THE USE OF MULTI-PERIOD LINEAR PROGRAMMING IN PLANNING A SELECT FARM LOCATED IN THE CARMAN AREA, MANITOBA

A Thesis Presented to the
Faculty of Graduate Studies and Research
University of Manitoba

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

---

by
Henri-Paul Blanchard
June 1968

ABSTRACT

The enterprise organization of a particular farm depends upon the quality and quantity of its resources. In order to allocate them so as to maximize his income, the farm operator must carefully plan his business. In this study, it was attempted to show how linear programming may be used in planning an individual farm according to two basic models: conventional static and multi-period linear programming.

This later model involves the simultaneous determination of optimum plans for a five-year planning horizon with decisions of each year affecting alternatives in subsequent and preceding years. In such a model of capital accumulation, attention was given to the maximization of the present value of a stream of net incomes.

The dual purposes of this thesis were (1) to determine alternative opportunities for increasing income on a selected farm and (2) to investigate the use of the multi-period linear programming technique as a tool for planning a farm over a finite period of time.

It was found that:

- no major adjustments would have to be made to the current farm organization in order to reach an optimum production plan.

- farm plans determined within a planning horizon were, in their competition for capital, different from those obtained under purely static conditions.
- the second model showed more flexibility in the use of capital, in that the more capital intensive lines of production were located in latter years of the planning period, thus benefiting of the internally accumulated capital.

This study showed that linear programming is a more appropriate and more useful farm planning tool if its conceptual model allows for: (1) the introduction of the time element in the decision-making process, (2) the consideration of annual fixed charges, including home withdrawals, and (3) the transfer and accumulation of operating capital over successive years.

ACKNOWLEDGMENTS

The author is respectfully indebted to a number of people who aided him in preparing this dissertation.

A debt of gratitude is expressed to Dr. W. J. Craddock for his guidance and constructive criticisms as advisor. His direction and assistance have been invaluable in the many facets of such a work. The encouragement and suggestions given by Dr. J. C. Gilson, Head of the Department of Agricultural Economics and Farm Management, are greatly appreciated.

Sincere thanks go to the operator of the case farm used in this study. His willing co-operation and source of information provided the base for applied analysis. Thanks are also due to various people in the Faculty of Agriculture and Home Economics and in the Manitoba Department of Agriculture who gave their time to provide the data used in designing the empirical framework for this study.

Financial assistance in the form of a graduate scholarship was provided by the "Conseil des Recherches Agricoles, Ministère de l'Agriculture et de la Colonisation du Québec", to which a very sincere word of appreciation is extended.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

A. INTRODUCTION

Today's farm firm is a complex and highly sophisticated business. As such it is based on the principle of perpetual existence. It is established and operated with the hope and expectation that it will go on forever and thus implies efficient operation. The only sure means of achieving this long run aim is effective planning. With the economic forces that affect the farm business, careful farm planning is now a necessity.

Farm planning is essential for making sound decisions because of the increasing complexities of farming and the precarious position of many inefficient farming businesses. Farm decision making is difficult because of the number and size of the eventualities and courses of action that must be taken into consideration. It is essentially a task that is best carried out individually for each farm because of the unique nature of many farm problems. It is a continuing process, for plans may need modifying as resources, techniques and/or prices change. The aim of farm planning is to make the best use of the farmer's resources for increasing his income and improving the standard of living of his family.

This study is devoted to one method of making farm plans which appears to offer considerable advantages.

This systematic evaluation procedure is called linear programming. Its development and use in planning individual farms is paralleled with the entry of electronic computers into the field of farm planning. Computers, because they can make numerous calculations very rapidly, allow more complex problems to be treated and many more alternatives to be combined than would be feasible by other means.

Planning in a Firm Household Context

A firm can be defined as an economic unit concerned with production and motivated to maximize profits. A household on the other hand can be defined as a socio-economic unit concerned with consumption and motivated to maximize satisfaction or utility.

Since economics deals with production and consumption, the interdependence between these two activities must be taken into account in explaining the behavior of individual economic units and in planning for the optimum use of resources. The importance of the farm family, which constitutes the basic institution in our agricultural industry, justifies the approach taken in this study where it is attempted to integrate it with the firm, its productive counterpart.

A specific form of interchange or communication between the farm firm and the farm household is hard to establish. A simplified presentation of the basic relationships is schematized in table I:1. The household with its

particular value orientation requires from the firm the means of achieving family goals, expressed in terms of utility. In turn the family must provide some of its resources to the farm firm as part of its goal-attainment process. The farm firm, on the other hand, requires the resources of the family and provides the monetary returns necessary to the family.

As farm units become larger and more highly commercialized, a greater separation is observed between the firm and the household, but nevertheless, within our family-farm type of farming, production and consumption decisions are still inter-linked.

TABLE I:1

BASIC RELATIONSHIPS BETWEEN THE FARM FIRM AND THE FARM HOUSEHOLD

Farm Household Activity		Farm Firm Activity
Provides	--RESOURCES---	Requires
Goal: Utility		Goal: Maximum Profit
Requires	..INCOME.....	Provides

In the present study, these considerations will be fulfilled by determining various maximum profits farm plans under the assumption of given income requirements for the household.

B. THE EMPIRICAL PROBLEM

Present day agriculture is faced with the problem of adjusting to changing conditions; changes within the agricultural industry and changes within the economy as a whole. This study is devoted to the production aspect of agriculture and more specifically to individual farming considered as an economic activity aiming at maximum efficiency.

Farm Organization and Growth

The empirical problems investigated in this study are (1) the farm organization or income problem, and (2) the growth problem of an individual operating unit.

Farm organization concerns the efficient allocation of all the resources; land, labor and capital, available in variable but limited proportions to the farm operator. An efficient use is achieved through a proper combination of enterprises having supplementary, complementary or competitive aspects. It is felt that the farmer can improve his income by making a better use of the resources available to him. In order to do this, the effects of alternative uses of resources on income must be known.

This study determines the optimum resource use and enterprise combination for an actual farm unit. The alternatives considered are within the farmer's reach and indicate some of the major potential adjustments necessary

to alleviate his overall farm income problem.

The problem of growth and development of the farm firm involves the dynamic and longer-run aspect of planning. Not only does the farmer want to stay in business, but his long run economic goal is to improve his financial position. He aims at a positive program of expansion through capital accumulation.

The farm growth problem is dealt with in this study through the development of mutually dependent yearly farm plans constituting a production program. It is felt that such plans will be more realistic by incorporating the time element and a greater firm-household interdependence into the planning model used.

In agricultural production there exists many links between successive productive years. The process of internal re-investment of the surplus income of each year in the form of operating capital for the following year is an important feature of the operation of the individual farm firm analyzed in a multi-year framework. The degree of success or failure of past years gives the farmer an indication of the growth tempo of his farm.

Present Problematic Situation

Costs of production in agriculture are high and for most items are continuing to increase, while prices for commodities sold have not increased proportionately, and,

moreover, are often subject to unpredictable variations. This price-cost-squeeze situation has led farmers to adopt more efficient methods of farming through accurate planning.

Emphasis is placed in this study on the planning of a mixed farm shifting toward diversified cropping. The farmer is interested in knowing whether or not livestock should be produced, and if so, what types of enterprises and at what level? If it is found that diversified cropping can bring a higher and more stable income, what steps should be taken in the direction of producing more field and cash crops? What crops are most appropriate? If land becomes a limiting resource will it be profitable to increase it? How, (buying or renting)? How does capital availability affect the growth of the farm? How much is required in each year? How would the farm expand without external capital borrowing? What are the effects of the home withdrawals on the farm firm?.... These are some of the practical questions that this study attempts to answer. The conceptual problem of developing and formulating an appropriate empirical model is also an important aim of this study.

C. PURPOSE AND OBJECTIVES

The overall purpose of this study is twofold: (1) to determine, for a case-study farm, the farm organizations that maximize net income for various resource and enterprise situations, and

(2) to investigate the use of multi-period linear programming procedures as a more adequate and more realistic approach to farm planning compared to the conventional or static model.

More specifically, the objectives are as follows:
(1) to determine, in a static framework, the level and combination of specific crop and livestock enterprises which constitute an optimum farm plan.

- to study the effect of changing resource situations on optimum farm production,
- to assess the place of crop and livestock production on the specific farm,
- to indicate various possibilities of expansion for the farm business in the long run,

(2) to determine a farm expansion program extending over a five-year period and taking into consideration yearly household withdrawals and farm fixed expenses.

- to develop several production programs with various resource situations and enterprise combinations.
- to show the effect of fixed capital withdrawals on the farm business.

This study is intended to illustrate, in a simple and rigid economic framework, the determination of optimum resource use and enterprise combination on a specific farm

through the use of (1) conventional static mono period linear programming and (2) inter-year linear programming. It is expected that the results of the inter-year programming model will be of greater value to the individual farmer in operating his business than the single period programming model.

D. SCOPE OF THE STUDY

The focus of this study is centered on the production problems of an individual farm and relates to a particular period of time. Such a micro-approach to farm production is appropriate because all adjustments in resource use must ultimately be made at the farm firm level. By studying the farm firm and analyzing the conditions which confront a producer, we will be able to provide him with information which would be useful in his decisions regarding the use of his resources.

A viable farm unit was selected which had a relatively good set of financial and physical records over a number of years. The analysis was confined to the resource allocation and enterprise combination problems specific to this individual farm. The crop and livestock interprises considered were limited to those found on the case farm in the past and corresponding to the preferences of the farmer.

Every farm situation is, in some respects unique. Exact duplications of the case-farm situation probably do

not exist. The approach used in this study is intended to identify and examine some of the planning problems of the selected farm, and then to make use of the solutions to formulate a set of planning objectives. No attempt is made, however, to make this farm a benchmark or representative situation for the area, although such a study would be of great value. No investigation or reconnaissance survey was done in the area to determine the degree of representativeness of the selected farm. However, while the approach of this study was not designed specifically to provide a basis for further generalizations, it is hoped that the findings will have a wider practical application than on this farm, and that the approach, if fruitful, could be used for other farm situations.

E. ANALYTICAL TOOL AND PROCEDURE

Linear programming is the conceptual and computational tool of this study. Two models are used separately. Firstly, the static or conventional model is used to determine optimum farm plans for various enterprise and resource situations. These situations or conditions were chosen to simulate the planning environment of the specific farm unit.

Secondly, an inter-year or multi-period model is employed in the development of optimum "production programs" of five yearly plans linked together in such a way that they are only optimum in terms of the 5-year period considered

in one block. This model determines the best plan or program for a finite series of years. The optimum for any one year depends on the solution for other years and on the availability of resources in any of the five years.

A second important characteristic of this second model is its inclusion of the home or consumption aspect of the farm unit. The amount of capital available for production in any one year (except for year 1) represents the surplus return of the previous year above the cost of family living. The tying together of farm planning and home planning, in their competition for the use of income, should throw some light on the production-consumption relationships of the farm unit.

In summary, conventional linear programming is used to determine a single optimum plan to be attained in an indefinite future and thus provides an orientation for the direction in which the farm should expand. The multi-period model is employed for the purpose of determining the most profitable system of farming over a 5-year period of time.

The procedure followed in this study involved identifying the available resources and other planning restraints of the case-study farm, selecting alternative enterprises, calculating various input-output coefficients from available sources and developing costs and returns for the alternative enterprises. The linear programming

techniques were then applied to the various planning situations.

F. LITERATURE REVIEW

The adoption and use of linear programming as a farm budgeting tool is not new although the technique itself is relatively recent (Dantzig,(33) chapter 21). There is no attempt here to proceed to an exhaustive survey and/or evaluation of the use of linear programming in agricultural economics.[1] Instead, a few references are selected to show the attainment of past work and to point out the orientation toward more useful and more appropriate programming models used at the individual farm level.

Early work in the United States, by Hildreth and Reiter((33), chapter 11) involved the development of a model to select the optimum combination of crop rotations without giving consideration to the livestock enterprises. Swanson and Fox (43) showed how an optimum combination of livestock enterprises can be selected with a given crop rotation. Peterson (34) presented a monoperiod programming model in which the livestock enterprises and the crop rotations were selected simultaneously in a static framework.

The application of the programming technique to a farm planning problem of more than one production period,

---

[1]For such a review of literature, the reader is referred to articles such as: (5),(26),(28),(33), and (39).

with the outcome of the first period determing later production or linked with the results of a finite future, was first discussed by E. R. Swanson (41). He developed a poly-period model of crop rotations and livestock enterprises, and demonstrated his methodological technique by constructing a long-run (5 years) farm production plan with specifications of the transition model (year 2). Swanson (40) also suggested an approach that would cast some light on the degree of flexibility which should be maintained in the organization of the farm. This involved the use of a programming model optimized to the price situation in each of several years. Loftsgard and Heady (35), using a model somewhat analogous to Swanson's, introduced the firm-household interrelationships in the determination of optimum farm plans. In 1959, Plaxico (35) outlined the general properties of dynamic conceptual models, and, after having interpreted the solution of a simplified example, cited a few applications which appear promising to farm managers. In addition to these examples, numerous other studies have been done in the United States in determining optimum farm plans. However, limited attention has been given to the linear programming model such as first used by Swanson and shortly after by Loftsgard and Heady.

In Canada, very few examples are available of the use of linear programming to determine optimum resource use and enterprise combination on farms.[2] Most of the

[2]For a detailed review of the farm business management activities of government agencies and universities in Canada

studies in the United States were made with complete disregard for time. The shift from a non optimum farm organization to the new one dictated by the linear programming solution would normally require a time period of several years.

For example, changes in the type of livestock production, or from mixed farming to grain farming may require a certain number of years. Most studies involving adjustment phenomena of this type take a point of time sufficiently far in the future that the production stream will have stabilized at its optimum level. The optimum plan is made for a particular year in the future without showing the intermediate steps and alternatives, and income is computed for that particular (unknown) year. It is evident that a comparison of the returns and capital requirements for this future plan with those of the given and actual existing plan, may lead to serious fallacies such as exploitive farming. It would be more appropriate and accurate to compare the streams of income over a finite period of years than compare the amounts of income at one point in time. To be worthwhile such a comparison necessitates a special consideration of (a) an appropriate discount rate,

---

see (37) and (38). Of particular interest to the development of this study is the work done by Gilson (79) and (20) at the University of Manitoba.

and (b) the appropriate length of time to be used in the programming model.

Loftsgard and Heady (30) have formulated one such model. By using appropriate discounting procedures, they arrived at a programming solution showing a production schedule over a finite period of years. Each year of the time space is considered even though it represents a transition from the existing initial plan to a new one which will maximize the present value of future incomes.

R. F. Hutton (26) stresses the need for a model in which time would be explicitly considered in the following terms:

> A great proportion of problems faced by the farmer in his decision environment, relate in some important way to time. However, most linear programming models used in farm management, even today, related to a single time period. By inference, this requires the farm manager, as user of our efforts, to exercise his intuitive judgment in infering how time would qualify the answers. A number of applications have been made, however, in which sequential time was considered. Dynamic linear programming models serve this purpose in a manner that presumes that there is feed-back and feed-forward information. All time periods are considered in the analysis of each time period.

Another neglected aspect in farm management research through programming is the problem of capital accumulation on the farm firm. In general, studies are based on the assumption of a given amount of capital (fixed and operating) in the programming model, and optimum long-run solutions do not allow for capital readjustments. A more realistic approach would be to start from the basic premise that the

amount of capital available for operating the farm each year is that part of net income obtained in the previous year and not consumed or used for other withdrawals, plus any long and short term credit which is at its disposal. The problem of growth and development of the farm firm is a dynamic problem. An appropriate tool is needed which would help to allocate this re-invested net income among the various capital inputs of the following year. The main advantage of linear programming techniques over the conventional or marginal theory of the firms is that they provide computational possibilities that are not present in the latter. On the empirical side, most programming models developed in the past were static and did not consider the farm growth problem. It seems that a natural extension of the use of linear programming in farm planning is its application to the problems of (1) the allocation of farm resources over time, and (2) capital re-investment in the farm firm within the framework of a multi-period or multi-year linear programming model. We now turn to the conceptual formulation of such a model.

CHAPTER II

THE CONCEPTUAL MODEL

The aim of this chapter is to present the conceptual basis of the study. The first section discusses production theory in relation to the time element, and, as a corollary the factor capital. The technique of multi--period linear programming is then introduced; and finally a simplified example shows its general operation.

A. PRODUCTION THEORY AND THE PROBLEM OF TIME

Economic theory is developed through the building of conceptual models that attempt to explain the past and present characteristics of the economy, and attempt to predict the behavior of future events.

Economic models can be divided into two broad categories with respect to time: (1) static models, that consider only the final result that could be achieved by a given set of forces without considering the route by which this result is reached, and (2) dynamic models that consider the way in which these forces produce change in an economic system, and the path that the change takes.[1] Static

---

[1] A more detailed classification of economic models is given by P. A. Samuelson in (36).

analysis is used to describe conditions of equilibrium of the economy (or the firm) at any point in time, while economic dynamics is the study of economic phenomena in relation to preceding and succeeding events.

The terminology used in this study is basically the Hicksian concept of economic dynamics (34, p. 5, 6) to which is added Baumol's cause-effect idea of "static involving time" (3, p. 4).

Production economics, developed along the marginal or continuous approach,[2] has not always explicitly considered the time element. The assumptions underlying monoperiodic production (9), state that outputs emerging from a segment of time (say a year) in the production process depend solely upon inputs in that segment and are independent of inputs in all other segments. This constitutes a highly artificial situation.

A more realistic representation of the dynamics of the firm is obtained by considering its operation through a succession of production periods. In the real world, one year's production activity is never entirely separate from the activities of preceding and subsequent years. In any given year its activity is generally closely interrelated

---

[2]For a discussion on the marginal approach to the theory of production, the interested reader is referred to R. G. D. Allen (1), S. Carlson (9), and J. R. Hicks (25). For a detailed treatment of the production economics principles applied to agricultural problems see L. A. Bradford (8), J. C. Gilson (19), (20) and E. O. Heady (21).

both with past and future years.

In Carlson's terms (9) p. 103), production is called poly-periodic when:

> The inputs or costs of one period are connected not only with the output or revenue of that period but with a series of future outputs or revenue; and conversely, the output or revenue of one period is the result of the inputs and costs of a series of previous periods.

The diagram of Figure 2:1 is a simplified illustration of the working of such a production model. Only two years or periods are shown, but the reasoning applies equally until the end of the planning period T. Initial inputs, x_j^1, $(j = 1, 2, \ldots, n)$ contribute to the production of sold $\tilde{y}_i^1$, $(i = 1, 2, \ldots, r)$ and intermediate outputs $\tilde{y}_i^1$, $(i = r+1, r+2, \ldots, m)$. These latter outputs are then assumed to be used in the second year along with a new bundle of resources, x_j^2, to produce outputs y_i^2.

With such an intertemporal setting, the theory of resource allocation over time is concerned with the choice among different schedules extending into the future. A schedule is composed of T yearly production plans. It is important to note that this pseudo-dynamic setting is not formulated so as to allow a sequential procedure that would lead to a progressive (or recursive) determination of the schedule. Instead, it tells us how to allocate future resources, today, and completely determines the production schedule. As a direct consequence of this, the price c_i^t, defines the present value of a unit of product i, to be

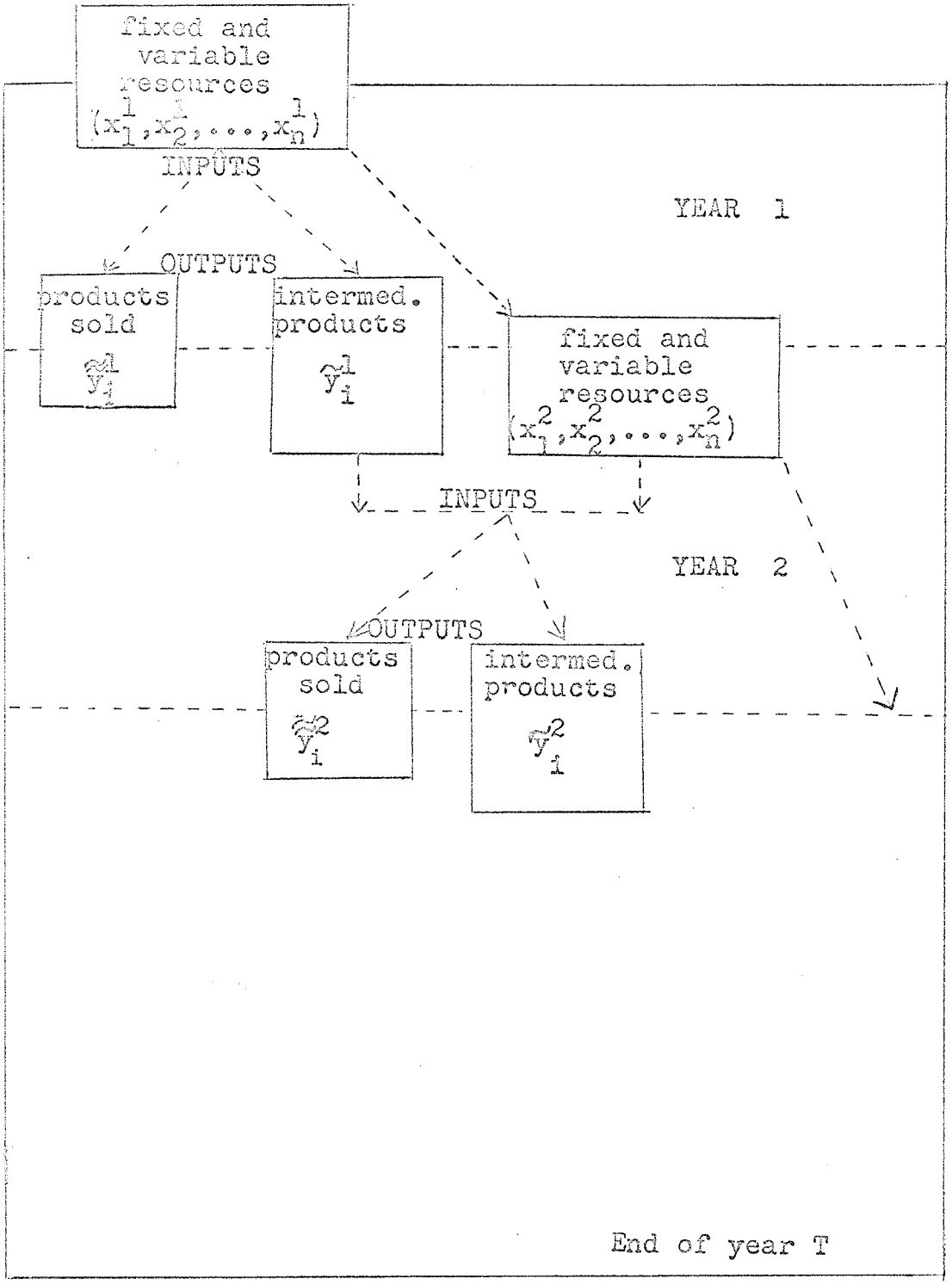

FIGURE 2:1

POLY-PERIODIC PRODUCTION MODEL

produced (and sold) at year t. It should be interpreted as a discounted price, $\tilde{c}_i^t = c_i^t \cdot (1 + r)^{-t}$ where r is the discount rate. The present value of the production schedule is $\tilde{c}Y' = \sum_{t=1}^{T} \sum_{i=1}^{m} t_i^t \; y_i^t$ where Y' is a vector representing the optimum production over time, and cY' constitutes the objective to be maximized.

Capital in Production

In the theory of the firm, the past is embodied in the results of previous decisions and is generally represented in accumulated capital. In the present study, the principle of optimality is first oriented towards the stream of outputs contributing directly to profit through their sale on the market, but consideration is also given to the comportment of capital in relation to time. The question of capital accumulation will be regarded as a corollary depending on the long run combination of factors. Our discussion of the theoretical problems relating to capital formation will be made within the restricted firm-household context characteristic of the agricultural firm.

Capital accumulation of the firm: Because of its importance in the elaboration of our computational model, we will treat the production problem as it relates to the accumulation of capital. This is nothing but a special case of the resource allocation problem due to the time factor. The spreading of capital over more than one year

may be due to the biological character of agricultural production, but from an economic point of view, capital, which is handed on from one year to the following, is the most important link which relates the single year to the rest of the dynamic process of production. Capital (operating and fixed) is the only resource that can be transfered between different successive periods of time. There is no such relationship as labor at time t_1 substituting for labor (or land) at time t_2, but capital utilization in t_1 can be postponed until t_2 and influence future production accordingly.

