios of the marginal value products to the marginal factor costs for all factors of production are equal. Such adjustment will insure that the marginal value product of the operator's labor will be equal to or at least approach the reservation price for his labor, albeit low.

A major alternative to staying in farming under these conditions is to leave and seek the best possible non-farm return to the human resource. This suggests that a farmer who is transferring out of agriculture is well advised to take advantage of job training opportunities. By so doing, his future non-farm earnings will most likely be increased.

It is also recommended that farmers beware of the tendency to over-

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[1]The term "reservation price" has been previously defined, see footnote 1, page 196.

supply farms with machinery. Excess machinery implies low marginal value productivity of machinery. An appropriate adjustment to this situation is to buy more land in order to minimize losses. This puts upward pressure on land values. As in the case of human resources, the problem of loss minimization can best be avoided by not overcommitting resources initially.

The farm population can collectively improve its earnings by supporting an education system which puts high priority on educating youth, farm and non-farm, for eventual employment in the non-farm sector of the national economy. In rural areas farm people are particularly influential in making policy decisions relative to elementary and secondary school curriculums. It is recommended that education directed toward non-farm employment, at least in secondary schools, should receive major emphasis in order that young persons from rural areas will have employment opportunities comparable with youth from urban areas. If young farm people can be encouraged to seek higher paying non-farm employment, not only will the national economy be expanded but also returns to those remaining in agriculture will be improved.

Although farmers will probably continue to bargain collectively for higher product prices, this type of group action cannot be particularly recommended as a means to improve long-run returns to agriculture. Without somehow restricting entry such action will most likely result in higher land prices without materially affecting returns to labor. This would benefit land owners but would contribute virtually nothing to improving total long-run returns to resources in the Triangle.

A final recommendation to farmers is to explore the possibilities of developing, through cooperative action, a means of providing access to machinery on a rental or lease basis. Such action will not likely solve the problem. It may, however, alleviate the problem at least to the extent that it is caused by indivisibilities. A reduction in continued overinvestment in machinery, which the study indicates is prevalent in the Triangle, would reduce upward price pressure on land and facilitate better adjustment.

To Extension

Assuming the conclusions drawn from this study are applicable to agricultural areas in general, the results of the study have several important implications for the Extension Service. Perhaps the most important is relevant to the problem of low returns to resources used in agriculture. To improve this situation, the Extension Service should increase emphasis on providing information about non-farm careers. Current earnings, training requirements, and outlook for potential growth in each occupation should be made available more generally to the farm population. It is probably not adequate to have such information called to the attention of a high school student when his entire prior training and planning at home has been based on the assumption he would engage in farming. Consequently a constant flow of information should be directed toward the farm population to help keep farm people, including parents, informed of occupational alternatives.

All media of communications available to an extension staff such as meetings, workshops, youth camps, newspapers, and farm magazines could be utilized in this effort. Perhaps most important, however, is the need to build such an education emphasis into the State Extension programs. Only by providing adequate program status will enough resources likely be devoted on a statewide basis to do an effective job.

As a program, career information can be built into activities associated with 4-H Club work, women's organizations sponsored by the Extension Service, and other functional parts of the statewide organization.

In making this recommendation it is recognized that it is not a complete solution to the problem of low returns to resources used in agriculture. Providing information certainly does not guarantee that people will act in any specified way. Such an informational program, however, should help some people avoid making mistakes in allocating resources to agriculture. This would be of importance to (1) individuals directly involved, in that they would predictably enter occupations with higher income streams, (2) individuals remaining in agriculture, since it would reduce competition for other resources (primarily land), and (3) the entire national economy, as a result of better resource allocation.

Attention should also be given to people who have made mistakes of committing resources to farming. The dispersion in cost data observed in this study strongly indicates that some farmers are likely to have negative labor earnings even when other durable assets are valued at salvage prices and charged at normal opportunity rates. Some of these persons are not aware the situation exists. If they were better informed through the use of elementary farm management techniques, e.g., budgeting and partial budgeting, it is predicted many of them would transfer out of agriculture. These techniques should be taught through farm management shortcourses supplemented with appropriate publications.

For individuals with low but yet positive labor returns from farming, it may be necessary to provide means to improve the salvage value of their human resources before they will be induced to transfer to non-farm employment. In this situation not only do they need to be assisted in recognizing the problem, but also in doing something to improve their non-farm occupational alternatives. The Extension Service should increase emphasis on cooperation with state employment agencies and federal agencies in charge of retraining programs. It should provide leadership in rural areas to facilitate making retraining programs available to farm people. The returns from such activities accrue directly to individuals transferring out of agriculture, to remaining farmers, and to the nations economy, as explained previously.

Another recommendation to the Extension Service is to increase emphasis on analyzing <u>total</u> resource use in all education programs. If each extension worker views his role as a part of education for <u>total</u> resource development, it should assist farm people to perceive resource allocation more realistically. For example, educational work regarding the use of fertilizers for dry-land farms in the Triangle can be done in such a way, using budgeting and partial budgeting, that farmers not only learn about fertilizer as a production factor but also learn important analytical techniques and the relationship of fertilizer to other production factors. This results in valuable complementarity between the work efforts of various specialists and field staff. Specifically one method of accomplishing this result is the team approach to teaching e.g., a production specialist and an economist. Opportunities for extension economists to work with other agencies associated with agriculture should also be exploited. For example, the Soil Conservation Service has a continuing program of developing enterprise cost studies for important crop and livestock enterprises in Montana. This program badly needs the contribution of economic analysis, including fixed asset theory, to more adequately explain the implications of the cost data and the inter-relationships among resources. More emphasis on cooperative efforts between economists and other professional persons working in agriculture has a potential of reaching many farmers with improved economic concepts and information.

The target audience for program emphasis on improving resource allocation and raising salvage values of farm labor is essentially farm people. However they can be reached indirectly through lenders, teachers (particularly those in secondary education), and others recognized as leaders influential in shaping career decisions of young people or in providing encouragement and means for older farmers to participate in retraining programs.

Finally, based on the conclusion that there is substantial overcapacity of machinery on farms in the Triangle, it is recommended that the Extension Service take leadership in finding ways to alleviate this problem. Such leadership should begin with the initiation of research to determine the causes of this overcapacity. If, for example, it is caused by indivisibilities of equipment size, steps may be taken to develop sources of equipment which are alternatives to ownership. This would permit machine use to be purchased or rented in discrete units rather than requiring the purchase of overcapacity.

