1969

The application of linear programming to farm management: a study of a central Iowa farm

Malcolm D. Bale
Iowa State University

159

THE APPLICATION OF LINEAR PROGRAMMING TO FARM MANAGEMENT: A STUDY OF A CENTRAL IOWA FARM

by

Malcolm David Bale

A Thesis Submitted to the

Graduate Faculty in Partial Fulfillment of

The Requirements for the Degree of

MASTER OF SCIENCE

Major Subject: Economics

Iowa State University
Ames, Iowa

1969

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

I. INTRODUCTION

A. Farm Management

The successful commercial farmer today is an intelligent, well-informed businessman oriented to and responding to commercial market situations in such a manner as to maximize profits.[1] In this context farm production is only partly dependent on natural resources and technology, and is equally or more dependent on economic variables such as prices, costs, and producers' income.

With the growing emphasis on economic aspects of farming together with the trend towards greater capital intensity on farms, farm management has become increasingly complex. The restriction on the magnitude of profits has become less one of aquaintance with farm practices and more one of properly fitting all production alternatives into an integrated plan consistent with resource supplies and market prices. In this setting farm management may be defined as those decisions that affect the profitability of the farm business. Management concerns the process of gathering information, of interpreting it, of making decisions, and of accepting the consequences of decisions made and acted upon in a previous time period. Accordingly, successful farm management requires that the manager have the ability to make the "right" decisions in the sense that, *ex-post*, they are the most profitable ones.

---

[1]This may not be a farmer's only objective, as explained on page 2.

The management process is not mechanistic but very much a human phenomenon. It is an aggregation of interacting human goals, beliefs, values, experiences, and expectations, constrained by exogenous physical, social, economic, and temporal phenomena. The management process is so complex, in fact, that social scientists are only now attempting to systematize it for the purpose of simulating it in mechanistic models. This approach is called a "Behavioral Thaory of the Firm" and has been described by Cyert and March (7) and applied by Shechter (36). Prior to this development the management process had only been studied in terms of its visible effects. Social scientists studied the results of management and pinned them to some objective scale of success-failure, often a profit scale. A great deal of research has been done in which organizational or operational goals were assumed, and then a set of managerial decisions deduced that would optimize the managers attainment of the assumed goal. Production economics has become a discipline of economics specializing in the search for production and organizational optima.

By now we are aware of the fact that goals other than profit maximization enter into decisions made by managers. We shall therefore redefine "right" decisions as used on page 1 to include all decisions resulting in the maximization of a farmer's objectives, one of which is to make a profit on his operation. Our definition of "successful management" now becomes broadened to include non-profit objectives as we in fact find in reality.

Implicit in the foregoing discussion is the fact that the need for management grows out of change and the inability to predict the future with certainty. The dynamic nature of the economy in which agriculture operates necessitates continual revision of farm plans as more information becomes available. As Heady and Jensen state, "If yields did not vary and prices fluctuate from year to year, a farmer's first decision might well be his last. He would devise a single and final plan for the farm based on realizing the most profit from his land and other resources in the pleasant expectation that this same economic situation might last for years" (21, p. 7).

Skillful management not only involves effective organization of short run plans but the ability to plan long run firm growth and development. In the long run a firm has more flexibility and more alternatives available to it as all resources become variable.

Some of the more general decisions affecting profitability in farming might be: 1) What size should a farm be and what land tenure system is most suitable? 2) What enterprises should be pursued and at what level? 3) At what time should farm products be sold or farm inputs purchased? 4) Should extra labor be hired and/or extra capital borrowed? What quantity of each should be employed and how should they be allocated between enterprises? 5) What types and rates of fertilizer should be applied? 6) What equipment is it profitable to purchase and how much custom work should be hired?

As is obvious from the above list, farm planning, if it incorporates all relevant farming practices, investment alternatives, and scarcity of resources, is a complicated process. Extension personnel and farmers seldom have the skill to consider fully all appropriate alternatives in formulating farm plans. A manager may be so involved with the everyday affairs of his firm that he cannot "step back" and view the farm as a whole to plan its future development. As a consequence a "piece-meal" approach to farm business decisions has been the norm. This approach ignores the direct or indirect effects that a given change in one part of the farm has on other parts, and as such may be severely limiting.

Linear programming as applied to farm management offers the opportunity to consider simultaneously all possible farming activities and, mindful of resource restraints, give a profit maximizing farm plan. In this study we utilize the technique of linear programming in analyzing the operations of a particular farm-firm.

B. Definitions and Concepts

The terminology of even that small part of the literature of economics relating to production in agriculture is highly volatile. The various interpretations to which certain words are open leads to considerable confusion. Already in this thesis words and phrases have been used without adequate explanation. Accordingly some explicit definitions of certain terms and concepts used in this study will now be given.

1. The farm-firm

We will consider a firm to be a business entity whose primary purpose is the creation (or increase) of monetary profit. A farm is a set of resources and activities functionally concerned with the creation of agricultural products. Thus a farm-firm by the above definitions is a business entity primarily concerned with creating monetary profit primarily by means of agricultural production. Business activities that are not agricultural production but involve a firms production, such as marketing livestock or merchandizing grain, are allowed in the firm but not in the farm. Some production activities of the farm that do not lead to the creation of monetary utility are allowed in the farm but not the farm-firm. This may include keeping a registered hog for show purposes. It is possible to further clarify the distinction between 'farm,' 'firm,' and 'farm-firm' by the use of Boolean algebra. Consider the venn diagram shown in Figure 1.

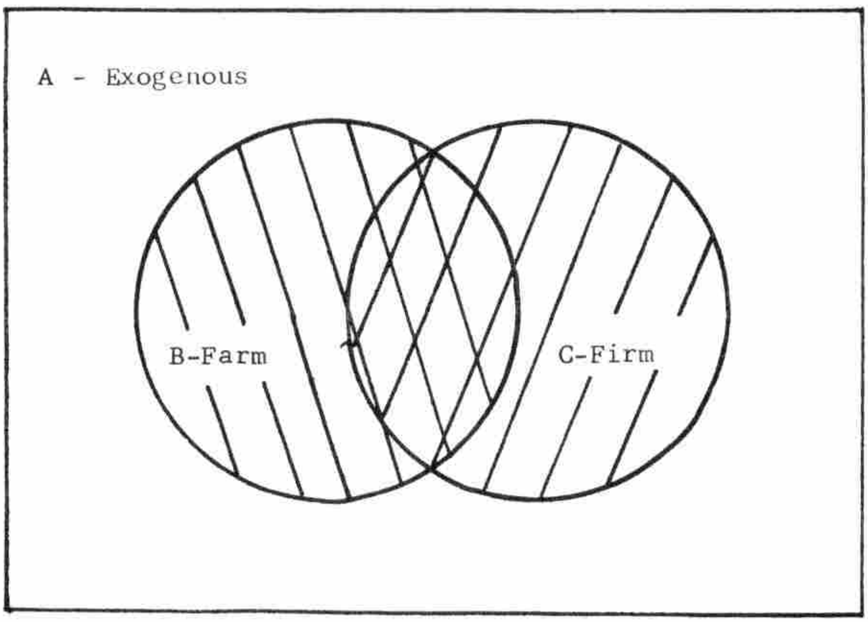

Figure 1. Farm, firm, and exogenous space

Space A, called 'Exogenous', is the compliment or disjoint of spaces B and C. Space B, labelled 'Farm,' includes all the resources, activities, and services related to the physical aspects of agricultural production. Space C, named 'Firm' includes all of the resources, activities, and services related to the business enterprise. The subspace 'B intercept C' is the collection of activities, resources, and services that are referred to as the 'farm-firm' in this study. By mathematical definition it includes only those elements that are members of both spaces B and C, i.e. $B \cap C$, such as land owned by the firm and used for raising crops. The subspace that we shall call 'farm-nonfirm' is defined as those elements in space B that are disjoint from space C, i.e. $B\,\overline{C}$ (read 'B not C'). Examples include non-business production activities such as prize hogs, and non-business decisions of the farm family such as taking vacations. The term 'firm-nonfarm' refers to those elements in space C that are not in space B, i.e. $C\,\overline{B}$ (read 'C not B'). This subset includes business activities not directly related to agricultural production such as investment in corporate stock or renting a farm house.

The independence of farm and firm in this study is not clear. For example, it may be necessary for a farmer to borrow short term production capital to finance livestock say, in order to make long term corporate share investments. Under this situation there clearly exists an interrelationship between 'farm' and 'firm' which is broader than our definition of 'farm-firm'. However, since information on 'firm-nonfarm' investment opportunities open to the farm manager are non existent, no attempt to incorporate this was made. Hutchinson (27) recognized (at least implicitly) the problem of the interrelationship of 'farm' and 'firm' with respect to capital investment and incorporated exogenous investment in his model. This is explained in greater detail later.

2. Investment

Investment is the process of allocating capital in the expectation of receiving a future income stream.

Interest is (a) the return to investment and includes such components as liquidity and time preference, and risk, or (b) the cost of credit. We may divide investments by origin into exogenous or firm investments. Exogenous investments are defined as those where capital is allocated to the firm from an outside source. This investment is commonly called credit and its cost is defined by contractual agreement. In this study short term production credit is not explicitly included for reasons discussed later. Long term financing of land is assumed available on a mortgage basis and is allowed at the current contractual interest rate.

A complication arises with respect to farm-firm investments. Allocations of farm capital to farm production activities have no defined contractual rate of return. A solution to this problem is to impute a rate of interest to farm-firm investments that is based upon the opportunity cost rate of return of an equivalent firm-nonfarm investment. Of the many bases available to estimate this it is important to choose one that might offer a real alternative to the farm-firm investment under evaluation. In this study the rate of return used is five percent on all investments except land which is six percent. These rates were chosen since the size and term of farm-firm investments is approximately the same as those that might be made in savings and loan associations or mortgage lenders, which currently pay at that rate.

3. Returns to entrepreneurship or net profit

We shall use these terms as synonyms in order to cover a broader audience.[1] We define entrepreneurship as the activity of making available to the firm those resources and services required by it. The return to entrepreneurship, or net profit, is estimated as the gross income generated by the farm-firms activities less rent (return on investment), cost of inputs used in production (operating costs[2]), and taxes. Gross income includes all receipts received by the farm-firm and should include inventory changes and capital gains or losses.

While investment functions may pertain to either "natural" or "legal" persons i.e. either actual persons or legal entities such as corporations, entrepreneurship is a function always carried out by a "natural" person.

The entrepreneur of a farm-firm may have zero investment in the business, may contribute no labor to the production process, and thus may only function as a decision maker bringing together those inputs required for the firm to operate. On the other hand the entrepreneur may be the owner

[1]The layman reader is more likely to understand the term 'net profit' while the economist may prefer the concept of 'entrepreneurship return' as defined here.

[2]Operating costs include remuneration of labor and management.

of all resources and may contribute all of the labor used in production activities of the farm. Both these extremes are atypical of U.S. farm structure. In the farm studied, labor and entrepreneurship, and some investment are supplied by the farm owners.

We have made a distinction between returns to entrepreneurship and the more usual terms of quasi-rent and pure economic profit (Ferguson 13, p. 318) because quasi-rent includes the opportunity cost of the inputs while returns to entrepreneurship does not, and pure economic profit concerns the short run return to fixed inputs whereas returns to entrepreneurship is considered to remain in the long term and is derived from all inputs.

By partitioning returns between labor and management, investment, and entrepreneurship, as defined here, it is possible to compare different farm-firm programs on a consistent basis. The return to entrepreneurship may be considered an efficiency criterion and as a residual may be allocated between consumption, firm-nonfarm investment, and farm-firm investment, as the entrepreneur desires.

4. Linear programming

For the moment we shall define linear programming as a computational method used in prescribing production patterns which maximize profits of firms, minimize costs of producing a specified commodity, or related types of aggregative analyses. We shall explain the computational method in greater detail in Chapter IV.

5. Process and activity

In linear programming terminology an activity is an enterprise such as the growing of corn or raising hogs. A process describes the enterprise more specifically. Thus we may have the activity of growing corn by process 1, 2, or 3, where different processes refer to different fertilizer applications.

6. Shadow price

The shadow price of a resource is its marginal value product. Thus the shadow price of a resource indicates the amount added to profit by a one unit increase in the level of resource available. Only resources which are limiting a plan have positive shadow prices. Shadow prices are of interest since they indicate possible gains in income through acquisition of an additional unit of scarce resource.

C. Summary

In this introductory chapter we have briefly examined the role of farm management and management decisions in successful farm operations. We have seen how complicated the entire management function may be and we have mentioned linear programming as a method of overcoming some of these difficulties. We have, by the explicit defintion of terms, established a common base from which we may now build. Therefore we now continue the analysis by outlining the aims of the study.