The final goal of economic activity is consumption. What is not consumed today will be consumed at a later date. Postponed consumption can be re-invested into production thus contributing to an increase in capital funds and to a larger future output. The most important component of capital accumulation is net income, which, in turn, depends upon the firm's resource base. The rate of capital accumulation by a particular firm (here a farm firm) depends on the allocation of net income between withdrawals and savings for investment back into the business. The context for this allocation is provided by the close intermingling of the farm business and the household in decision-making. The main variables involved in the accumulation process are determined from the annual addition of capital to annual net income minus annual fixed withdrawals. In this context, there is a competition between the household for funds for

consumption and the business for funds for investment.

Figure 2:2 depicts the process of capital allocation. Let X_a on the horizontal axis be the firm accumulated capital, and X_c on the vertical axis be the home consumed capital. The point of tangency E_1 between the iso-resource curve PP_1 and the iso-product or indifference curve II_1 specifies the optimum allocation of the capital resource between production for present consumption OA, and for capital accumulation (OB) in the first year.

Time enters into the picture simply by adding the amounts of capital relating to year two to those of year one. Hence the tangency point E_2 is the optimum allocation for year two. If we consider T years, we have T production possibilities curves, T indifference curves and a series of T tangency points between them. Joining these points a growth path over time, OE, is obtained corresponding to a given technology and appropriate indifference curves. Expressed mathematically we have the condition $\frac{dXc}{dXa} = \frac{dX'c}{dX'a}$ at each at each equilibrium point on the growth path, where $\frac{dXc}{dXa}$ is the slope of a production possibilities curve PP^t, and $\frac{dX'c}{dX'a}$ is the corresponding slope on the iso-product curve II^t.

Within this framework it follows that there is only one optimum growth path corresponding to an individual economic unit, since in such a pseudo-dynamic system, a decision made during one time period has direct consequences on subsequent time periods. For example, if the allocation

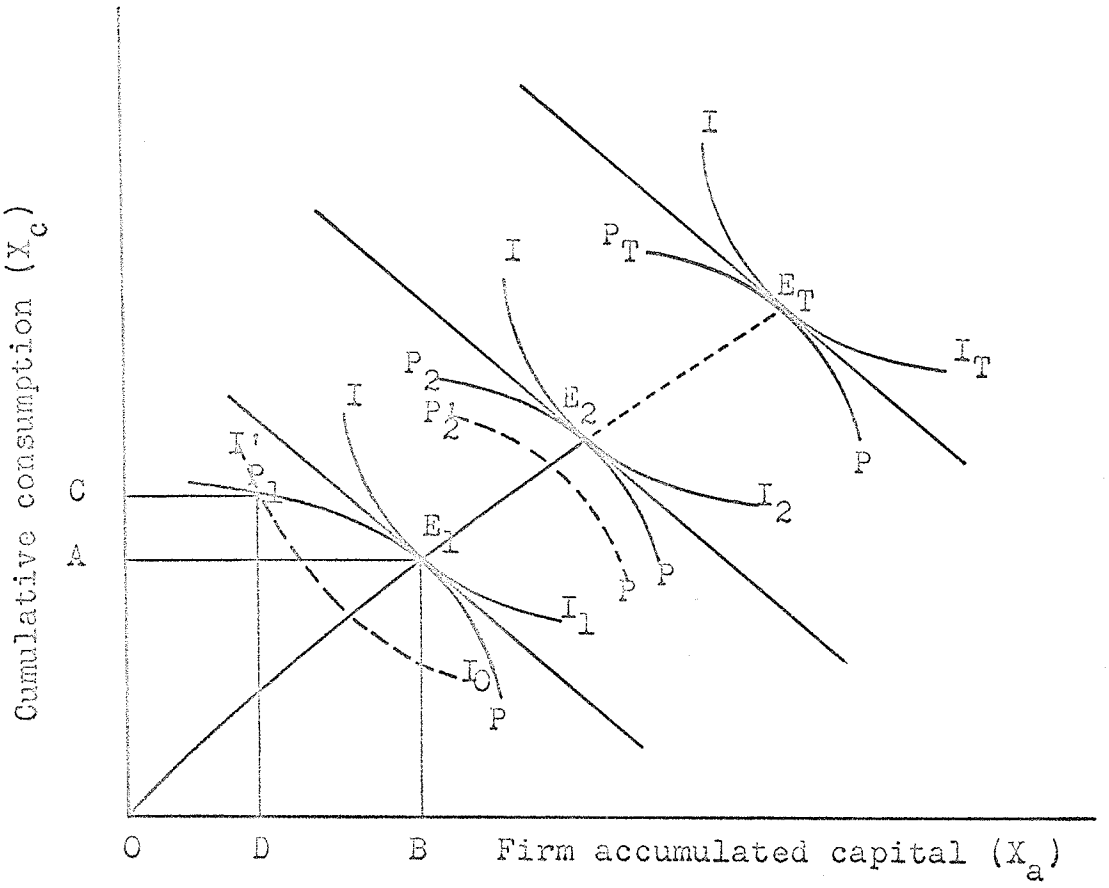

FIGURE 2:2

FIRM OPTIMUM GROWTH OVER TIME

of capital in year one is OC for consumption and OD for firm investment it will result in a lower level of output as shown by $I'I_0$ which lies below II_1. As a result of less capital invested in period one, the production possibilities curve for year two will lie below the previous level of P_2P, as shown in Figure 2:2 by $P_2'P$.

Generalizing to T production periods we obtain the formulation of our conceptual multi-period model where the restrictions and decisions for each period are functions of choices made in previous periods and future expectations.

Capital investment in a firm-household context: In agriculture, the firm is usually inseparably inter-linked with the household, thus implying that their needs for capital are competitive with each other. In this section we shall consider the factors affecting investment decisions for productive purposes (by the firm) and for non-productive or consumption purposes (by the household).

Let us consider the case of a farm operator with certain resources such as land, machinery, and labor, and a limited amount of capital at the beginning of production period t_1. Further assume that the farm invests in fertilizer, where the residual effects are neglected, and that the production period extends from t_1 to t_2.

This simplified situation is depicted in Figure 2:3. Two successive time periods are related through the cash fund in year t_1 (vertical axis) and the additional

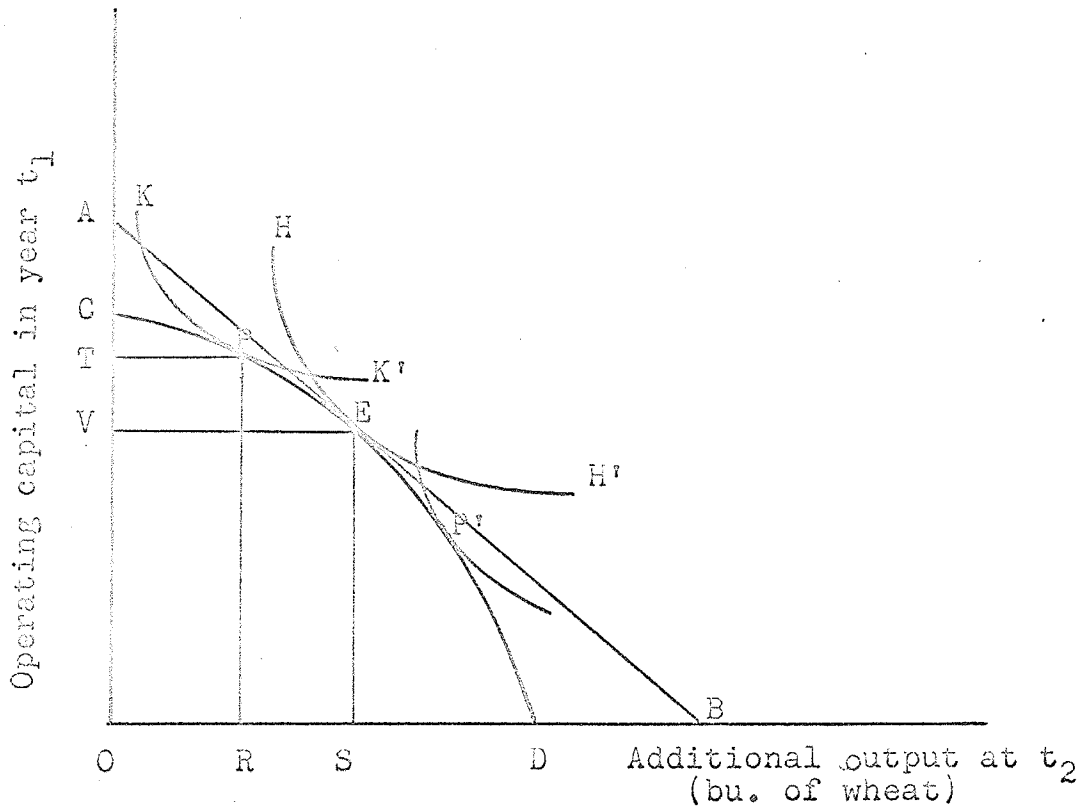

FIGURE 2:3

CAPITAL TRANSFORMATION CURVE

physical product in year t_2 expressed in bushels of wheat (horizontal axis). Let OC be the amount of cash available to the farmer at the beginning of year 1. If he consumes all this amount for living expenses, no fertilizer is purchased and, of course, no increase in wheat yield due to fertilizer appears (point C on the Y-axis). At the other extreme, if OC is totally used to purchase fertilizer an additional output OD will result. Any point between C and D can be drawn in a similar fashion. For example, at point F the farmer will invest CV of cash in fertilizer at t, and obtain OS additional output at t_2. This family of points representing the technical possibilities of connecting a given amount of cash at the beginning of a production period into additional product at t_2 by investing in some factor of production, is called the "capital transformation curve". Curve CD in Figure 2;3 depicts this relationship.

The price ratio between the price of output at t_2 and the cost of operating capital in year t_1 is represented by the line AB. The point of tangency with the transformation curve CD and the indifference curve HH indicates that at E the net monetary returns of the firm will be maximized by the investment of CV of cash in fertilizer at t_1, while OV is used for home consumption.

If we let KK' represent the indifference level of the household as a consumer between cash at t_1 and cash t_2, the tangency point P lying to the left of E, shows

a higher position on the indifference map (Figure 2:3). Hence the utility of the farmer will be maximized at this point where he uses CT of cash for the home and CT of cash for the purchase of fertilizers. A third situation may also arise where much more cash is used for fertilizers such as shown by tangency point P' located on a lower indifference curve.

This discussion shows that there are three main factors affecting the investment decisions of a farm operator whose firm and household are inter-linked. They are: (1) the capital transformation curve (2), the relative prices of outputs and inputs, and (3) the indifference system. The results of this analysis can be equally generalized to the study of T years with m products and n resources.

This study is not concerned with the sociological aspect of how farm business decisions are interrelated with the farmer's consumption decisions. Rather it analyzes the farm firm from the economic standpoint of profit maximization under the assumption of given monetary requirements by the farm household. The following section presents the analytical tool used for this purpose.

B. MULTI-PERIOD LINEAR PROGRAMMING

Linear programming[3] is the analytical and computational

[3] For further details on the mathematical and algebraic basis underlying the linear programming and for a more detailed discussion on its logic, basic concepts and assumptions, the reader is referred to the following references listed in the appendix: (2),(6),(7),(10),(12),(13),(14),(17),(19), (20),(22),(23), and (29).

tool used in this study. It essentially consists of the maximization of a linear function:

$$(2.1) \qquad Z = \sum_{j=1}^{n} c_j x_j$$

subject to a set of linear inequalities:

$$(2.2) \qquad \sum_{j=1}^{n} a_{ij} \cdot x_j \leqslant b_i \qquad (i = 1, 2, \ldots, m)$$

and

$$(2.3) \qquad x_j \geqslant 0 \qquad (j = 1, 2, \ldots, n).$$

Equation (2.1) is the profit equation which is to be maximized with n activities, x_j, and where c_j is the unit price or net return of each activity. Equation (2.2) is the system of linear inequalities representing the manner in which the m resources b_i, are transformed into the n activities according to the fixed coefficient a_{ij}, and equation (2.3) is the non-negativity constraint for the levels of the n activities. In this study, a_{ij}, b_i, and c_j are assumed to be known and constant.

Programming Within a Planning Horizon

It was seen in a preceding section how the time element injects a new dimension into the planning process. This is equally true of the linear programming technique when developed as a planning tool.

The assumption of a timeless static environment applied to the usual formulation of linear programming problems tend to ignore certain practical important problems

of production timing, capital acquisition and accumulation, and the impact of a decision in one time period on production opportunities and choices during subsequent periods. Conceptual and empirical models are greatly simplified, but in turn, they become less realistic. Hence a programming model that will allow us to handle time and change is needed.

Dorfman (12, p. 89) states the analytical framework of such a model in the following terms:

> If we consider a production program as continuing over a number of periods of time, specify the quantity of each input and output that becomes available at the beginning of each period as a function of activities in earlier periods, and seek to determine the level of each process in each period, the framework of a dynamic analysis results.

Because of the restricted sense given to the word "dynamic" in this study, it will be more convenient and more adequate to use the expression "multi-period" or "multi-year" programming instead of dynamic programming.[4]

The relationship of multi-period linear programming to the conventional static technique is roughly similar to that of Hicksian dynamics to pure economic statics. In the conventional case, an optimum plan is developed for some specific point in time assuming that the economic forces that govern today's production will still prevail; no consideration is given to the time interval necessary for the

---

[4] This terminology will also avoid further confusion with Bellman's (4) dynamic programming which is of a distinctly different character.

plan to reach the optimum situation. Multi-period programming consists of a static analysis imbedded in a framework where time is considered as an additional factor in the establishment of its constraints, activities and objective function. Optimum plans are developed for a series of years so that both transitional and final equilibrium plans are explicitely shown.

The specific emphasis in this model is on problems of planning over time; that is, more than one period of production is considered. The model can also be viewed as the development of a long-run plan showing the transitory steps or short-run plans.

Swanson (42) describes it as a single model in which the properties of growth have been imbedded. It differs from a single period model by specifying activities separately for each production year and providing for the transfer of capital from one period to the next, the amount depending on the level of the surplus generated in the first period, to maximize discounted income over the long-run.

The multi-period model yields a series of jointly optimal solutions over time where the resulting optimal solution for any one year depends on the optimal in other years of the planning period. It can also be viewed as a firm growth model in the limited sense of a growth response permitted by capital accumulation.

Formulation of the Model

Multi-period linear programming is essentially identical to the conventional technique, except that it explicitely takes into account the time dimension.[5] A distinction is made between restrictions and activities of different time periods. In an optimum T-year solution, the plan for each year is the most profitable in terms of the T-year planning period.

In an abbreviated form, a multi-period linear programming model is concerned with the maximization of:

$$(2.4) \quad PV \sum_{t=1}^{T} \sum_{j=1}^{n} \bar{c}_j^t x_j^t$$

subject to (2.5) $$\sum_{t=1}^{T} \sum_{j=1}^{n} a^t x^t \leqslant b_i^t$$

and (2.6) $$x_j^t \geqslant 0$$

for i = 1, ... , m (resources)

j = 1, ... , n (activities)

t = 1, ... , T (years)

---

[5] For a discussion on this technique used in a setting analogous to the present study see: L. D. Loftsgard and E. O. Heady (30).

Equation (2.4) is the objective function and PV represents the summation of the discounted net returns produced by n activities over T years; (2.5) is the set of linear restraints for m resources; and (2.6) is the non-negativity assumption for the activity levels.

The notation used is as follows: x_j^t is the level of activity j in year t: $\bar{c}_j^t$ is the discounted net return (or compounded cost) of each unit of activity j in year t in the objective function; b_i^t is the level of the i-th resource available in the t-th year and exogenously determined except for capital in this study; and finally, a_{ij}^t is the amount of the i-th resource required by one unit of the j-th activity in the t-th year.

Table II:1 illustrates the multi-year linear programming technique in the conventional tableau form. The programming activities and restrictions are listed for each year separately. The sub-matrices along the main diagonal, A_t^t, represent the input-output coefficients of individual years in the conventional static model. The main feature of this setting is represented by the inter-year coefficients located in the lower left hand diagonal area. For example, A_1^2 is the sub-matrix of coefficients resulting from year 1 production and affecting the resource levels and production activities of year 2. The objective function to be maximized

TABLE II:1

DIAGRAMMATIC ILLUSTRATION OF MULTI-YEAR LINEAR PROGRAMMING

		ACTIVITIES (x_j^t)			
YEAR	Restriction Level (b_j^t)	Year 1 $P_1^1\ P_2^1 \dots P_j^1\ P_n^1$	Year 2 $P_1^2\ P_2^2 \dots P_n^2$	... Year t ... (P_j^t)	Year T $P_1^T\ P_2^T \dots P_n^T$
1	1	$a_{11}^1 \dots a_{1n}^1$			
	2	$a_{21}^1 \dots a_{2n}^1$			
	:	:			
	i	$a_{i1}^1 \dots a_{ij}^1 \dots a_{in}^1$			
	.	:			
	.				
	m	$a_{m1}^1 \dots a_{mn}^1$			
2	m+1	$1A^2$	$2A^2$		
	:				
	2m				
:					
t	(t-1)m+1	$1A^t$	$2A^t$	tA^t	
.	:				
.	tm				
	(T-1)m+1	$1A^T$	$2A^T$	tA^T	TA^T
T	:				
	Tm				
Objective Function (PV)		$c_1^1\ c_2^1 \dots c_n^1$	$(\bar{c}_j^2)$	$(\bar{c}_j^t)$	$(\bar{c}_j^T)$

over T years is shown at the bottom of the table.

C. HYPOTHETICAL 2-YEAR PLANNING PROBLEM

In this section, a brief example is developed to show how the multi-period model is used in the solution of a simplified farm planning problem. The figures used have been chosen for illustrative purposes only.

Assume a farmer has at his disposal the resources listed in Table II:2 below: 400 acres of land, 2700 hours of annual labor and $7,000 of operating capital. He is confronted with the problem of planning his cropping and livestock enterprises for the next two years.

TABLE II:2

RESOURCES AVAILABLE ON SAMPLE FARM

ITEM	UNIT	AMOUNT
Total improved land	acre	400
Spring and summer labor	hour	1,000
Fall and winter labor	hour	1,700
Operating capital	dollar	7,000

The production alternatives considered comprise three crop enterprises: wheat, oats and flax, and two livestock enterprises: feeder hogs fattened to market weight

at the rate of three lots per year, and steer calves fed in drylot from their purchased weight of 430 lbs. in mid-October to about 930 lbs. in May.

Table II:3 contains the basic information required for programming this hypothetical farm situation. Physical yeilds, unit prices and variable production costs are used to arrive at the net return figure for each activity. Labor requirements are also specified for the five activities.

TABLE II:3

DATA ON CROPS AND LIVESTOCK PRODUCTION ACTIVITIES USED FOR ILLUSTRATIVE PLANNING PROBLEM

ITEM	WHEAT	OATS	FLAX	F. HOGS	F. CATTLE
Unit	(1 acre)	(1 acre)	(1 acre)	(3 head)	(1 head)
Physical output per unit	30 bu.	60 bu.	10 bu.	3 x 96% x 150 lbs.	97% x 930 lbs.
Unit price	1.50	0.55	3.00	26.00/cwt.	25.30/cwt.
Gross return per unit	45.00	33.00	30.00	112.32	228.23
Operating costs	12.00	12.00	10.00	91.00	204.00
Return over variable costs	33.00	21.00	20.00	21.32	24.23
Total labor requirement (hr.)	5.0	5.0	4.0	2.0/month	2.0/month
Spring and summer	2.0	1.5	1.2	7.0	1.0
Fall and winter	3.0	3.5	2.8	17.0	16.0

In this example, it is further assumed that: (1) no capital is externally borrowed, (2) individual crops are subject to acreage restrictions, (for example, a minimum of 50 acres of oats must be produced while no more than 200 acres of wheat and flax), (3) intermediate products are dealt with as if they were sold and then charged to the secondary enterprise, and (4) a 5 per cent discount factor is applied to year 2 prices.

The farmer's objective is to allocate his resources among five production activities in such a way as to simultaneously maximize net returns for the farm over the entire two-year period while taking into account farm fixed costs and family living withdrawals.

The complete initial simplex tableau is presented in Table II:4. In this two-stage or two-year linear programme, 12 different activities and 16 restrictions represent the planning possibilities. In addition to the five activities and four resources mentioned above, several others have been added to make the model functional. First, acreage restrictions are put on each crop for each year, (rows 2, 3, 4 and 11, 12, 13). Secondly, row 8 constitutes a special restriction whereby farm fixed charges and family living requirements - here totalling $6,000 - must be subtracted from the programmed return figure for the same year before capital is available for year 2; activity P_6 fullfills this "forced in" function. Finally, a "regenerated capital"

TABLE II: 4

INITIAL PROGRAMMING MATRIX FOR HYPOTHETICAL PLANNING PROBLEM

time → ↓						YEAR I							YEAR II				
	17				c_j's →	33.00	21.00	20.00	21.32	24.23	0	0	31.43	20.00	19.047	20.305	23.076
	ROW No.	RESTRAINTS ITEM	SIGN	LEVEL	UNIT	ACTIVITIES Wheat 1 ac.	Oats 1 ac.	Flax 1 ac.	Hogs 3 hd.	Cattle 1 hd.	Fix C. $	Cap. Trsf. $	Wht. 1 ac.	Oats 1 ac.	Flax 1 ac.	Hogs 3 hd.	Cattle 1 hd.
				P_{13}		P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}
YEAR I	1	Total Land	=	400	ac.	1.0	1.0	1.0									
	2	W. Land	<	200	ac.	1.0											
	3	O. Land	>	50	ac.		-1.0										
	4	F. Land	<	200	ac.			1.0									
	5	S & S Labor	<	1000	hr.	2.0	1.5	1.2	7.0	1.0							
	6	F & W Labor	<	1700	hr.	3.0	3.5	2.8	17.0	16.0							
	7	Op. Cap.	<	7000	$	12.0	12.0	10.0	91.0	204.0							
	8	F. Costs	=	6000	$						1.0						
	9	Regen. Cap.	=	0	$	-33.00	-21.00	-20.00	-21.32	-24.23	1.0	1.0					
YEAR II	10	Total Land	=	400	ac.								1.0	1.0	1.0		
	11	W. Land	<	200	ac.								1.0				
	12	O. Land	>	50	ac.									-1.0			
	13	F. Land	<	200	ac.										1.0		
	14	S & S Labor	<	1000	hr.								2.0	1.5	1.2	7.0	1.0
	15	F & W Labor	<	1700	hr.								3.0	3.5	2.8	17.0	16.0
	16	Op. Cap.	<	0	$							-1.0	12.0	12.0	10.0	91.0	204.

restriction (row 9), coupled with a capital transfer activity (P_7) constitute the important link between the two consecutive years. This activity allows the surplus return of year one to be re-invested in the business in year two and thus constitutes the operating capital figure if external borrowing is not considered.

Results: The optimum two-year production program for the sample problem is presented in Table II:5. The enterprises found in the optimum solution differ only in the level of livestock. In addition to wheat and oats grown at their maximum in year 1, feeder hogs are produced at the level of 69 head while feeder cattle are practically non existent. In year 2, where $5,303.71 of capital is available from year one, only 16.6 hogs are fed while the same two crops are produced at the level of 200 acres respectively. The total return over variable costs diminishes from $11,303.72 in year one to $10,398.39 in year two.

Further information may be found by examining the marginal value products of the most restricting resources. In comparative terms; it can be seen that operating capital becomes more restricting in year 2 with a shadow price[6] of $0.223 indicating that each additional dollar of operating capital would increase the income figure by 22.3 cents.

---

[6]The term "shadow price" associated with a restricting resource indicates the amount by which total profit would increase if one unit of this resource was added to the plan.