Also a continuing informational program about optimum resource allocation associated with changes in technology would be especially valuable. Such information should assist farmers and prospective farmers in planning and consequently help them avoid costly mistakes in resource allocation.

This program should be supported by information on an area basis. For example if farmers were informed about the extent to which certain innovations were being adopted on an area basis, (for example large tractors) they would be in a better position to appraise the aggregate effects on land prices. Information of this kind, most likely requiring the cooperation of research workers, would be of considerable value to individual farmers in planning and decision making.

To recapitulate, the Extension Service should, (1) increase emphasis on providing information on alternative careers, (2) encourage and participate in retraining programs for existing farmers who could be made better off by transferring out of agriculture, (3) increase emphasis on teaching analysis of total resource allocation through short courses, printed materials, and cooperative activities between economists and staff members from extension and from other agencies working in agriculture, and (4) assume leadership in solving the problem of machinery overcapacity through initiating research and encouraging appropriate action based on the research.

To Research

During the course of this project cost-return structures for dry-land farms were initially studied largely within the theoretical framework of neo-classical marginal analysis. The problems that have confronted researchers doing similar work within this theoretical framework were encountered and handled in traditional ways. Later in the course of the study fixed asset theory, an extension of neo-classical marginal analysis, was introduced. At this point it was recognized that the earlier study of cost-return structures would have provided more conclusive results had the fixed asset theory extension been introduced earlier. The ambiguities present in the construction of average selected cost curves could have been avoided and the construction of total selected cost curves under arbitrary asset value assumptions would have been unnecessary. Similarly the analysis of land-machinery ratios under conditions of uncertainty might have provided greater insights and explanatory power had it been made within the framework of fixed asset theory. Therefore it is strongly recommended that, in pursuing objectives similar to those of this study, future research workers integrate the complete body of theory into the initial conceptual framework.

The problems associated with asset fixity suggest that continued research should be conducted to determine optimum resource combinations over time as changes take place in technology. This type of research would be particularly valuable to farm operators in the Triangle since they are continually confronted with the important decision of when to adopt new types of machines.

In this study a sequence of decisions leading up to a virtual lifetime commitment to agriculture has been examined. The vital role of overinvestment in machinery has been pointed out. Changes in technology create a situation which is especially conducive to overinvestment in machinery because of lack of information, desire on the part of farmers to try out the latest equipment, and lack of understanding of the macro effects of such investments.

An example will illustrate. The recent introduction of large 4-wheel drive tractors found a receptive market among farmers in the Triangle. Overcommitment by some farmers has occurred because they were uninformed about the acreage required to make such an investment feasible. Others have been taken in by the glamour of modern equipment. In either case they got into a situation which required the rental or purchase of additional land to minimize losses. As explained earlier, this situation has put pressure on land prices which will result in greater adjustment difficulties for other farmers in the years ahead.

It would be desirable, if through research, a continuing evaluation of resource combinations under new systems of technology were made available. Such research would provide the necessary information for more adequate farm planning. To carry this research an important step further, estimates could be developed for the area, of the potential optimum utilization of innovations regarding durable assets. Such information would be helpful in preventing overcommitment of an entire area, which would predictably entail large capital losses.

Although this study was confined to the micro level of resource allocation, the individual fixed assets which earn low returns can also be considered at a macro level, e. g., in terms of the entire Triangle trade area.

If the cost of malallocation of resources is defined as the difference between maximum potential net income to the area and present net income to the area under existing resource allocation, a number of interesting questions arise. For example, what part of this "cost" is due to the institutions (capital gains tax, property transfer systems, etc.) which cause divergence between acquisition and salvage prices? If this cost turns out to be large, which this study suggests may well be the case, it might be possible to get action at the appropriate political and/or social level to change the institutions.

A similar question regarding the cost to the area of allocating resources to small farms should be explored. The results of this study support the hypothesis that rather substantial amounts of underemployed labor are committed to small farms. Further investigation of this problem could conceivably lead to socio-political action which would change institutions to permit further and more appropriate expansions of farm size.

The problem of machinery overcapacity should also be studied on an area basis. It would be interesting to know how the economy of the Triangle would be changed if farms were consolidated and power and machinery needs were supplied to meet given specifications. Research studies of this type would be beneficial for indicating the magnitude of the economic problem relative to machinery overcapacity.

Studies at the macro level (any level above that of the individual firm) have several advantages over studies concerned only with the firm. First, they are more dramatic. The problem of minimizing losses seems much more important when multiplied by the number of farms in the area.

Secondly, macro studies imply solutions through social action rather than individual action. If changes in institutions are required individual action is futile. Change will come only through appropriate social action. A third advantage is that macro studies are likely to consider certain variables which may be overlooked at the micro level. For example the price pressure put on land as farmers collectively try to expand is easily overlooked at the micro level.

The recommendations to the Extension Service will also require the support of several research projects of a different nature. Particularly needed is research regarding projected incomes from virtually all kinds of occupations. Such research should integrate projections of growth for various parts of the economy, anticipated technological changes, unemployment, and other factors relevant to projecting specific occupational incomes. The objective of providing this type of information would be to assist individuals in appraising the value of their human resource for different occupational alternatives.

Research relative to the decision making processes used by rural young people in making initial choices of careers would be helpful. What type of information do rural young people use? To what extent is anticipated future income a determining factor? Do they make realistic projections of future income for farm and non-farm occupations? Answers to these questions would be helpful in determining allocations of research and extension funds and in developing educational programs.

Various operations research projects could be helpful in bringing about needed adjustments indicated in the study. For example consolidation of farms through incorporation, in which case land owners could retain title to their land by leasing it to the corporation, offers a potential means of increasing farm size while at the same time possibly achieving better machinery balance. Leadership from research and extension workers, in this and other alternatives, could be influential in bringing about better total resource allocation.

In summary, research recommendations are as follows: (1) approach studies of cost structure and economies of size with complete contemporary theoretical framework including fixed asset theory, (2) continue studies of optimum resource use as changes continue to take place in technology, particularly with respect to durable assets, (3) initiate studies on a trade area basis to evaluate macro economic costs of resource malallocation and to provide useful economic information for farm planning, (4) support extension activities with operations research projects appropriate to the problems to be solved, (5) emphasize research regarding projected income from farm and non-farm occupations, and (6) investigate the decision-making processes of young people regarding careers to help provide needed insights.