II. OBJECTIVES

The general objective of this study is to apply linear programming methods, as a farm management tool, to the problem of profit maximization on an individual farm-firm. The study attempts to determine the feasibility of providing optimum plans and estimates of the resulting net income for individual farmers when plans are developed directly from their records and are tailored to suit their particular situation and objectives. In addition, the study endeavors to show how the combination of farm activities may alter over time as additional land is acquired.

Within this overall framework specific objectives are:

1. To analyze input-output data from records of a particular farm by programming optimum enterprise combinations and resource supplies of the individual farm-firm.
2. To determine the optimum resource use for the farm-firm by considering only those alternative resource uses consistent with the objectives and plans of the farm manager.
3. To establish the sensitivity of optimum plans. The sensitivity analysis includes:
   a) The effect of cost changes on optimum activity levels.
   b) The value of changing the resource restraint levels and the interval over which the value is valid. This information is important because it indicates how a problem may be adjusted to increase profit, and when the problem should be recomputed because of cost or price changes.

4. To specify a pattern of grain storage, sales, and purchases consistent with prices, grain use, and storage capacity.
5. To ascertain capital "flows" over a yearly period.
6. To indicate an optimum resource allocation between activities on an expanded land base by examination of several static models.
7. To examine the profitability of a turkey raising enterprise when competing with various other livestock activities for labor and other cropping activities for land.
8. To quantify the optimum farm size for a farm-firm with the activities and resources specified here, operating in the Clarion-Nicollet-Webster soil association area of Iowa.
9. To form a generalized model of the farm-firm so that future information on prices, technology, etc., may be incorporated into the model to give revised and updated farm plans.

Having elucidated the objectives of the study we shall continue by describing the present farm-firm.

III. THE SETTING OF THE STUDY FARM

As long ago as 1776 Adam Smith noted in his epoch-making book on economic ideology that "the gain in product from the division of labor... is owing to three different circumstances: firstly to the increase in dexterity in every particular workman; secondly, to the saving of time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labor...." (37, p. 13) To the Agricultural Economist nowhere has this phenomenon been more clearly illustrated than in the development of farms over the last decade. The farm analyzed in this study exemplifies this division of labor: a) labor is divided between enterprises so that each man may specialize in a particular area, and b) modern capital intensive equipment has replaced labor and enhanced its productivity.

The 720 acre farm which is located in Boone County, Iowa, consists of four tracts of land lying along five miles of road (see Figure 2). The farm, whose modus operandi is as a limited liability corporation, is operated by a father and two sons. Each has a particular area of interest within the total farm operation. One is in charge of the intensive and highly mechanized hog system, another tends turkeys, arranges produce sales, and does the bookwork, while the third is primarily involved in crop production. Of the 720 acres, 520 are owned by the corporation, 160 are leased from members of the family and forty acres are leased privately on a 50-50 share basis.

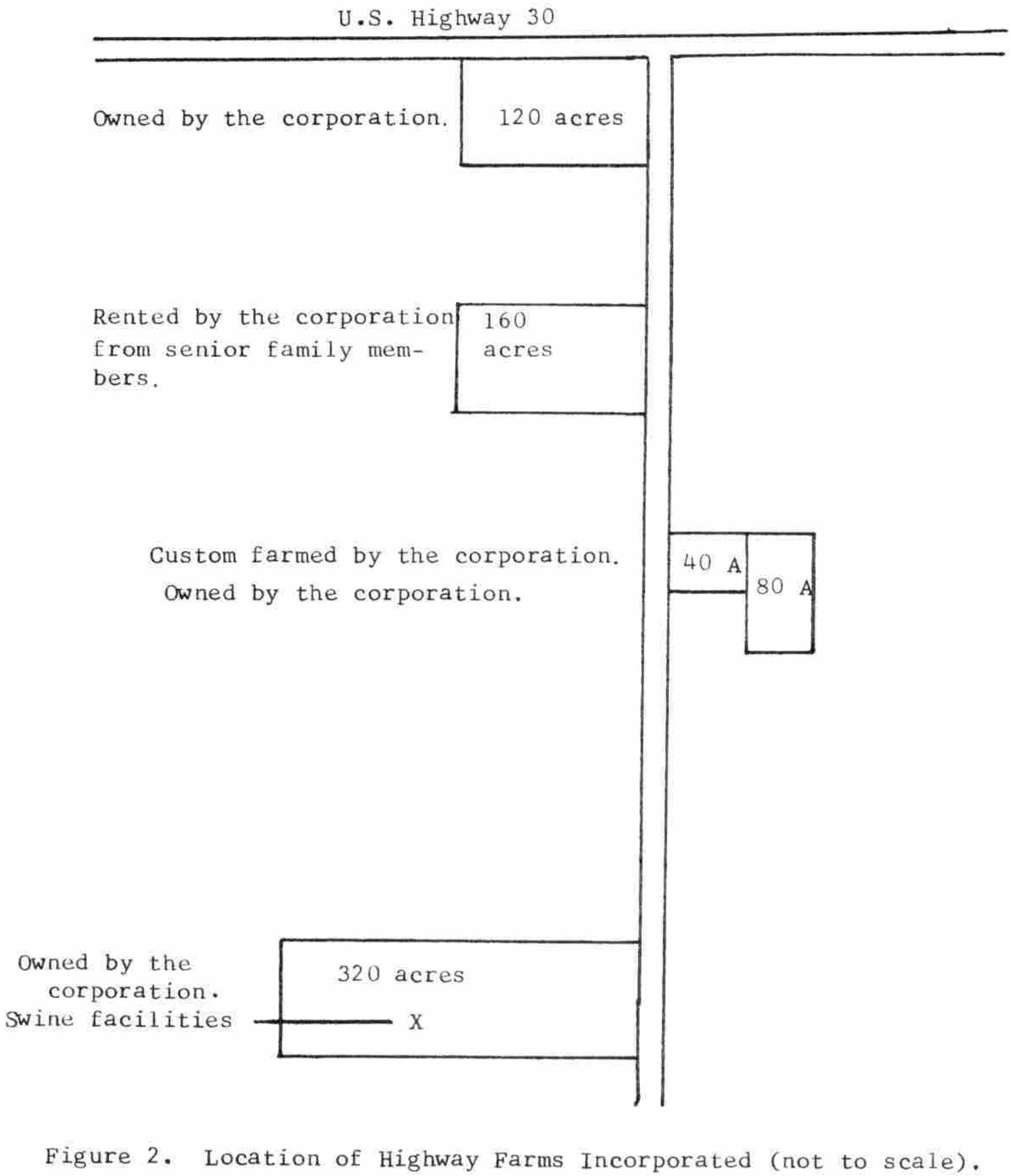

Figure 2. Location of Highway Farms Incorporated (not to scale).

The farm is located in the Clarion-Nicollet-Webster soil association, an area known for its highly fertile soil. It is completely flat (0 to 4% slope), well drained, and has a moderate to high level of organic matter.

A. Present Management Practices

1. Hog production

Over 1000 hogs are raised annually. Sows are continuously farrowed in a completely confined central farrowing-nursery house containing 20 farrowing crates and sixteen nursery pens. After weaning at 40 lbs young hogs are transferred to open-shed concrete lots where they are grown out to 220 lbs. The growing lots have a modified cattle auger feed system and automatic heated water troughs.

The insulated farrowing-nursery building has a heated floor, thermostatically controlled ventilation fans which periodically provide an air change, and an automatic watering service. Feed however is carried in by hand.

Manure disposal is effected by sloping floors in the farrowing pens and nursery units leading to a central gutter which in turn carries wastes to a storage pit. The pit is pumped out weekly and the contents spread on the land.

Thus the total farrowing system is designed so that one man can tend the maximum number of litters possible.

Gilts are chosen from litters and are later crossed with boars purchased annually from the Iowa Swine Testing Station. A three way cross using Durocs, Hampshires, and Yorkshires is currently employed. Sows are kept for about five years before being replaced.

Hogs are sold on the farm to a local buyer.

2. Turkey production

Between 12,000 and 13,000 turkeys are raised from day old poults to 28 lb birds, annually. The first of two batches of 6,500 birds arrives in mid March and is sold in mid September, while the second batch is started on 1 June and sold on 1 December.

Poults are brooded in an environmentally controlled insulated building. For the first week of their lives they are kept on peat litter and contained by low corrugated cardboard walls. They are subsequently placed in wire mesh pens with wire floors and kept here for the next five weeks. If weather conditions are suitable, birds are moved outside during the last week of their confinement in order to harden them off and give them the benefit of the sun before being placed on the range. The remaining eighteen weeks of their growing period is spent on the range.

White strains of tom turkeys are raised. Although tests show that bronze strains out-perform whites in feed efficiency, (29) the farm managers raise whites because of the greater net revenue resulting from slightly higher prices received for the more attractive broad breasted white turkeys. Similarly, despite the fact that hens consume less feed per pound of weight gain, toms are chosen because they utilize a higher grain-lower protein ration, giving them a cost advantage over hens.

Although contracts guaranteeing a liveweight price per pound at time of delivery are becoming more common, the farmer sells his flock on the farm to the highest bidder at the time the birds reach market weight.

3. Crop production

Because of the high price paid to diverted land under the Federal Government Feed Grain Program, the practice has been to participate in this program up to the legal limit. Thus of the 680 cropable acres corn is only raised on one half of the farm's corn base acreage of 350 acres. That is, 175 acres of corn is grown and a matching 175 acres is placed in meadow and left idle. A further 40 acres are planted in an oat-alfalfa mix and used for pasturing turkeys. The balance of 290 acres is divided between oat and soybean production.

In its first year a crop of oats is harvested from the turkey pasture. A cut of hay is taken from it in the second year, prior to releasing turkeys onto it.

Although the land possesses the potential to produce continuous corn, a haphazard rotation is practiced with the exception of a forty acre rented block which is planted in continuous corn. Land to be cropped is fall plowed for several reasons:

1. The farm enterprises do not include pasturing animals and therefore fallen grain and stalks do not constitute a forage source.

2. Under the present farm organization spring labor is always limiting.

3. Since the soil dries and warms earlier if Fall plowed, Spring tillage and planting may commence earlier.

Six row equipment with a 75 h.p. tractor is employed and crops are planted in 30 inch rows. Corn is planted at a population density of between 21,000 and 25,000 plants per acre.

Because of the closely spaced rows and high plant populations heavy rates of fertilizer are applied to corn. A typical fertilizer program is: 150 pounds per acre of anhydrous ammonia applied as a preplanting treatment when the land is being tilled in spring; 90 pounds per acre of 6-24-24 N.P.K. applied at planting; and 150 pounds per acre of 0-52-52 plowed down in Fall.

Herbicides (either 2,4-D or atrazine) are applied when corn is four to six inches high, and an insecticide (either aldrin or diazinon) is applied at planting time to control corn borer and other pests. Using the above husbandry the farm yields an average of 125 bushels of corn per acre.

Fertilizer is not applied to soybeans but a herbicide, Amiben , is applied at a rate of ten pounds per acre. Soybeans currently yield forty bushels per acre.

Oats are fertilized when planted with 120 pounds per acre of 30-10-10 N.P.K. giving an average yield of ninety-five bushels per acre.

4. Grain storage

Present facilities allow for storage of 70,000 bushels of grain in a 5,000 bushel corn crib, a 5000 bushel silo, and an assortment of steel bins.

Included in ancillary equipment are two fixed grain driers, a mobile grain drier, and a feed grinding and mixing mill.

In addition to storing Federal Government grain, the corporation stores its own corn, oats, and soybeans. Further, some of the additional corn needed throughout the year for hog production is bought shortly after harvest when its price is lowest and stored in the farm's bins until required.

The corporation's equity on the 520 acres of land and fixed improvements is around sixty percent of its market value. This however does not include 160 acres of freehold land leased by the corporation from family members which will eventually be bequeathed to the younger shareholders of the corporation. Given this situation the firm has no difficulty in arranging either short term working capital loans, or longer term mortgages on property purchases.

It is in this general framework that the study is set. Because of the obvious complexity in designing an optimum farm plan consistent with resource quantities and because of the corporation's desire to expand its total operation in the future, assistance was sought by the operators thus giving this study its origins.

We now have an insight into the current operation of the study farm. The following chapter deals with some theoretical aspects concerned with the method of analysis used in the study.

IV. TECHNIQUE AND METHODOLOGY OF LINEAR PROGRAMMING

Five basic linear programming models are analyzed in this study, the details of which are described subsequently under the heading "Farm Programming Models."

In this chapter the following items are discussed: Firstly, the origins of linear programming are briefly surveyed; secondly, a general static linear programming model is described; thirdly, the assumptions of the technique are discussed; and finally, three production economics principles important in the understanding of linear programming logic are reviewed.