TABLE II:5

OPTIMUM 2-YEAR PRODUCTION PROGRAM FOR HYPOTHETICAL FARM

Year of Plan	Optimum Combination of Enterprises				Annual Fixed Costs	Resource Situation			Shadow Price	Discounted Net Return (Surplus return)
	ITEM	LEVEL	UNIT	RETURN		ITEM	AMOUNT IDLE			
1	Crops					Land	0	ac.	20.61	
	Wheat	200	ac.	6,600.		S. & S. Labor	138.07	hrs.	0	
	Oats	200	ac.	4,200.		F. & W. Labor	0	hr.	1.30	
	Livestock					Operating Capital	0	$	0.043	
	F. Cattle	.497	head	12.06						
	F. Hogs	69.18	heads	491.66						
	TOTAL RETURN OVER VAR. COSTS			11,303.72	6,000					5,303.71
2	Crops					Land	0	ac.	17.32	
	Wheat	200	ac.	6,286.		S. & S. Labor	261.25	hrs.	0	
	Oats	200	ac.	4,000.		F. & W. Labor	305.9	hrs.	0	
	Livestock					Operating Capital	0	$	0.223	
	F. Hogs	16.6	heads	112.39						
	TOTAL RETURN OVER VAR. COSTS			10,398.39	6,000					4,398.39

In year one the corresponding value is $0.043, which is lower than a commercial interest rate of 6 per cent. On the other hand, the marginal value product on land and fall and winter labor decreases from year one to year two. In conclusion it can be said that external borrowing would increase income in year two, while in year one the maximum interest rate could be paid is 4.3 per cent.

On the basis of the shadow prices associated with land and labor in each year, it follows that their relative scarcity diminishes over time. In terms of possibilities for expansion, this farm would benefit from increasing its land base and its fall and winter labor supply in year one. Correspondingly, a new injection of operating capital in year two would greatly enhance the income figure. The shadow prices are of primary interest in the analysis of an optimum solution, since they indicate possible gains in income through the acquisition of scarce resources.

CHAPTER III

ANALYTICAL PROCEDURE

The first step in planning for a more profitable farm business is to carefully analyze and appraise the existing farm organization. In this chapter, attention is first devoted to an analysis of the past performance of the farm business and its household counterpart during several recent years of operation (1960-1967). A final section deals with the specification of the empirical model.

A. THE CASE-STUDY FARM

This study is based on the resource endowments of a farm unit located in the Carman (South-Central) area of Manitoba. Eight years of business records were available. This farm's structure has shifted from a mixed or crop-livestock type of farming to greater emphasis on diversified cropping. However, as will be shown shortly livestock production still contributes significantly to income. Before proceeding to a historical analysis of the farm records, the characteristics of the land resource, and some of the problems associated with its use will be outlined.

The Altona soil association constitutes the predominant soil type on the selected farm. A second type, the Myrtle, is also present in a few fields. The texture

varies from a fine sandy clay loam to loam, although no extreme is encountered. This range from fairly light to heavier soils permists a large selection of crops to be grown. Drainage is fair to good but constitutes a problem because of flooding risks due to a very flat topography.

This land has a good natural fertility and is highly responsive to nitrogen and phosphorus inputs which are present in the soil in amounts varying from very low to medium. This soil has been used intensively for crops production, but after 80 years of cropping, moderate conservation practices are essential. Cropping practices can be applied without serious difficulties for a fairly wide range of crops.

Record Analysis

In this section a series of inter-year comparisons are made for the years 1960 to 1967 for selected financial aspects of the farm firm. These figures are then followed by a similar presentation of the family living expenditures.

1. The Farm Business

Three sets of figures will be used to succintly analyze the farm business: a financial statement, an operating statement and a farm organization statement. In order to show the growth over time of this farm, and to assess the basic changes that have occurred during the last eight years, an inter-year comparative framework is used.

A comparative financial statement is found in Table A-1[1]. It consists of a summary of the capital resources employed in the farm business. These inventories show that the operator's farm capital has more than tripled from $49,629 in 1960 to $150,233 in 1967. A major part of this rise in capitalization was due to an increase in land values. Between the years 1963 and 1964 a real capital gain of $16,000 occured on real estate for the same amount of land. In 1967, $25,000 worth of land was added to the business. Some of the major farm assets which have increased in value over the period are machinery which has increased fourfold to $29,717, and the grain inventory with a similar rise to $25,481. The livestock inventory remained comparatively low and stable at $7,600 in 1966.

On the other hand the farm liabilities have also increased but at a somewhat lower rate, thus allowing an increase in the operator's net worth value. It is also interesting to note the spectacular rise in the intermediate-term debts. As will be shown shortly this is largely explained by higher operating costs.

The comparative operating or income statement, Tables A-2 and A-3, enables us to make a direct comparison between corresponding income and expense figures for different

---

[1]The tables discussed herein may be found in Appendix A at the end of the thesis.

years. This, in turn, permits us to detect various trends in the farmer's business, and see where larger receipts originate or which enterprises are responsible for the larger outlays in the various years.

In Table A-2, it can be seen that diversified cropping constitutes the major source of income - $24,982 in 1967 - and that oilseed crops occupy a larger proportion of this income. The receipts from livestock are mainly from feeder cattle while hog production is declining in 1967.

The cash operating costs are shown in Table A-3. Again, it can be observed that crop production has increased in importance over livestock. Another important point is the increase in fertilizer expenditures from $158 in 1961, to $5,487 in 1967.

The above expenses can be basically attributed to either crop or livestock production. Other cost items called fixed and overhead costs are presented in Table A-4 and are based also on the inventories and data obtained from the farm. The total figure ranges from a low of $2,975 in 1960 to a high of $7,994 in 1967 with machinery depreciation, real estate taxes and interest on loans as the major constituents.

The information contained in the financial and operating statements is not in itself sufficient to assess the success of the farm business. Physical records are also needed in order to measure the operating efficiency of

the various enterprises. The income from crops and livestock, and the cost of producing the income must be related to the size of each enterprise.

In Table A-5 the kinds of crops grown, the number of acres and the average yeild of each crop are shown. The main crops have been wheat, oats, flax and field peas. No barley has entered into the cropping system at any time.

The main features arising out of Table A-5 are that (1) yields vary in an unpredictable fashion with perhaps a slight tendency to increase over time -- 1961 was a comparatively bad year for all crops due to very dry conditions -- (2) wheat is the main crop in terms of acreage, (3) summerfallowing is no longer practiced (4) flax and field peas acreages are fairly constant and (5) new crops such as rapeseed and sunflowers were added in 1966 and 1967. Finally, the total improved land acreage was fixed at 535 acres until 1966 when 285 additional acres were rented. It is to be noted that this land was purchased at the end of 1967.

Table III:1 below shows the size of the two livestock enterprises found on the case farm. From the previous tables one may have concluded that crop production was increased at the expense of livestock. However this is not a case of one being substituted for the other as shown in Table III:1.

TABLE III:1

LIVESTOCK ENTERPRISES AND NUMBERS ON THE CASE FARM

Type	1960	1961	1962	1963	1964	1965	1966	1967
Steers sold	4	21	27	35	37	36	36	37
Hogs sold	43	94	101	135	155	128	115	42

The number of steers sold remained constant at 36 to 37 head per year. Hogs have followed the same tendency except in 1967 when their number decreased from 115 to 42 head. It would be more appropriate to say that livestock production did not expand in volume over time. In reality it is not the main interest of the farmer and constitutes chiefly a risk aversion measure.

A financial summary of the farm earnings and expenses along with a few indices of the general performance of the farm are presented in Table A-6. Total variable costs (Table A-2) are subtracted from total farm receipts to give a figure similar to that which is obtained directly from a linear programming analysis. These returns above variable costs have doubled since 1960 and amounted to $18,801 in 1967. By deducting the farm fixed costs (Table A-4) and the family living expenses (Table III-2) from the above figures one obtains respectively, the net farm earnings and the debt carrying capacity of the farm. Net farm earnings decreased from a level of $6,207 in 1960, to a low of $2,909 in 1962,

and then augmented steadily to $10,807 in 1967. The amount remaining for debt repayment failed to increase significantly over the 1960 level of $3,858. In 1962 a negative figure of $-576 was even realized, indicating no possibility for expansion in that year.

The general performance of the farm can also be assessed with the aid of three indexes. The rate of capital turnover, expressed in terms of years, represents the time it takes for the value of total production to equal average farm capital. The average value for the period is 3.8 with a low of 3.1 at the beginning and a high of 5.2 in 1967. This indeed may also be expressed as a percentage figure between gross profit and capital investment. The gross expense ratio expresses the total farm expenses as a per cent of gross profit. The largest figure occurs in 1966 with 75.86 per cent. The equity ratio is simply the operator's equity in the business in terms of farm assets. It can be seen that the farmer has not only increased his total capital investment, but also owns a larger portion of it with 76.46 per cent in 1967.

2. The Farm Household

A farm is a place of business but it is also a place to live, and this latter aspect cannot be separated from the former. Expenses related to the household and other personal spending are shown in Table III:2. The

cost of living means the cost of consumption by the family, and it excludes all expenditures connected with the production operations of the farm business. For joint expenses such as electricity, telephone and the automobile where part of the service is used by the household, a proportional amount is allocated to the household on personal accounts. The home-consumed products are also recorded in the household accounts as an expense, but they appear as receipts in the business account. It can be seen in Table III:2 that the total family expenses show an increase from $2,349 in 1960 to $7,147 in 1967.

TABLE III:2

TOTAL HOUSEHOLD AND LIVING EXPENSES FOR THE CASE FARM FAMILY

YEAR	AMOUNT
1960	$2349
1961	3139
1962	3485
1963	3190
1964	5201
1965	6236
1966	6118
1967	7147

Farm Summary: The main characteristics of the case farm's resources and enterprises will now be summarized. This preliminary evaluation will serve as a guide for building up the programming model in the following section.

Until 1965 this farm consisted of 560 acres of land, 535 acres of which were suitable for crop production. In 1966, 285 acres were rented. This land was purchased in 1967. Labor was supplied mainly by the owner-operator. In the busy seasons of spring and fall additional labor was supplied by a part-time hired man. The amount of operating capital used for production purposes increased from $5,415 in 1960, to $18,100 in 1966, as shown by the total variable costs row in Table A-6.

An important portion of this capital was provided by short-term borrowing. A complete complement of machinery was available for production. It was considered sufficient to satisfactorily perform the required operations, although it constituted one of the most important capital investments in the past. Farm buildings presented no particular problems except that provision should be made in the near future for the construction of a hog finishing barn.

A fairly large variety of crops were grown in the past. It is interesting to note the substitution of oilseed and forage crops for summerfallowing. This more intensive use of farm cropland in an area of good to excellent soil productivity illustrates the tendency towards the

elimination of the summerfallow acreage with the development of new and improved herbicides and the use of more fertilizer. Such crops as forage seeds and oil seeds in addition to yielding returns competitive with cereal crops, also helped in the distribution of risk both from a production and marketing standpoint. They also fulfilled an important role in weed control and soil conservation in the land use pattern. The farm operator indicated his intention of specializing in mixed cropping during future years. Hence a number of different crops will be considered as potential future production alternatives.

The livestock inventory originally indicated small scale production of beef and dairy cattle, hogs and hens. Livestock production has gradually oriented towards beef cattle and hog finishing as the only livestock enterprises. The main reasons why the farmer has undertaken livestock feeding in recent years seems to allow the marketing of surplus grain, the utilization of idle resources such as labor and buildings, and the reduction of the risk element associated with specialized grain farming. These enterprises provided him with more flexibility in production and insured him a more stable income.

Farmer's Objective

Farm planning objectives are generally oriented towards income maximization. However, an optimum farm plan

should also be the one that maximizes satisfaction to the farm family. Since there is no accurate measure for family values, goals, social backgrounds and preferences for various farm enterprises, the economic objective of maximum money income, which is assumed to give the most satisfaction, is the criterion used in this study. Stability of income is also an important consideration since farm real-estate mortgage payments and family expenses must be met each year.

In summary, the operator of this farm, in trying to choose the combination of enterprises that will make the best use of his available resources, wants to maximize his profit in each particular year, but with some degree of stability over a finite planning period. This implies that he is willing to sacrifice one year's income through, say, diversification and soil conservation practices, if the return from the following years appears to be more stable. The mathematical model developed in this study shall explore this assertion since it will attempt to maximize accumulated net returns over a five-year planning period.

B. THE EMPIRICAL MODEL

This section is devoted to the presentation of the basic programming material and the elaboration of the various situations to be programmed.

I. Specification of the Programming Model

In order to program a farm it is necessary to get the following information about the farm and its operator: (1) farm size, (2) capital position, (3) labor supply, (4) cropping enterprises and pattern of crop production, (5) types of livestock activities, (6) labor, capital, feed and other requirements for each individual enterprise, (7) price and yield data, and (8) other items which may tend to restrict production such as buildings, and (9) the farmer's own preferences toward specific enterprises.

The setting up of the farm planning model involves the performing of the following steps in order to give the conceptual model an empirical content. Firstly, the resource and other programming restrictions are specified; secondly, the enterprises are listed and described; thirdly, appropriate input-output coefficients are calculated for each enterprise considered; fourthly, the return from each production alternative is budgeted; and finally optimum plans are computed for various situations.

1. Programming Restrictions

The restrictions, in essence, describe the farm being programmed. They comprise the farm resources, the farm intermediate commodities such as home grown feed, the delivery quotas affecting the sale of cereals, the acreage restrictions for crops, and finally the annual farm fixed

costs and family withdrawals. The above items used in the construction of the matrix were confined to the situations found on, or hypothesized for the case farm.

(a) The Farm Resources: The resource base of the study farm was used to determine the level from which adjustments could take place. This base included those fixed and variable resources that might affect the organization of the farm. Limits were placed on resources such as improved land, operator and hired labor, operating (cash) capital and capital borrowing, hog building space and the amount of cereals which could be marketed. The resources available to the farm business and used in the programming model are listed in Table III:3. They are described in the following paragraphs.

Land is the basic resource for crop farming. In this study, the land acreage is subdivided into owned land and additional (rented or purchased) land. Initially owned land is fixed at 535 acres while 285 acres are available for rent or purchase.

The operator supplies most of the labor without any family help, but he will hire an additional man when urgently needed. The available labor is broken down seasonally to reflect the availability during critical labor periods. According to this distribution, spring is considered to be two months from April 15 to June 15, summer two months from June 16 to August 15, fall two months from

August 16 to October 15, and winter 6 months from October 16 to April 16. The break down of hired labor is also similar except that no provision is made to hire a man over the winter season. The operator is assumed to be available for 2,850 hours of productive labor each year, while a maximum of 1,080 hours can be hired annually.

TABLE III:3

RESOURCE RESTRICTIONS FOR LINEAR PROGRAMMING

ITEM	UNIT	LEVEL
IMPROVED LAND		
Total owned	ac.	535
Available for rent	ac.	285
Available for purchase	ac.	285
LABOR		
Operator		
Spring (April 15-June 15)	hr.	500
Summer (June 16-Aug. 15)	hr.	500
Fall (Aug. 16-Oct. 15)	hr.	500
Winter (Oct. 16-April 16)	hr.	1,350
Hired		
Spring	hr.	360
Summer	hr.	360
Fall	hr.	360
CAPITAL		
Operating capital	$	8,500
Short term borrowing limit	$	10,000
Long term borrowing limit	$	50,000
HOG BUILDING SPACE	head	150
MARKETING QUOTAS		
Specified acreage, all cereals	bu./ac.	9
Special quotas		
Oats	bu./ac.	10
Barley	bu./ac.	10

Capital is divided into two groups: operating capital and fixed or investment capital. Operating capital appears to be one of the most limiting resources on the case farm. Its initial level is fixed at $8,500. A major part of the operating cash comes from borrowed funds and the operator visualizes that this will be the case for the years to come. A limit of $10,000 is placed on the short-term credit available at an interest rate of 7.5 per cent, but plans will also be computed for alternative levels. This short-term money is assumed to be paid back within one year. A new loan is obtained for each succeeding year if needed. Long term capital is not readily available to the farm and a limit of $50,000 is put on the borrowing capacity. The corresponding interest charge is 6 per cent. In summary, the operating capital limit includes the cash available from the previous year's production plus the short-term borrowed money; and the fixed capital restriction represents the long term borrowing limit.

The farm studied has adequate machinery and equipment to handle any of the production alternatives considered. Machinery, therefore, is considered fixed for a given year, variable over a planning period and not limiting. In addition to the equipment owned, arrangements are made with a neighbor for the joint use of machinery. If any specialized equipment was required by any crop or livestock enterprises, its purchase was included as a cost against

these enterprises.

Building space is also assumed adequate with the exception of the hog barn which needs to be replaced in order to maintain feeder hog production. The capacity of the old barn is assumed to be 150 head annually. Hence, the possibility of building a new hog barn will be introduced into the model.

A final restraint, which is not under the farmer's control, is the delivery quota on cereal crops. Because of its primary importance as a major output of the case farm, wheat must not only be produced in the most efficient way and in the optimum quantities, but the farmer must be assurred of its sale at the best market price. This delivery quota system is particularly significant in periods when the grain supplies are in excess of commercial storage and handling facilities. The basic specified acreage quota[2] assumed in this study is nine bushels. Oats and barley are also given special quotas of ten bushels per acre.

(b) Restrictions on Farm Intermediate Products:

An intermediate product is one that is the output of one or more activities and the input of one or more other activities. This second category of restrictions represents the farm commodities having more than one function. Home

---

[2] A specified acreage quota of nine units means that nine bushels of a cereal crop can be sold (delivered to the elevator) for each acre used by cereals, forages and summerfallowing.

grown feeds may be fed to livestock or sold. Wheat, oats, barley, forage hay and seed (meadow fescue and timothy) enter into this category. A crop may also have two outputs such as grain and straw. Relationships are needed to provide for the transfer of feed from crop enterprises to livestock enterprises or to feed selling activities. These restrictions limit consumption to the amount produced, except where provision is made for their purchase from an external source, although they may be sold if produced in excess of consumption requirements. The difference between production and consumption must be greater than or equal to zero. In the case of a positive number, the corresponding amount is sold. In programming terms a direct sale occurs when there is no consumption or other use on the farm as is assumed for forage seeds. In this case the net return figure is a positive number representing the unit price over variable costs.

(c) Land Use "Proportionality" Restrictions for Crops: It is necessary to grow certain crops within given proportions, in order to ensure the maintenance of the fertility, and the condition and cleanliness of the soil. This is one of the most fundamental of the rigidities imposed on the use of land for agricultural purposes. For example, it might seem more profitable to plant the entire cultivated area of a farm with the highest return crop. However, this would not be desirable since such a policy would

rapidly lead to lowered yields through the loss of soil condition and fertility, the accumulation of cereal diseases, and weed problems among others.

To ensure a more appropriate land use pattern, proportionality restrictions are introduced on the crops. Table III:4 lists the types and levels of restrictions imposed by rotational considerations. These figures are based on the farm past performance and on the farmer's knowledge of his land and business. They specify the maximum or minimum proportions of cultivated land that are permitted for each crop taken individually, or collectively as a group.

TABLE III:4

RESTRICTIONS ON CROP ACREAGES

	PER CENT OF TOTAL IMPROVED LAND	
CROP	Maximum	Minimum
Cereals	70	
Wheat	50	
Oats and Barley		20
Oilseeds	30	15
Flax		10
Sunflowers	15	
Forages	12	
Field peas	10	

In order to be introduced in the model, these restrictions are expressed mathematically in the following manner. Table III:4 states that the wheat acreage (x_1) must be less than or equal to 50 per cent of the acreage of all the cropping activities (x_1 to x_k). Hence,

$$(1) \quad x_1 \leqslant 0.50 \sum_{j=1}^{k} x_j$$

or

$$(2) \quad x_1 - 0.50\, x_1 \leqslant 0.50 \sum_{j=2}^{k} x_j$$

$$(3) \quad (1 - 0.50)x_1 \leqslant 0.50 \sum_{j=2}^{k} x_j$$

$$(4) \quad 0.50x_1 - 0.50 \sum_{j=2}^{k} x_j \leqslant 0$$

Equation (4) is the one appearing in the simplex tableau. In essence it says that each acre of land grown in wheat makes .5 acres available to the other crops. (x_2 to x_k), or inversely, one acre of each other crop creates a .5 acre of permissible wheat land.[3]

(d) Special Restrictions: The restrictions listed here are those needed specifically for the construction of

---

[3] All other maximum restrictions are obtained in a similar manner. In the case of a minimum, the inequality is multiplied by -1 to conserve the same sign.

the multi-year model. They are connected to corresponding special activities and their role is to ensure the functioning of the model. They comprise (1) an annual cost requirement which must be accounted for before production is determined in the following year, and (2) a regenerated capital row consisting of the accumulation of the returns over variable expenses during one production year. This latter row is connected to the fixed cost requirements in such a way that the surplus return is transferred to a following year. Table III:5 indicates the data used in the model as the fixed amount of funds that must be met each year of the planning period. These figures were derived from the above record analysis of the case farm and represent the levels of the more recent years.

TABLE III:5

ANNUAL FARM FIXED COSTS AND TOTAL FAMILY EXPENSES USED FOR PLANNING THE CASE-FARM BUSINESS OVER A FIVE YEAR PERIOD

YEAR NUMBER	FARM FIXED COSTS	FAMILY LIVING EXPENSES	TOTAL
1	5712	5201	10913
2	4550	6236	10786
3	7790	6118	13908
4	7994	7147	15141
5	8250	7380	15630

2. Programming Activities

The second step in the specification of the programming model consists of selecting the various possible relevant enterprise alternatives or activities. Those activities which compete for scarce resources are grouped into three categories: (1) production activities such as crop and livestock enterprises, (2) miscellaneous activities, and (3) a group called special activities which is required for the multi-period model. These different activities are outlined below.

(a) Production Alternatives: A number of production alternatives are considered for improving income on the farm. Most of the crop and livestock activities presented here were found on the case farm during the past, or correspond to the farmer's likes. Since one of the practical objectives of this study was to indicate profitable courses of action to the operator, the preferences of the operator for particular enterprises were considered.

The crop enterprises considered in this study were handled in a special manner, that is, on an individual crop basis, instead of being considered as a specific crop rotation or sequence with a given level of fertilizer. Each crop, in turn, is allowed to be fitted into a sequence within the limits of the previously stated combinations. By using this approach it is expected that the plans obtained will approximate more closely the decision making realm of the

farmer. It is further assumed that the farmer does not follow a specific sequence of crops from year-to-year on the same parcel of land. Instead, in any particular year, he produces those crops that he thinks will maximize profits for that year, after taking into consideration such factors as soil fertility and characteristics, preceeding crops, yields, expected prices, feed requirements and even weather conditions. Moreover, this approach allows more flexibility in the land use pattern from one year to the following since one can hardly change from one rotation to another in two consecutive years.

The matrix provides for the production of the following crops: wheat, oats, barley, flax, rapeseed, sunflowers, field peas, meadow fescue, and timothy. Straw and hay baling activities were also considered.

The livestock production alternatives are restricted to beef cattle and hogs. Moreover, attention is given only to the fattening of purchased animals. The main criterion used for differentiating the livestock enterprises is the proportion of home grown feeds in their rations.

Only one basic type of hog production is considered, the purchase and finishing of feeder pigs. Six activities were developed: (1) three using current facilities and (2) three using a new hog barn. These activities are based on different rations utilizing various proportions of home grown feed as shown in Table 7 of Appendix B. Feeder pigs

are purchased at 35 pounds per head and are fed out for market at a weight of 200 pounds. A 4-month feeding period allows a turnover of three lots of hogs per year which is the unit used in the programming activity.

The cattle finishing activities are: (1) good to choice steer calves purchased at the average weight of 440 pounds and sold at approximately 940 pounds seven months later, and (2) good to choice yearling steers fattened from 700 to 1050 pounds over a 5-month period.[4] Each type is offered a choice of two rations using various amounts of home grown feeds (wheat, oats, barley, hay and straw) as shown in Table 6 of Appendix B.

(b) Miscellaneous Activities: Although other kinds of crop and livestock enterprises are possible on the farm, they were not considered as relevant by the farmer. The above are the principal productive activities considered for this study. However, in addition to them certain other activities are required to make the model realistic and permit more flexibility.

Activities allowing for the purchase of oats, barley and hay, and for the selling of wheat, oats, barley, timothy (seed), meadow fescue (seed), hay and cereals

---

[4]It is assumed that all animals are purchased in mid-October. Rations for both feeder calves and yearlings are high concentrate rations meaning that they contain at least 75 per cent concentrate by weight. The rations constitute the basis for differentiating between the four cattle enterprises.

produced in amounts beyond their respective quotas. The selling activities are necessary for those crop activities providing only for their production, and a lower return is assumed due to the costs involved in storing them or because of a sale in the neighborhood at a lower price.