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APPENDIX A

Appendix A is a description of the 400-Acre Budget Model showing gross revenue, expenses, machinery inventory, operational timeliness specifications, capital investment, and imputed returns to capital and residual returns to the operator based on two levels of land values.

APPENDIX A

TABLE 1.--Annual Costs and Returns for a Dry-land Wheat Farm Producing 400-Acres of Crop per Year Estimated to be Maximizing Net Farm Income Within Given Restrictions.

Item		Dollars
Gross Annual Revenues:		
Wheat:	260 A X 25 bu. X $1.05[a]	$6,825
	260 A X 25 bu. X .45 X $1.31[b]	3,832
Barley:	140 A X 33 bu. X $ .80[c]	3,696
	Total Gross Farm Revenue	$14,353
Annual Expenses:		
Fuel and oil		$ 960
Auto		88
Weed and insect control		300
Labor hired		280
Machinery repair		640
Building repair		100
Seed		644
Utilities		160
Property Taxes		1,000
Insurance		360
Supplies and small tools		160
Depreciation on machinery		1,933
Depreciation on buildings		133
	Total Annual Expenses	$6,758
Net Farm Income:		$7,595

[a]Two hundred sixty acres represents the usual wheat allotment for a farm of this size, 25 bushels is the assumed normal yield, and $1.05 is the average Commodity Credit Corporation loan price for Montana.

[b]The coefficient .45 is the amount of normal production eligible for certificate payments under the present government price support program and $1.31 is the estimated value of these certificates at the time of this writing.

[c]One hundred forty acres represents the usual feed grain base for a farm of this size, 33 bushels is the assumed normal yield, and $.80 is the estimated long term normal market price for barley.

TABLE 2.--Machinery, Equipment, and Buildings for a Dry-land Wheat Farm Producing 400-Acre of Crop per Year Estimated to be Maximizing Net Farm Income within given Restrictions.

Machinery Equipment and Buildings	Size	Acquisition Cost	Life	End of Life Salvage Value	Cost Less Salvage	Annual Depreciation	Annual Depreciation Per Acre	Average Investment	Average Investment Per Acre
		dlr.	yrs.	dlr.	dlr.	dlr.	dlr.	dlr.	dlr.
Tractor (gasoline used)	60DPH	3000	6	300	2700	450	1.13	1650	413
Combine (used)	14 feet	4000	6	1000	3000	500	1.25	2500	625
Truck (used)	1 1/2 ton	4000	20	400	3600	180	.45	2200	550
Pickup	1/2 ton	2600	5	100	1500	300	.75	1850	463
Duckfoot & rod	16 feet	1600	12	160	1440	120	.30	880	220
Oneway (used)	16 feet	500	10	50	450	45	.11	275	69
Rod weeders	24 feet	1000	18	100	900	50	.13	550	138
Disk (tandem)	14 feet	1000	18	100	900	50	.13	550	138
Drills	24 feet	2550	18	250	2300	128	.32	1400	350
Harrow	18 feet	180	18	18	162	9	.02	99	22
Grain Elevator & mtr.	40 feet	1000	20	100	900	45	.11	550	138
Shop equipment		1000	20	100	900	45	.11	550	138
Misc. equipment		250	20	25	225	11	.03	138	35
Shop	800 sq. ft.	2400	40	240	2160	54	.14	1320	330
Grain storage	11,000 bu.	3520	40	352	3168	79	.20	1936	484
Total	---	---	--	---	---	2066	5.18	16448	4113

TABLE 3.--Field Operation Timeliness Calculations for Budget Model of Farm Producing 400-acres of Crop per Year.

Critical Operation	Days Required
1. Summer fallow tillage:[a]	
$\dfrac{460 \text{ Acres}}{\dfrac{4.5 \text{ mi./hr. X } 16 \text{ ft. X } 10 \text{ hrs. X } 82.5 \text{ percent}}{825}}$	6.4 days
2. Seeding:[b]	
$\dfrac{260 \text{ Acres}}{\dfrac{3.0 \text{ mi./hr. X } 24 \text{ ft. X } 10 \text{ hrs. X } 68.75 \text{ percent}}{825}}$	4.3 days
3. Combining:[c]	
$\dfrac{400 \text{ Acres}}{\dfrac{2.0 \text{ mi./hr. X } 14 \text{ ft. X } 14 \text{ hrs. X } 82.5 \text{ percent}}{825}}$	10 days

[a]This formula assumes 82.5 percent field efficiency and is based on the general formula for determining field capacity $C = \frac{SWE}{825}$ which is explained in detail on pages 59-60 of this report.

[b]Field efficiency of 68.75 percent is used in the calculation which follows the general form for determining field capacity.

[c]Field efficiency of 82.5 percent is assumed for combining, again using the general form for determining field capacity. This rate of efficiency is somewhat high according to standards established by the American Society of Agricultural Engineering (See Table 1, page 60). However, the experience of farmers in the study area, when combining a standing crop of normal yield per acre, supports the higher rate of efficiency. With combines of larger capacity than the one used in this budget, speed traveled may be somewhat increased.

TABLE 4.--Capital Investment for a Dryland Farm Producing 400 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $100 per Acre for Land.

Item	Amount	Price	Investment
	acres	dollars	dollars
Land	860	100	86,000
Machinery	---	---	13,192
Buildings	---	---	3,256
Operating Capital	---	---	2,346
Total Investment	---	---	104,794

TABLE 5.--Capital Investment for a Dry-land Farm Producing 400 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $158.47 per Acre for Land.

Item	Amount	Price	Investment
	acres	dollars	dollars
Land	860	158.47	136,284
Machinery	---	---	13,192
Buildings	---	---	3,256
Operating Capital	---	---	2,346
Total Investment	---	---	155,078

TABLE 6.--Residual Return to Operator for Labor and Management for a Dry-land Farm Producing 400 Acres of Crop per Year Using Average Inventory Values for Buildings and Machinery and Alternative Land Values.

Item	Value of Land @ $100/acre	Value of Land @ $158.47/acre
	dollars	dollars
Gross Farm Income	14,353	14,353
Less Cash Farm Expenses	4,692	4,692
Net Cash Income	9,661	9,661
Less Depreciation	2,066	2,066
Net Farm Income	7,595	7,595
Less 5% Return to Capital	5,240	7,754
Return to Operator for Labor and Management	2,355	-161

APPENDIX B

Appendix B is a description of the 900 Acre Budget Model showing gross revenue, expenses, machinery inventory, operational timeliness specifications, capital investment, and imputed returns to capital, and residual returns to the operator based on two levels of land values.