A. The Origins of Linear Programming

Historically, the general problem of linear programing was developed and applied in 1947 by George B. Dantzig and Marshall Wood, both mathematicians of the U.S. Department of the Air Force. They proposed that "the interrelationships between the activities of a large organization (should) be viewed as a linear programming type model and the optimizing program determined by the maximization of a linear objective function" (42, p. 17). Equally important was the concurrent development of the simplex algorithm for the solution of a linear program by digital computers, presented by Dantzig to a conference in Chicago, Illinois in 1949 and published in 1951 (9).

Since then linear programming has become an important tool in mathematics, engineering, industrial planning, business and economics.

The history of its use in agricultural economics is almost as old as the method itself. At the same comference at which Dantzig presented his papers, Hildreth and Reiter tendered their contribution, "On the Choice of a Crop Rotation Plan" (24). Since this publication in 1951 the literature of agricultural economics has abounded with applications of the technique to agricultural problems. That this should come to pass is no accident. It is surely because linear programming approximates two essential features of many economic problems. Firstly, in practice economic choices are made between a finite set of competing alternatives, and secondly, the best choice among alternatives is often severely constrained by numerous economic, technological, institutional and social factors.

By 1956, after several problems had been overcome, linear programming was firmly established as a valuable tool in farm management analysis. It was regarded by many as a formalized extension of farm budgeting capable of solving much more complex problems than the latter. One of the noteworthy contributions to this specific area at that time was published by Heady and Gilson (20). They noted the following important conclusion which has served as the rationale for further individual farm management studies. Their research showed "that there is not an optimum set of livestock enterprises or management practices (i.e., level of grain feeding) for all farms, but that recommendations should differ between farms depending on their capital and labor situations, as well as on their ability to stand risks." (20, p. 712) Subsequently, literature dealing with the use of linear programming in farm management has taken two paths. Firstly, many publications have dealt with the application of original models to various other farm situations, and secondly, others have dealt with modifications of the original model in order to increase its informational content. The reader is referred to Kopetz (34) for details on this latter development.

B. A Mathematical Statement of the General Static Linear Programming Model

At the outset it is necessary to realize that linear programming, like other activity analyses, is entirely mathematical in nature. It was developed primarily as a computational method to deal with the calculation of explicit solutions to complicated practical allocation problems for which numerical data is available. Although programming *per se* may not be able to tell us anything about a particular part of an economy, it can help us find the implications of the economic information we have assumed. That is, there is a connection between these methods and the much older idea of pricing, implicit or market, of scarce resources.[1]

Generally, programming is concerned with the determination of the optimal solution to a problem. Linear programming involves the maximization or minimization of a linear objective function subject to a set of linear constraints. Thus the general linear programming problem is to find the vector $(x_1, x_2, \ldots., x_n)$ which maximizes the linear objective function,

---

[1]This connection became apparent to the economists who took part in the development of linear programming. For example see Koopmans (32) and Dorfman (11).

$$Z = \sum_{j=1}^{n} c_j x_j \tag{1}$$

subject to the linear constraints

$$x_j \geq 0 \qquad j = 1,2,...,n \tag{2}$$

and $$\sum_{j=1}^{n} a_{ij} x_j \leq , = , \geq b_i \qquad i = 1,2,...,m \tag{3}$$

Equation 3 is multipled by -1 where necessary to make all $b_i \geq 0$. Thus by inclusion of slack variables the equation may be rewritten as

$$\sum_{j=1}^{n+m} a_{ij} x_j = b_i \qquad i = 1,2,...,m \tag{4}$$

where a_{ij} is the input coefficient expressing how many units of resource i are required to produce one unit of activity j,

b_i is the number of units of the i^{th} resource available for allocation,

c_j is the net revenue per unit of the j^{th} activity,

x_j is the level of the j^{th} activity,

n is the number of real activities, and

m is the number of disposal (slack) activities.

The mathematical formulation of the programming problem may be stated more compactly in matrix form as:

$$\max \quad c'x \tag{5}$$

$$\text{subject to} \quad Ax = b \tag{6}$$

$$x \geq 0 \tag{7}$$

where

x is the column vector of activity levels,

b is the column vector of resource restrictions,

c' is the transposed row vector of net returns, and

A is the m x n matrix of input-output coefficients.

A slight modification of the above model allows the formulation of a parametric programming model. Frequently the researcher wishes to know how the optimal solution of a given linear programming model changes as one of its parameters is altered. As there are three basic sets of data in the model, viz; the c vector, the b vector, and the A matrix, there are three corresponding types of parametric programming operations. Parameterizing the net revenue coefficients, that is, parametric programming of the objective function, the problem may be expressed as:

$$\max\ (c + d)'\ x \qquad (8)$$

$$\text{subject to}\quad Ax = b \qquad (9)$$

$$x \geq 0 \qquad (10)$$

where d is a vector of identical dimensions as c.

Parametric programming is a post-optimal procedure commencing after a solution to the basic linear programming model (where d = 0) has been obtained. Since agricultural product prices typically vary from year to year this modification is very useful in a linear programmed farm management analysis.

For further details on linear programming, its extensions, and its agricultural application, the reader is referred to Dantzig (8) and Heady and Candler (19).

C. The Assumptions of Linear Programming

Heady and Candler list the four major assumptions made in the application of linear programming as:

> 1. Additivity and linearity. The activities must be additive in the sense that when two or more are used, their total product must be the sum of their individual products....
>
> 2. Divisability. It is assumed that factors can be used and commodities can be produced in quantities which are fractional units....
>
> 3. Finiteness. It is assumed that there is a limit to the number of alternative activities and to the resource restrictions which need be considered....
>
> 4. Single value expectations. In general...(the assumption is made) that resource supplies, input-output coefficients, and prices are known with certainty. (19, p. 17)

These assumptions are not as restrictive as superficially appears. It has been adequately demonstrated elsewhere that the linear programming model is a logical extension of linear economic theory which is itself a restatement of the conventional theory of competitive equilibrium (12, ch. 13 and 14). In fact "linear programming is marginal analysis appropriately tailored to a finite number of activities" (12, p. 133).

If the assumption of a homogenous production function of degree one, which is the basis of this theory, is acceptable, it is difficult to argue with the linearity assumption employed in programming.[1] However because of resource indivisabilities variable proportions may have to be admitted in some cases. Fortunately such a situation may be approximated by means

---

[1] For a discussion on the respectability of the assumption of constant returns to scale see Samuelson (35, p. 84).

of a series of linear segments.[1]

The divisability assumption, while a necessary mathematical requirement in the simplex method, may be adapted to the particular empirical problem. Thus if the solution specifies that 452.37 acres of corn be grown, we may reasonably ignore the decimal figure. Indeed, we may even feel justified in rounding off even further and reporting the answer as 450 acres. For other programming problems where a fractional answer is totally meaningless and unacceptable a modification known as integer programming[2] may be used. Thus the divisability assumption is not as restrictive as it may first appear.

The additivity assumption may impose certain limitations. It does not permit, for example, a complementary relationship between any two activities.

The finiteness assumption also, while a necessary mathematical requirement, does not impose any restrictions in empirical investigations. It is true that fertilizer, for example, may be applied in infinitesmally small increasing amounts on a farm. A farmer however is far from interested in considering this number of alternatives. We may therefore only include three or four discrete levels in an analysis. Besides the practical side which renders the finiteness assumption non-restrictive, the degree of finiteness depends on the capacity of the computer being used to

---

[1]For example see Candler and Musgrave (6).

[2]See R. E. Gomory (16, 17).

solve the problem. Modern computers now have the capacity to handle several thousand activities and as a consequence the finiteness assumption does not become circumscriptive.

The assumption of single valued expectations while certainly unrealistic for some farming situations may be partially overcome by the use of parametric techniques previously mentioned where resource supplies, prices, and input coefficients, are allowed to vary. This modification however does not explicitly consider the effects of, for example, weather variability or risk aversion. Thus a better solution to the problem of variability or risk in programming analyses is to use stochastic linear programming, where we assume that some coefficients are random variables. Examples and explanation of the use of this technique may be found in Beale (2) and Candler (5).

We have now found that in empirical analyses the assumptions of linear programming are not so restrictive as to limit the usefulness of the technique.

D. Principles Involved in Combining Farm Enterprises

Three basic production economics principles are involved in this study: the factor-product relationship; the factor-factor relationship; and the product-product relationship. Since an understanding of these principles enhances our recognition of problems involved in integrating many farm activities into an overall profit maximizing plan, a modified version of them, depicting linear relationships as assumed in this study, will be presented.

1. The factor-product principle

This principle concerns changes in output of a given product resulting from changes in the level of inputs used in its production. The classical production function,

$$Y = f(x_1, x_2, \ldots, x_n) \tag{11}$$

is assumed to be a single-valued continuous function with continuous first- and second-order partial derivatives at every point on the function, where

Y = the quantity of output of a given product

$x_1, x_2, \ldots, x_n$ = the quantities of inputs used in the production of Y, and

f = some mathematical function.

If we now vary x_1 holding all other factors fixed then we may derive a production function similar to that shown in Figure 3. It will be continuous and the point of profit maximization will be that unique point where the slope of the production function equals the inverse price ratio of the product and factor. That is, the equilibrium position is where

$$\frac{dY}{dX_1} = \frac{Px}{Py} \tag{12}$$

where Px = the unit cost of X_1

and Py = the unit price of Y.

In the case of linear programming analyses, the production function is discontinuous being represented by a series of linear segments as shown in Figure 3. At a point of discontinuity there does not exist a uniquely

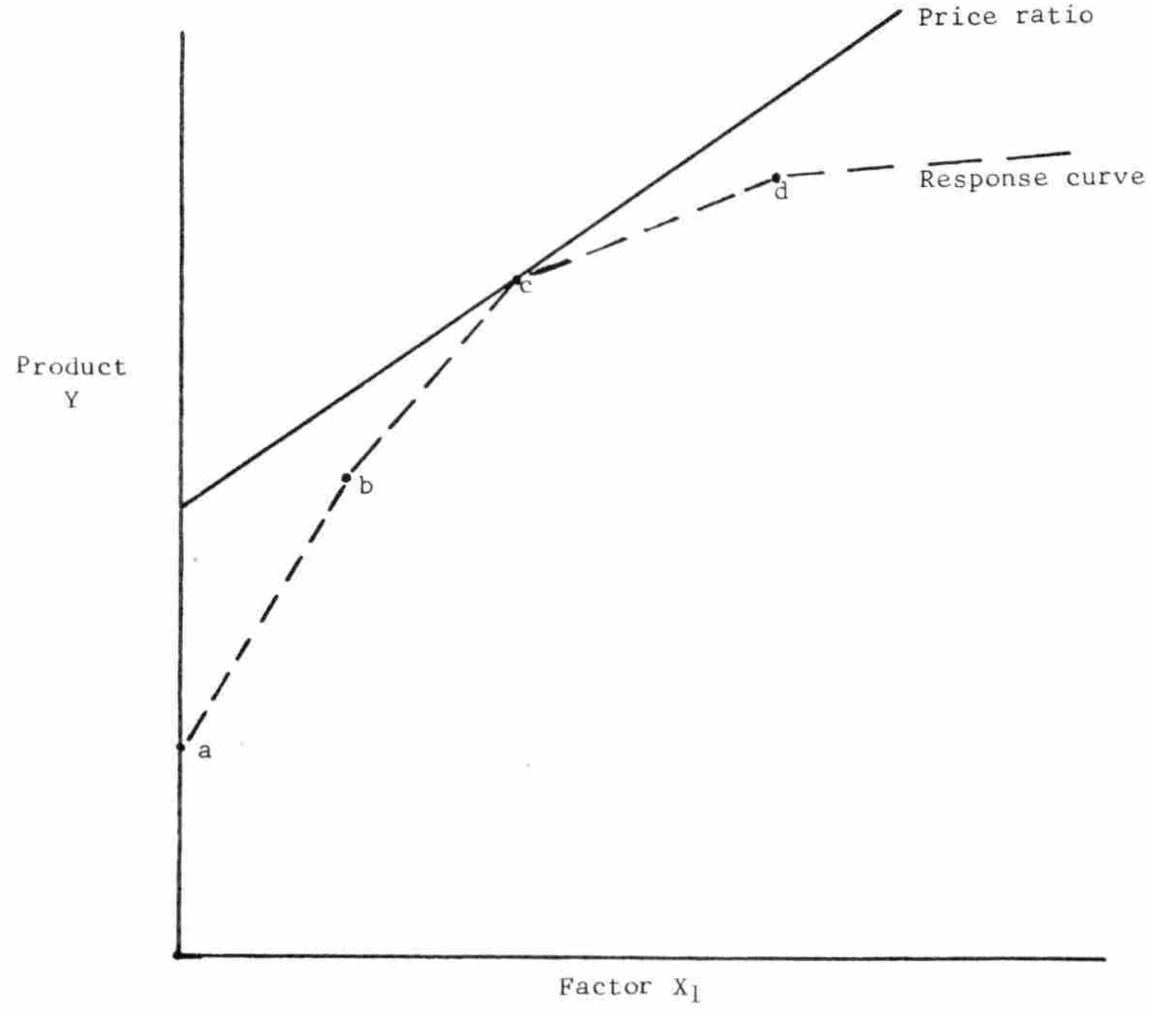

Figure 3. A discontinuous production function; the response of product Y to discrete changes of factor X_1

defined plane tangential to the isoquant thus the equilibrium equation above cannot be used. Instead, the equilibrium position is found where the following inequalities hold:

$$\frac{dY^{\ell}}{dX_1^{\ell}} \geqslant \frac{Px}{Py} \geqslant \frac{dY^{r}}{dX_1^{r}} \qquad (13)$$

where $\frac{dY^{\ell}}{dX_1^{\ell}}$ = the left-hand partial derivative at the given point, and

$\frac{dY^{r}}{dX_1^{r}}$ = the right-hand partial derivative at the given point. At

the given point. At any point where there is no discontinuity the right-hand and left-hand derivatives are identical hence the inequality converges to the equality

$$\frac{dY}{dX_1} = \frac{Px}{Py}$$

which is the same as equation 12 for the continuous case. In the discontinuous case however, when equation 12 occurs, the equilibrium is not a unique one.