Three labor hiring activities corresponding to spring, labor, and fall labor are included. They are limited, as previously stated, to a maximum of one man working 360 hours per month.

The acquisition of additional land represents an important expansion alternative for the case farm. Two alternatives are examined: (1) land renting on a cash payment basis, and (2) land buying. For the programming model, it is assumed that only improved land can be rented or purchased.

An activity allows for the construction of a hog finishing barn in order to provide for the expansion of this production beyond the capacity of the existing building.

Finally, two capital borrowing activities complete the activities of the static model. Short term and long term funds were assumed to be available at established interest rates.

(c) Special Activities:

This last group of activities is necessary to give the multi-period model its characteristic features. Firstly, a withdrawal activity is "forced" into the final

solution at the level specified by the summation of the farm fixed costs and the family living requirements for each year of the planning period, such as given in Table III:5. Secondly, an inter-year income or capital transfer activity is introduced for every year to transfer the surplus return of that year to the following year. In farming, operating capital generally is allocated for family living and farm production from the same fund. Family living thus competes with farm production in the use of available capital. An important assumption of this study is that all net income not consumed by the household is invested back into the farm business. In other words, external possibilities of investment are not considered.

3. Technical Coefficients

After having determined the restraints and the activities to be included in the model, the next step is to develop a complete set of input-output coefficients for each of the above enterprises and resources. It is now necessary to know the amount of each limiting resource that is required by each enterprise.

These coefficients are presented in Appendix B. They are of a single value nature, that is, they include no variability and are assumed to be known with certainty and reflect a good management level.[5]

---

[5] In addition to the case-farm records, the following sources of information were used in the calculation of the various input-output coefficients and enterprise budgets: (11),(15), (16),(18), and (44).

Table B-1 contains the recommended fertilizer applications and the estimated yield data for the selected crops to be grown. Table B-4 shows the labor requirements per acre and by season for the individual crops programmed. It is based on the information contained in Tables B-2 and B-3.

The assumed labor requirements for the livestock enterprises are given in Table B-5. Tables B-6 and B-7 present the feed inputs required for each unit of feeder cattle and feeder hogs respectively.

4. Prices and Enterprise Budgets

A final and important step in the specification of the programming model is the construction of enterprise budgets on the basis of specific assumptions regarding prices and costs.

The problem of choosing appropriate prices for farm planning is a difficult one regardless of the planning tool used. Since the planning period of this study encompasses the current years, and since planning deals with the future, average current prices, taking into account the most recent trends, are used. It is assumed that a normal economy will prevail in the years to come.

The assumed prices paid and received by the farmer in this study are presented in Appendix B, Table 8. These prices are then introduced into the calculation of the

specific enterprise budgets. Costs and returns were calculated on a per acre basis for crops (Table B-10) and on a per head basis for livestock enterprises (Tables B-11 and B-12).

Finally, the complete linear programming set up is illustrated with the aid of two tables. The matrix for the basic static model is presented in Table B-13, and Table B-14 shows the first three years of activities and restrictions for the multi-period model.

II. Phases of the Analysis and Programming Situations

In order to reach the objectives stated in chapter I an appropriate framework is required. The analysis is performed in two distinct phases. Phase one makes use of the static linear programming model with the resources and activities representing the planning environment of one single year. Various optimum farm plans are calculated to study the effects of eliminating certain activities. In phase two, the multi-period linear programming model is used and appropriate modifications are brought to the basic matrix. It was attempted to analyze similar alternatives in both the static and multi-period models.

This later model covers a planning horizon of five years consisting of one year production periods. A six per cent discount rate was applied to prices and costs of years two through five of the planning period. This

discounting procedure has the effect of putting more weight on the initial years of the horizon. In other words it lessens the importance of later years relative to the earlier ones, but it does not change the relative importance of the activities within the same year.

The primary characteristics of each of the situations to be analyzed under the static and the multi-year models are listed in Tables III:6 and III:7 respectively. These characteristics must be interpreted in terms of variations from a basic situation. It was attempted to group them in such a way that similar situations within each model could be readily compared.

Before presenting and analyzing the final optimum solutions, it must be remembered that their accuracy and validity is highly dependent upon the following factors: (1) the selection and appropriate specification of the resource restrictions and alternative enterprises, (2) the accuracy of the assumed technical input-output relationships, and (3) the validity of the prices and costs in the various enterprise budgets.

TABLE III:6

CHARACTERISTICS OF ALTERNATIVE PROGRAMMING SITUATIONS CONSIDERED UNDER THE STATIC MODEL

NUMBER	IDENTIFICATION
S.1	Basic plan
S.2	Renting of land
S.3	Purchase of land
S.4a	No short-term capital borrowed
S.4b	Borrowing of $5,000
S.4c	Borrowing of $15,000
S.4d	Borrowing of $20,000
S.6a	No barley production
S.6b	No field peas production
S.6c	No meadow fescue production
S.6d	No sunflower production
S.7	No beef cattle production
S.8	No livestock production
S.9a	Open quota on wheat
S.9b	Open quota on oats
S.9c	Open quota on barley
S.9d	Open quota on all cereals
S.10	No hay selling
S.11	Purchase of land and no S.T. capital borrowing
S.12a	Purchase of land, no barley production
S.12b	Purchase of land, no barley production, no hay selling
S.13a	Purchase of land, no livestock production
S.13b	Purchase of land, no livestock production, open quota on all cereals.
S.14a	Purchase of land, increase in fall labor.
S.14b	Purchase of land, increase in fall labor, and borrowing of $15,000 of short-term capital.

TABLE III:7

CHARACTERISTICS OF ALTERNATIVE PROGRAMMING SITUATIONS CONSIDERED UNDER THE MULTI-PERIOD MODEL

NUMBER	IDENTIFICATION OF THE PROGRAMS
M.1	Basic program
M.2	Renting of land
M.3a	Purchase of land (10-year repayment period)
M.3b	Purchase of land (15-year repayment period)
M.3c	Purchase and renting of land
M.4a	No short-term capital borrowed
M.4e	$50,000 of short-term capital available for borrowing over 5 years.
M.5	$1,000 increase in annual fixed costs
M.6a	no barley production
M.7	No beef cattle production
M.8	No livestock production
M.9a	Open quota on wheat
M.10	No hay selling
M.11	Purchase of land and no capital borrowing
M.12a	Purchase of land and no barley production
M.12b	Purchase of land, no barley production and no hay selling.
M.13b	Purchase of land, no livestock production and open quota on all cereals.
M.14a	Purchase of land and increase in fall labor
M.15	Purchase of land and $50,000 available for borrowing over a five-year period

CHAPTER IV

RESULTS AND ANALYSIS OF OPTIMUM SOLUTIONS

The optimum or most profitable plans and programs are presented in this chapter. These results are based on the assumptions and restrictions outlined for each situation in the preceding chapter. They are not designed to fit a particular set of resource and price conditions in a particular year, but instead, they should serve as guideposts applicable under average conditions. For each farm situation analyzed it will be attempted to show: (1) the amount of expected returns, (2) the kinds and levels of livestock and cropping enterprises, and (3) the use (or non-use) of resources.

The plan of discussion is divided into two sections corresponding to the two phases of the study and the groupings adopted at the end of the previous chapter.

(1) The static farm plans are discussed with the aid of two tables. Firstly, Table IV:1 shows the organization of each optimum plan. For each column or farm plan, the returns over variable costs, the levels of crop acreages and sales, the number of livestock fed and finally the capital borrowing situations are given. Table IV:2 is concerned with the resource use data showing the amounts unused or the shadow prices associated with those resources that are the most restricting.

(2) The results of each situation involving a five-year production program are summarized in Table IV:3. This table gives the following information for each year: the levels of the various crop and livestock enterprises, the number of acres purchased or rented, the returns to fixed factors, the expenses to be met, including (a) the farm fixed costs and home consumption withdrawals, (b) the total amount of short-term credit, and (c) the portion of long-term credit assumed to be repaid each year. Finally, the resulting discounted net returns are given. They represent the profit figure flowing from one year to the next where it becomes available for production.

The results are discussed in a roughly parallel presentation in order to facilitate the comparisons between the two models used. A basic or benchmark solution is first presented in each phase and will provide a basis of comparison. Collateral situations are then discussed with the use of the two models. These situations include the same general conditions or restrictions, but a change is made in a particular item to determine how it affects the optimum. Single and multiple alterations of the basic plan are made to analyze (1) the effects of increasing the land base, (2) the effects of varying the amount of short-term capital available, (3) the effects of additional labor in peak periods, (4) the effects of removing various enterprises from the farm plan, (5) the effects of the absence of

grain marketing quotas and (6) the effects on farm organization of multiple alterations.

A. STATIC AND MULTI-YEAR PROGRAMMING RESULTS

1. Basic solutions

The two initial solutions, one for each model, were designed to determine an overall optimum organization for the farm. The conditions were those listed in the previous chapter; the land was fixed at 535 acres, $10,000 of short-term capital were available each year, and all the enterprises were allowed to compete.

The basic static plan is identified as S.1 and listed in column one of Tables IV:1 and IV:2. The return realized from this optimum production plan is equal to $21,836. It represents the combination of crop and livestock enterprises to be attained in the long run in order to maximize the return to the available resources. This plan includes 150 acres of wheat, 52 acres of oats, 55 acres of barley, 80 acres of flax and sunflowers, 54 acres of field peas and 64 acres of meadow fescue. No rapeseed and timothy are produced. The amount of wheat sold on the specified acreage quota is 2,889 bushels while 2,656 bushels are sold at a much lower price of $1.25 per bushel on a non quota basis. The ten-bushel special quotas on oats and barley are fully utilized allowing for the sale of 523 bushels of oats and 547 bushels of barley. This latter

crop is also sold on a non quota basis at $0.85 per bushel. This sale amounts to 640 bushels. Finally, 225 hundred weight of timothy seed and 50 tons of hay complete the selling activities. Livestock production is also included in the plan with 75 head of steer calves fed a heavy grain ration composed of oats and barley. No feeder hogs enter the plan. The resource situation shows us that land and operating capital are the most restricting resources. The shadow price associated with the operator's land is $27.52 and additional dollar of short-term capital would increase profits by $0.26. Since no new investments are made, no long-term capital is borrowed. No summer labor is hired and little hired spring and fall labor is utilized.

The basic five-year production program, M.1 of Table IV:3.1, will be analysed in terms of its variations from the above plan. The procedure followed will consist in observing the behaviour of the main activities over the planning period and comparing their levels to the results of the static plan.

It must be first remembered that the multi-period model involves the simultaneous determination of five optimum plans, with the decisions of each year affecting successive years. It is a model of capital accumulation where attention is directed to the maximization of the present value of the stream of net incomes.

The return to fixed resources amounts to $25,298

in year one and varies from a low of $22,752 in year four to a high of $30,114 in the following year. A first observation is thus the higher income figure in each year compared to the static solution. The acreages in wheat, flax, sunflowers, field peas and meadow fescue are not only stable over the five-year period but their levels are the same as in the static plan. The main differences occur in the production of oats and barley. In year one, six acres of oats and 101 acres of barley are grown. Over the years these crops stabilize themselves at 26 acres of oats and 81 acres of barley in years two and five, while their levels are 31 acres and 76 acres respectively in years three and four. Steer calves which were fed at the level of 75 head in the first plan, enter the program at the level of 9 head in year one, 37 head in years two and five, and 45 head in the remaining two years. It appears that the growing of oats is closely related to the presence of livestock, and that this latter production, because of its requirements for a less profitable crop (oats), lowers the returns if performed at a higher level.

The amount of short term capital borrowed varies from zero in years two and three, to $10,000 in the fifth year. This postponement of capital borrowing to years four and five, occurs when the amount of net income over all expenditures transferred to the operating capital of the following year, is very low. In year four only $3,383 is

transferred to year five and forces the operator towards larger borrowings. The corresponding amount transferred from year one to year two is $13,364. It must be noted that the entire amount of short-term capital is assumed to be repaid within one year.

2. Effects of increasing the land base

In the initial programming situations, farm adjustments were viewed in the framework of how labor, capital and the other resources could be used most profitably on existing acreages. This assumption of income improving adjustments on a fixed land base is now removed, and the farmer has the opportunity of re-organizing his farm through the acquisition of additional land. Two methods of acquiring more land are analysed: (1) the renting of 285 acres at a fixed charge of ten dollars per acre, and (2) its purchase at a cost of $150.

The optimum static plan S.2 shows that 280 acres of land are rented when renting is the only acquisition alternative. Operator's and borrowed short term capital must be allocated to other activities in order to bring a return of $25,594. The largest portion of this new land is utilized by wheat (228 acres) while oats is produced on only 12 acres. Steer calves are at the level of 17 head and fall labor is very restricting with a shadow price of $13.56 per hour. The program M.2, the counterpart of S.2, does not quite

offer the same picture of the farm organization. Wheat remains fairly stable at a level close to the static plan but year five shows a decline to 194 acres. Again, oats and barley acreages vary in the opposite direction, the former being substituted for the latter over time. The acreage rented decreases from 285 acres in year one to 158 acres in year five. No capital is borrowed in years two and three where $25,796 and $22,001 are respectively transferred from the preceding year; however, $4,307 and $10,000 are borrowed in the last two years. Livestock production shows a continuous expansion of the steer calf enterprise from a level of six head in year one to 83 head in year five.

A second possibility of expansion toward more extensive farming is the purchase of 285 acres of improved land. This situation is depicted in solutions S.3 and M.3. Under the static conditions of 271 acres are purchased and the return to fixed resources is $27,057. The maximum available short-term capital is used and 39 calves are fed. The multi-year model also offers two situations, differing only by the amount of long-term capital paid back each year. In M.3a the repayment period is assumed to be ten years while it takes fifteen years to pay the land in situation M.3b. The results of these two programs are much alike except that the returns are a little greater in M.3b. and the feeder calf enterprise operates at a higher level in years one, two and four, where more short-term capital is

used. A third situation, M.3c, allows for the simultaneous purchase and renting of land. It can be seen that a lower level of land is purchased in year one, 256 acres, with 26 acres being rented. The annual returns to fixed resources do not greatly differ in the three situations analysed in a multi-year context, but they are significantly higher than the returns obtained under analogous situations with the static model.

3. Effects of varying the amount of short-term capital

Capital is a drastically limiting resource in today's farming and each farmer is interested to know the most efficient way of using this production factor. The objective of this section is to determine how varying levels of short-term capital affect the optimum combination of enterprises, and how the two planning models used in this study can handle such situations.

As borrowed operating capital increases from zero to $20,000 the static plans (S.4a, S.4b, S.4c and S.4d) show an expansion in livestock production. It must be noted however, that the maximum amount that needs to be borrowed is $17,893. This amount allows an annual production of 50 head of steer calves and 453 head of feeder hogs, thus implying the construction of a new hog barn. The returns however, failed to increase significantly. From a low of $19,116 when no capital was borrowed, they increased to

$22,699 when borrowing amounted to $20,000.

In a multi-year setting, it can be observed that the absence of borrowing forces the farmer to leave his land partly idle. For example, in year five of program M.4a, 110 acres are not cultivated because of a lack of capital. To think of a self-expansion of the farm business in such a situation would rapidly lead to serious difficulties. Livestock production reaches a high of 47 head of calves in year three but disappears in further years. Total returns also diminishes over time and barely covers the farm fixed costs and family withdrawals of $15,630 in year five.

Program M.4e presents a better picture of the farm business. In this situation, $50,000 of short-term capital is available to the full five-year period. It can be observed that total annual returns more than double from $25,299 in year one to $52,454 in year five. The maximum number of steer calves is 80 head in year four and 150 hogs are fed in year five with an oats-wheat ration. Cereal crops are still sold to the maximum amount allowed by their respective quotas but they are fed to livestock instead of being sold at lower (non-quota) prices. The total amount of capital borrowed over the period is $32,486 out of which $22,405 is borrowed in year five. One of the most restricting resources, in addition to land is fall labor.

A program was developed in which the annual fixed costs requirements were increased by $1,000 in order to show

the effects on income and the farm organization. As expected, lower returns resulted, particularly in year five with $19,693 compared to $30,114 in the basic program. One of the main changes in the organization of the farm is the abandonment of oats production and consequently of feeder cattle. The only capital borrowed is in year five, at a level of $3,063.

4. Effects of the exclusion of various enterprises

The situations developed in this section are intended to illustrate various sub-optimum plans and programs. The static plans S.6a, S.6b, S.6c and S.6d have the commom characteristic of excluding one crop enterprise found in the basic solution, S.1. The returns are, of course, below the optimum, but the difference in many cases is very small. Various competitive relationships are observed: oats are substituted for barley (S.6a), wheat is substituted for field peas (S.6b), timothy production replaces meadow fescue (S.6c), and finally the exclusion of sunflowers allows more flax to be produced. No significant variation occurs in the levels of livestock except that an oats-wheat ration is used for calves when no barley is grown.

The resource situations are also identical with the maximum amount of short-term capital borrowed.

The exclusion of barley production was also analysed with the multi-year model in M.6a. The cropping pattern was analogous to the static case, but the production of steer

calves is at a lower level with a maximum of about 40 head in year two and three. Higher returns are obtained in the initial years of the planning period, than in the latter years because of the discouting procedures. The only borrowing activity occurs in year five at the level of $4,224.

The place and importance of livestock production on the case farm was determined with the aid of plans S.7 and S.8 and programs M.7 and M.8. In the absence of beef cattle, feeder hogs are fed at the level of 511 head in the static model, while a maximum of 201 head are fed annually in the second model. The production of crops remain stable over the period but not more than 26 acres of oats need to be grown compared to 53 in the static case (S.7). The complete exclusion of livestock (S.8 and M.8) not only results in a stable crop production pattern in which oats are not included, but the farm organization obtained is identical in both the static and the multi-year model. The only difference is that practically no capital is borrowed in the latter case indicating a self-expansion of the farm.

In this study, hay is given a price of $12 per ton. It can be seen that the hay selling activity was included in all optimum solutions. In some years, however, it is a fact that no market exists for hay, especially if it is of a lower quality. In order to simulate such a situation, two solutions (S.10 and M.10 were computed where all enterprises were allowed to compete except for hay selling.

A nominal low price of $2 per ton was given to hay. The results show that the loss of the hay market need not reduce returns provided the proper re-organization of the farm business is carried out. No changes have occurred in the optimum static plan, the only difference being 50 tons of hay which is assumed to be ploughed down thus reducing the returns accordingly. The optimum program M.10 shows that adjustments were made through increases in the livestock enterprises and consequently the acreage in oats and barley. In addition to 78 head of cattle, 150 hogs are fed annually.

5. Effects of Varying Grain Marketing Quotas

The overall effects of removing marketing quotas on cereals are illustrated in plans S.9a, S.9b, S.9c and S.9d, and in program M.9a. An open wheat quota immediately brings 230 acres into production according to the static model. This acreage is still below the 50 per cent (268 acres) maximum allowed by the model. Similar increases occur with oats and barley but the number of calves fed remains roughly stable at 75 head in the static plans. Only one program, (M.9a), is determined with an open quota on wheat. In year one 268 acres of wheat are produced and, interestingly enough, this acreage declines steadily over the years, to a low of 150 acres in year five. It seems that the sale of larger amounts of wheat in the former years has generated enough capital to allow the increase in the number of livestock.

6. Various Possibilities of Expansion of the Farm Business

The above plans and programs differed from the basic solution in only one way in order to study the effects of single alterations. In this section, multiple modifications are brought to the original matrix in an attempt to investigate their effects on optimum farm organizations. One basic characteristic of these new situations is the possibility of increasing the land base by the purchase of up to 285 acres. Hence, in situations S.11 and M.11 additional land is available for purchase while no short-term capital is borrowed. The results obtained under the two models differ significantly. In the static case only 8 acres of land can be purchased and no livestock appear in the plan. The annual return over variable costs is $19,293. In using the second model, the results can be summarized as follows. Year one production is roughly similar to the above, but since $14,213 is transferred to year two it provides the capital necessary to increase crop production and 278 acres are purchased. In the following years livestock production reaches a high of 64 head per year and declines thereafter.

Situations 12.a and 12.b where the possibility of purchasing land is combined to the absence of barley production and a hay market illustrate the phenomena explained with the exception that returns and activity levels are higher because of additional land. Fall labor and operating capital

are always the most limiting resources. The exclusion of livestock combined with open quotas on cereals (S.13b and M.13b) indicate a land use pattern slightly similar in the two models, except that all available land is purchased and more wheat is produced with the multi-year model. This plan also results with the largest profit figure, $29,174.

A situation where fall labor can be increased to two men and $15,000 of capital is available is illustrated in S.14b. The corresponding return is $28,619. It must be noted that steer calves are at the same level as in the basic plan S.1.

The final five-year program, M.15, emphasizes two important features of the multi-period model, (1) the purchase of land in year one (270 acres), increasing the land base for each year of the planning period, and (2) the borrowing of larger amounts of short-term capital while $50,000 is available for the entire five-year period. The solution is an example of a stable organization adjusting itself over time. All the activities are identical for the first three years and shift to a new optimum for the last two years. The realized returns range from $39,450 in year one to $34,347 in year five. These two years also utilize $10,337 and $14,222 of capital respectively.

B. GENERAL OBSERVATIONS AND SUMMARY

The short-run problem facing farmers is the selection of a farm production plan which will maximize returns to the fixed resources. But farmers are also faced with long-run problems in operating their businesses. They must think of a pattern of production which will allow them to not only stay in business but also to improve their financial position and consequently their standard of living. Planning must be understood in terms of several future years. This involves a more detailed consideration of the production factors that are subject to variations over the years. One of the main items entering this category is operating capital, if one assumes that external market conditions are not within the farmer's reach.

Under the conditions assumed in this study, the following general observations can be made with respect to the optimal solutions. The purchase or renting of additional land is more profitable if accompanied by a corresponding increase in fall labor and short-term capital. Land purchase brings a higher return than renting since the annual repayment does not draw directly on the available short-term capital except for this which is repaid each year. This latter resource is a limiting factor in nearly all the computed plans, and when considered in a multi-year context, larger amounts are borrowed in critical years than under

the static model. At low levels of operating capital this resource is all used to operate the cropping enterprises and is not available for livestock production. This is shown in several multi-year results where livestock increases with the accumulation of more capital. Livestock production then appears to remain as a secondary enterprise and complementary relationships exist at high levels of operating capital.

In all the computed solutions, no feed was purchased at any time. The production of oats is preferred to its purchase when necessary for livestock production. Rapeseed and timothy production were not included in any optimum farm organization. Sunflowers, field peas and meadow fescue are produced at the maximum acreage allowed by the model indicating their profitability in the cropping sequence. The optimum farm plans for five successive years are also dependent on the amount of family living expenses and farm fixed costs of each year. These charges are subtracted from the annual return figure before the remaining portion becomes available for production in the following year.

Finally, a look at the more recent years of operation of the case farm indicate that its overall organization would benefit by introducing barley production as a substitute for oats which represented 110 acres in 1967. The wheat acreage is also at high levels than dictated in the optimum programs and plans. Livestock production, with 37

head of steer calves and a declining hog production is also below the optimum. This would likely benefit from larger short-term capital borrowings, the hiring of additional labor and the acquisition of additional land among future possibilities of expansion. It is understood, however, that the exact combination of enterprises in a particular year is highly subject to the prevailing market price structure.