APPENDIX B

TABLE 1.--Annual Costs and Returns for a Dry-land Wheat Farm Producing 900 Acres of Crop per Year Estimated to be Maximizing Net Farm Income Within Given Restrictions.

Item	Dollars
Gross Annual Revenue:	
Wheat: 585 A. X 25 bu. X $1.05[a]	15,356
585 A. X 25 bu. X .45 X $1.31[b]	8,621
Barley: 315 A. X 33 bu. X .80[c]	8,316
Total Gross Farm Revenue	$32,293
Annual Expenses:	
Fuel and oil	1,440
Auto	180
Weed and insect control	405
Labor hired	1,485
Machinery repair	1,395
Building repair	180
Seed	1,444
Utilities	315
Property Taxes	2,385
Insurance	540
Supplies and small tools	225
Depreciation on machinery	4,524
Depreciation on buildings	234
Total Annual Expenses	$14,752
Net Farm Income:	$17,541

[a]Five hundred eighty-five acres represents the usual wheat allotment for a farm of this size, 25 bushels is the assumed normal yield, and $1.05 is the average Commodity Credit Corporation loan price for Montana.

[b]The coefficient .45 is the amount of normal production eligible for certificate payments under the present government price support program and $1.31 is the estimated value of these certificates at the time of this writing.

[c]Three hundred fifteen acres represents the usual feed grain base for a farm of this size, 33 bushels is the assumed normal yield, and $.80 is the estimated long term normal market price for barley.

TABLE 2.--Machinery, Equipment, and Buildings for a Dry-land Wheat Farm Producing 900 Acres of Crop per Year Estimated to be Maximizing Net Farm Income within given Restrictions.

Machinery Equipment and Buildings	Size	Acquisition Cost	Life	Salvage	Cost Less Salvage	Annual Depreciation	Annual Depreciation Per Acre	Average Investment	Average Investment Per Acre
		dlr.	hrs.	dlr.	dlr.	dlr.	dlr.	dlr.	dlr.
Tractor	100 DBH	10500	10	3000	7500	750	.83	6750	750
Tractor (used)	60 DBH	3000	6	300	2700	450	.50	1650	183
Truck	2 ton	5600	10	1500	4100	410	.46	3550	394
Truck (used)	1 1/2 ton	4000	10	1200	2800	280	.31	2600	289
Pickup	1/2 ton	2600	4	1100	1500	375	.42	1850	206
Pickup (used)	1/2 ton	500	10	50	450	45	.05	275	31
Combine	20 feet	12000	8	5000	7000	875	.97	8500	944
Duckfoot & rod	24 feet	2400	10	480	1920	192	.21	1440	160
Duckfoot & rod (used)	16 feet	800	6	80	720	120	.13	440	49
Rod weeders	36 feet	1500	20	150	1350	68	.08	825	92
Oneway	14 feet	750	15	75	675	45	.05	412	46
Disk	21 feet	1800	10	180	1620	162	.18	990	110
Harrow	36 feet	360	18	36	324	18	.02	198	22
Drills	36 feet	3900	10	1200	2700	270	.30	2550	283
Grain elevator	60 feet	600	15	60	540	36	.04	330	37
Grain elevator	22 feet	225	15	23	202	13	.01	124	14
Tractor - utility	26 DBH	4000	20	400	3600	180	.20	2200	244
Sprayer on jeep (used)		2100	20	210	1890	95	.11	1155	128
Shop equipment		2500	20	250	2250	113	.13	1375	153
Misc.		600	20	60	540	27	.03	330	37
Shop	800 sq. ft.	2400	40	240	2160	54	.06	1320	147
Grain Storage	25,000 bu.	8000	40	800	7200	180	.20	4400	489
Total	---	---	--	---	---	4758	5.29	43264	4808

TABLE 3.--Field Operation Timeliness Calculations for Budget Model of Farm Producing 900-acres of Crop Per Year.

Critical Operation	Days Required
1. Summer fallow tillage:[a]	
$\dfrac{\text{1035 Acres}}{\dfrac{\text{4.5 mi./hr. X 40 ft. X 10 hrs. X 82.5 percent}}{825}}$	5.75 days
2. Seeding:[b]	
$\dfrac{\text{586 Acres}}{\dfrac{\text{3.0 mi./hr. X 36 ft. X 10 hrs. X 68.75 percent}}{825}}$	6.5 days
3. Combining:[c]	
$\dfrac{\text{900 Acres}}{\dfrac{\text{3.2 mi./hr. X 20 ft. X 14 hrs. X 82.5 percent}}{825}}$	10 days

[a]This formula assumes 82.5 percent field efficiency and is based on the general formula for determining field capacity $C = \dfrac{SWE}{825}$ which is explained in detail on page 59-60 of this report.

[b]Field efficiency of 68.75 percent is used in the calculation which follows the general form for determining field capacity.

[c]Field efficiency of 82.5 percent is assumed for combining, again using the general form for determining field capacity. This rate of efficiency is somewhat high according to standards established by the American Society of Agricultural Engineering (See Table 1, page 60). However, the experience of farmers in the study area, when combining a standing crop of normal yield per acre, supports the higher rate of efficiency.

TABLE 4.--Capital Investment for a Dry-land Farm Producing 900 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $100 per Acre for Land.

Item	Amount	Price	Investment
	Acres	Dollars	Dollars
Land	1935	100	193,500
Machinery	---	---	37,544
Buildings	---	---	5,720
Operating Capital	---	---	4,997
Total Investment	---	---	241,761

TABLE 5.--Capital Investment for a Dry-land Farm Producing 900 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $158.47 per Acre for Land.

Item	Amount	Price	Investment
	Acres	Dollars	Dollars
Land	1935	158.47	306,639
Machinery	---	---	37,544
Buildings	---	---	5,720
Operating Capital	---	---	4,997
Total Investment	---	---	354,900

TABLE 6.--Residual Return to Operator for Labor and Management for a Dry-land Farm Producing 900 Acres of Crop per Year Using Average Inventory Values for Buildings and Machinery and Alternative Land Values.

Item	Value of Land @ $100/acre	Value of Land @ $158.47/acre
	dollars	dollars
Gross Farm Income	32,293	32,293
Less Cash Farm Expenses	9,994	9,994
Net Cash Income	22,299	22,299
Less Depreciation	4,758	4,758
Net Farm Income	17,541	17,541
Less 5% Return to Capital	12,088	17,745
Return to Operator for Labor and Management	5,453	-204

APPENDIX C

Appendix C is a description of the 1500 Acre Budget Model showing gross revenue, expenses, machinery inventory, operational timeliness specifications, capital investment, imputed returns to capital, and residual returns to the operator based on two levels of land values.