2. The factor-factor principle

This principle is concerned with the substitution of one resource for another in the production of a given quantity of product. In the two factor case the expression for this relationship is,

$$Y = f(X_1, X_2) \qquad (14)$$

where X_1 and X_2 = two substitutable resources used in the production of Y, a fixed level of output. The locus of all the combinations of X_1 and X_2

which satisfies equation 14 forms an isoquant. When the production function is continuous so too is the isoquant, its slope at any point giving the marginal rate of substitution of X_1 for X_2. If we let the factors X_1 and X_2 represent quantities of corn and oats used in the production of 100 pounds of pork (Y) then the least cost combination of producing 100 pounds of pork from corn and oats is found by equating the marginal rate of substitution with the inverse price ratio. That is,

$$- \frac{dX_2}{dX_1} = \frac{Px_1}{Px_2} \qquad (15)$$

Given that the isoquant is 'well-behaved' this relationship gives a unique solution. In linear programming however the isoquant is formed from several discrete processes and as such consists of a series of linear segments as depicted in Figure 4. The least-cost combination of the two resources is where an isocost line just touches or is "tangential" to the isoquant. If "tangency" occurs on a corner as shown in Figure 4 then the least cost combination is stable over the range of resource prices

$$- \frac{dX_1^{l}}{dX_2^{l}} \geq \frac{Px_2}{Px_1} \geq - \frac{dX_1^{r}}{dX_2^{r}} \qquad (16)$$

This is one reason why a linear program can give the same solution over a range of prices. On the other hand if the price ratio (isocost line) has the same slope as one segment of the isoquant then there are many different resource combinations which give the same product at the same minimum resource cost.

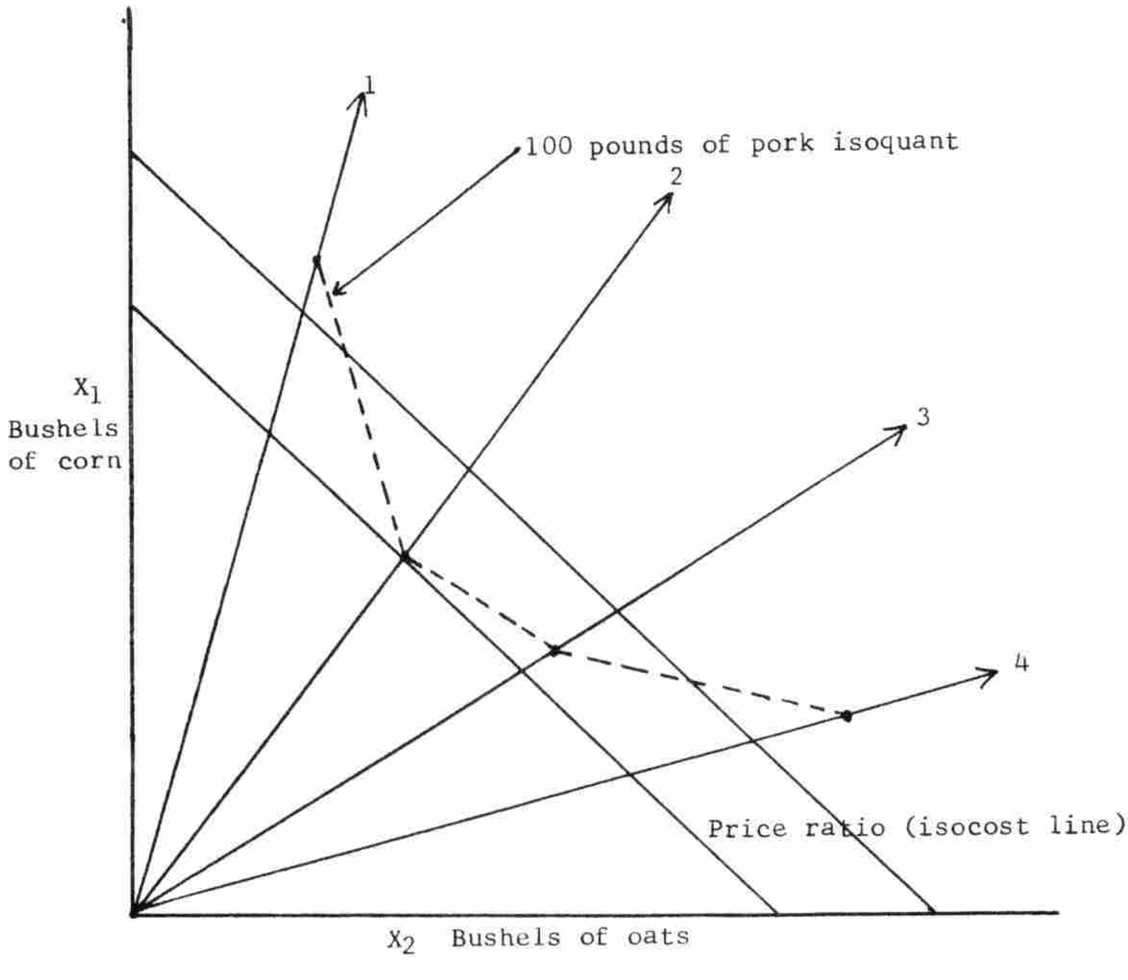

Figure 4. Different processes for the activity of producing 100 pounds of pork from corn and oats

3. The product-product principle

This principle is concerned with the optimum combination of products given a fixed quantity of resources. In its implicit form it may be expressed as

$$f(Y_1, Y_2, X) = 0 \tag{17}$$

Assuming that equation 17 can be solved explicitly for X, then

$$X = f(Y_1, Y_2) \tag{18}$$

In this example let Y_1 be bushels of corn produced, Y_2 be bushels of oats produced, and X be the quantity of labor available. In addition we shall assume there is a maximum quantity of corn that can be produced on the given land. A production possibility curve (product transformation curve) is defined as the locus of output combinations that can be secured from a given input quantity X.

In its continuous form a "well-behaved" production possibility curve is concave to the origin due to the changing marginal rate of transformation of resource into products. In a linear programming analysis we assume that the marginal rate of transformation is constant however restraints, such as a maximum corn acreage or total available labor in our example, restrict the feasible area so that the production possibility curve, although consisting of segments, is likewise concave to the origin. This is presented in Figure 5. As with the previous principles the conditions of constrained revenue maximization used in the case of continuous functions cannot be employed. Instead we specify that for constrained

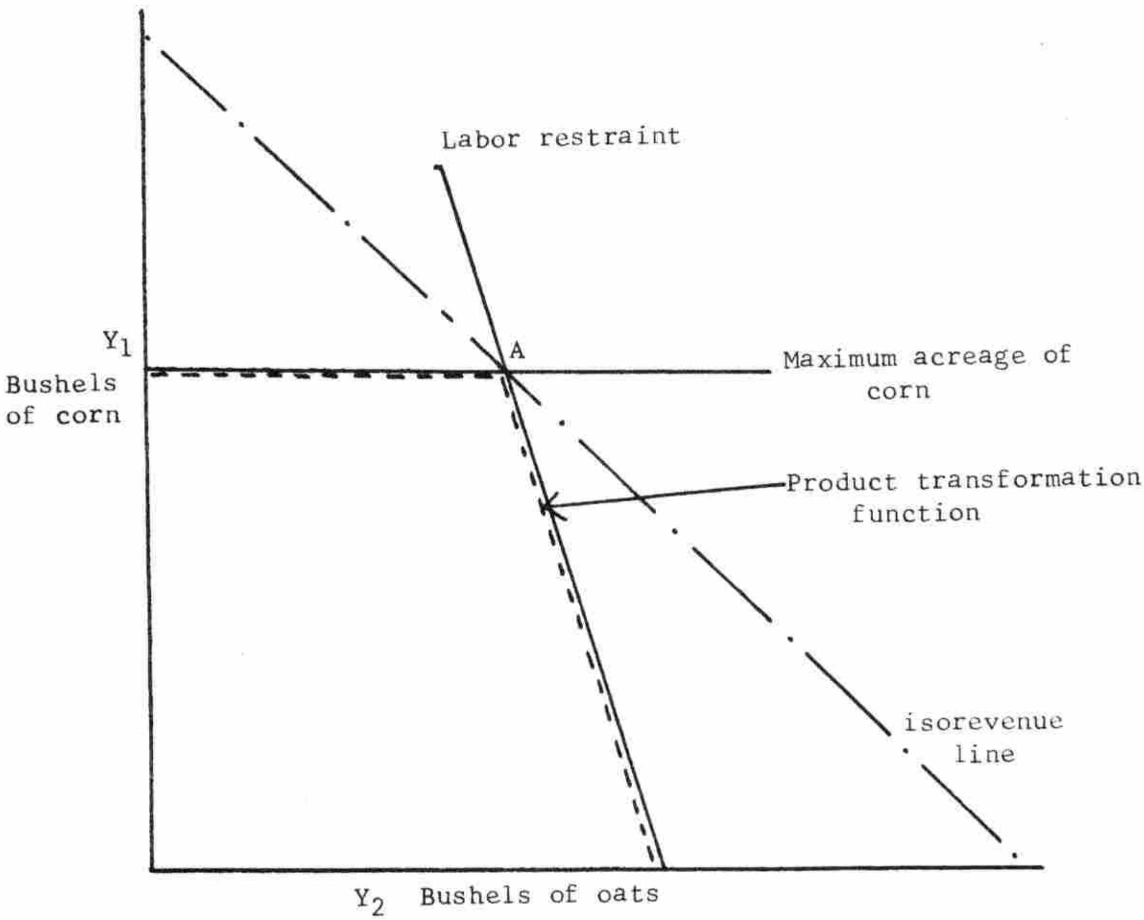

Figure 5. A linear programming representation of a product transformation function and isorevenue line, showing the point of constrained maximum profit, A

revenue maximization it is necessary that the inequality

$$- \frac{dY_1^{\ell}}{dY_2^{\ell}} \geqslant \frac{Py_2}{Py_1} \gtrless - \frac{dY_1^r}{dY_1^r} \qquad (19)$$

hold. As explained with previous principles this equilibrium will be stable over a range of prices.

A detailed account of the preceding principles may be found in Heady (18) chapters 2 through 8 and Henderson and Quant (23) chapter 3. For a discussion on the relationship between continuous and discontinuous functions the reader is referred to Samuelson (35, p. 70).

4. Integration of the factor-factor and product-product principles

If the factor-factor isoquant of Figure 4 were superimposed upon the product transformation function of Figure 5, then, ignoring price relationships, the optimum point of integration between the two crops and the hog ration occurs where the two functions just touch, i.e. at point A in Figure 6.