TABLE IV:1

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Basic plan	Renting of land
Column Number		1	2
Plan Number		S.1	S.2
RETURNS TO FIXED RESOURCES		$21,836	$25,594
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	150	228
Oats	ac.	52	12
Barley	ac.	55	152
Flax	ac.	80	122
Rapeseed	ac.		
Sunflowers	ac.	80	122
Field Peas	ac.	54	82
Meadow Fescue	ac.	64	98
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	2,889	4,403
Wheat, no quota	bu.	2,656	4,048
Oats, on quota	bu.		
Oats, sp quota	bu.	523	115
Oats, no quota	bu.		
Barley, on quota	bu.		
Barley, sp. quota	bu.	547	1,515
Barley, no quota	bu.		640
Timothy	cwt.		
Meadow Fescue	cwt.	225	343
Hay	ton	50	95
Livestock			
Steer calves:			
Oats-barley ration	head	75	17
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.		
Operating capital	dol.	10,000	10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Purchase of land	No. S.T. cap. borrowed
Column Number		3	4
Plan Number		S.3	S.4a
RETURNS TO FIXED RESOURCES		$27,059	$19,116
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	226	150
Oats	ac.	27	1
Barley	ac.	134	106
Flax	ac.	121	80
Rapeseed	ac.		
Sunflowers	ac.	121	80
Field Peas	ac.	80	54
Meadow Fescue	ac.	97	64
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	4,352	2,889
Wheat, no quota	bu.	4,001	2,656
Oats, on quota	bu.		
Oats, sp quota	bu.	268	6.3
Oats, no quota	bu.		
Barley, on quota	bu.		
Barley, sp. quota	bu.	1,344	1,064
Barley, no quota	bu.	5,003	4,656
Timothy	cwt.		
Meadow Fescue	cwt.	338	225
Hay	ton	90	64
Livestock			
Steer calves:			
Oats-barley ration	head	39	1
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.	33,859	
Operating capital	dol.	10,000	

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Borr. S.T. cap. $5,000	Bor. S.T. cap. $15,000
Column Number		5	6
Plan Number		S.4b	S.4c
RETURNS TO FIXED RESOURCES		$20,538	$22,643
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	150	142
Oats	ac.	27	79
Barley	ac.	80	37
Flax	ac.	80	80
Rapeseed	ac.		
Sunflowers	ac.	80	80
Field Peas	ac.	54	54
Meadow Fescue	ac.	64	64
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	2,889	2,889
Wheat, no quota	bu.	2,656	1,742
Oats, on quota	bu.		
Oats, sp quota	bu.	267	783
Oats, no quota	bu.		
Barley, on quota	bu.		
Barley, sp. quota	bu.	803	368
Barley, no quota	bu.	2,630	
Timothy	cwt.		
Meadow Fescue	cwt.	225	225
Hay	ton	57	51
Livestock			
Steer calves:			
Oats-barley ration	head	39	69
Oats-wheat ration	head		
Feeder hogs	head		237
Capital Borrowing			
Investment capital	dol.		1,513
Operating capital	dol.	5,000	15,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Bor. S.T. cap. $20,000	No barley production
Column Number		7	8
Plan Number		S.4d	S.6a
RETURNS TO FIXED RESOURCES		$22,699	$21,335
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	137	150
Oats	ac.	93	107
Barley	ac.	27	
Flax	ac.	80	80
Rapeseed	ac.		
Sunflowers	ac.	80	80
Field Peas	ac.	54	54
Meadow Fescue	ac.	64	64
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	2,889	2,889
Wheat, no quota	bu.	1,004	1,335
Oats, on quota	bu.		
Oats, sp quota	bu.	931.5	1,070
Oats, no quota	bu.		4,056
Barley, on quota	bu.		
Barley, sp. quota	bu.	268	
Barley, no quota	bu.		
Timothy	cwt.		
Meadow Fescue	cwt.	225	225
Hay	ton	55	50
Livestock			
Steer calves:			
Oats-barley ration	head	50	
Oats-wheat ration	head		75
Feeder hogs	head	453	
Capital Borrowing			
Investment capital	dol.	5,309	
Operating capital	dol.	17,893	10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		No field peas production	No meadow fescue production
Column Number		9	10
Plan Number		S.6b	S.6c
RETURNS TO FIXED RESOURCES		$20,909	$21,614
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	203	150
Oats	ac.	50	52
Barley	ac.	57	55
Flax	ac.	80	80
Rapeseed	ac.		
Sunflowers	ac.	80	80
Field Peas	ac.		54
Meadow Fescue	ac.	64	
Timothy	ac.		64
Crop Sales			
Wheat, on quota	bu.	3,370	2,889
Wheat, no quota	bu.	4,152	2,657
Oats, on quota	bu.		
Oats, sp quota	bu.	500	523
Oats, no quota	bu.		
Barley, on quota	bu.		
Barley, sp. quota	bu.	570	547
Barley, no quota	bu.	822	634
Timothy	cwt.		257
Meadow Fescue	cwt.	225	
Hay	ton	50	50
Livestock			
Steer calves:			
Oats-barley ration	head	72	76
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.		
Operating capital	dol.	10,000	10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		No sun-flowers production	No beef cattle production
Column Number		11	12
Plan Number		S.6d	S.7
RETURNS TO FIXED RESOURCES		$21,586	$20,830
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	150	150
Oats	ac.	53	53
Barley	ac.	54	54
Flax	ac.	161	80
Rapeseed	ac.		
Sunflowers	ac.		80
Field Peas	ac.	54	54
Meadow Fescue	ac.	64	64
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	2,889	2,889
Wheat, no quota	bu.	2,656	1,592
Oats, on quota	bu.		
Oats, sp quota	bu.	528	528
Oats, no quota	bu.		
Barley, on quota	bu.		
Barley, sp. quota	bu.	542	542
Barley, no quota	bu.	602	2,387
Timothy	cwt.		
Meadow Fescue	cwt.	225	225
Hay	ton	50	64
Livestock			
Steer calves:			
Oats-barley ration	head	76	
Oats-wheat ration	head		
Feeder hogs	head		511
Capital Borrowing			
Investment capital	dol.		4,551
Operating capital	dol.	10,000	10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		No livestock production	Open quota on wheat
Column Number		13	14
Plan Number		S.8	S.9a
RETURNS TO FIXED RESOURCES		$19,075	$23,206
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	150	230
Oats	ac.		45
Barley	ac.	107	63
Flax	ac.	80	53
Rapeseed	ac.		
Sunflowers	ac.	80	27
Field Peas	ac.	54	54
Meadow Fescue	ac.	64	64
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	2,889	8,518
Wheat, no quota	bu.	2,654	
Oats, on quota	bu.		
Oats, sp quota	bu.		
Oats, no quota	bu.		
Barley, on quota	bu.		1,615
Barley, sp. quota	bu.	1,070	
Barley, no quota	bu.	4,711	
Timothy	cwt.		
Meadow Fescue	cwt.	225	225
Hay	ton	64	50
Livestock			
Steer calves:			
Oats-barley ration	head		74
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.		
Operating capital	dol.		10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Open quota on oats	Open quota on barley
Column Number		15	16
Plan Number		S.9b	S.9c
RETURNS TO FIXED RESOURCES		$21,972	$22,366
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	78	78
Oats	ac.	139	46
Barley	ac.	40	133
Flax	ac.	80	80
Rapeseed	ac.		
Sunflowers	ac.	80	80
Field Peas	ac.	54	54
Meadow Fescue	ac.	64	64
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	2,889	2,889
Wheat, no quota	bu.		
Oats, on quota	bu.		
Oats, sp quota	bu.	7,842	
Oats, no quota	bu.		
Barley, on quota	bu.		
Barley, sp. quota	bu.	402	5,392
Barley, no quota	bu.		
Timothy	cwt.		
Meadow Fescue	cwt.	225	225
Hay	ton	50	50
Livestock			
Steer calves:			
Oats-barley ration	head	77	75
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.		
Operating capital	dol.	10,000	10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Open quota on all cereals	No hay selling
Column Number		17	18
Plan Number		S.9d	S.10
RETURNS TO FIXED RESOURCES		$23,206	$21,386
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	230	150
Oats	ac.	45	53
Barley	ac.	62	54
Flax	ac.	54	80
Rapeseed	ac.		
Sunflowers	ac.	27	80
Field Peas	ac.	54	54
Meadow Fescue	ac.	64	64
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	8,518	2,889
Wheat, no quota	bu.		2,655
Oats, on quota	bu.		
Oats, sp quota	bu.		528
Oats, no quota	bu.		
Barley, on quota	bu.	1,615	
Barley, sp. quota	bu.		528
Barley, no quota	bu.		598
Timothy	cwt.		
Meadow Fescue	cwt.	225	225
Hay	ton	50	
Livestock			
Steer calves:			
Oats-barley ration	head	74	76
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.		
Operating capital	dol.	10,000	10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Land purch. no capital borrowing	Land purchase no barley
Column Number		19	20
Plan Number		S.11	S.12a
RETURNS TO FIXED RESOURCES		$19,293	$26,426
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	152	225
Oats	ac.		161
Barley	ac.	109	
Flax	ac.	81	720
Rapeseed	ac.		
Sunflowers	ac.	81	120
Field Peas	ac.	65	80
Meadow Fescue	ac.	54	96
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	2,935	4,335
Wheat, no quota	bu.	2,698	3,295
Oats, on quota	bu.		
Oats, sp quota	bu.		1,606
Oats, no quota	bu.	8	9,976
Barley, on quota	bu.		
Barley, sp. quota	bu.	1,087	
Barley, no quota	bu.	4,783	
Timothy	cwt.		
Meadow Fescue	cwt.	228	337
Hay	ton	65	189
Livestock			
Steer calves:			
Oats-barley ration	head		
Oats-wheat ration	head		39
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.	1,062	33,474
Operating capital	dol.		10,000

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Land purchase no barley no hay selling	Land purchase no livestock
Column Number		21	22
Plan Number		S.12b	S.13a
RETURNS TO FIXED RESOURCES		$25,935	$26,037
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	226	230
Oats	ac.	162	
Barley	ac.		164
Flax	ac.	121	123
Rapeseed	ac.		
Sunflowers	ac.	121	123
Field Peas	ac.	81	82
Meadow Fescue	ac.	97	98
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	4,367	4,428
Wheat, no quota	bu.	3,294	4,067
Oats, on quota	bu.		
Oats, sp quota	bu.	1,618	
Oats, no quota	bu.	9,973	
Barley, on quota	bu.		
Barley, sp. quota	bu.		1,640
Barley, no quota	bu.		7,221
Timothy	cwt.		
Meadow Fescue	cwt.	340	344
Hay	ton		98
Livestock			
Steer calves:			
Oats-barley ration	head		
Oats-wheat ration	head	41	
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.	34,218	
Operating capital	dol.	10,000	4,994

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Land purchase no livestock open quotas	Land purchase additional fall labor
Column Number		23	24
Plan Number		S.13b	S.14a
RETURNS TO FIXED RESOURCES		$29,174	$27,322
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	270	230
Oats	ac.		26
Barley	ac.	163	139
Flax	ac.	81	123
Rapeseed	ac.		
Sunflowers	ac.	122	123
Field Peas	ac.	82	82
Meadow Fescue	ac.	98	98
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	9,962	4,428
Wheat, no quota	bu.		4,067
Oats, on quota	bu.		
Oats, sp quota	bu.		
Oats, no quota	bu.		
Barley, on quota	bu.	8,811	
Barley, sp. quota	bu.		1,640
Barley, no quota	bu.		7,221
Timothy	cwt.		
Meadow Fescue	cwt.	343	344
Hay	ton	98	98
Livestock			
Steer calves:			
Oats-barley ration	head		
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.	35,107	
Operating capital	dol.	5,100	4,994

TABLE IV:1 (continued)

STATIC FARM PLANS: OPTIMUM COMBINATIONS OF ENTERPRISES

Identification of the Plan		Land purchase add. fall labor S.T. bor.= $15,000	
Column Number		25	
Plan Number		S.14b	
RETURNS TO FIXED RESOURCES		$28,619	
ACTIVITIES	UNIT		
Crop Acreages:			
Wheat	ac.	230	
Oats	ac.	51	
Barley	ac.	113	
Flax	ac.	123	
Rapeseed	ac.		
Sunflowers	ac.	123	
Field Peas	ac.	82	
Meadow Fescue	ac.	98	
Timothy	ac.		
Crop Sales			
Wheat, on quota	bu.	4,428	
Wheat, no quota	bu.	4,072	
Oats, on quota	bu.		
Oats, sp quota	bu.	510	
Oats, no quota	bu.		
Barley, on quota	bu.		
Barley, sp. quota	bu.	1,130	
Barley, no quota	bu.	3,244	
Timothy	cwt.		
Meadow Fescue	cwt.	344	
Hay	ton	84	
Livestock			
Steer calves:		74	
Oats-barley ration	head		
Oats-wheat ration	head		
Feeder hogs	head		
Capital Borrowing			
Investment capital	dol.	35,625	
Operating capital	dol.	15,000	

TABLE IV:2

STATIC FARM PLANS: UNUSED RESOURCES (OR SHADOW PRICES)

Identification of the Plan		Basic plan	Renting of land	Purchase of land	No. S.T. cap. borrowed
Column Number		1	2	3	4
Plan Number		S.1	S.2	S.3	S.4a
RESOURCES	UNIT				
Land					
Owned	ac.	(27.52)*	(12.90)	(7.50)	(28.42)
Purchased	ac.	(27.52)	(12.90)	14	(28.42)
Rented	ac.	(14.18)	5		(14.81)
Operator Labor					
Spring	hr.	(1.67)	(1.61)	(1.60)	74
Summer	hr.	87	(1.61)	(1.60)	86
Fall	hr.	(1.67)	(15.17)	(20.64)	(1.70)
Winter	hr.	172	738	478	1,069
Hired Labor					
Spring	hr.	283	180	143	360
Summer	hr.	360	230	238	360
Fall	hr.	267	(13.56)	(19.05)	300
Operating Capital					
Operator's capital	dol.	(0.33)	(0.29)	(0.27)	(0.36)
Borrowed capital	dol.	(0.26)	(00.21)	(0.19)	(0.28)
Borrowed Investment Capital	dol.	50,000	50,000	16,141	50,000

*Denotes dollars per unit mentioned.

TABLE IV:2 (continued)

Identification of the Plan		Borr. S.T. cap. $5,000	Bor. S.T. cap. $15,000	Bor. S.T. cap. $20,000	No barley production
Column Number		5	6	7	8
Plan Number		S.4b	S.4c	S.4d	S.6a
RESOURCES	UNIT				
Land					
Owned	ac.	(27.52)	(30.96)	(30.16)	(27.24)
Purchased	ac.	(27.52)	(23.46)	(22.66)	(27.24)
Rented	ac.	(14.18)	(19.70)	(19.42)	(14.07)
Operator Labor					
Spring	hr.	(1.67)	(1.40)	(1.34)	(1.64)
Summer	hr.	87	7	(1.34)	87
Fall	hr.	(1.67)	(1.40)	(1.71)	(1.64)
Winter	hr.	616	(1.97)	(2.54)	169
Hired Labor					
Spring	hr.	358	214	176	283
Summer	hr.	360	360	294	360
Fall	hr.	283	124	(0.37)	261
Operating Capital					
Operator's capital	dol.	(0.33)	(0.13)	(0.07)	(0.31)
Borrowed capital	dol.	(0.26)	(0.05)	2,107	(0.24)
Borrowed Investment Capital	dol.	50,000	48,487	44,690	50,000

TABLE IV:2 (continued)

Identification of the Plan		No field peas productinn	No meadow fescue production	No sunflowers production	No beef cattle production
Column Number		9	10	11	12
Plan Number		S.6b	S.6c	S.6d	S.7
RESOURCES	UNIT				
Land					
Owned	ac.	(25.79)	(27.10)	(27.05)	(28.61)
Purchased	ac.	(25.79)	(27.10)	(27.05)	(21.11)
Rented	ac.	(12.44)	(13.76)	(13.70)	(16.53)
Operator Labor					
Spring	hr.	(1.66)	(1.66)	(1.66)	(1.51)
Summer	hr.	131	87	124	(1.51)
Fall	hr.	(1.66)	(1.66)	(1.66)	(1.51)
Winter	hr.	212	171	163	651
Hired Labor					
Spring	hr.	287	283	281	293
Summer	hr.	360	360	360	308
Fall	hr.	216	266	266	49
Operating Capital					
Operator's capital	dol.	(0.33)	(0.33)	(0.33)	(0.21)
Borrowed capital	dol.	(0.25)	(0.25)	(0.25)	(0.13)
Borrowed Investment Capital	dol.	50,000	50,000	50,000	45,449

TABLE IV:2 (continued)

Identification of the Plan		No livestock production	Open quota on wheat	Open quota on oats	Open quota on barley
Column Number		13	14	15	16
Plan Number		S. 8	S. 9a	S.9b	S.9c
RESOURCES	UNIT				
Land					
Owned	ac.	(34.48)	(32.92)	(29.29)	(31.35)
Purchased	ac.	(34.48)	(32.92)	(29.29)	(31.35)
Rented	ac.	(24.48)	(20.34)	(16.35)	(18.77)
Operator Labor					
Spring	hr.	76	(1.57)	(1.61)	(1.37)
Summer	hr.	87	111	87	87
Fall	hr.	(1.25)	(1.57)	(1.61)	(1.57)
Winter	hr.	1,082	192	169	171
Hired Labor					
Spring	hr.	360	287	283	283
Summer	hr.	360	360	360	360
Fall	hr.	301	253	267	266
Operating Capital					
Operator's capital	dol.	144	(0.25)	(0.29)	(0.25)
Borrowed capital	dol.	10,000	(0.18)	(0.21	(0.18)
Borrowed Investment Capital	dol.	50,000	50,000	50,000	50,000

TABLE IV:2 (continued)

Identification of the Plan		Open quota on all cereals	No hay selling	Land Purch. no capital borrowing	Land purchase no barley
Column Number		17	18	19	20
Plan Number		S.9d	S.10	S.11	S.12a
RESOURCES	UNIT				
Land					
Owned	ac.	(32.93)	(26.22)	(7.50)	(7.50
Purchased	ac.	(32.93	(26.22)	277	17
Rented	ac.	(20.35)	(12.75)		
Operator Labor					
Spring	hr.	(1.57)	(1.68)	69	(1.55)
Summer	hr.	111	211	80	(1.55)
Fall	hr.	(1.57)	(1.68)	(3.25)	(20.54)
Winter	hr.	192	184	1,078	471
Hired Labor					
Spring	hr.	287	289	360	144
Summer	hr.	360	360	360	240
Fall	hr.	254	270	292	(19.00)
Operating Capital					
Operator's capital	dol.	(0.25)	(0.35)	(3.25)	(0.24)
Borrowed capital	dol.	(0.18)	(0.29)	(1.60)	(0.16)
Borrowed Investment Capital	dol.	50,000	50,000	48,938	16,526

TABLE IV:2 (continued)

Identification of the Plan		Land purchase no barley no hay selling	Land purchase no livestock	Land Purchase No Livestock open quotas	Land purchase Additional fall labor	Land purchase add. fall labor S.T. bor. = $15,000
Column Number		21	22	23	24	25
Plan Number		S.12b	S.13a	S.13b	S.14a	S.14b
RESOURCES	UNIT					
Land						
Owned	ac.	(7.30)	(31.12)	(7.50)	(26.23)	(26.23)
Purchased	ac.	11	(23.62)	4	(18.73)	5.84
Rented	ac.		(20.37)		(12.89)	
Operator Labor						
Spring	hr.	(1.36)	(1.34)	(1.34)	(1.67)	(1.67)
Summer	hr.	99	(1.34)	(1.34)	(1.67)	(1.67)
Fall	hr.	(20.65)	(1.34)	(27.51)	(1.67)	(1.67)
Winter	hr.	487	939	938	495	50
Hired Labor						
Spring	hr.	148	210	230	135	61
Summer	hr.	360	227	230	227	226
Fall	hr.	(19.08)	2.6	(26.17)	346	330
Operating Capital						
Operator's capital	dol.	(0.25)	(0.07)	(0.075)	(0.33)	(0.33)
Borrowed capital	dol.	(0.17)	5,006	4,900	(0.26)	(0.26)
Borrowed Investment Capital	dol.	15,781	14,375	14,892	14,375	14,375

TABLE IV:3 .1

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.1 Basic program				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	150	150	150
Oats	6	26	31	31	26
Barley	101	81	76	76	81
Flax	80	80	80	80	80
Rapeseed					
Sunflowers	80	80	80	80	80
Meadow fescue	64	64	64	64	64
Timothy					
Field Peas	54	54	54	54	54
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,889	2,889	2,889
Wheat, no qta.(bu.)	2,654	2,654	2,654	2,654	2,653
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	60	259	312	312	260
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,010	810	758	758	810
Barley,no qta.(bu.)	4,244	2,689	2,280	2,276	2,689
Timothy (cwt.)					
M. fescue (cwt.)	225	225	225	225	225
Hay (ton)	63	57	56	56	57
Livestock					
Steer calves:(head)					
Oats-barley ration	9	37	45	45	37
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	25,298	25,185	24,097	22,752	30,114
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	1,022			4,228	10,000
L.T. credit repaid					
DISCOUNTED NET RETURNS	13,364	14,399	10,189	3,383	4,484

TABLE IV:3 .2

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.2 Renting of land				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	230	228	222	221	194
Oats	4	13	51	52	58
Barley	160	150	108	106	81
Flax	123	122	119	119	104
Rapeseed					
Sunflowers	123	122	119	119	104
Meadow fescue	98	98	95	95	83
Timothy					
Field Peas	82	81	79	79	69
Sales:					
Wheat, on qta.(bu.)	4,428	4,399	4,272	4,267	3,742
Wheat, no qta.(bu.)	4,067	4,040	3,924	3,920	3,437
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	40	128	505	521	576
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,600	1,301	1,077	1,060	810
Barley,no qta.(bu.)	6,903	6,173	3,034	2,905	1,621
Timothy (cwt.)					
M. fescue (cwt.)	344	342	332	332	291
Hay (ton)	97	94	81	81	68
Livestock					
Steer calves:(head)					
Oats-barley ration	6	18	73	75	83
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased					
Land rented	285	280	256	255	158
RETURNS	38,417	36,582	35,909	33,954	28,733
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	8,614			4,307	10,000
L.T. credit repaid					
DISCOUNTED NET RETURNS	18,890	23,796	22,001	14,506	3,103

TABLE IV:3.3

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.3a Purchase of land (10-year repayment)				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	228	228	220	225	220
Oats	16	16	48	30	55
Barley	146	146	110	131	103
Flax	122	122	119	121	118
Rapeseed					
Sunflowers	122	122	119	121	118
Meadow fescue	98	98	95	97	95
Timothy					
Field Peas	81	81	79	80	79
Sales:					
Wheat, on qta.(bu.)	4,387	4,387	4,281	4,341	4,258
Wheat, no qta.(bu.)	4,030	4,029	3,932	3,988	3,911
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	162	162	480	299	548
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,463	1,463	1,105	1,308	1,029
Barley,no qta.(bu.)	5,894	5,894	3,242	4,749	2,678
Timothy (cwt.)					
M. fescue (cwt.)	341	341	333	338	331
Hay (ton)	93	93	82	88	80
Livestock					
Steer calves:(head)					
Oats-barley ration	23	23	69	43	79
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	277				
Land rented					
RETURNS	38,919	36,712	35,818	33,186	32,095
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	7,993			742	10,000
L.T. credit repaid	3,469	3,469	3,469	3,469	3,469
DISCOUNTED NET RETURNS	16,544	22,457	18,441	13,834	2,996

TABLE IV:3.4

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.3b Purchase of land (15 yr. repayment)				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	227	227	221	222	221
Oats	20	20	55	47	55
Barley	142	142	103	111	103
Flax	122	122	118	119	118
Rapeseed					
Sunflowers	122	122	118	119	118
Meadow fescue	97	97	95	95	95
Timothy					
Field Peas	81	81	79	79	79
Sales:					
Wheat, on qta.(bu.)	4,375	4,375	4,258	4,283	4,258
Wheat, no qta.(bu.)	4,018	4,018	3,911	3,934	3,911
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	200	200	548	473	548
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,420	1,420	1,029	1,114	1,028
Barley,no qta.(bu.)	5,575	5,575	2,678	3,305	2,678
Timothy (cwt.)					
M. fescue (cwt.)	340	340	331	333	331
Hay (ton)	92	92	80	82	80
Livestock					
Steer calves:(head)					
Oats-barley ration	29	29	79	68	79
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	275				
Land rented					
RETURNS	39,077	36,861	36,066	33,787	32,095
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	8,696	74		2,517	10,000
L.T. credit repaid	2,295	2,295	2,295	2,295	2,295
DISCOUNTED NET RETURNS	17,173	23,706	19,863	13,834	4,170