APPENDIX C

TABLE 1.--Annual Costs and Returns for a Dry-land Wheat Farm Producing 1500 Acres of Crop per Year Estimated to be Maximizing Net Farm Income Within Given Restrictions.

Item	Dollars
Gross Annual Revenue:	
Wheat: 975 A. X 25 bu. X 1.05[a]	$25,594
975 A. X 25 bu. X .45 X $1.31[b]	14,369
Barley: 525 A. X 33 bu. X .80[c]	13,860
Total Gross Farm Revenue	53,823
Annual Expenses:	
Fuel and oil	2,325
Auto	270
Weed and insect control	825
Labor hired	2,925
Machinery repair	2,325
Building repair	300
Seed	2,400
Utilities	375
Property Taxes	4,050
Insurance	600
Supplies and small tools	300
Depreciation on machinery	6,999
Depreciation on buildings	370
Total Annual Expenses	24,064
Net Farm Income	$29,759

[a]Nine hundred seventy-five acres represents the usual wheat allotment for a farm of this size, 25 bushels is the assumed normal yield, and $1.05 is the average Commodity Credit Corporation loan price for Montana.

[b]The coefficient .45 is the amount of normal production eligible for certificate payments under the present government price support program and $1.31 is the estimated value of these certificates at the time of this writing.

[c]Five hundred twenty-five acres represents the usual feed grain base for a farm of this size, 33 bushels is the assumed normal yield, and $.80 is the estimated long term normal market price for barley.

TABLE 2.--Machinery, Equipment, and Buildings for a Dry-land Wheat Farm Producing 1500 Acres of Crop per Year Estimated to be Maximizing Net Farm Income within given Restrictions.

Machinery Equipment and Buildings	Size	Acquisition Cost	Life	Salvage	Cost Less Depreciation	Annual Depreciation	Annual Depreciation Per Acre	Average Investment	Average Investment Per Acre
		dlr.	yrs.	dlr.	dlr.	dlr.	dlr.	dlr.	dlr.
Tractor[a]	155 DBH	31000	10	17000	14000	1400	.93	24000	1600
Tractor (used)	90 DBH	5000	6	500	4500	750	.50	2750	183
Truck	2 ton	5600	8	1800	3800	475	.32	3700	247
Truck (used)	22 ton	4200	8	1200	3000	375	.25	2700	180
Truck (used)	1 1/2 ton	1200	15	120	1080	72	.05	660	44
Pickup	1/2 ton	2600	3	1100	1500	500	.33	1850	123
Pickup (used)	1/2 ton	500	7	50	450	64	.04	275	18
Combine	16 feet	9000	8	3400	5600	700	.47	6200	413
Combine	16 feet	9000	8	3400	5600	700	.47	6200	413
Duckfoot & rod	36 feet	3600	10	1200	2400	240	.16	2400	160
Duckfoot & rod (used)	22 feet	1100	6	110	990	165	.11	605	40
Rod Weeder	48 feet	2000	20	200	1800	90	.06	1100	73
Oneway	14 feet	750	10	150	600	660	.04	450	30
Disk - tandem	32 feet	3150	5	1500	1650	350	.23	2325	155
Harrow	48 feet	480	15	48	432	29	.02	264	18
Drills	60 feet	6500	10	2000	4500	450	.30	4250	283
Grain elevator	60 feet	600	10	60	540	54	.04	330	22
Grain elevator	22 feet	225	10	23	202	20	.01	124	08
Tractor - utility	26 DBH	4000	20	400	3600	180	.12	2200	147
Sprayer on used jeep		2100	13	210	1890	145	.10	1155	77
Shop equipment		3000	20	300	2700	135	.09	1650	110
Misc.		1000	20	100	900	45	.03	550	37
Shop	1000 sq. ft.	3000	40	300	2700	68	.04	1650	110
Grain Storage	42,000 bu.	13440	40	1344	12096	302	.20	7392	493
Total	---	---	--	---	---	7369	4.91	74780	4984

[a]Crawler or four-wheel drive.

TABLE 3.--Field Operation Timeliness Calculations for Budget Model of Farm Producing 1500-Acres of Crop per Year.

Critical Operation	Days Required
1. Summer fallow tillage:[a]	
$\frac{1725 \text{ Acres}}{\frac{4.5 \text{ mi./hr. X } 58 \text{ ft. X } 10 \text{ hrs. X } 82.5 \text{ percent}}{825}}$	6.6 days
2. Seeding:[b]	
$\frac{1725 \text{ Acres}}{\frac{3.0 \text{ mi./hr X } 60 \text{ ft. X } 10 \text{ hrs. X } 68.75 \text{ percent}}{825}}$	6.5 days
3. Combining:[c]	
$\frac{1500 \text{ Acres}}{\frac{3.3 \text{ mi./hr. X } 32 \text{ ft. X } 14 \text{ hrs. X } 82.5 \text{ percent}}{825}}$	10 days

[a]This formula assumes 82.5 percent field efficiency and is based on the general formula for determining field capacity $C = \frac{SWE}{825}$ which is explained in detail on pages 59-60 of this report.

[b]Field efficiency of 68.75 percent is used in the calculation which follows the general form for determining field capacity.

[c]Field efficiency of 82.5 percent is assumed for combining again using the general form determining field capacity. This rate of efficiency is somewhat high according to standards established by the American Society of Agricultural Engineering (See Table 1, page 60). However, the experience of farmers in the study area, when combining a standing crop of normal yield per acre, supports the higher rate of efficiency.

TABLE 4.--Capital Investment for a Dry-land Farm Producing 1500 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $100 per Acre for Land.

Item	Amount	Price	Investment
	acres	dollars	dollars
Land	3225	100	322,500
Machinery	---	---	65,738
Buildings	---	---	9,042
Operating Capital	---	---	8,348
Total Investment	---	---	405,628

TABLE 5.--Capital Investment for a Dry-land Farm Producing 1500 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $158.47 per Acre for Land.