Whilst many farmers may think in terms of Figure 6, producing feeds in the same proportion as they feed it to their livestock, it is possible for them to improve their profit position by considering the relative prices of the crops. Since both corn and oat grains are negotiable it is possible for farmers to sell one grain and purchase the other if relative prices so dictate. Referring to Figure 7 if both grain crops and hogs were produced according to relative prices grains would be produced in amounts represented by point B and hogs would be fed grains in proportions

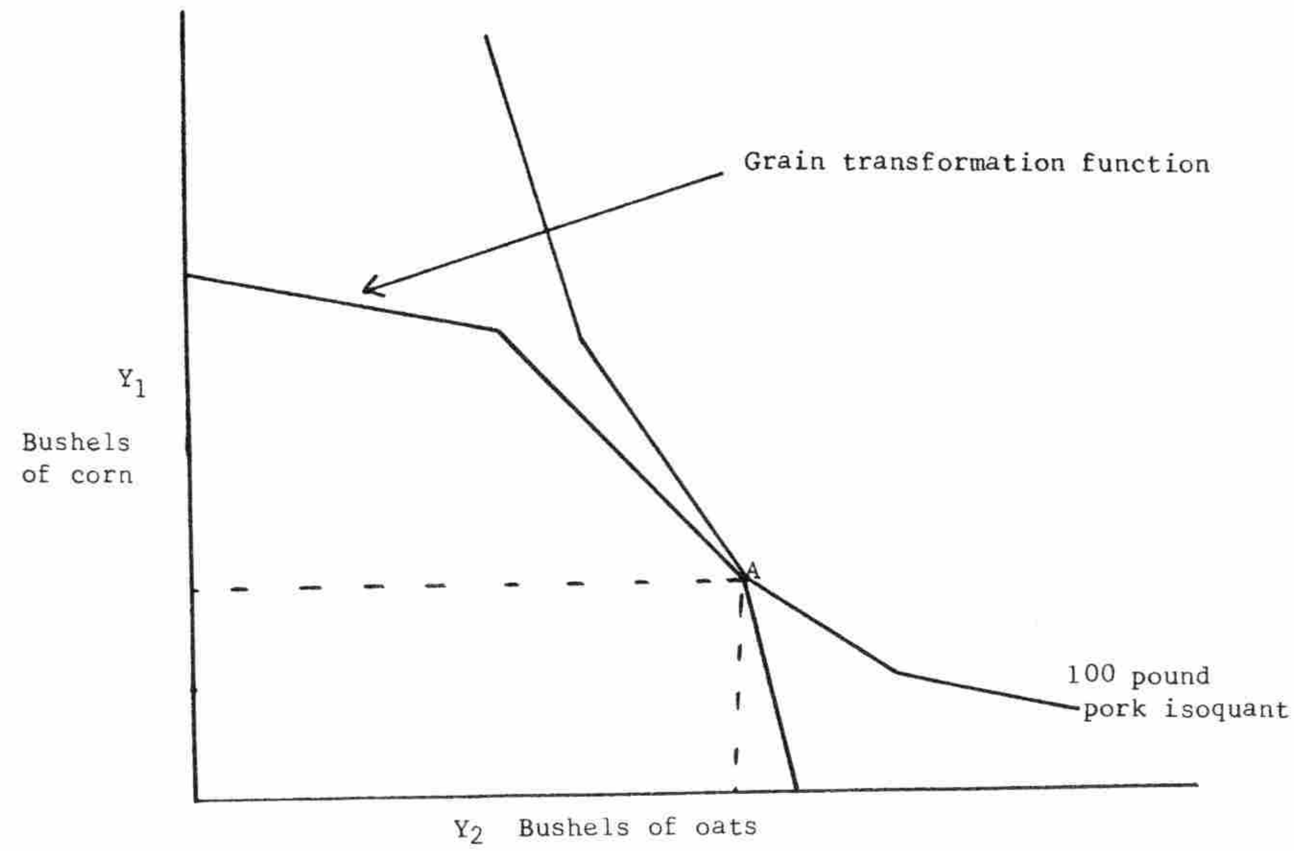

Figure 6. Integration of the grain transformation function with the pork isoquant

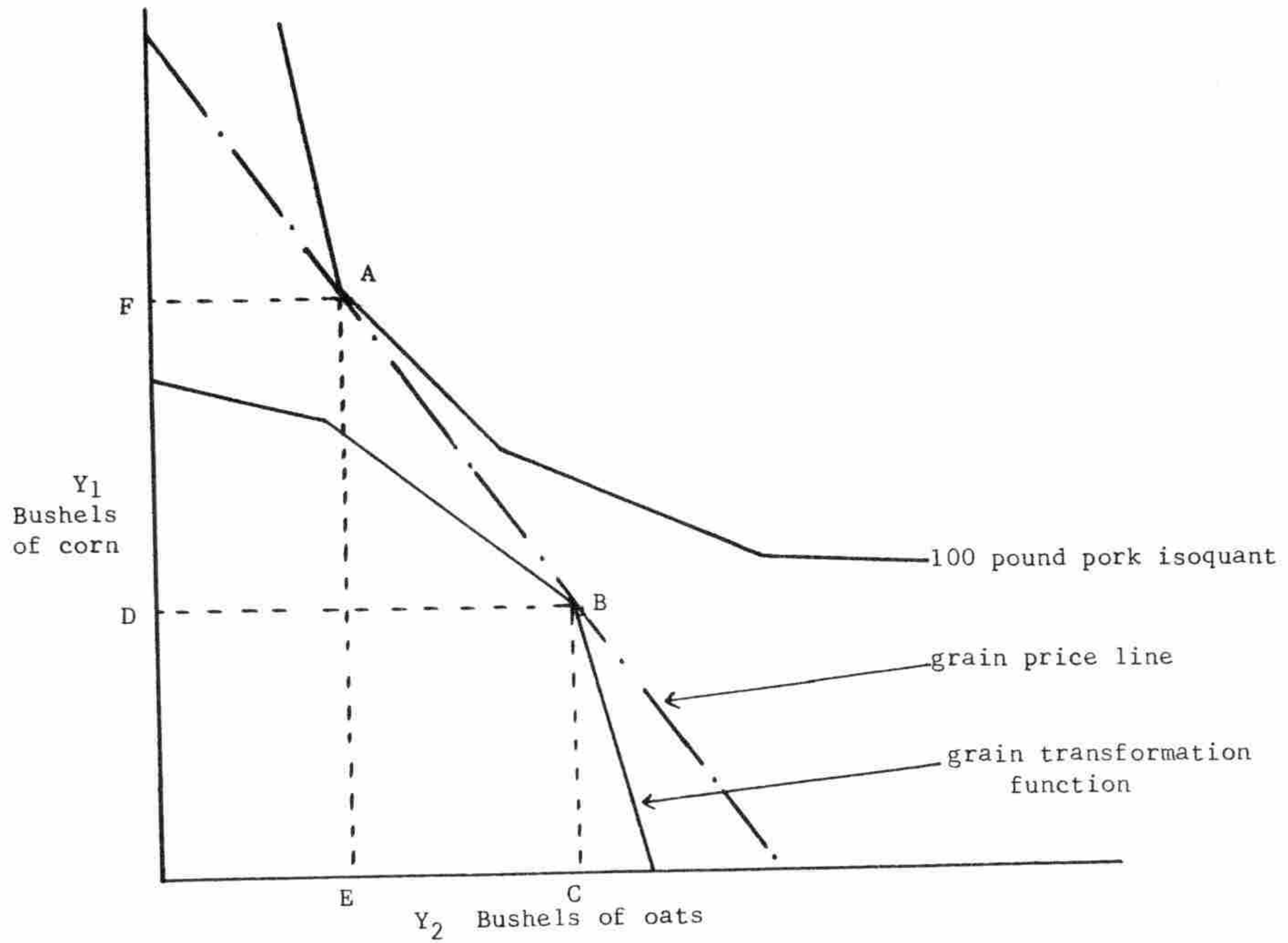

Figure 7. Integration of the grain transformation function with the pork isoquant, allowing buying and selling of grains

represented by point A. This being the situation OC of oats and OD of corn will be produced while OE of oats and OF of corn will be fed to hogs. Accordingly, CE of oats will be sold and DF of corn will be purchases.

The principle illustrated in Figure 7 was permitted to operate in the linear programming models about to be described. Several buying and selling activities for different types of livestock at different times of the year and for the various crops were included in the model to give the farm-firm maximum flexibility and to allow profit maximization within the resources available.

In this chapter we have outlined the history of linear programming, described the general linear programming model and a modification of it, and discussed the assumptions implicit in a linear programming analysis. In addition we have taken a cursory examination of three basic production economics principles and we have seen how they relate to linear programming. In the succeeding chapter we shall describe the models constructed to depict various farm situations.

V. FARM PROGRAMMING SITUATIONS

In building a linear programming model Dantzig (8) recommends the following steps be taken:

> Step 1: Define the Activity Set. Decompose the entire system under study into all of its elementary functions, the activities, and choose a unit for each activity in terms of which its quantity, or 'level', can be measured.
>
> Step 2: Define the Item Set. Determine the classes of objects, the 'items', which are consumed or produced by the activities, and choose a unit for measuring each item. Select one item such that the net quantity of it produced by the system as a whole measures the 'cost' of the entire system.
>
> Step 3: Determine the Input-Output Coefficients....
>
> Step 4: Determine the Exogenous Flows. Determine the net outputs or inputs of the items between the system, taken as a whole, and the outside.
>
> Step 5: Determine the Material Balance Equations....for each item write down the material balance equation which asserts that the algebraic sum of the flows of that item into each activity is equal to the exogenous flow of the item.

The result of model building thus, is the collection of mathematical relationships characterizing all feasible (or acceptable) programs of the system. This collection is the linear programming model, and the above steps will be followed in constructing the models used in this study. In every case, all enterprises and restraints which might enter into the farm situation were developed in close consultation with the farm operators.

A. Model 1

This model is designed to indicate the optimum allocation of resources between presently practiced enterprises and the level of these enterprises on the study farm. The optimum allocation of resources is defined as that allocation which maximizes profit. Only activities presently employed and resources and facilities presently available are considered. Any difference between the optimized solution of this model and present farm situation should indicate adjustments possible within the present farm structure capable of improving net profit.

Step 1. Activities or enterprises:

a. Crop enterprises: Typically, central Iowa farmers produce four crops, viz., corn, oats, soybeans and meadow. Although the usual husbandry involves a rotation of some combination of these, the study farm does not practice a set rotation because soil conditions and pest problems are such that conuous monocropping may be practiced if desired. Despite carryover effects which invariably exist between a crop planted in one year and a crop planted on the same area in the preceeding year, these interrelationships are assumed away in the model since fertilizer applications are always heavy and crop yields consistently high regardless of the previous land use.

One level of fertilization for those crops fertilized is considered, this level being the usual application used on the farm as detailed on page 18 .

Since payment received from the Federal Government for diverted land under the Feed Grain Program decreases as the proportion of a farm's corn base acreage placed into diverted acres increases, it was necessary to incorporate a "multiple right-hand side" routine into the program (3, p. 77).

This allows a comparison of the profitability of different degrees of participation to be made with non-participation.

Figure 8 shows how this portion of the model was constructed. It is necessary to construct the model in this form in order that it behave in a manner portraying reality. The usual way of incorporating activities using land would be to have each activity use an acre of the total land resource and limited to some maximum acreage. Since 20% diverted land receives a higher payment than 40% diverted land which in turn receives a larger payment than 50% participation in the grain program as shown in Table 1, it is not reasonable to set the model up in that form. If it were and if diverted land were to enter at the 50% level then the program would bring the highest returning 20% diverted land in up to its limit, and then bring the 40% diverted land in up to its limit, and fill the remaining 10% with the lowest returning 50% diverted land. This possibility must be excluded from the program as farmers do not get paid for diverted land in that manner. Accordingly the model was built as shown in Figure 8 and operated as is now described.

In the first computer "run" only 'Land C' and 'RHSA' of the resources shown are at non zero levels. This configuration excludes diverted land from entering the solution allowing the program to select that combination and area of the specified crops (corn, oats, soybeans, and turkey pasture) that is consistent with the resource restraints yet maximizes profit. By altering the resource quantity of RHSA the program may be restricted to prodicing a maximum acreage of corn as specified by that quantity.

The second right hand side "run" involves setting Land B at 350 acres,

Resource	Quantity		Diverted land 20%	Diverted land 40%	Diverted land 50%	Corn land supply 1	Corn land supply 2	Corn	Oats	Soybeans	Turkey pasture
Land A	0	≥				-1	-1	1			
Land B	0,350	≥	1	1	1	1					
Land C	680	≥	1	1	1	1	1		1	1	1
RHS A	0,680	≥					1				
RHS B	0, 70	≥	1								
RHS C	0,140	≥		1							
RHS D	0,175	≥			1						

Figure 8. A portion of the initial L.P. tableau showing incorporation of diverted land activities

Table 1. Crop prices used in the study

Crop	Activity	Period[a]	Price/bushel
Corn 1	selling	DJF	$1.02
Corn 2	selling	MAM	1.05
Corn 3	selling	JJA	1.13
Corn 4	selling	SON	1.00
Corn 1	buying	DJF	1.06
Corn 2	buying	MAM	1.09
Corn 3	buying	JJA	1.17
Corn 4	buying	SON	1.04
Oats 1	selling	DJF	.68
Oats 2	selling	MAM	.70
Oats 3	selling	JJA	.64
Oats 4	selling	SON	.60
Soybeans 1	selling	DJF	2.50
Soybeans 2	selling	MAM	2.55
Soybeans 3	selling	JJA	2.71
Soybeans 4	selling	SON	2.40
Hay	selling		19.30 per ton
Diverted land up to 20%			81.00 per acre
Diverted land 20% to 40%			72.57 per acre
Diverted land 40% to 50%			70.89 per acre

[a]Capital letters refer to respective months.