TABLE IV:3.5

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.3c Purchase and renting of land				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	230	226	221	224	221
Oats	4	24	51	38	51
Barley	160	137	107	122	107
Flax	123	121	119	120	119
Rapeseed					
Sunflowers	123	121	119	120	119
Meadow fescue	98	97	95	96	95
Timothy					
Field Peas	82	81	79	80	79
Sales:					
Wheat, on qta.(bu.)	4,428	4,360	4,270	4,314	4,270
Wheat, no qta.(bu.)	4,067	4,004	3,922	3,963	3,922
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	40	245	513	381	513
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,600	1,370	1,069	1,217	1,069
Barley,no qta.(bu.)	6,803	5,201	2,973	4,071	2,973
Timothy (cwt.)					
M. fescue (cwt.)	344	339	332	336	332
Hay (ton)	97	90	81	86	81
Livestock					
Steer calves:(head)					
Oats-barley ration	6	35	74	55	74
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	256				
Land rented	29	17		8	
RETURNS	38,416	37,035	35,936	33,468	31,977
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	6,056			1,951	10,000
L.T. credit repaid	3,197	3,197	3,197	3,197	3,197
DISCOUNTED NET RETURNS	18,250	23,052	18,831	13,179	3,150

TABLE IV:3.6

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.4a No S.T. capital borrowed				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	150	177	119
Oats	1	29	32	9	
Barley	106	78	75	98	85
Flax	80	80	80	54	63
Rapeseed					
Sunflowers	80	80	80	80	63
Meadow fescue	64	64	64	64	51
Timothy					
Field Peas	54	54	54	54	42
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,889	3,129	2,294
Wheat, no qta.(bu.)	2,654	2,654	2,654	3,402	2,106
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	6	293	323	92	
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,064	777	746	978	850
Barley,no qta.(bu.)	4,659	2,431	2,193	3,992	3,738
Timothy (cwt.)					
M. fescue (cwt.)	225	225	225	225	178
Hay (ton)	64	56	56	62	51
Livestock					
Steer calves:(head)					
Oats-barley ration	1	42	47	13	
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	24,924	25,403	24,167	21,735	15,636
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid					
L.T. credit repaid					
DISCOUNTED NET RETURNS	14,011	14,617	10,259	6,594	6

TABLE IV:3.7

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.4e $50,000 of S.T. cap. avail. over 5 yr.				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	150	150	144
Oats	6	26	31	56	72
Barley	101	81	76	51	41
Flax	83	80	80	80	86
Rapeseed					
Sunflowers	83	80	80	80	80
Meadow fescue	64	64	64	64	64
Timothy					
Field Peas	54	54	54	54	54
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,889	2,889	2,889
Wheat, no qta.(bu.)	2,654	2,654	2,654	2,654	2,036
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	60	260	312	559	724
Oats, no qta. (bu.)					
Barley, on qta.(bu.)					
Barley, sp qta.(bu.)	1,010	810	758	311	407
Barley, no qta.(bu.)	4,244	2,689	2,280	362	
Timothy (cwt.)					
M. fescue (cwt.)	225	225	225	225	225
Hay (ton)	63	57	55	49	50
Livestock					
Steer calves:(head)					
Oats-barley ration	9	37	45	80	76
Oats-wheat ration					
Feeder hogs: (head)					150
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	25,299	25,185	24,097	24,201	52,454
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	1,022			9,060	22,405
L.T. credit repaid					
DISCOUNTED NET RETURNS	13,364	14,399	10,189		14,419

TABLE IV:3 .8

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.5 Increase in annual fixed costs				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	159	177	150
Oats	1	24	25		
Barley	107	83	82	107	107
Flax	80	80	70	54	80
Rapeseed					
Sunflowers	80	80	80	80	80
Meadow fescue	64	64	64	64	64
Timothy					
Field Peas	54	34	54	54	54
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,975	3,130	2,889
Wheat, no qta.(bu.)	2,653	2,653	2,920	3,402	2,654
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	6	241	253		
Oats, no qta. (bu.)					
Barley,on qta.(bu.)	1,064	829	817	1,070	1,070
Barley, sp qta.(bu.)	4,659	2,832	2,740	4,708	4,708
Barley,no qta.(bu.)					
Timothy (cwt.)					
M. fescue (cwt.)	225	225	225	225	225
Hay (ton)	64	58	58	64	64
Livestock					
Steer calves:(head)					
Oats-barley ration	1	35	36		
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	24,914	25,064	23,835	21,476	19,693
Annual expenses:					
Farm fixed and home	11,903	11,786	14,908	16,141	16,630
S.T. credit repaid					3,063
L.T. credit repaid					
DISCOUNTED NET RETURNS	13,011	13,278	8,927	5,335	

TABLE IV:3.9

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.6a No barley production				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	150	150	150
Oats	107	107	107	107	107
Barley					
Flax	80	80	80	80	80
Rapeseed					
Sunflowers	80	80	80	80	80
Meadow fescue	64	64	64	64	64
Timothy					
Field Peas	54	54	54	54	54
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,889	2,889	2,889
Wheat, no qta.(bu.)	2,635	1,958	1,907	2,480	2,437
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	1,070	1,070	1,070	1,070	1,070
Oats, no qta. (bu.)	7,968	5,931	5,777	7,502	7,374
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)					
Barley,no qta.(bu.)					
Timothy (cwt.)					
M. fescue (cwt.)	225	225	225	225	255
Hay (ton)	64	57	56	63	62
Livestock					
Steer calves:(head)					
Oats-barley ration					
Oats-wheat ration	1	40	43	10	12
Feeder hogs: (head)					
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	24,583	24,859	23,601	20,944	19,854
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid					4,224
L.T. credit repaid					
DISCOUNTED NET RETURNS	13,670	14,073	9,693	5,803	

TABLE IV:3.10

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M. 7 No. beef cattle production				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	150	150	150
Oats	19	20	26	26	26
Barley	88	87	81	81	81
Flax	80	80	80	80	80
Rapeseed					
Sunflowers	80	80	80	80	80
Meadow fescue	64	64	64	64	64
Timothy					
Field Peas	54	54	54	54	54
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,889	2,889	2,889
Wheat, no qta.(bu.)	2,264	2,245	2,132	2,132	2,132
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	193	203	259	259	259
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	877	867	811	811	811
Barley,no qta.(bu.)	3,857	3,815	3,567	3,567	3,567
Timothy (cwt.)					
M. fescue (cwt.)	225	225	225	225	225
Hay (ton)	64	64	64	64	64
Livestock					
Steer calves:(head)					
Oats-barley ration					
Oats-wheat ration					
Feeder hogs: (head)	150	156	201	201	201
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	26,099	24,680	23,608	22,283	25,720
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	3,533	575		3,713	10,000
L.T. credit repaid		13	90	90	90
DISCOUNTED NET RETURNS	11,653	13,306	9,610	3,339	

TABLE IV:3 .11

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.8 No livestock production				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	150	150	150
Oats					
Barley	107	107	107	107	107
Flax	80	80	80	80	80
Rapeseed					
Sunflowers	80	80	80	80	80
Meadow fescue	64	64	64	64	
Timothy					
Field Peas	54	54	54	54	
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,889	2,889	2,889
Wheat, no qta.(bu.)	2,653	2,653	2,653	2,653	2,653
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)					
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,070	1,070	1,070	1,070	1,070
Barley,no qta.(bu.)	4,708	4,708	4,708	4,708	4,708
Timothy (cwt.)					
M. fescue (cwt.)	225	225	225	225	225
Hay (ton)	64	64	64	64	64
Livestock					
Steer calves:(head)					
Oats-barley ration					
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	19,296	23,471	22,155	20,911	19,693
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid				145	2,773
L.T. credit repaid					
DISCOUNTED NET RETURNS	8,383	12,685	8,247	5,625	1,290

TABLE IV:3.12

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.9a Open Wheat quota				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	268	230	230	177	150
Oats	13	32	43	25	39
Barley	94	75	64	82	68
Flax	54	54	54	54	80
Rapeseed					
Sunflowers	27	27	27	80	80
Meadow fescue	27	64	64	64	64
Timothy					
Field Peas	54	54	54	54	54
Sales:					
Wheat, on qta.(bu.)	9,899	8,512	8,511	6,532	3,543
Wheat, no qta.(bu.)					
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)					
Oats, no qta. (bu.)					
Barley,on qta.(bu.)	3,611	2,096	1,158	2,645	2,203
Barley, sp qta.(bu.)	937	752	638	819	
Barley,no qta.(bu.)					
Timothy (cwt.)	94	225	225	225	225
M. fescue (cwt.)	23	55	51	57	52
Hay (ton)					
Livestock					
Steer calves:(head)					
Oats-barley ration	22	52	70	41	63
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	29,624	28,886	27,867	24,460	23,223
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	3,153				7,593
L.T. credit repaid					
DISCOUNTED NET RETURNS	15,558	18,100	13,959	9,319	

TABLE IV:3.13

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.10 No hay selling				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	150	150	149	150	141
Oats	1	26	29	47	74
Barley	106	81	78	60	41
Flax	80	80	80	80	80
Rapeseed					
Sunflowers	80	80	80	80	80
Meadow fescue	64	64	64	64	64
Timothy					
Field Peas	54	54	54	54	54
Sales:					
Wheat, on qta.(bu.)	2,889	2,889	2,889	2,889	2,889
Wheat, no qta.(bu.)	2,654	2,654	2,654	2,654	1,952
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	13	262	287	474	737
Oats, no qta. (bu.)					
Barley, on qta.(bu.)					
Barley, sp qta.(bu.)	1,057	808	783	596	417
Barley, no qta.(bu.)	4,607	2,671	2,478	1,026	
Timothy (cwt.)	225	225	225	225	225
M. fescue (cwt.)					
Hay (ton)					
Livestock					
Steer calves:(head)					
Oats-barley ration	2	38	41	68	78
Oats-wheat ration					
Feeder hogs: (head)					150
Land Acquisition:					
Land purchased					
Land rented					
RETURNS	10,913	10,786	13,908	15,141	15,630
Annual expenses:					
Farm fixed and home			9	8,038	22,545
S.T. credit repaid					
L.T. credit repaid					
DISCOUNTED NET RETURNS	13,292	13,767	9,420		14,965

TABLE IV:3.14

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.11 Purchase of land, no external cap.				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	152	230	223	226	230
Oats		4	45	25	3
Barley	108	160	114	137	161
Flax	81	123	119	121	123
Rapeseed					
Sunflowers	81	123	119	121	123
Meadow fescue	65	98	95	97	98
Timothy					
Field Peas	54	82	79	81	82
Sales:					
Wheat, on qta.(bu.)	2,928	4,428	4,292	4,358	4,428
Wheat, no qta.(bu.)	2,689	4,067	3,942	4,003	4,067
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)		35	448	247	32
Oats, no qta. (bu.)					
Barley, on qta.(bu.)					
Barley, sp qta.(bu.)	1,084	1,605	1,142	1,367	1,608
Barley, no qta.(bu.)	4,772	6,942	3,512	5,180	6,967
Timothy (cwt.)					
M. fescue (cwt.)	228	344	334	339	344
Hay (ton)	65	97	83	90	98
Livestock					
Steer calves:(head)					
Oats-barley ration		5	64	36	5
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	7	278			
Land rented					
RETURNS	25,216	36,207	33,699	33,006	30,363
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid					
L.T. credit repaid	90	3,563	3,563	3,563	3,563
DISCOUNTED NET RETURNS	14,213	21,858	18,228	14,302	11,170

TABLE IV:3 .15

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.12a Land purchase, no barley				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	227	227	221	226	219
Oats	162	162	158	161	157
Barley					
Flax	122	122	119	121	117
Rapeseed					
Sunflowers	122	122	119	121	117
Meadow fescue	97	97	94	97	94
Timothy					
Field Peas	81	81	79	81	78
Sales:					
Wheat, on qta.(bu.)	4,385	4,385	4,267	4,357	4,229
Wheat, no qta.(bu.)	3,660	3,660	2,793	3,463	2,516
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	1,623	1,623	1,580	1,614	1,566
Oats, no qta. (bu.)	11,074	11,074	8,463	10,481	7,627
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)					
Barley,no qta.(bu.)					
Timothy (cwt.)					
M. fescue (cwt.)	341	341	331	339	329
Hay (ton)	94	93	82	91	79
Livestock					
Steer calves:(head)					
Oats-barley ration					
Oats-wheat ration	21	21	64	31	78
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	277				
Land rented					
RETURNS	38,211	35,980	34,913	32,220	31,308
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	7,643				10,000
L.T. credit repaid	3,462	3,462	3,462	3,462	3,462
DISCOUNTED NET RETURNS	16,193	21,732	17,543	13,617	2,216

TABLE IV:3 .16

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.12b Land purchase, no barley and hay sell.				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	229	229	225	229	222
Oats	163	163	161	163	158
Barley					
Flax	123	123	121	123	119
Rapeseed					
Sunflowers	123	123	121	123	119
Meadow fescue	98	98	96	98	95
Timothy					
Field Peas	82	82	80	82	79
Sales:					
Wheat, on qta.(bu.)	4,414	4,414	4,342	4,414	4,277
Wheat, no qta.(bu.)	3,629	3,629	3,114	3,629	2,656
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	1,635	1,635	1,608	1,635	1,584
Oats, no qta. (bu.)	10,981	10,981	9,428	10,981	8,049
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)					
Barley,no qta.(bu.)					
Timothy (cwt.)					
M. fescue (cwt.)	343	343	358	343	333
Hay (ton)					
Livestock					
Steer calves:(head)					
Oats-barley ration					
Oats-wheat ration	24	24	50	24	73
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	282				
Land rented					
RETURNS	37,495	35,305	33,950	31,420	30,655
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	7,882	1,255			10,000
L.T. credit repaid	3,530	3,530	3,530	3,530	3,530
DISCOUNTED NET RETURNS	15,170	19,374	16,512	12,479	1,495

TABLE IV:3.17

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M. 13b Land pur., no livestock, open cer. qtr				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	245	245	245	232	232
Oats			5		
Barley	164	164	159	164	164
Flax	108	108	108	123	123
Rapeseed					
Sunflowers	123	123	123	123	123
Meadow fescue	98	98	98	96	96
Timothy					
Field Peas	82	82	82	82	82
Sales:					
Wheat, on qta.(bu.)	9,062	9,062	9,062	8,595	8,595
Wheat, no qta.(bu.)					
Oats, on qta. (bu.)			409		
Oats, sp qta. (bu.)			55		
Oats, no qta. (bu.)					
Barley,on qta.(bu.)	8,856	8,856	6,976	8,856	8,856
Barley, sp qta.(bu.)			1,585		
Barley,no qta.(bu.)					
Timothy (cwt.)					
M. fescue (cwt.)	344	344	344	335	335
Hay (ton)	98	98	98	96	96
Livestock					
Steer calves:(head)					
Oats-barley ration					
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	285				
Land rented					
RETURNS	33,088	27,970	31,092	28,901	22,669
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	5,032				3,476
L.T. credit repaid	3,563	3,563	3,563	3,563	3,563
DISCOUNTED NET RETURNS	13,580	13,621	13,621	10,197	3,341

TABLE IV:3.18

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.14a pur. of land and additional fall lab.				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	230	230	230	230	230
Oats		26	50	54	42
Barley	164	138	114	110	122
Flax	123	123	123	123	123
Rapeseed					
Sunflowers	123	123	123	123	123
Meadow fescue	98	98	98	98	98
Timothy					
Field Peas	82	82	82	82	82
Sales:					
Wheat, on qta.(bu.)	4,428	4,428	4,428	4,428	4,428
Wheat, no qta.(bu.)	4.067	4,067	4,067	4,067	4.067
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)		264	500	539	419
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,640	1,376	1,140	1,101	1,221
Barley,no qta.(bu.)	7,216	5,167	3,327	3,025	3,955
Timothy (cwt.)					
M. fescue (cwt.)	344	344	344	344	344
Hay (ton)	98	91	85	84	87
Livestock					
Steer calves:(head)					
Oats-barley ration		37.9	72	77.5	60.3
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	285				
Land rented					
RETURNS	38,134	37,714	35,069	35,223	32,531
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	4,976			4,602	10,000
L.T. credit repaid	3,563	3,563	3,563	3,563	3,563
DISCOUNTED NET RETURNS	18,682	23,365	19,598	11,917	3,338

TABLE IV:3.19

FIVE YEAR PRODUCTION PROGRAM: OPTIMUM FARM ORGANIZATION

Program No. & Identif.	M.15 Land purchase, $50,000, S.T. capital for 5 years				
Year of Plan	Year 1	Year 2	Year 3	Year 4	Year 5
ACTIVITIES					
Crops: Acres in:					
Wheat	225	225	225	221	221
Oats	29	29	29	55	55
Barley	138	132	132	103	103
Flax	121	121	121	118	118
Rapeseed					
Sunflowers	121	121	121	118	118
Meadow fescue	96	96	96	95	95
Timothy					
Field Peas	80	80	80	79	79
Sales:					
Wheat, on qta.(bu.)	9,344	4,344	4,344	4,258	4,258
Wheat, no qta.(bu.)	3,990	3,990	3,990	3,911	3,911
Oats, on qta. (bu.)					
Oats, sp qta. (bu.)	290	290	290	548	548
Oats, no qta. (bu.)					
Barley,on qta.(bu.)					
Barley, sp qta.(bu.)	1,319	1,319	1,319	1,028	1,028
Barley,no qta.(bu.)	4,823	4,823	4,823	2,678	2,678
Timothy (cwt.)					
M. fescue (cwt.)	338	338	338	331	331
Hay (ton)	89	89	89	80	80
Livestock					
Steer calves:(head)					
Oats-barley ration	42	42	42	79	79
Oats-wheat ration					
Feeder hogs: (head)					
Land Acquisition:					
Land purchased	270				
Land rented					
RETURNS	39,430	37,211	35,122	34,049	34,347
Annual expenses:					
Farm fixed and home	10,913	10,786	13,908	15,141	15,630
S.T. credit repaid	10,357	4,099		5,926	14,222
L.T. credit repaid	3,369	3,369	3.369	3,369	3,369
DISCOUNTED NET RETURNS	14,811	18,957	17,845	9,613	1,126

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In this study it was proposed that multi-period linear programming be used to provide some quantitative basis for the farmer to use in the formulation of his production plans. The empirical content was provided by a real existing and operating farm unit of the Carman area. Although no statistical evidence supports this view, it was felt that the problems encountered on the studied farm represent a situation of growing interest in the area.

By the explicit introduction of time into the model, the effect of capital accumulation and the impact of a decision in one year on the organization, production and income during subsequent years was determined. This pseudo-dynamic model allowed for the transfer of income from production in one year to the operating capital of the following year. Thus this model appears more realistic and more flexible than the static model in that the assumption that resources are required and returns received simultaneously is not necessary. Furthermore, in the long run the years are interrelated, and changes in resource structure over time, particularly in the accumulation of capital, must be taken into consideration when planning is done properly. A

further advantage of the model lies in its greater flexibility in the resource allocation process; it also permits mapping out the planned changes in the farm organization as time goes by. It must also be remembered that the longer the planning period, the more flexible is the model in terms of reflecting changes over time, and the more meaningful is the expectation of changes in the farm organization.

Farm Planning Through Programming

The validity of any linear programming analysis is heavily dependent on the reliability of the information being used. A major problem in programming individual farms is that insufficient records are available. Many farms do not have adequate records on which to base management decisions and moreover, traditional farm accounting techniques are not refined enough to provide the information required by linear programming. It is true that there is a scarcity of ideal data for the programming of farms, but this is not a justification for denying the use of this technique for farm planning purposes. The availability of computing facilities is no longer a serious restraint to a wider practical use of this management tool since high capacity computers are now available at various points in the country.

If linear programming or any other computerized planning techniques are being applied successfully to a growing number of other businesses today, there is no reason

why their use could not be expanded into the business of farming. Their development will be slow or fast depending on (1) the ability to develop refined input-output data on an individual farm basis, (2) the rapidity with which a rigorous training can be given to extension workers, and (3) the degree of collaboration between the researcher, the policy maker, and the extension worker.

An equally important step toward a wider application of programming techniques would be an educational process to explain those techniques to the farmer so that he understands the "whats and whys" associated with their use. Linear programming will still remain a powerful research tool in the future, but urgent steps must be taken to make it a planning tool available to all progressive farmers.

Recommendations for Further Study

This study, because of its limited scope and its apparent weaknesses, presents itself as a starting point for several other investigations. Some recommendations which might be the object of future studies are outlined here.

The length of the planning period used in this study was only five years. It was assumed that because of uncertainty considerations, crop and livestock plans do not extend beyond a time span of this length. In subsequent studies, the time period should be expanded to ten or twenty

years in order to determine the more appropriate planning horizon associated with each type of farming. The time period programmed should be long enough to determine an equilibrium in yearly plans. Similarly, this study assumed a unique discount rate of six per cent, optimum programs should be made using different discount rates.

The model used was deterministic and single valued expectations were assumed for input-output coefficients and prices. Stochastic and parametric programming models would overcome this limitation of the assumption of perfect knowledge. The objective function, which was the maximization of discounted net returns, may offer other alternatives also relevant to farming such as the maximization of the net worth value over the planning period. It would then become a farm growth study. Another refinement that could be brought to the model is the addition of a "recursive" type of solution with the aid of a moving horizon. Programs would be made for a number of years and various modifications would be made to the matrix as the time horizon was advanced annually. Such a procedure would result in a more accurate making of farm decisions.

In this study, production alternatives and resource supplies with the exception of operating capital rented land and annual fixed costs, were identical for each of the five years. Many variations in those two basic components could be made for the various years of the model in order to fit

to reality. Prices and input-output coefficients could also be allowed to vary over the years to account for alternative market situations and changes in technology.

The household counterpart of farming was dealt with in a relatively simple manner in this study. Living expenses were treated as "exogenous" to the determination of yearly plans although they had to be exactly met. More complete studies should allow both household and farm activities in the over-all farm plan. Such an inter-dependence could be set up by means of various consumption activities. An important consideration for future farm planning on a whole farm basis is that household consumption as well as farm production should be considered in making farm management recommendations.

BIBLIOGRAPHY

1. Allen, R. G. D., Mathematical Economics, London: The Macmillan Co. Ltd., 1956.

2. Babbar, M. M., "A Note on Aspects of Linear Programming Technique," J.F.E., Vol. XXXVII, No. 2, May 1955, pp. 333-341.

3. Baumol, W. J., Economic Dynamics, 2nd edition, New York: The Macmillan Co. Ltd., 1959.

4. Bellman, Richard, Dynamic Programming, Princeton, New Jersey: Princeton University Press, 1957.

5. Bishop, C. E., "Application of Mathematical Programming to Agricultural Economic Problems, Programming Farm-Nonfarm Allocation of Farm Family. Resources, J.F.E., Vol. XXXVIII, No. 2, May 1956, pp. 396-407.

6. Boles, James N., "Linear Programming and Farm Management Analysis," J.F.E., Vol. XXXVII, No. 1, February 1955, pp. 11-24.

7. Boulding, Kenneth E., and W. A. Spivey, Linear Programming and the Theory of the Firm, New York: McGraw-Hill Book Co., Inc., 1960.

8. Bradford, Lawrence A., and Glenn L. Johnson, Farm Management Analysis, New York: John Wiley and Sons Inc., 1953.

9. Carlson, Sune, A Study on the Pure Theory of Production, New York: Kelley and Millman Inc., 1956.

10. Charnes, A., W. Cooper, and A. Henderson, An Introduction to Linear Programming, New York: John Wiley and Sons Inc., 1953.

11. Department of Agricultural Economics and Farm Management, Farm Management Handbook, University of Manitoba, (Unpublished Material).

12. Dorfman, Robert, Linear Programming and the Theory of the Firm, Berkeley and Los Angeles: University of California Press, 1951.

13. _____, "Mathematical or Linear Programming: A Non-mathematical Exposition," American Economic Review, Vol. XLIII, Dec., 1953, pp. 797-825.

14. _____, P. A. Samuelson, and R. M. Solow, Linear Programming and Economic Analysis, New York: McGraw-Hill Co., Inc., 1958.

15. Dubois, M. J., Economic Aspects of Farm Machinery Use in Crop Production, Reston-Cromer Area, Manitoba, 1965, Winnipeg: Economics Branch, Canada Department of Agriculture, August, 1965.

16. Faculty of Agriculture and Home Economics, Principles and Practices of Commercial Farming, Winnipeg: University of Manitoba, 1965.

17. French, Charles E., "Activity Analysis: An Agricultural Marketing Tool," J.F.E., Vol. XXXVII, No. 5, Dec., 1955, pp. 1236-1248.

18. Garland, S. W., and L. M. Johnson, Crop Production Requirements in Manitoba, Ottawa: Economics Division, Canada Department of Agriculture, Dec., 1958.