Item	Amount	Price	Investment
	acres	dollars	dollars
Land	3225	158.47	511,066
Machinery	---	---	65,738
Buildings	---	---	9,042
Operating Capital	---	---	8,348
Total Investment	---	---	594,194

TABLE 6.—Residual Return to Operator for Labor and Management for a Dry-land Farm Producing 1500 Acres of Crop per Year Using Average Inventory Values for Buildings and Machinery and Alternative Land Values.

Item	Value of Land @ $100/acre	Value of Land @ $158.47/acre
	dollars	dollars
Gross Farm Income	53,823	53,823
Less Cash Farm Expenses	16,695	16,695
Net Cash Income	37,128	37,128
Less Depreciation	7,369	7,369
Net Farm Income	29,759	29,759
Less 5% Return to Capital	20,281	29,710
Return to Operator for Labor and Management	9,478	49

APPENDIX D

Appendix D is a description of the 2400 Acre Budget Model showing gross revenue, expenses, machinery inventory, operational timeliness specifications, capital investment, and inputed returns to capital and residual returns to the operator based on two levels of land values.

APPENDIX D

TABLE 1.--Annual Costs and Returns for a Dry-land Wheat Farm Producing 2400 Acres of Crop per Year Estimated to be Maximizing Net Farm Income Within Given Restrictions.

Item	Dollars
Gross Annual Revenue:	
Wheat: 1560 A. X 25 bu. X $1.05[a]	$40,950
1560 A. X 25 bu. X .45 X $1.31[b]	22,991
Barley: 840 A. X 33 bu. X .80[c]	22,176
Total Gross Farm Revenue	$86,117
Annual Expenses:	
Fuel and oil	3,720
Auto	384
Weed and insect control	1,800
Labor hired	4,920
Machinery repair	3,600
Building repair	456
Seed	3,840
Utilities	504
Property Taxes	6,000
Insurance	960
Supplies and small tools	720
Depreciation on machinery	8,908
Depreciation on buildings	475
Total Annual Expenses	$36,287
Net Farm Income:	$49,830

[a]Fifteen hundred sixty acres represents the usual wheat allotment for a farm of this size, 25 bushels is the assumed normal yield, and $1.05 is the average Commodity Credit Corporation loan price for Montana.

[b]The coefficient .45 is the amount of normal production eligible for certificate payments under the present government price support program and $1.31 is the estimated value of these certificates at the time of this writing.

[c] Eight hundred forty acres represents the usual feed grain base for a farm of this size, 33 bushels is the assumed normal yield, and $.80 is the estimated long term normal market price for barley.

TABLE 2.--Machinery, Equipment, and Buildings for a Dry-land Wheat Farm Producing 2400 Acres of Crop per Year Estimated to be Maximizing Net Farm Income within Given Restrictions.

Machinery Equipment and Buildings	Size	Acquisition Cost	Life	Salvage	Cost Less Salvage	Annual Depreciation	Annual Depreciation Per Acre	Average Investment	Average Investment Per Acre
		dlr.	yrs.	dlr.	dlr.	dlr.	dlr.	dlr.	dlr.
Tractor[a]	155 DHP	31000	10	17000	14000	1400	.58	24000	1000
Tractor	100 DHP	10500	8	4000	6500	813	.34	7250	302
Tractor (used)	60 DHP	3000	10	300	2700	270	.11	1650	69
Truck	2 ton	5600	8	1700	3900	488	.20	3650	152
Truck	2 ton	5600	8	1700	3900	488	.20	3650	152
Truck (used)	1 1/2 ton	1200	15	120	1080	72	.03	660	28
Pickup	1/2 ton	2600	3	1000	1600	533	.22	1800	75
Pickup (used)	1/2 ton	500	6	50	450	75	.03	275	11
Combine	22 feet	13000	8	5000	8000	1000	.42	9000	375
Combine	22 feet	13000	8	5000	8000	1000	.42	9000	375
Duckfoot & rod	36 feet	3600	10	1200	2400	240	.10	2400	100
Duckfoot & rod	24 feet	2400	10	900	1500	188	.08	1650	69
Duckfoot & rod (used)	16 feet	800	10	80	720	72	.03	440	18
Rod weeder	48 feet	2000	10	400	1600	160	.07	1200	50
Oneway	20 feet	2100	10	400	1700	170	.07	1250	52
Disk - tandem	32 feet	3150	5	1150	2000	400	.17	2150	90
Harrow	48 feet	480	10	48	432	43	.02	264	11
Drills	96 feet	10400	10	3200	7200	720	.30	680	28
Grain elevator (10")	60 feet	2000	15	200	1800	120	.05	1100	46
Grain elevator (6")	42 feet	600	15	60	540	36	.02	330	14
Grain elevator (6")	22 feet	225	8	23	202	25	.01	124	05
Tractor - utility	26 DHP	4000	20	400	3600	1180	.08	2200	92

[a]See footnote on following page.

TABLE 2.--Machinery, Equipment, and Buildings for a Dry-land Wheat Farm Producing 2400 Acres of Crop per Year Estimated to be Maximizing Net Farm Income within given Restrictions. (Continued)

Machinery Equipment and Buildings	Size	Acquisition Cost	Life	Salvage	Cost Less Salvage	Annual Depreciation	Annual Depreciation Per Acre	Average Investment	Average Investment Per Acre
		dlr.	yrs.	dlr.	dlr.	dlr.	dlr.	dlr.	dlr.
Weed sprayer on used jeep	40 feet	2100	10	210	1890	189	.08	1155	48
Shop equipment		3500	20	350	3150	158	.07	1925	80
Misc.		1500	20	150	1350	68	.03	825	34
Shop	1000 sq. ft.	3000	40	300	2700	68	.03	1650	69
Grain storage	67000 bu.	18090	40	1809	16281	407	.17	9950	415
Total	---	---	--	---	---	9383	3.91	90228	3760

[a] Crawler or four-wheel drive.

TABLE 3.--Field Operation Timeliness Calculations for Budget Model of Farm Producing 2400 Acres of Crop per Year.

Critical Operation	Days Required
1. Summer fallow tillage:[a]	
$\dfrac{2760 \text{ Acres}}{\dfrac{4.5 \text{ mi./hr.} \times 76 \text{ ft.} \times 10 \text{ hrs.} \times 82.5 \text{ percent}}{825}}$	8.0 days
2. Seeding:[b]	
$\dfrac{1560 \text{ Acres}}{\dfrac{3.0 \text{ mi./hr.} \times 96 \text{ ft.} \times 10 \text{ hrs.} \times 68.75 \text{ percent}}{825}}$	6.5 days
3. Combining:[c]	
$\dfrac{2400 \text{ Acres}}{\dfrac{3.3 \text{ mi./hr.} \times 44 \text{ ft.} \times 14 \text{ hrs.} \times 82.5 \text{ percent}}{825}}$	11.8 days

[a]This formula assumes 82.5 percent field efficiency and is based on the general formula for determining field capacity $C = \frac{SWE}{825}$ which is explained in detail on pages 59-60 of this report.