Land C at 680 acres, RHSA at zero and RHSB at 70 acres. By doing this diverted land may now enter up to a limit of 20% of the total corn base acreage (350 acres). Further, the total area of corn is limited to the balance of 350 acres after diverted acres (if they enter the plan) have been subtracted. This is effected by the use of "corn land supply" columns as shown. If the program has selected corn and/or diverted land, the area they occupy is deducted from the total farm acreage and the balance may be allocated to any of the other crops as selected by the computer.

The third right hand side requires that RHSB be set to zero and RHSC be set to 140 acres. Similarly the fourth right hand side has RHSB and RHSC set at zero while RHSD enters at 175 acres. The mechanizm for these is the same as that described for the second right hand side except that diverted land may enter up to a maximum of 40% of the corn base acreage in the case of the third right hand side and up to 50% in the case of the fourth right hand side.

Corn grain produced may be fed to livestock or sold. Since corn silage is not a useful intermediate product in hog and turkey production it is not included in this model.

Corn may also be purchased or sold in any of four quarterly periods defined in Table 1, at the indicated prices. Likewise if oats and/or soybeans are produced they may be sold in any of the four periods at specified prices. Grain prices used in the study are based on the latest four year monthly averages (28).

Since grain storage is limited to 70,000 bushels, multiple grain merchandizing activities together with dated livestock grain consumption allow the program to simultaneously solve the grain inventory problem. The problems in building a model that does this together with an explanation of the model are given subsequently (pages 56 to 60).

Straw produced from oat production is utilized on the farm as bedding for livestock.

b. Livestock activities: Thirteen livestock activities are included in model 1. With the exception of a turkey producing activity, all concern hog production. Since model 1 is intended to indicate possible reorganization of activities presently employed, cattle are excluded from the analysis. In subsequent models they may enter. Hogs may be raised from weanlings produced on the farm or from purchased weanlings. Also weanlings produced on the farm may be sold at 40 pounds. Each of these activities are divided into four three-monthly periods. The reason for doing this is to reflect seasonal price differences (as denoted in Table 2) and to allow the program to select the optimum integration of these activities, in terms of their resource requirements, with other activities. Thus we may find that during winter months when no labor is required for crop production, some of the hog activities enter the program at the maximum level, whereas in spring when labor may become limiting, hog production is reduced in order to allow the labor to be used for crop planting.

Other activities in the model are included for functional purposes only.

Table 2. Livestock prices used in the study (selling prices $/head)

Livestock activity	Selling period	Gross price	Net price
Hogs 1	DJF	$ 39.32	$26.65
Hogs 2	MAM	35.97	23.22
Hogs 3	JJA	42.43	29.68
Hogs 4	SON	37.74	25.07
Feeder hogs 1	DJF	38.50	15.28
Feeder hogs 2	MAM	35.22	12.42
Feeder hogs 3	JJA	41.58	16.58
Feeder hogs 4	SON	36.96	14.95
Weanlings 1	DJF	16.92	8.68
Weanlings 2	MAM	16.55	8.45
Weanlings 3	JJA	17.65	9.60
Weanlings 4	SON	15.98	7.78
Turkeys (10 birds)	S and D	56.00	33.13
Steer calves 1	Aug	278.50	111.95
Steer calves 2	Aug	278.50	119.78
Yearlings 3	April	274.60	88.26
Yearlings 4	April	274.60	90.53
Steers 3	Sept.	271.80	74.09
Steers 4	Sept.	271.80	75.33
Both yearlings and steers 3	Ap and S	546.40	171.36
Both yearlings and steers 4	Ap and S	546.40	175.33

Step 2: The Item Set (resource restraints):

a. Land: Since model 1 depicts the study farm in its present form, the area of land involved is 720 acres. Forty acres of this are covered by buildings, yards , roads, etc., leaving 680 acres of cropping land. Since fertilizer treatments and crop response are the same over the total area, the division of land into soil types was not necessary.

b. Labor: Presently the farm is operated by three labor units giving a total of 36 months of man labor per year. The labor supply is divided into five periods in order to reflect differing seasonal labor requirements. The maximum number of hours per period which the labor is prepared to work was determined by communication with the farm-firm operators. By examination of the quantity of labor in each period indicated in the optimal solution of the program, it is possible to specify the periodic labor requirements necessary if the plan is to be implemented. It is assumed that all activities requiring labor draw it from the total i.e. no custom work is allowed. It is possible however to hire an additional labor unit on a permanent basis. The operators feel that the firm would hire additional labor if it were profitable but because part time labor is difficult to obtain at crucial periods the only alternative the firm would consider is hiring a permanent full-time hand. The maximum available labor hours per period for three, four and five labor units is presented in Table 3. Hiring an extra labor unit adds $8,000 to the fixed cost of the firm.

c. Livestock restrictions: A maximum of 500 piglets may be farrowed and nursed over any three month period in facilities described previously.

Table 3. Distribution of the firm's labor supply[a]

Period	Working days	Maximum hours per day	labor unit	3 units	4 units	5 units
Dec.Jan.Feb.	72	6	432	1296	1728	2160
March April	48	8	384	1152	1536	1920
May June	48	11.5	552	1656	2208	2760
July Aug	48	8.5	408	1224	1632	2040
Sept.Oct.Nov.	72	10	720	2160	2880	3600
Total	288		2496	7488	9984	12480

[a]Source: Private communication with firm managers.

Space for growing-finishing hogs is limited to 420 hogs per period.

The maximum number of turkeys that may be raised annually, due to building limitations, is 20,000 birds.

d. Capital: Only operating capital is considered in the study in the manner shown in Figure 9. Capital expenditures and receipts are dated and placed into the relevant capital supply row. The numerals on the rows indicate the quarter of the year and correspond to those on livestock and grain activities. Four capital transfer columns allow surplus or deficit capital in any one period to be carried over to the next. Capital remaining in the fourth period is transferred back to the first period. It will be noted that the level of 'capital supply 1' is zero rather

Resource	Level		Buy		--etc-	Sell	Feeder	--etc	Capital transfer cols.				Fixed cost pay. act.			
			Corn 1	Corn 2		Sb.4	Hogs 1		1	2	3	4	1	2	3	4
Capital supply 1	0	≥	1.06				-26.89		1			-1	1			
Capital supply 2	0	≥		1.08					-1	1				1		
Capital supply 3	0	≥								-1	1				1	
Capital supply 4	0	≥				-2.40	11.61				-1	1				1
Fixed costs 1	21,832	=											1			
Fixed costs 2	21,832	=												1		
Fixed costs 3	21,832	=													1	
Fixed costs 4	21,832	=														1

Figure 9. A portion of the initial L.P. tableau showing the structure of the capital activities

than being at some positive level (indicating the quantity of working capital available at the beginning of the production year) as is frequently found in similar linear programming models. The reason for constructing our model in this way is to allow the program to dictate what quantity of capital should be available at the beginning of that period. Thus in the optimal solution the entry found on 'capital transfer column 4' indicates that sum of cash that should be on hand at the beginning of the first period (end of the fourth period) if the optimal plan is to be implemented. Although borrowing is not explicitly included in our model it is easy for the farmer to find out how much he must borrow. Since the program tells us what quantity of capital must be available at the beginning of the production year if the plan is to be executed, then the difference between that sum and what the farmer actually has on hand represents the total that he must borrow or will have as a surplus.

Fixed costs (which include salaries) are endogenously deducted from the capital supply by means of fixed cost paying activities. Annual fixed costs are divided equally between the four quarters and paid accordingly.[1]

Since no entry was made in the objective row for the fixed cost paying activities the objective function gives the gross returns resulting from the optimal plan whereas the capital supply rows indicate the net returns that would result.

---

[1]The possibility of labor merely drawing living expenses over three periods and receiving a large lump sum payment in the fourth period was considered. With the exception of small changes in the capital 'flows' the optimized plan remained unchanged. We therefore chose to allocate salaries in four even portions since the operators, like many people, are making time payments on various household items and thus prefer an even flow of income.

Capital transfer columns indicate the quantity of capital carried over from one period to the next. Thus it is possible to observe the quantity of capital available at the end of any period and to trace the annual pattern of capital "flows" over discrete three month intervals if the plan is followed.

Capital borrowing is not explicitly allowed because as the model depicts an equilibrium situation the program would not borrow in any period unless it could repay it in another, and since the objective function is always positive in this model, this is always the case. If borrowing were incorporated into the model the program would need to repay capital borrowed in one period in the next period and this activity would compete with the capital transfer rows. If, on the other hand, a large enough sum of capital is on hand at the beginning of the year the program will not need to borrow. Hutchinson (27) incorporated borrowing into his study by allowing the program to borrow and repay over a three month period, and also allowing it the opportunity to invest capital exogenously for a minimum of six months. While this approach has some merit it was not considered in our study because of the numerous exogenous investments available and their often unknown return.

Step 3. Input-output coefficients:

Input-output coefficients were derived from a wide variety of sources, primary ones for the various categories of data being given below.

Present farm situation: Background information on cropping patterns, crop yields, fertilizer and therapeutant treatments, hog and turkey production systems, and general farm operations, were obtained from interviews with the farm manager. Specific details on feed consumption and costs, labor charges, taxation, interest payments on mortgages, depreciation, etc., were supplied from the firm's records.

Labor coefficients: Since records of labor utilization were not kept on the study farm, it was necessary to obtain these from other sources then modify them in consultation with the farm operators. Labor coefficients were obtained from the following sources: a) cropping labor coefficients were obtained from James (30), b) swine labor coefficients were modified from Trede (39), c) Turkey labor coefficients were derived from a study of Iowa turkey producers (29), and d) cattle labor coefficients were obtained from Hutchinson (27). Actual labor coefficients used in the study may be found in Table 24.

Costs: As is often the convention, input costs are divided into two general categories. a) fixed costs; those that are incurred irrespective of the level of production, e.g. depreciation and property taxes, and b) variable costs; those that vary with the level of production, e.g. fuel and fertilizer costs.

a. Fixed costs: Data on capital expenditures of buildings, machinery, and equipment, were obtained where possible from the farm depreciation schedule. Otherwise, the replacement cost of each item was calculated by deducting the trade-in value of the replaced item from the new cost of the replacement item. Straight line depreciation as used in the farm records was used to calculate annual depreciation. Machinery and equipment repair costs are charged at three percent per annum of the replacement cost and building repairs at one and one half percent of the new cost. Taxes and insurance are calculated at two percent per annum of the replacement cost of machinery and equipment, and at 1.3 percent of the new cost of buildings (after D. A. Hull _et al._, 26). Interest on capital invested in machinery, buildings, and equipment, is calculated at five percent[1] of the average value of the item, where the average value is fifty percent of the replacement cost (after E. O. Heady, _et al._, 22).

In the case of hog and turkey facilities, the cost of constructing a similar building and equipment was found and annual fixed costs derived accordingly. The reason for doing this rather than using the actual farm values and depreciation was because many buildings have been considerably modified in terms of their associated equipment. This equipment has often been installed by the operators thus the labor costs associated with it, and the actual equipment costs do not appear in the structures total cost. Further, some buildings are used for turkey production over spring and summer, and for hog production over winter. To overcome these complications, the cost of replacement buildings and equipment were used. The itemized capital cost of these structures may be found in Tables 12, 13, and 14.

---

[1]Although a five percent interest rate seemed reasonable when this study was initiated, recent increases in the cost of credit have rendered this figure on the low side.

A schedule of machinery on the farm, and its annual fixed costs may be found in Table 9, whilst a similar schedule of fixed costs of buildings and equipment may be found in Table 11. Table 17 summarizes all the fixed costs considered in the study.

b. Variable costs: Tractor operating costs are itemized on Table 4 while Table 6 details the total variable costs associated with crop production. Tables 7 to 10 itemize the variable costs and revenue of the livestock activities.