19. Gilson, J. C., An Application of Linear Programming to Farm Planning, Technical Bulletin, No. 2, Winnipeg: Department of Agricultural Economics and Farm Management, University of Manitoba, May, 1960.

20. _____, Economic Aspects of Alternative Crop Rotations and Beef Production Systems (an Application of Linear Programming), Technical Bulletin, No. 3, Winnipeg: Department of Agricultural Economics and Farm Management, University of Manitoba, May, 1960.

21. Heady, E. O., Economics of Agricultural Production and Resource Use, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1952.

22. _____, "Simplified Presentation and Logical Aspects of Linear Programming Technique," J.F.E., Vol. XXXVI, No. 5, Dec., 1954, pp. 1035-1048.

23. _____, and W. Candler, Linear Programming Methods, Ames, Iowa University Press, 1958.

24. Hicks, J. R., Capital and Growth, London: Oxford University Press, 1965.

25. _____, Value and Capital, 2nd edition, Oxford: Clarendon Press, 1946.

26. Hutton, R. F., "Operation Research Techniques in Farm Management," J.F.E., Vol., XLVII, Dec., 1965, pp. 1400-1411.

27. Johnson, L. M., Changes in Farm Organizations: Somerset-Manitou Area, Manitoba, Winnipeg: Canada Department of Agriculture, Economics Division, 1964.

28. King, Richard A., "Some Applications of Activity Analysis in Agricultural Economics," J.F.E., Vol. XXXV, No. 5, December, 1953, pp. 823-833.

29. Koopmans, Tjalling C. (ed.), Activity Analysis of Production and Allocation, New York: John Wiley and Sons Inc., 1951.

30. Loftsgard, Laurel D., and E. O. Heady, "Application of Dynamic Programming Models for Optimum Farm and Home Plans," J.F.E., Vol. XL, No. 1, February, 1959, pp. 51-62.

31. Manitoba Department of Agriculture, Manitoba Farm Outlook 1968, Winnipeg: R. S. Evans, Queen's Printer, January, 1968.

32. McAlexander, R. H., and R. F. Hutton, Linear Programming Techniques Applied to Agricultural Problems, Pennsylvania: Department of Agricultural Economics and Rural Sociology, Pennsylvania State University, 1959.

33. McCorkle, Chester O., Jr., "Activity Analysis: Programming as a Tool in Farm Management Analysis," J.F.E., Vol. XXXVII, No. 5, December, 1955, pp. 1222-1235.

34. Peterson, G. A., "Selection of Maximum Profit Combinations of Livestock Enterprises and Crop Rotations," J.F.E., Vol. XXXVII, No. 3, August, 1955, pp. 546-554.

35. Plaxico, James S., "Dynamic Programming and Management Strategies in the Great Plains," in Management Strategies in Great Plains Farming, Publication No. 19, Lincoln Nebraska: Great Plains Council, May, 1959, pp. 12-22.

36. Samuelson, Paul A., The Foundations of Economic Analysis, Cambridge Massachusetts: Harvard University Press, 1947.

37. Stutt, R. A., An Inventory of Agricultural Economics Research in Canada, 1964 to 1966, Ottawa: Canada Department of Agriculture, Economics Branch, February, 1967.

38. _____, "Farm Management in Canada," Canadian Farm Economics, Vol. II, August 1967, pp. 12-22.

39. Swanson, Earl R., "Applications of Linear Programming in Agricultural Production Economic Research," paper presented to Cowles Commission Seminar, University of Chicago, February 10, 1955.

40. _____, "Application of Programming Analysis to Corn Belt Farms," J.F.E., Vol. XXXVIII, No. 2, May, 1956, pp. 408-419.

41. _____, "Integrating Crop and Livestock Activities in Farm Management Activity Analysis," J.F.E., Vol. XXXVII, No. 5, December, 1955.

42. _____, "Programming Optimal Farm Plans" in Farm Size and Output Research, Southern Cooperative Series Bulletin No. 36, Still-water: Oklahoma Agricultural Experiment Station, pp. 47-58.

43. _____, and Kirk Fox, "The Selection of Livestock Enterprises by Activity Analysis," J.F.E., Vol. XXXVI, No. 1, February, 1954, pp. 78-86.

44. Tonn, B. E., Economic Aspects of Farm Machinery Use in Crop Production in South Central Manitoba, 1964, Winnipeg: Economics Branch, Canada Department of Agriculture, August, 1965.

APPENDIX A

TABLE A-1

CASE FARM COMPARATIVE FINANCIAL STATEMENT

ITEM	1960	1961	1962	1963	1964	1965	1966	1967
Real Estate	$30000	$30000	$30000	$30000	$56000	$56000	$56000	$81000
Buildings and improvements	780	2280	268	273	323	-	7979	7237
TOTAL FIXED FARM CAPITAL	30780	32280	30268	30273	56123	56000	63979	88237
Cattle	3830	3760	6190	6080	4940	5500	6200	6500
Hogs	876	952	1025	1400	1150	1920	1400	-
Other livestock	310	310	25	-	-	-	-	-
Grain and Feed	6870	4525	5872	7535	8953	13007	12120	25481
Supplies	185	160	365	238	827	667	338	298
Machinery and Equipment	6778	7597	11059	14411	13667	21931	29514	29717
TOTAL OP'S FARM CAPITAL	49629	49584	54804	59937	85860	99025	113551	150233
Household and Personal Cap.	3458	3684	4201	3631	5555	5620	6554	7820
TOTAL OP'S CAPITAL	53087	53268	59005	63568	91415	104645	120005	158053
Long Term Debt	18728	17634	16562	15992	14368	12763	10622	30471
Intermediate Term Debt	850	1500	5400	4080	5910	8940	13450	12820
Short Term Debt	-	112	-	3400	-	7	-	-
TOTAL FARM ACCOUNTS PAYABLE	19578	19246	21962	23472	20278	21710	24072	43291
OPERATOR'S NET WORTH	33509	34022	37043	40096	71137	82935	89479	114762
CHANGE IN NET WORTH	-	513	3021	3053	31041	11798	6544	25283

TABLE II-2

CASE FARM COMPARATIVE OPERATING STATEMENT-RECEIPT ITEMS

	1960	1961	1962	1963	1964	1965	1966	1967
Receipts from Crops (Cash received)								
Wheat	5118	3575	3304	2839	4281	5891	8224	9937
Oats	1363	184	508	905	544	898	1002	181
Flax	1481	2778	3408	1205	3038	566	3311	3511
Rapeseed	-	-	-	-	-	299	2013	2300
Sunflowers	-	-	-	-	-	-	1021	2054
Timothy	-	-	-	-	630	1635	1328	1385
Meadow Fescue	726	171	137	1008	-	-	-	345
Field Peas	961	794	797	1284	2087	1692	1041	2079
Clover	-	-	-	-	56	115	-	-
Other Crops	93	-	-	-	-	15	-	377
Miscellaneous receipts (crops)	1022	853	1278	1535	1481	2054	2767	2813
TOTAL CROP RECEIPTS	10764	8355	9432	8776	12117	13165	20707	24982
Receipts from Livestock								
Cattle	1227	5474	6925	8602	8209	8410	9038	8898
Hogs	1428	3575	4254	5219	5939	5945	6220	1948
Other	1178	813	635	-	-	-	-	-
TOTAL LIVESTOCK RECEIPTS	3833	9862	11814	13821	14148	14355	15258	10846
TOTAL FARM RECEIPTS	14595	18217	21246	22597	26265	27520	35965	35828

TABLE A-3

CASE FARM COMPARATIVE OPERATING STATEMENT-VARIABLE COST ITEMS

	1960	1961	1962	1963	1964	1965	1966	1967
CROP EXPENSES								
Seed purchased	463	464	355	168	595	565	752	592
Fertilizer and chemicals	168	158	712	1402	2408	2070	5014	5487
Machinery costs								
Truck	262	707	437	306	329	786	387	512
Tractor	1277	1278	836	972	721	441	750	590
Combine	420	79	271	222	329	413	202	254
Other equip. repairs & tools	142	224	256	265	399	542	762	684
Custom work and hired labor	1015	699	713	1132	752	1454	1439	1705
LIVESTOCK EXPENSES								
Hog								
Cost of weanlings	777	1133	1099	1643	1637	1652	1700	-
Feed, supplies and others	103	696	705	915	839	785	666	-
Veterinary and medicine	23	49	28	35	34	48	11	-
Cattle								
Cattle purchased	-	2296	5629	5385	4169	5315	5924	6336
Feed, supplies and others	295	310	529	587	346	372	262	295
Veterinary and medicine	13	23	85	31	38	28	7	-
Other livestock	377	42	9	-	-	-	-	-
MISCELLANEOUS EXPENSES								
Car (farm share)	80	99	88	95	148	280	224	572
TOTAL OPERATING VAR. COSTS	5415	8257	11752	13158	14218	14751	18100	17027

TABLE A-4

CASE-FARM ANNUAL FIXED AND OVERHEAD COSTS

ITEM	1960	1961	1962	1963	1964	1965	1966	1967
Real estate taxes	690	833	824	951	990	950	1017	1253
Machinery depreciation	38	113	2887	1979	2033	1310	4918	4742
Building depreciation	143	321	268	202	254	247	247	222
Insurance on bldg. & mach.	41	46	47	49	50	51	51	51
New bldg., improv. & repairs	1230	2615	1218	1602	969	689	280	185
Hydro and telephone (2/3)	108	132	147	150	139	180	184	168
Interest paid on loans	690	921	1155	1196	1170	1174	920	1080
Miscellaneous	35	35	39	40	107	49	173	293
TOTAL COSTS LESS INTEREST	2975	5016	6585	6169	5712	4550	7790	7994
(Owned farm capital)	(30051)	(30338)	(32842)	(36465)	(65582)	(77315)	(89479)	(106942)
Interest on owned cap. (5%)	1500	1517	1642	1823	3279	3866	4474	5347
TOTAL FIXED & OVERHEAD COSTS	4475	6533	8227	7992	8981	8416	12264	13341

TABLE A-3

CASE FARM LAND USE PATTERN, 1960-1967

		1960		1961		1962		1963		1964		1965		1966		1967	
		ac.	yield	ac.	yield	ac.	yield	ac.	yield	ac.	yield	ac.	yield	ac.	yield	ac.	yield
Wheat - 1st crop	(bu.)	95	33	120	16.7	100	20.5	85	22	65		100					
Wheat - on stubble	(bu.)	62	25.5			40	18	155	20.2	170	29.8	150	30	302	25.6	350	33.6
Oats	(bu.)	50	60	55	25.4	60	65.8	100	61	105	67	105	70	90	50	110	72.7
Mixed grains	(bu.)	37	35.1	60	20	90	40	-	-	-	-	-	-	-	-	-	-
Flax	(bu.)	85	10	83	6.1	75	14.9	70	11	55	11.5	60	17.9	108	6.9	80	10
Rapeseed	(bu.)	-	-	-	-	-	-	-	-	-	-	30	15	135	13.9	65	24.3
Sunflowers	(lb.)	-	-	-	-	-	-	-	-	-	-	-	-	80	438	98	1070
Field peas	(bu.)	30	21.3	35	11.4	25	18	40	18	40	20	30	30.3	40	11.2	32	26.5
M. fescue - seed	(lb.)	25	291	25	36.5	25	600	-	-	-	-	-	-	-	-	30	230
Timothy - seed	(lb.)	-	-	-	-	-	-	25	-	25	190	25	308	50	360	50	400
Timothy - hay aftermath	(Ton)	-	-	-	-	-	-	-	-	-	-	-	1.2	-	-	-	1.6
Clover - seed	(lb.)	-	-	-	-	-	-	-	-	50	100	-	-	-	-	-	-
Hay	(Ton)	13	1	50	.5	15	1.7	-	-	25	.85	-	-	5	.25	-	-
Miscellaneous crops		25	-	13	-	-	-	-	-	-	-	-	-	10	-	5	-
Summerfallow		114	-	95	-	106	-	60	-	-	-	35	-	-	-	-	-
TOTAL IMPROVED LAND		536		536		536		535		535		535		820		820	
Owned		536		536		536		535		535		535		535		535	
Rented		-		-		-		-		-		-		285		285	

TABLE A-6

CASE-FARM FINANCIAL RESULTS AND GENERAL PERFORMANCE

	1960	1961	1962	1963	1964	1965	1966	1967
FINANCIAL SUMMARY								
Total farm receipts	14597	18217	21246	22597	26265	27520	35965	35828
Total variable costs	- 5415	- 8257	-11752	-13158	-14218	-14751	-18100	-17027
Returns above variable costs	9182	9960	9494	9439	12047	12769	17865	18801
Fixed and overhead costs	- 2975	- 5016	- 6585	- 6169	- 5712	- 4550	- 7790	- 7994
Net farm earnings	6207	4944	2909	3270	6335	8219	10075	10807
Family living expenses	- 2349	- 3139	- 3485	- 3190	- 5201	- 6236	- 6118	- 7147
Debt carrying capacity	3858	2805	- 576	80	1134	1983	3957	3660
GENERAL FARM PERFORMANCE								
Capital turnover (%)	32.3	25.6	32.3	28.6	23.3	25.82	19.2	-[1]
Capital turnover, rate (years)	3.1	3.9	3.1	3.5	4.3	3.9	5.2	-
Gross expense ratio (%)	-	-	-	64.90	55.11	46.39	75.8	-
Equity ratio (%)	66.8	68.8	67.6	66.8	76.38	78.08	77.2	76.4

[1] Not available.

APPENDIX B

TABLE B-1

RECOMMENDED FERTILIZER TREATMENTS AND ESTIMATED CROP YIELDS ASSUMED ON THE CASE FARM*

	AVERAGE RECOMMENDATIONS (lbs. of nutrient per acre)			YIELD	
	N	P_2O_5	K_2O	AMOUNT	UNIT
WHEAT	60	35	0	37	bu.
OATS	60	35	0	85	bu.
" (straw)				.9	ton
BARLEY	60	35	0	54	bu.
FLAX	60	0	0	19	bu.
RAPESEED	75	20	0	13.5	cwt.
SUNFLOWERS	60	40	0	12	cwt.
FIELD PEAS	0	0	0	30	bu.
MEADOW FESCUE	70	30	0	350	cwt.
" " (hay)				1	ton
TIMOTHY	70	30	0	400	cwt.
" (hay)				1	ton

*Information supplied by Peter Fehr, Soils Department, University of Manitoba.

TABLE B-2

NUMBER OF HOURS REQUIRED TO WORK ONE ACRE, ONCE OVER, BY DIFFERENT MACHINES*

Machine	Size	Hours per Acre	
		Machine time	Man time
Plow	4-14 in.	.37	.40
Cultivator	14 ft.	.20	.23
Disker	15 ft.	.20	.23
Harrow	36 ft.	.09	.10
Seed drill & F.A.	14 ft.	.20	.30
Fertilizer spreader		.06	.10
Sprayer	56 ft.	.08	.12
Swather	15 ft.	.21	.23
Combine	12 ft.	.30	.35
Mow	7 ft.	.30	.40
Rake	10 ft.	.30	.40
Bale (P.T.O.)		.75	.85
Haul cereals to storage		.25	.25
Haul hay & straw		1.0	1.2

*The information contained in tables B-2, B-3, B-4 and B-9 is based on the following sources:

Dubois, M. J., Economic Aspects of Farm Machinery Use in Crop Production, Reston-Cromer Area, Manitoba, 1965, Economics Branch, Canada Department of Agriculture, Winnipeg, Manitoba, April 1966.

Tonn, B. E., Economic Aspects of Farm Machinery Use in Crop Production in South Central Manitoba, 1964, Economics Branch, Canada Department of Agriculture, Winnipeg, Manitoba, August 1965.

Garland, S. W., and L. M. Johnson, Crop Production Requirements in Manitoba, Economics Division, Canada Department of Agriculture, Ottawa, Dec. 1958.

Principles and Practices of Commercial Farming, Faculty of Agriculture and Home Economics, University of Manitoba, Winnipeg.

Farm Management Handbook, Department of Agricultural Economics and Farm Management, University of Manitoba (Unpublished).

TABLE B-3

MISCELLANEOUS OR OVERHEAD LABOR REQUIRED FOR CROPS
BY SEASON AND ON A PER ACRE BASIS

	HOURS (MAN TIME) PER SEASON PER ACRE			
	SPRING	SUMMER	FALL	WINTER
Repairing (machinery and building)	.05	.03	.05	.20
Marketing	.04	.02	.03	.10
Seed preparation	.05	-	-	.15
TOTAL PER SEASON	.14	.05	.08	.45

TABLE B-4

LABOR REQUIREMENTS (MAN TIME) PER ACRE AND BY SEASON FOR VARIOUS CROPPING ENTERPRISES

OPERATION	WHEAT	OATS	BARLEY	FLAX
SPRING (April 15 - June 15)				
Disc or Cultivate	.23	.23	.23	.23
Harrow	.20	.20	.20	.20
Sow	.30	.30	.30	.30
Miscellaneous	.14	.14	.14	.14
	.87	.87	.87	.87
SUMMER (June 16 - August 15)				
Spray	.12	.12	.12	.12
Miscellaneous	.05	.05	.05	.05
	.17	.17	.17	.17
FALL (August 16 - October 15)				
Swath (or rake)	.23	.23	.23	.23
Combine (or bale)	.35	.35	.35	.35
Haul	.25	.25	.25	.25
Plow or cultivate	.40	.40	.40	.23
Miscellaneous	.08	.08	.08	.08
	1.31	1.31	1.31	1.14
WINTER (October 16 - April 16)				
Miscellaneous	.45	.45	.45	.45
TOTAL PER ACRE	2.80	2.80	2.80	2.63

TABLE B-4 (continued)

OPERATION	RAPESEED	SUNFLOWERS	FIELD PEAS	M. FESCUE
SPRING (April 15 - June 15)				
Disc or Cultivate	.23	.23	.23	
Harrow	.20	.20	.20	
Sow	.30	.30	.24	
Miscellaneous	.14	.14	.14	.14
	.87	.87	.81	.14
SUMMER (June 16 - August 15)				
Spray	.12	.12	.12	.12
Cultivate		.46		
Mow and rake or swath			.23	.80
Combine			.35	.35
Haul			.25	.1
Miscellaneous	.05	.05	.05	.05
	.17	.63	1.00	1.42
FALL (August 16 - October 15)				
Swath (or rake)	.23	.23		
Combine (or bale)	.35	.35		
Haul	.25	.25		
Plow or cultivate	.23	.23	.23	.08
Fertilize				
Miscellaneous	.08	.08	.08	.08
	1.14	1.14	.31	.26
WINTER (October 16 - April 16)				
Miscellaneous	.45	.45	.45	.45
TOTAL PER ACRE	2.63	3.09	2.57	2.27

TABLE B-4 (continued)

OPERATION	TIMOTHY	HAY BALING	STRAW BALING
SPRING (April 15 - June 15)			
Miscellaneous	.14	.14	.14
	.14	.14	.14
SUMMER (June 16 - August 15)			
Spray	.12		
Mow and rake or swath	.80	.40	
Combine (or bale)	.35	.85	
Haul	.1	1.20	
Miscellaneous	.05	.05	.05
	1.42	2.50	.05
FALL (August 16 - October 15)			
Swath (or rake)			.40
Combine (or bale)			.85
Haul			1120
Plow or cultivate	.08		
Fertilize	.10		
Miscellaneous	.08	.08	.08
	.26	.08	2.53
WINTER (October 16 - April 16)			
Miscellaneous	.45	.45	.45
TOTAL PER ACRE	2.27	3.17	3.17

TABLE B-5

LABOR REQUIREMENTS FOR LIVESTOCK ENTERPRISES

ENTERPRISE	No. of Hours
Feeder Hogs (Old Barn)	2 hours per hog per month
Feeder Hogs (New Barn)	1.6 hour per hog per month
Feeder Cattle	2 hours per head per month

TABLE B-6

BEEF CATTLE RATIONS: TOTAL FEED REQUIREMENTS PER HEAD*

	Fattening 440-lb. Calves to 940 lbs.				Fattening 700-lb. Yearlings to 1050 lbs.			
FEED ITEMS	Oats and Barley		Wheat and Oats		Oats and Barley		Barley & Oats (no straw)	
	lbs.	bus.	lbs.	bus.	lbs.	bus.	lbs.	bus.
Wheat	-	-	1050	17.5	-	-	-	-
Oats	1877	52.138	1897	52.694	1733	48.138	1229	34.138
Barley	1126	23.458	-	-	945	19.687	1418	29.541
Supplement & minerals	56	-	56	-	31	-	31	-
Hay (aftermath)	375	.187T	375	.187T	221	.11T	472	.236T
Oat straw	320	.16T	376	.187T	220	.11T	-	-
TOTAL PER HEAD	3754		3754		3150		3150	

*Based on information contained in Principles and Practices of Commercial Farming, Faculty of Agriculture and Home Economics, University of Manitoba, Winnipeg 1965, pp. 233-234.

TABLE B-7

FEEDER HOG RATIONS: TOTAL FEED REQUIREMENTS PER HEAD*

Feed Items	Oats and Barley		Wheat and Oats		Oats	
	lbs.	bus.	lbs.	bus.	lbs.	bus.
Wheat	-	-	155	2.593	-	-
Oats	309	8.583	348	9.667	486	13.5
Barley	195	4.0	-	-	-	-
Pig Starter	-	-	-	-	50	-
Hog Supplement	86	-	69	-	84	-

*Based on information contained in Principles and Practices of Commercial Farming, Faculty of Agriculture and Home Economics, University of Manitoba, Winnipeg, 1965, p. 210.

TABLE B-8

PRICE ASSUMPTIONS USED IN THE STUDY

INPUTS AND SERVICES

Item	Unit	Price
SEED		
Wheat	(bu.)	$ 2.15
Oats	(bu.)	1.30
Barley	(bu.)	1.65
Flax	(bu.)	4.75
Rapeseed	(lb.)	0.14
Sunflowers	(lb.)	0.30
Timothy	(lb.)	0.21
Meadow Fescue	(lb.)	0.19
Field peas	(bu.)	3.15
FERTILIZER		
Nitrogen (N)	(lb.)	0.12
Phosphate (P_2O_5)	(lb.)	0.085
COMMERCIAL FEED		
Pig starter	(cwt.)	5.60
Hog supplement	(cwt.)	6.20
Cattle supplement	(cwt.)	5.36
Barley purchased	(bu.)	1.30
Ration, prepairing and hauling	(Ton)	5.00
COSTS OF ANIMALS		
Calf	(cwt.)	24.60
Yearling	(cwt.)	23.80
Weanling	(head)	14.50
Transportation "in":		
cattle	(cwt.)	0.40
hogs	(head)	0.10
Transportation "out":		
cattle	(cwt.)	0.70
hogs	(head)	1.10
Hired labor	(hr.)	1.25

OUTPUTS

Item		Unit	Price
CROPS			
Wheat	Low	(bu.)	$ 1.25
	Medium	(bu.)	1.65
	High	(bu.)	1.90
Oats	Low	(bu.)	0.45
	Medium	(bu.)	0.55
	High	(bu.)	0.85
Barley		(bu.)	0.95
Malting barley		(bu.)	1.00
Flax		(bu.)	2.75
Rapeseed		(lb.)	0.0380
Sunflowers		(lb.)	0.0475
Timothy (seed)		(lb.)	0.10
M. Fescue (seed)		(lb.)	0.125
Field peas		(bu.)	1.85
Hay (aftermath)		(Ton)	12.00
Straw - no market value			
LIVESTOCK			
Good to choice steers		(cwt.)	25.30
Market hogs		(cwt.)	26.40

TABLE B-9

COST OF OPERATING FARM MACHINES PER HOUR OF USE, AND COST OF MACHINERY OPERATIONS PER ACRE

Machine	Size	Var. Cost per hour of use			Var. Cost per Acre		
		Repairs	Fuel Lubricants	Total	Machine	Tractor	Total
Tractor (gas)	3-4 pl.	.11	.71	.82			
Tractor (D.)	4-5 pl.	.12	.66	.78			
Combine (S.P.)	12 ft.	.86	.84	1.70	.51	-	.51
Swather (P.T.O.)	15 ft.	.20	.01	0.21	.04	.17	.21
Plow	4 pl.	.35	.01	0.36	.24	.52	.76
Cultivator (or disker)	14 ft.	.23	.01	0.24	.048	-	.22
Harrow	36 ft.	.10	-	0.10	.01	.07	.08
Drill	14 ft.	.38	.02	0.40	.08	.16	.24
Weed sprayer	56 ft.	.34	-	0.34	.03	.07	.10
Mower	7 ft.	.20	.02	0.22	.066	.25	.316
Rake	10 ft.	.20	.01	0.21	.063	.25	.313
Baler		1.31	.04	1.35	.98	.37	1.35
Trucking (grain)		-	-	-	-	-	.17
Fertilizer spreader				0.06	.04	.05	.09

TABLE B-10

CROP ENTERPRISE BUDGETS

	WHEAT			OATS			BARLEY		
RECEIPT ITEMS									
Value of crop	37 bu. @ 1.47= $54.39			85 bu. @ 0.55= $46.75			54 bu. @ 0.95= $51.30		
				.9 Ton straw for livestock (nor market value)					
GROSS VALUE PER ACRE			54.39			46.75			51.30
EXPENSE ITEMS									
	Mach.C.	Mat.	Total	Mach.C.	Mat.	Total	Mach.C.	Mat.	Total
Pre-growing and growing costs									
Cultivator or disker (2)	.98		.98	.98		.98	.98		.98
Harrow (2)	.16		.16	.16		.16	.16		.16
Drill (inc. seed treatment & cleaning)	.24	1.25bu.	3.01	.24	2bu.	2.84	.24	1.5bu.	2.72
Fertilizer		10.08	10.08		10.08	10.08		10.08	10.08
Spray	.10	1.25	1.35	.10	1.25	1.35	.10	1.25	1.35
Harvesting Costs									
Swather	.21		.21	.21		.21	.21		.21
Combine	.51		.51	.51		.51	.51		.51
Hauling	.17		.17	.17		.17	.17		.17
Crop Insurance			0.97			0.79			1.12
Sub-Total cash costs			17.44			17.09			17.30
Interest on above cash cost			1.05			1.03			1.04
T. Enterpr. Var. Costs (C_j values)*			18.49			18.12			18.34
NET RETURN PER ACRE			35.90			28.63			32.96

*Annual fixed costs are not allocated to individual crops but charged against the entire farming operation.