[b]Field efficiency of 68.75 percent is used in the calculation which follows the general form for determining field capacity.

[c]Field efficiency of 82.5 percent is assumed for combining again using the general form for determining field capacity. This rate of efficiency is somewhat high according to standards established by the American Society of Agricultural Engineering (See Table 1, page 60). However, the experience of farmers in the study area, when combining a standing crop of normal yield per acre, supports the higher rate of efficiency.

TABLE 4.--Capital Investment for a Dry-land Farm Producing 2400 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $100 per Acre for Land.

Item	Amount	Price	Investment
	Acres	Dollars	Dollars
Land	5160	100	516,000
Machinery	---	---	78,628
Buildings	---	---	11,600
Operating Capital	---	---	13,452
Total Investment	---	---	619,680

TABLE 5.--Capital Investment for a Dry-land Farm Producing 2400 Acres of Crop per Year Using Average Inventory Values for Machinery and Buildings and $158.47 per Acre for Land.

Item	Amount	Price	Investment
	Acres	Dollars	Dollars
Land	5160	158.47	817,705
Machinery	---	---	78,628
Buildings	---	---	11,600
Operating Capital	---	---	13,452
Total Investment	---	---	921,385

TABLE 6.--Residual Return to Operator for Labor and Management for a Dry-land Farm Producing 2400 Acres of Crop per Year Using Average Inventory Values for Buildings and Machinery and Alternative Land Values.

Item	Value of Land @ $100/acre	Value of Land @ $158.47/acre
	dollars	dollars
Gross Farm Income	86,117	86,117
Less Cash Farm Expenses	26,904	26,904
Net Cash Income	59,213	59,213
Less Depreciation	9,383	9,383
Net Farm Income	49,830	49,830
Less 5% Return to Capital	30,984	46,069
Return to Operator for Labor and Management	18,846	3,761

APPENDIX E

Appendix E is a reproduction of the questionnaire which was used in the telephone interviews to gather data relative to tractor size and crop acreage.

APPENDIX E

QUESTIONNAIRE FOR TELEPHONE SURVEY TO DETERMINE TRACTOR POWER CAPACITY OF DRYLAND FARMS

Mr.________________________,this is ______________________________ from the Agricultural College at Bozeman. We are conducting a survey to determine the tractor power capacity of dry-land wheat farms in the Triangle. We would like you to help us by answering a few questions about your farming operations.

First would you tell us the make, model, and year of your tractor or tractors?

Make	Year	Model Designation	Hours Used Last Year

In order to establish tillage capacity I would like to know how many feet of chisel plow you pull behind each tractor for the first spring tillage operation?____________________At what speed or gear?___.

That works out to about_________acres per hour or_________________. acres in a ten-hour day. Does this agree with your experience?________

Now would you tell me how many acres of grain crops you produced last year?___________. How many acres of summer fallow did you have?

____.

Could you add more land to your farming operation without buying more machinery and tractor power, working multiple shifts, or reducing

yields because of lack of timely tillage?_____________________________

If yes, how much?____________________________acres cropped per year.

Do you believe this would be the most desirable balance between land and machine capacity?_________________________

Do you have livestock on your farm?__________________________

Do you hire neighbors or custom operators to do any of your tillage?____.

APPENDIX F

Appendix F is a summary of cost, yield, and price coefficients used in the construction of the model budgets.

TABLE 1.--Estimated Purchase Price of New Equipment in Montana, Length of Life Until Obsolete, Average Investment, and Wear-out-Life.

Item	Size	Life[a] Until Obsolete	Life[a] Wear-out Life	Typical New 1966 Cost	Average[b] Investment
		yrs.	hours	dollars	dollars
Vehicles					
Pickup	1/2 ton	10	---	2,600	1,430
Truck (inc. box & hoist)	2 ton	12	---	5,600	3,080
Jeep		10	---	2,690	1,480
4-Wheel drive pickup	1/2 ton	10	---	3,443	1,894
2-Wheel Drive Tractors[c]					
Gasoline:					
W- 45	45 dhp[d]	15	12,000	4,900	2,695
W- 55	55 dhp[d]	15	12,000	6,013	3,307
W- 65	65 dhp[d]	15	12,000	6,435	3,540
W- 75	75 dhp[d]	15	12,000	7,020	3,861
W- 85	85 dhp[d]	15	12,000	7,675	4,222
Diesel:					
W- 45	45 dhp[d]	15	12,000	5,590	3,075
W- 55	55 dhp[d]	15	12,000	6,727	3,700
W- 65	65 dhp[d]	15	12,000	7,287	4,008
W- 75	75 dhp[d]	15	12,000	7,866	4,327
W- 85	85 dhp[d]	15	12,000	8,495	4,673
W- 95	95 dhp[d]	15	12,000	10,420	5,731
W-105	105 dhp[d]	15	12,000	11,476	6,312
4-Wheel Drive Tractors-Smaller Front Wheels[c] (add $1800 to prices for 2-wheel drive units)					

TABLE 1.--Estimated Purchase Price of New Equipment in Montana, Length of Life Until Obsolete, Average Investment, and Wear-out-Life. (Continued).

Item	Size	Life[a] Until Obsolete	Life[a] Wear-out Life	Typical New 1976 Cost	Average Investment[b]
		yrs.	hours	dollars	dollars
4-Wheel Drive Diesel Tractors-Equal Size Wheels[c]					
4WD-110	110 dhp[d]	15	12,000	15,885	8,737
4WD-155	155 dhp[d]	15	12,000	31,000	17,050
4WD-180	180 dhp[d]	15	12,000	36,500	20,075
Crawler Tractors-Diesel[c]					
C- 50	50 dhp[d]	15	12,000	10,750	5,913
C- 75	75 dhp[d]	15	12,000	16,765	9,221
C-120	120 dhp[d]	15	12,000	22,500	12,375
C-180	180 dhp[d]	15	12,000	37,500	20,625
Duckfoot Rod Weeder Combinations					
	16 feet	12	2,500	1,600	880
	20 feet	12	2,500	2,000	1,100
	32 feet	12	2,500	3,200	1,760
	48 feet	12	2,500	4,800	2,640
Oneways					
	14 feet	15	2,500	750	413
	16 feet	15	2,500	1,200	660
	20 feet	15	2,500	2,100	1,155
Rod Weeders					
	24 feet	15	2,500	1,000	550
	36 feet	15	2,500	1,500	825
	48 feet	15	2,500	2,000	1,100

TABLE 1.--Estimated Purchase Price of New Equipment in Montana, Length of Life Until Obsolete, Average Investment, and Wear-out-Life. (Continued).