B. Model 2

In construction this model is almost identical to model 1 differences being that cattle activities, larger resource quantities, and altered input-output coefficients, have been added. In this model eight row cropping equipment has replaced six row equipment used in model 1 with consequent changes in labor coefficients and cost entries. Sixteen cattle feeding activities have been added. These are:

(a) Feeding steer calves: Calves may be purchased in November at 450 lbs and raised in feedlots until they reach a weight of 1050 lbs in August. Calves may be fed on either of two rations, and may be fed by a self-unloading wagon method, or a conveyor feeding system. In the model these four activities are called "Calf---", where the first digit indicates the ration, the letter "A" denotes a self unloading wagon feeding system, and "B" indicates a conveyor feeding system.

(b) Fall feeding yearling steers: Steers may be purchased at 600 lbs in October and sold at 1050 lbs in April. They may be fed either of two rations, and may be fed by either of the two systems outlined above. These activities are termed "Yrlg.---" in the program where the nomenclature is the same as previously explained.

(c) Spring feeding yearling steers: In late April 700 lb steers may be purchased for sale at 1050 lbs in September. As with (a) and (b) they may be fed either of two rations by either of two feeding systems. These activities are named "Steer---".

(d) Feeding Spring steers and Fall steers: These activities are merely a combination of (b) and (c) activities. Since Fall fed steers occupy the feedlot for 190 days from October until early April, and Spring fed steers require the same facilities for 145 days from late April to September, it is possible to combine these activities into one. As with other cattle activities they may be fed either ration by either feeding method. In the program these activities are denoted as "Both---".

Further details of input-output coefficients, costs, and returns, are given in Tables 15 and 16.

Since there are presently no cattle feeding facilities on the farm all costs associated with raising beef are allocated between each animal. This procedure assumes constant costs and perfect divisability of facilities over the entire range, a somewhat heroic assumption at the extremes, i.e. for enterprises raising fewer than 300 head or more than 1200 head, but probably a reasonable approximation within those limits. Each cattle beast raised requires .004 acre of land, or approximately 180 square feet. The cattle land requirement is subtracted endogenously in the model.

Hogs, feeder-pigs, and weanlings may be raised in facilities described previously. In addition, once the facilities reach maximum capacity, the relevant expansion activity of the twelve different swine activities may enter the model. Expansion activities are identical to their corresponding regular activity except that capital costs associated with the production of swine which were considered fixed in the regular activities are allocated as a per hog per year cost in the expansion activities. As with the cattle activities constant scale returns are assumed.

In a similar manner turkey production may exceed the capacity of present facilities by a turkey expansion activity. This activity also has all capital costs associated with turkey production allocated as an annual per bird cost.

The possibility of hiring one or two extra labor units is allowed in model 2. A maximum of two hired hands was selected arbitrarily by the operators as the maximum number of men they would want to supervise.

A further modification made in this model is the addition of an activity which allows grain bins to be purchased. If it is profitable to employ additional grain storage the model will do so thus indicating the optimum storage capacity that the farm-firm should utilize.

At this point it is appropriate to explain the operation of the grain inventory portion of the linear programming model as depicted in Figure 10.

Since grains may be purchased and sold at varying prices at different times of the year, since grain consumption by farm livestock occurs unevenly over the year whilst production eventuates at a specific time, and since grain storage capacity is limited or can only be expanded at some cost, there clearly exists a grain storage inventory problem, the solution to which is that pattern of corn purchases, grain sales, and storage bin investments that will maximize profits.

In terms of total storage capacity the following equality must hold.

$$S_{t-1} + P_t + B_t = U_t + Q_t + S_t \qquad (20)$$

where

t = the time period,

S = the quantity of grain in storage,

P = grain produced,

B = grain bought,

U = the quantity of grain utilized as animal feed, and

Q = the quantity of grain sold.

In Figure 10, which is based on equation 20, time periods representing quarterly terms coincidental with quarters used in grain and hog activities, provide rows into which coefficients from activities requiring grain storage are placed. It was recognized that once grains enter storage they lose their identity. Consequently, unless structured otherwise, when livestock require a quantity of corn from storage, the program, failing to distinguish between corn, oats, and soybeans, will feed livestock with the lowest priced grain, namely oats. So that this complication

Resource			Corn (acre)	Oats (acre)	Beans (acre)	Buy corn 1	2	3	4	Sell corn 1	2	3	4	Corn stor.trans. 1	2	3	4	Corn transfer 1	2	3	4
Corn production	0	≥	-125							1	1	1	1								
Oatgrain	0	≥		-95																	
Soybeans	0	≥			-40																
Time period 1	0	=				-1															-1
Time period 2	0	=					-1													-1	
Time period 3	0	=						-1											-1		
Time period 4	0	=							-1									-1			
Time period 11	0	=								1				1			-1				1
Time period 22	0	=									1			-1	1					1	
Time period 33	0	=										1			-1	1			1		
Time period 44	0	=	-125										1			-1	1	1			
Time period 1A	0	=																			
Time period 2A	0	=																			
Time period 3A	0	=		-95																	
Time period 4A	0	=			-40																
Gr.store max.1	70000	≥												1							
Gr.store max.2	70000	≥													1						
Gr.store max.3	70000	≥														1					
Gr.store max.4	70000	≥															1				

Figure 10. A portion of the initial L.P. tableau showing the construction of the grain inventory problem

Resource		Bt.corn trans.[a] 1	2	3	4	Sell oats 1	2	3	4	Sell beans 1	2	3	4	Grain storage 1	2	3	4	Buy gr.st.[b]	Corn consump- Hogs 1.	Cattle etc.
Corn production	0 ≥																			
Oatgrain	0 ≥					1	1	1	1											
Soybeans	0 ≥									1	1	1	1							
Time period 1	0=	1			-1														4.85	a
Time period 2	0=	-1	1																.43	b
Time period 3	0=		-1	1															.19	c
Time period 4	0=			-1	1														4.85	d
Time period 11	0=																			
Time period 22	0=																			
Time period 33	0=																			
Time period 44	0=																			
Time period 1A	0=					1				1				1			-1			
Time period 2A	0=						1				1			-1	1					
Time period 3A	0=							1				1			-1	1				
Time period 4A	0=								1				1			-1	1			
Gr.store max.1	70000 ≥	1												1				-1		
Gr.store max.2	70000 ≥		1												1			-1		
Gr.store max.3	70000 ≥			1												1		-1		
Gr.store max.4	70000 ≥				1												1	-1		

Figure 9. (Continued)

[a] Bought corn transfer.

[b] Buy grain storage.

could not arise corn was placed into separate time period rows from soybeans and oats. Thus producing an acre of oats requires 95 bushels of storage capacity in the third period ('time period 3A'), buying a bushel of corn in the second period utilizes one bushel of storage space in 'time period 2', and raising hogs for sale in period one adds to the storage space in all four periods as corn is consumed. Four 'grain storage' activities transfer oats and beans remaining at the end of one period into the next period. They also transfer the balance into corresponding 'grain storage maximum' rows, which enforce the restriction that total grain stored per period may not exceed 70,000 bushels. Four activities named 'bought corn transfer' allow the balance of bought corn and corn consumed by livestock to be transferred from one period to another. Additionally they transfer the balance into 'grain storage maximum' rows in an identical way as was done for oats and soybeans. The reason that it is necessary to include 'time period' rows, which are set equal to zero, is so that the act of transferring grain from one period to the next will not add to the grain storage capacity as would otherwise occur. A 'buy grain storage' activity allows storage bins to be purchased at 5.6 cents per bushel and adds one bushel of storage to each 'grain store maximum' row.

Initially this was how the grain inventory problem was built. However a difficulty was encountered. It proved profitable for the program to buy grain storage _ad infinitum_ filling it with corn purchased in period four and storing it for sale in period three. That is, the farm-firm was to become a grain dealer. This problem was rectified by separating produced corn from bought corn. It was therefore necessary to add four more time period rows, 'time period 1:1 to 4:4'. Corn raised on the farm goes into 'time period 4:4' since corn is harvested in the fourth period. From here it may be transferred to any other period by four 'corn storage transfer' activities. As with previously described grain storage transfers, these activities transfer the quarterly balance into 'grain store maximum' rows. Corn may now be sold only from corn actually produced on the farm. Additionally, four 'corn transfer' activities are included in order that produced corn may be transferred into rows where it may be used in livestock production.

By this rather bulky but necessary construction the grain inventory problem is solved in a manner that does not violate reality.

C. Models 3, 4, and 5

These models are duplications of model 2, differences being confined to the land area considered in each. The area of land in model 3 is 1300 acres or 1285 cropping acres. In model 4 the area involved is 1680 acres or 1600 cropping acres. Model 5 has a land base of 2000 acres or 1920 cropping acres. In each of these, plans are obtained for three, four, and five labor units. Since it is assumed that the land area may be purchased within a four mile radius of the present homestead, no attempt to define different soil types and thus different crop coefficients was deemed necessary.

The entire structure of model 5 is presented in computer "print-out" form in Appendix C. As can be seen, the size of the model is 95 columns by 51 rows.

In this chapter we have examined and described the construction of the linear programming models used in this study. It now remains to present the results of them.

VI. PRESENTATION OF RESULTS

Preceding chapters have dealt with problems associated with farm management and have described the framework of programming models used in this study. The empirical findings under various planning situations are now presented. No attempt to draw conclusions will be made in this chapter as those aspects are covered in Chapter VII. Optimum plans for each model are presented in Appendix B and these will be referred to by table number throughout this chapter. In every case the information given by the optimum plan is:

1. The gross return,

2. The net profit (return to entrepreneurship),

3. The grain crops that should be produced and their level of production,

4. The livestock that should be raised and its level of production,

5. The scheduling of grain sales and corn purchases (if required),

6. The quarterly capital transfers,

7. The daily labor hours that must be worked in order that the plan be implimented.

A. Model 1

The results of six separate situations are shown in Table 18. The codes at the top of the table refer to different "right hand sides" of model 1. BJ1 lists the optimum plans for the 720 acre farm with three labor units while BJ2 gives the optimum plan when an additional labor unit is hired. BJ5 and BJ6 present optimum plans when corn production is limited to 420 acres for three and four labor units respectively while BJ7 and BJ8 list optimum plans for the farm for three and four labor units when seventy acres of land are diverted into pasture under the Federal Government Feed Grain Program.

The net profit resulting from plan BJ1 is $29,554. In this plan 66 acres are used for turkey pasture while the balance of croppable land, 614 acres, is used to raise corn. Turkeys enter the plan at the maximum level of 20,000 birds being limited by presently available turkey facilities. The shadow price on turkey buildings is $1.43 per head and sensitivity analysis shows that the shadow price holds up to 23,980 birds. That is, the marginal value productivity of investing in expanded turkey facilities is $1.43 per head up to 23,980 birds.

When corn is allowed to freely enter the program it comes in at the maximum possible level after turkey pasture has been deducted. Corn is therefore a feasible and more profitable enterprise than raising soybeans, oats, or diverting land. The shadow price on land is $77.77 per acre which holds over the next twenty acres.

Although soybeans have not entered the optimum plan at a positive level they are very closely conpetitive with corn since soybeans are in the basis of the solution at zero level. The sensitivity analysis reveals that the income penalty (the amount that gross returns will decrease) if an acre of soybeans is forced into the plan is $2.46 and this penalty holds up to 54 acres of beans. Just how much more profitable corn production is over other alternatives is shown in Figure 11. The dotted line traces out net profit with three labor units as the maximum corn acreage is reduced and soybeans enter. The reduction of corn to 550 acres allowing 65 acres of soybeans to enter leaves net revenue virtually unaffected lowering it from $29,554 to $29,334. Livestock activities are unaffected. When corn is limited to 420 acres however, beans occupying the remaining 196 acres, net profit declines to $26,883. This fall in profit is a result of the lower returns per acre for soybeans and the need to purchase greater quantities of corn for livestock feed. Also, since labor is limiting in some periods it is not possible for additional livestock to be raised in order to offset the drop in net profit. We notice from Figure 11 that net profit continues to decline monotonically as corn production is curtailed in favor of soybeans. Once diverted land enters at over 70 acres (20 percent) however, net profit descends rapidly to a value of $22,097. At this point 210 acres of corn, 264 acres of soybeans, and 140 acres of diverted land are being produced. Thus in this example, the opportunity cost of participating in the feed grain program at the 40 percent level is the difference between net profits of the plans where 614 acres of corn are produced and where 210 acres of corn are produced. This cost is $7,457.