TABLE B-10 (continued)

	FLAX			RAPESEED			SUNFLOWERS		
RECEIPT ITEMS									
Sale of crop	19 bu. @ 2.75= $52.25			13.5 cwt. @ 3.80= $51.30			12 cwt. @ 4.75= $57.00		
GROSS RECEIPT PER ACRE			52.25			51.30			57.00
EXPENSE ITEMS									
	Mach.C.	Mat.	Total	Mach.C.	Mat.	Total	Mach.C.	Mat.	Total
Pre-growing and growing costs									
Cultivator or disker	.44		.44	.44		.44	.88		.88
Harrow	.16		.16	.16		.16	.16		.16
Drill	.24	.5bu.	2.62	.24	6lbs.	1.08	.24	3.5lbs.	1.29
Fertilizer		7.20	7.20		10.70	10.70		10.60	10.60
Spray	.10	1.25	1.35		1.25	1.25	.10	1.25	1.35
Harvesting costs									
Swather	.21		.21	.21		.21	.21		.21
Combine	.51		.51	.51		.51	.51		.51
Hauling	.17		.17	.17		.17	.17		.17
Crop Insurance			1.34						
Sub-total cash costs			14.00			14.52			15.17
Interest on above cash costs			.84			.87			.91
T. Enterpr. Variable Costs			14.84			15.39			16.08
NET RETURN PER ACRE			37.41			35.91			40.92

TABLE B-10 (continued)

	FIELD PEAS			MEADOW FESCUE			TIMOTHY		
RECEIPT ITEMS									
Value of crop	30 bu. @ 1.85= $55.50			350 lbs. @ 12.50= $43.75 (1 ton @ 12.00= $12.00)			400 lbs. @ 10.00= $40.00 (1 ton @ 12.00= $12.00)		
GROSS VALUE PER ACRE			55.50			55.75			62.00
EXPENSE ITEMS									
	Mach.C.	Mat.	Total	Mach.C.	Mat.	Total	Mach.C.	Mat.	Total
Pre-growing and growing costs									
Cultivator or disker	.44		.44	.15		.15	.15		.15
Harrow	.16		.16	.05		.05	.05		.05
Drill	.24	23bu.	7.49	.08	10lbs/3	.71	.08	6lbs/3	.50
Fertilizer		-	-	.09	10.95	11.04	.09	10.95	11.04
Sprayer	.10	1.25	1.35						
Harvesting costs									
Swather	.21		.21	.21		.21	.21		.21
Combine	.51		.51	.51		.51	.51		.51
Hauling	.17		.17	.17		.17	.17		.17
Sub-total cash costs			10.33			12.84			12.63
Interest on above cash costs			.62			.77			.76
T. Enterp. Var. Costs			10.95			13.61			13.39
NET RETURN PER ACRE			44.55			42.14			48.61

TABLE B-10 (continued)

	HAY BALING (1 Ton)	STRAW BALING (1 Ton)
		No market value
VALUE PER ACRE	12	
EXPENSE ITEMS	Total	Total
Rake	.31	.35
Baler	1.35	1.50
Hauling	.25	.30
SUB-total cash cost	1.91	2.15
Interest on above cash costs	.11	.13
T. ENTERP. VAR. COST/ACRE	2.02	2.28

TABLE B-11

FEEDER HOG BUDGETS

	Reg. Ration		Wheat Ration		Oat Ration	
RECEIPT ITEMS						
Sale of animal (96% x 152 lbs.)		38.52		38.52		38.52
Premium on 50% grade A		1.50		1.50		1.50
Total Gross Receipts		40.02		40.02		40.02
EXPENSE ITEMS						
Purchase cost of weanling		14.50		14.50		14.50
Veterinary and medicine		0.40		0.40		0.40
Transportation "in"		0.10		0.10		0.10
Purchased feed						
-Pig starter @ 5.60 cwt					50 lbs.	2.80
-Hog suppl. @ 6.20 cwt	76 lbs.	5.33	69 lbs.	4.28	84 lbs.	5.20
-Prep. ration @ 5.60 per T.	.3 T	1.50	.285 T	1.43	.31 T	1.55
Misc. (power and equipment)		1.25		1.25		1.25
Transportation "out"		1.10		1.10		1.10
Marketing charges		0.35		0.35		0.35
Sub-total cash costs		24.53		23.41		27.25
Interest on above cash costs (6% for 4 months)		0.49		0.47		0.55
TOTAL ENTERPRISE VARIABLE COSTS		25.02		23.88		27.80
NET RETURN ABOVE VARIABLE COSTS		15.00		16.14		12.22

TABLE B-11 (continued)

	Reg. Ration		Wheat Ration		Oat Ration	
RECEIPT ITEMS						
Sale of animal 96% x 152 lbs @ 26.40 (3% death loss, 1% tissue shrink.)		38.52		38.52		38.52
Premium on 50% grade A		1.50		1.50		1.50
TOTAL GROSS RECEIPTS PER HEAD		40.02		40.02		40.02
EXPENSE ITEMS:	Q	Cost	Q	Cost	Q	Cost
Purchase cost of weanling		14.50		14.50		14.50
Veterinary and medicine		0.40		0.40		0.40
Transportation "in"		0.10		0.10		0.10
Purchased feed						
Pig starter @ 5.60 cwt					50 lbs.	2.80
Hog suppl. @ 6.20 cwt	86 lbs.	5.33	69 lbs.	4.28	84 lbs.	5.20
Preparing ration @ 5.00/T	.3 T.	1.50	.285 T.	1.43	.31 T.	1.55
Power equipment and miscellaneous costs		2.40		2.40		2.40
Transportation "out"		1.10		1.10		1.10
Marketing charges		0.35		0.35		0.35
Sub-total cash costs		25.68		24.56		28.40
Interest on above cash cost (6% for 4 months)		.51		.49		.57
New hog barn. interest on $\frac{1}{2}$ invest. (6% head)*	17.55	.53		.53		.53
Depreciation		1.75		1.75		1.75
Total Enterprise Variable Costs		28.47		27.33		31.25
NET RETURNS ABOVE VARIABLE COSTS		11.55		12.69		8.77

*New hog barn: 36' x 70', slotted floors, fully equipped.
Total investment cost: $15,800.
Capacity 300 heads (900 heads per year)
Expected life 10 years.

TABLE B-12

BUDGETS FOR BEEF CATTLE ENTERPRISES

	440-lb. Calf Fattened to 940 lbs.			
	Ration with oats and barley		Ration with oats and wheat	
RECEIPT ITEMS				
Sale of animal (good to choice) (less 2% death loss, 1% tissue shrink)	97% x 940 lbs. @ 25.30 per cwt.		97% x 940 lbs. @ 25.30 per cwt.	
Total Gross Receipts		230.68		230.68
EXPENSE ITEMS				
Purchase cost of animal		108.24		108.24
Transportation "in"		1.76		1.76
Veterinary and medicine		1.00		1.00
Purchased feed				
-Prot. suppl. and minerals	56 lbs.	3.00	56 lbs.	3.00
-Grain rolling (feed prep.)	1.53 T.	7.70	1.5 T.	7.50
Miscellaneous (equipment and power)		4.25		4.25
Transportation "out"		6.58		6.58
Sub-total cash costs (operating cap.)		132.53		132.33
Interest on above cash costs	6% for 7 mo.	4.82	6% for 7 mo.	4.82
TOTAL ENTERPRISE VARIABLE COSTS		136.35		136.15
NET RETURN ABOVE OPERATING COSTS (not including home-grown feed)		94.33		94.53

TABLE B-12 (continued)

	700-lb. YEARLING FATTENED TO 1050 lbs.			
	Ration with oats and barley		Ration with barley and oats	
RECEIPT ITEMS				
Sale of animal (good to choice) (less 2% death loss, 1% tissue shrink)	97% x 1050 lbs. @ 25.30 per cwt.		97% x 1050 lbs. @ 25.30 per cwt.	
Total Gross Receipts		257.68		257.68
EXPENSE ITEMS				
Purchase cost of animal		166.60		166.60
Transportation "in"		2.80		2.80
Veterinary and medicine		0.90		0.90
Purchased feed				
-Prot. suppl. and minerals	31 lbs.	1.66	31 lbs.	1.66
-Grain rolling (feed prep.)	1.35 T.	6.75	1.34 T.	6.70
Miscellaneous (equipment and power)		3.95		3.95
Transportation "out"		7.00		7.00
Sub-total cash costs (operating cap.)		189.66		189.61
Interest on above cash costs	6% for 8 mo.	7.55	6% for 8 mo.	7.55
TOTAL ENTERPRISE VARIABLE COSTS		197.21		197.16
NET RETURN ABOVE OPERATING COSTS (not including home-grown feed)		60.47		60.52

TABLE B-13

MATRIX FOR THE BASIC STATIC MODEL

ROW No.	ITEM	SIGN	UNIT	LEVEL	GROW WHEAT 1 ac.	GROW OATS 1 ac.	GROW BARLEY 1 ac.	FLAX 1 ac.
39	OBJECTIVE FUNCTION ($c'_j s$)				-18.49	-18.12	-18.34	-37.41
	RESTRICTIONS				PRODUCTION ACTIVITIES			
	FARM RESOURCES							
	LAND							
1	Max.add. land		ac.	285,140				
2	Owned land		ac.	535,820	1.	1.	1.	1.
3	Max. purchased		ac.	285,140				
4	Max. rented		ac.	285,140				
	LABOR							
5	Op. spring labor		hr.	500	.87	.87	.87	.87
6	Op. summer labor		"	500	.17	.17	.17	.17
7	Op. fall labor		"	500	1.31	1.31	1.31	1.14
8	Op. winter labor		"	1,350	.45	.45	.45	.45
9	Hired spring labor		"	360				
10	Hired summer labor		"	360				
11	Hired fall labor		"	360				
	CAPITAL							
12	Op. S.T. capital		$	8,500.	17.44	17.09	17.30	14.
13	S.T. borrowing limit		$	10,000.				
14	Invest. capital		$	0.				
15	L.T. borrowing limit		$	50,000.				
	INTERMEDIATE PRODUCTS							
16	Wheat supply		bu.	0.	-37.			
17	Oats "		"	0.		-85.		
18	Barley "		"	0.			-54.	
19	Timothy "		cwt.	0.				
20	M. Fescue supply		"	0.				
21	Hay "		T.	0.				
22	Straw "		T.	0.		-0.9		
23	Hay baled		T.	0.				
24	Straw baled		T.	0.				
	CROP QUOTAS							
25	Spcd. ac. quota		bu.	0.	-9.	-9.	-9.	
26	Oat quota		bu.	0.		-10.		
27	Barley quota (feed)		bu.	0.			-10.	
28	Barley quota (malt)		bu.	0.				
29	HOG BUILDING SPACE		hd.	150				
	CROP PROPORT. RESTR.							
30	Cereals Mx. (70%)		ac.	0	0.30	0.30	0.30	-0.70
31	Wheat Mx. (50%)		"	0	0.50	-0.50	-0.50	-0.50
32	Oats & Bly. Mn.(20%)		"	0	0.20	-0.80	-0.80	0.20
33	Oilseeds Mn. (15%)		"	0	0.15	0.15	0.15	-0.85
34	Oilseeds Mx. (30%)		"	0	-0.30	-0.30	-0.30	0.70
35	Flax Mn. (10%)		"	0	0.10	0.10	0.10	-0.90
36	Sunfl. Mx (15%)		"	0	-0.15	-0.15	-0.15	-0.15
37	Forage Mx. (12%)		"	0	-0.12	-0.12	-0.12	-0.12
38	F. peas Mx. (10%)		"	0	-0.10	-0.10	-0.10	-0.10

39	35.91	40.92	44.55	-13.61	-13.39	-2.28	-2.02	45.00	48.42

PRODUCTION ACTIVITIES

ROW No.	RAPE 1 ac.	SUNFL. 1 ac.	F. PEAS 1 ac.	GROW M.FESC. 1 ac.	GROW TIMOTHY 1 ac.	STRAW BALING 1 ton	HAY BALING 1 ton	FH OB REG. R. 3 heads	FHOB WHT. R. 3 heads
1									
2	1.	1.	1.	1.	1.				
3									
4									
5	.87	.87	.81	.14	.14	.155	.14	1.	1.
6	.17	.63	1.	.99	.99	.055	2.5	1.	1.
7	1.14	1.14	.34	.26	.26	2.811	.08	1.	1.
8	.45	.45	.45	.45	.45	.5	.45	3.	3.
9									
10									
11									
12	14.52	15.17	10.33	12.84	12.63	2.15	1.91	73.59	70.23
13									
14									
15									
16									7.78
17								25.75	29.
18								12.	
19					-4.				
20				-3.5					
21				-1.	-1.		1.		
22						1.			
23							-1.		
24						-1.		.3	.3
25				-9.	-9.				
26									
27									
28									
29								3.	3.
30	-0.70	-0.70	-0.70	-0.70	-0.70				
31	-0.50	-0.50	-0.50	-0.50	-0.50				
32	0.20	0.20	0.20	0.20	0.20				
33	-0.85	-0.85	0.15	0.15	0.15				
34	0.70	0.70	-0.30	-0.30	-0.30				
35	0.10	0.10	0.10	0.10	0.10				
36	-0.15	0.85	-0.15	-0.15	-0.15				
37	-0.12	-0.12	-0.12	0.88	0.88				
38	-0.10	-0.10	0.90	-0.10	-0.10				

39	36.66	34.65	38.07	26.31	94.33	94.53	60.47	60.50	0

PRODUCTION ACTIVITIES

ROW No.	FHOB OAT R. 3 heads	FHNB REG. R. 3 heads	FHNB WHT. R. 3 heads	FHNB OAT R. 3 heads	FC CALF O-B 1 head	FC CALF O-W 1 head	FC YEAR O-B 1 head	FC YEAR B-O 1 head	LAND BUY 1 ac.
1									1.
2									-1.
3									1.
4									
5	1.	.7	.7	.7	2.	2.			
6	1.	.7	.7	.7					
7	1.	.7	.7	.7					
8	3.	2.1	2.1	2.1	12.	12.	12.	12.	
9									
10									
11									
12	81.75	77.04	73.68	85.20	132.53	132.33	189.66	189.61	
13									
14									125.
15									
16			7.78			17.5			
17	40.5	25.75	29.	40.5	52.138	52.694	48.138	34.138	
18		12.			23.458		19.687	29.541	
19									
20									
21									
22									
23					.187	.187	.11	.236	
24	.3				.16	.187	.11		
25									
26									
27									
28									
29	3.								
30									
31									
32									
33									
34									
35									
36									
37									
38									

39	-10.00	-1.25	-1.25	-1.25	-0.075	-0.06	0	-0.75	-1.00

MISCELLANEOUS ACTIVITIES

ROW No.	LAND RENT	LABOR HIRING			BORR. CAP.		BUILD	BUYING	
		SPR.	SUM.	FALL	S.T.	L.T.	H. BARN	OATS	BLY
	1 ac.	1 hr.	1 hr.	1 hr.	$	$	1 head	1 hr.	1 bu.
1	1.								
2	-1.								
3									
4	1.								
5		-1.							
6			-1.						
7				-1.					
8									
9		1.							
10			1.						
11				1.					
12	10.	1.25	1.25	1.25	-1.			.75	1.00
13					1.				
14						-1.	52.65		
15						1.			
16									
17								-1.	
18									-1.
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29							-3.		
30									
31									
32									
33									
34									
35									
36									
37									
38									

39	-13.00	1.65	1.25	0.55	0.55	0.45	0.95	0.75	1.00

MISCELLANEOUS ACTIVITIES

ROW No.	BUYING HAY	SALE OF CROPS							
		WHT	WHT.N.Q.	OATS	O.S.Q.	O.N.Q.	BLY.	BLY.N.Q.	M.BLY.
	1 ton	1 bu.	1 bu.	1 bu.	1 bu.	1 bu.	1 bu.	1 bu.	1 bu.
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12	13.								
13									
14									
15									
16		1.	1.						
17				1.	1.	1.			
18							1.	1.	1.
19									
20									
21									
22									
23	-1.								
24									
25		1.		1.			1.		
26					1.				
27									
28									1.
29									
30									
31									
32									
33									
34									
35									
36									
37									
38									

39	0.95	10.00	12.50	12.00

MISCELLANEOUS ACTIVITIES

ROW No.	SALE OF CROPS			
	BLY.S.Q. 1 bu.	TIM. cwt.	M. FSC. cwt.	HAY Ton
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18	1.			
19		1.		
20			1.	
21				
22				
23				1.
24				
25				
26				
27	1.			
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				

TABLE B-14

DIAGRAMMATIC ILLUSTRATION OF A THREE-YEAR

LINEAR PROGRAMMING MODEL

IDENTIFICATION OF SYMBOLS USED IN THE MATRIX

SYMBOL	ROW OR RESTRICTION NAME
COST	OBJECTIVE FUNCTION TO BE MAXIMIZED
LNDOW	MAXIMUM LAND THAT CAN BE OWNED
LNDMX	OWNED LAND
LNDPU	LAND AVAILABLE FOR PURCHASE
LNDRT	LAND AVAILABLE FOR RENTING
OSPLB	OPERATOR SPRING LABOR
OSULB	OPERATOR SUMMER LABOR
OFALB	OPERATOR FALL LABOR
OWILB	OPERATOR WINTER LABOR
HSPLB	HIRED SPRING LABOR
HFALB	HIRED FALL LABOR
OSTCAP	OPERATOR SHORT-TERM CAPITAL
STBOLM	BORROWING LIMIT ON S.T. CAPITAL
INVCAP	FARM INVESTMENT CAPITAL
LTBOLM	BORROWING LIMIT ON L.T. CAPITAL
WHTSPY	SUPPLY OF WHEAT
OATSPY	SUPPLY OF OATS
BLYSPY	SUPPLY OF BARLEY
TIMSPY	SUPPLY OF TIMOTHY
FSCSPY	SUPPLY OF MEADOW FESCUE
HAYSPY	SUPPLY OF HAY
STWSPY	SUPPLY OF STRAW
HAYBLD	HAY BALED
STWBLD	STRAW BALED
SPACQTA	SPECIFIED ACREAGE QUOTA
OATQTA	SPECIAL QUOTA ON OATS
BLYQTA	SPECIAL QUOTA ON BARLEY
HBLDSP	HOG BUILDING SPACE
CERMX	MAXIMUM ACREAGE OF CEREALS
WHTMX	MAXIMUM ACREAGE IN WHEAT
O+BMN	MINIMUM ACREAGE ON OATS AND BARLEY
OILMN	MINIMUM ACREAGE IN OILSEED CROPS
OILMX	MAXIMUM ACREAGE IN OILSEED CROPS
FLXMN	MINIMUM ACREAGE IN FLAX
SFLMX	MAXIMUM ACREAGE IN SUNFLOWERS
FORMX	MAXIMUM ACREAGE IN FORAGE CROPS
FPSMX	MAXIMUM ACREAGE IN FIELD PEAS
BOCAP	REPAYMENT OF BORROWED S.T. CAPITAL
FIXCOST	ANNUAL FIXED CHARGES TO THE FARM
REGCAP	AMOUNT OF CAPITAL REGENERATED
INVRP	AMOUNT OF INV. CAPITAL REPAID

SYMBOL	COLUMN OR ACTIVITY NAME
GWHT	GROWING OF WHEAT
GOATS	GROWING OF OATS
GBLY	GROWING OF BARLEY
FLAX	PRODUCTION OF FLAX
RAPE	PRODUCTION OF RAPESEED
SUNFL	PRODUCTION OF SUNFLOWERS
PEAS	PRODUCTION OF PEAS
GFSC	GROWING OF MEADOW FESCUE
GTIM	GROWING OF TIMOTHY
STWBL	STRAW BALING
HAYBL	HAY BALING
FHORR	FEEDER HOGS,OLD BARN, REGULAR RATION
FHORW	FEEDER HOGS,OLD BARN, WHEAT RATION
FHOOR	FEEDER HOGS, OLD BARN, OAT RATION
FHNRR	FEEDER HOGS, NEW BARN, REGULAR RATION
FHNWR	FEEDER HOGS, NEW BARN, WHEAT RATION
FHNOR	FEEDER HOGS, NEW BARN, OAT RATION
FCLOB	STEER CALVES, OAT-BARLEY RATION
FCLOW	STEER CALVES, OAT-WHEAT RATION
FYROB	YEARLINGS FED WITH OATS AND BARLEY
FYROO	YEARLINGS FED WITH BARLEY(MORE) AND OATS
BLAND	PURCHASE OF LAND
RLAND	RENTING OF LAND
HSPLB	HIRING OF SPRING LABOR
HSULB	HIRING OF SUMMER LABOR
HFLLB	HIRING OF FALL LABOR
BSTCP	BORROWING OF SHORT-TERM CAPITAL
BLTCP	BORROWING OF LONG-TERM CAPITAL
BLDHBN	CONSTRUCTION OF A HOG BARN
BOATT	PURCHASE OF OATS
BYBLY	PURCHASE OF BARLEY
BYHAY	PURCHASE OF HAY
SLWQ	SALE OF WHEAT
SLWNQ	SALE OF NON-QUOTA WHEAT
SLOQ	SALE OF OATS
SLOSQ	SALE OF OATS ON SPECIAL QUOTA
SLONQ	SALE OF OATS OUTSIDE THE QUOTA
SLBLYQ	SALE OF BARLEY
SLBYNQ	SALE OF BARLEY OUTSIDE THE QUOTA
SLBYSQ	SALE OF BARLEY ON SPECIAL QUOTA
SLTIM	SALE OF TIMOTHY
SLFSC	SALE OF MEADOW FESCUE
SLHAY	SALE OF HAY
FIX	ANNUAL FIXED CHARGES
STO CAP	TRANSFAR OF SURPLUS INCOME
STCR	REPAYMENT OF SHORT-TERM CREDIT
LTCR	REPAYMENT OF LONG-TERM CREDIT

SYMBOL	RANGE OF NUMBERS		
U	.01	THROUGH	.099
T	.1	"	.99
1	1.0	"	1.0
A	1.0	"	10.0
B	10.0	"	100.0
C	100.0	"	1000.0
D	1000.0	"	10000.0
E	10000.0	"	100000.0