Item	Size	Life[a] Until Obsolete	Life[a] Wear-Out Life	Typical New 1966 Cost	Average[b] Investment
		yrs.	hours	dollars	dollars
Disks (tandem)					
	14 feet	15	2,500	1,000	550
	21 feet	15	2,500	1,800	990
	32 feet	15	2,500	3,150	1,733
Drills	24 feet	20	1,200	2,600	1,430
	36 feet	20	1,200	3,900	2,145
	48 feet	20	1,200	5,200	2,860
	96 feet	20	1,200	10,400	5,720
Harrows (spike)	18 feet	20	2,500	180	99
	36 feet	20	2,500	360	198
	54 feet	20	2,500	540	297
	72 feet	20	2,500	720	396
Combines-Self Propelled	14 feet	10	2,000	7,500	4,125
	16 feet	10	2,000	9,000	4,950
	20 feet	10	2,000	12,000	6,600

[a]The length of life until obsolete and wear-out life are estimates prepared by The American Society of Agricultural Engineers, Agricultural Engineers Yearbook, St. Joseph, Michigan, 1965, p. 252.

[b]Average investment assumes a salvage value of 10 percent of new cost and is calculated as follows:

$$\text{Average Investment} = \frac{\text{New Cost + Salvage Value}}{2}$$

[c]Tractor costs are based on farmer interviews and retail prices adjusted to include transportation costs, suggested by the National Farm and Power Equipment Dealers Association, Official Tractor and Farm Equipment Guide, NRFEA Publications, Inc., St. Louis, Mo., 1965. Transportation costs to Montana are estimated to be $3.00 per cwt.

[d]Based on maximum drawbar horsepower; not 75 percent of pull at maximum power.

TABLE 2.--Estimated Cost of Repairs and Maintenance.

Machine	Cost in Percent of New Cost[a]	
	Average per 100 hrs.	Total during wear-out life
	Percent	Percent
Tractors		
Crawler-type	.65	78
Wheel-type	1.00[b]	120
Combine	2.70	54
Duckfoot-Rod Weeder	6.00	150
Oneway	5.00	125
Rod Weeder	6.00	150
Disk-tandem	6.50	163
Drill	8.00	96
Harrow (spike)	6.00	120

Source: The American Society of Agricultural Engineers, *Agricultural Engineers Yearbook*, St. Joseph, Michigan, 1965, p. 252, and interviews with farmers--16 observations.

[a]Repair and maintenance costs include daily servicing and lubrication of all machines except tractors but do not include fuel or engine oil. As an approximation of daily servicing and lubrication costs for wheel-type tractors, add 0.2 percent of new cost per 100 hours; for medium-size crawler-type tractors add 0.15 percent.

[b]Approximately one fourth of total repair and maintenance cost is for tires.

TABLE 3.--Price Coefficients Used In Budget Models.

Item	Unit	Amount	Subject to:
		dollars	
For Items Sold:			
Wheat	bu.	1.05	CCC loan rate (see p.70)
Wheat	bu.	1.31	On 45% of normal crop (see page 70)
Barley	bu.	.80	Cash market
For Items Purchased:			
Labor	hr.	1.50	Hired labor only
Seed wheat	bu.	1.55	Field run, not cleaned
Seed cleaning & smut treatment	bu.	.15	
Wire worm treatment of seed	bu.	.30	
Seed barley	bu.	.85	Field run, not cleaned
Diesel fuel	gal.	.178	
Gasoline	gal.	.28	Inc. $.10 state & fed. taxes.

TABLE 4.--Yield Coefficients Used in the Budget Models.

Crop	Unit	Yield
Wheat	bu. per acre	25
Barley	bu. per acre	33

TABLE 5.--Cost Coefficients Used in Budget Models for Permanent Improvements.

Item	Unit	Amount	Subject to:
		dollars	
Grain storage buildings:			
400 acre model	bu.	.32	Cost of new construction
900 acre model	bu.	.32	Cost of new construction
1500 acre model	bu.	.30	Cost of new construction
2400 acre model	bu.	.27	Cost of new construction
Shop building:			Cost of new construction
Metal	sq.ft.	3.25	inc. inside finish and concrete floor
Single-wall frame	sq.ft.	2.00	" " " " " "
Double-wall frame	sq.ft.	2.50	" " " " " "
Machine storage			
Metal	sq.ft.	2.00	Cost of new construction
Single-wall frame	sq.ft.	1.50	" " " "

TABLE 6.--Average Costs of Crop Produced per Acre for Each Budget Model.

Item	Cost per Acre in Dollars			
	400 acre	900 acre	1500 acre	2400 Acre
Fuel and oil[a]	2.40	1.60	1.55	1.55
Auto	.22	.20	.18	.16
Weed and insect control	.75	.45	.55	.75
Labor hired	.70	1.65	1.96	2.05
Machinery repair	1.60	1.55	1.55	1.50
Building repair	.25	.20	.20	.19
Seed and seed treatment[b]	1.61	1.60	1.60	1.60
Utilities	.40	.35	.25	.21
Property taxes	2.50	2.65	2.70	2.50
Insurance	.90	.60	.40	.40
Supplies and small tools	.40	.25	.20	.30
Depreciation on machinery	4.83	5.03	4.67	3.71
Depreciation on buildings	.33	.26	.25	.20
Total Selected Operating Costs per acre	16.89	16.39	16.04	15.12
Interest on investment[c]	19.39	19.72	19.81	19.19
Operator's Labor & Management[d]	12.50	5.56	3.33	2.08
Total Cost per Acre	48.78	41.67	39.18	36.39

[a]Excludes state and federal tax refunds.

[b]Assumes treatment for wire worm each alternate crop year.

[c]Assumes land values of $158.47 per acre and average value of machinery and equipment investment at an interest rate of 5 percent.

[d]Assumes the operator's labor and management is valued at $5,000 per year for each model budget.