Besides turkeys, which we have already mentioned, other livestock that enters plan BJ1 are raising piglets to sell as feeders (called 'weanlings' on Table 18). The program specifies that 355 head should be raised

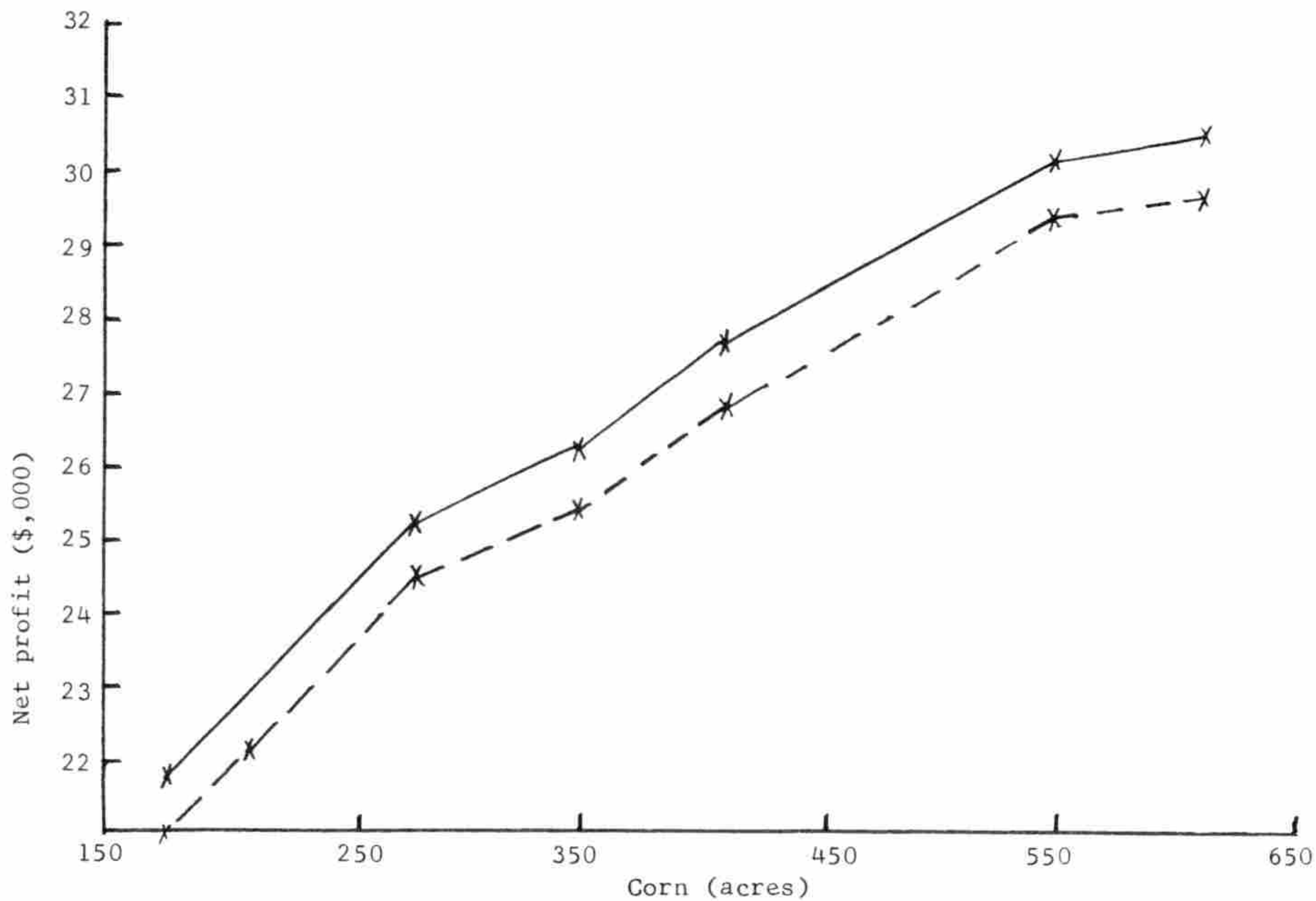

Figure 11. Net profit from optimum plans of Model 1 (720 acre farm) at different levels of corn production, with:
three units of labor -------; and
four units of labor ________

for sale in period 1 (December, January, February), that 500 head should be raised for sale in period 2, that 66 should be sold in period 3, and that 138 should be sold in period 4. In period 2 weanlings are raised at their maximum level, the limiting resource being farrowing-nursery facilities. The shadow price on this restraint is $3.99 per head. Sensitivity analysis indicates that this value holds up to 1222 head. That is, expanding farrowing facilities so that up to 1222 piglets may be raised per quarter adds $3.99 per head to the gross returns (objective function) of the program.

As we might expect labor becomes a restraining resource over spring and summer having a shadow price of $9.84 per hour in March-April (Labor 2), $.16 in May-June, and $12.60 in July-August. In this study examination of shadow prices on labor is of limited value in formulating recommendations for two reasons. Firstly, we have assumed, very reasonably, that labor may only be hired in integer units of one man year. Thus we cannot meaningfully make the statement that hiring a man for an hour in March-April will add $9.84 to gross returns, since hiring casual labor is not admitted. Secondly, the total available labor hours per period was found by asking the operators "what is the maximum daily hours you are prepared to work per period?" The shadow price on labor is therefore not useful in ascertaining the return to additional hours worked since the operators have previously decided that they are not prepared to work more than the stated maximum. The only usefulness of labor shadow prices is to indicate to the operators the opportunity cost to them of not working longer hours. From the sensitivity analysis portion of the linear programming printout we find that the shadow price of $9.84 in March-April holds for an additional 400 hours. That is, the gross returns (and net profit in this case) forfeited because each labor unit is not prepared to work an extra 2.8 hours per day over this period is $3936.00. Similarly in May-June where the shadow price is $.16 for 63 hours the penalty for not working an extra 25 minutes each per day is $10.08. In the months July-August the net profit foregone by not working an additional 33 minutes each per day is $958.

As we see from Table 18 slightly less labor is required in some months when we move to plans that have smaller acreages of corn. It is notable however that there is no slack labor over May to August. This is because turkeys remain in the plans at their maximum level and require sizable quantities of labor over that time.

The effect on net profit and optimum plans of hiring an additional labor unit is presented in plans BJ2, BJ6, and BJ8 of Table 18. As can be seen, although the act of hiring another man adds $8,000 to fixed costs, the net profit of the plans is greater than that of corresponding three labor unit plans. Comparing BJ1 with BJ2, which have three and four labor units respectively, we find that net profit of BJ1 is $29,554 while for BJ2 it is $30,350. That is, if an additional man is hired at a cost of $8,000 per year, net profit is estimated to increase by $796. Further, daily working hours for all labor are decreased. The solution therefore indicates that hiring an additional man is a profitable adjustment.

Examining the activities that have entered plan BJ2 we find that with the exception of raising more weanlings and consequently buying more corn, all enterprises enter at the same level as the parallel three labor unit plan. Hiring an extra hand merely adds 375 weanlings to annual hog production.

The solid line in Figure 11 traces out net profit of optimum plans as corn acreage is reduced when four labor units are employed. The vertical distance between this line and the dotted line at any point indicates the marginal profit of hiring an additional man. As the figure attests, the profit margin remains constant regardless of which plan is put into effect. It is therefore always profitable to have four men operating the farm. We may alternatively state that when three labor units are employed the resource labor is limiting and is being spread too thinly over the farm depicted by model 1. Its marginal value product is positive and large. If a fourth labor unit is engaged the marginal value productivity of labor is still positive but of a smaller magnitude. Utilizing four labor units leads to a more optimal farm structure than operating the farm with three.

Another alternative farm structure worthy of consideration is the possibility of cash renting the cropping land in order that the operators may specialize in livestock production. The basic model was altered so that 620 acres of land was rented out at $50 per acre. Of the remaining 100 acres, a maximum of 80 acres could be used for turkey production, the remaining twenty being occupied by hog buildings, sheds, grain bins, and houses. Since the machinery compliment required to operate such a system is considerably less than that required when 620 acres of land are cropped, fixed costs were accordingly adjusted. The results of this model are shown in Table 19, BJIR depicting a situation where three men are employed and BJ2R being where an additional hand is hired.

The net profit when three men are employed is $23,494 - $6,060 less than plan BJ1 where 614 acres of corn are raised, but $2,520 more than where the operators opt to participate in the Government Grain Program at the fifty percent diversion level.

Table 19 presents the level of activities that have entered the optimal solution. Greater quantities of corn are purchased than in previous solutions but since grain storage is no longer at its maximum in any period, all corn required for livestock production is purchased in period 4 when it is cheapest and is stored until used. In period 1, 327 220 pound hogs and 500 40 pound weanlings are sold. In period 2 a further 500 weanlings are sold. The activity 'hog expansion 3' enters the solution at 233 head. Hogs raised for sale in period 3 require farrowing space in period 2. Since weanlings completely fill this space it is necessary that the hog expansion activity enter where the returns have been adjusted to allow for the construction of further farrowing space.

Turkeys enter the solution at the maximum level of 20,000 head and turkey expansion, where the costs of enlarged facilities are accounted for, enters at 4,240 head.

As daily working hours indicate, the seasonal demand for labor under this plan is more even than in plans where crops are grown. It is no longer necessary for the operators to work up to eleven hours per day over the spring-summer period.

The effect of hiring an additional hand is shown in BJ2R of Table 19. As with previous situations it is profitable to do this as net profit increases from $23,494 with three labor units to $24,723 with four labor units.

The only production activity that is altered from BJ1R is hog production. The plan specifies that 701 hogs should be raised for sale in period 1.

This concludes the presentation of results of model 1.

B. Model 2

The optimum results of nine separate situations are presented in Table 20. As with model 1 each situation represents the optimum plans when either different quantities of labor or different maximum corn acreages are placed in the model. In model 2 982 acres are available for crop production, the remaining 58 acres being used for yards, buildings etc.

The net profit resulting from plan BO1 where three men are employed is $44,848. Corn occupies 892 acres and the balance of 90 acres is utilized as turkey pasture. Neither soybeans, oats, or diverted land enter this solution. Sensitivity analysis indicates that forcing in an acre of soybeans would reduce returns by $6.02 for the marginal acre only.

Although the analysis specifies that forcing in an acre of diverted land would reduce returns by a mere $2.34 we must ignore this portion of the analysis as diverted land cannot enter until corn production is reduced to below the Federal Government corn base acreage for the farm. This is 491 acres in model 2. The shadow price on oats is $38.60 which is constant up to 22 acres of oats. Further, sensitivity analysis reveals that the per acre cost of raising corn (the value in the objective function) may increase by $3.41 or decrease by $308 before the optimum plan will alter.

As we might expect the shadow price on land is smaller than in model 1 because a larger area of land is being considered. In model 2 the marginal revenue resulting from the addition of an extra acre of land is $59.80 and this remains unchanged up to 1037 acres.

The principal livestock raised under this plan is turkeys, entering the solution at 27,250 birds. In addition the plan specifies that 172 weanlings be raised for sale in period 2. With such a small number entering the optimal solution it is doubtful whether the operators would maintain farrowing facilities and a breeding herd merely to produce 172 weanlings.

In this model the program may select the optimum grain storage capacity (if in excess of 70,000 bushels) for each plan. In B01 the program finds it profitable to purchase grain bins which will hold an additional 41,400 bushels of grain. The penalty for purchasing more than this quantity is 1.6 cents per bushel up to 45,625 bushels whereas the penalty for purchasing less is 1.4 cents on the marginal bushel only. Turning to the corn merchandizing activities we find that most corn is purchased in period 4 when it is cheapest. Small quantities are purchased in periods 1 and 2 as more storage space becomes available. The balance in storage in period 3 is sold when corn price is highest. This also means that the grain bins are empty going into period 4 so that harvesting and buying new seasons corn can take place.

Since the main production activities of this plan, viz., raising corn and turkeys, are activities requiring spring, summer, and fall labor, we find that labor is virtually idle over the winter months of period 1, the program indicating that it is only necessary for each hand to work about two hours per day. On the other hand during labor periods 2, 3, and 4 labor utilization is at the maximum allowed having a shadow price of $30.88, $27.57 and $6.22 per hour in labor periods 2, 3 and 4 respectively. In model 2 we find that labor has become a far more limiting resource than in model 1 as indicated by the larger shadow prices on labor. In labor 2 alone the shadow price of $30.88 is constant over the next 153 hours. That is, the operators forfeit $4724 by not working for an additional 1.1 hours each per day during the months March and April.

Plans B07 and B14 illustrate how the basic three labor unit plan alters when corn is limited to 600 acres (in the case of B07) and when corn is limited to half of the corn base acreage the other half being placed in diverted land, (in the case of plan B14).

In B07 net profit has decreased by $2,355 to $42,493. As Table 20 shows the principal difference is the substitution of soybeans for corn, the absence of weanling production, and the inclusion of the fattening of 78 feeder hogs.

In plan B14 net profit has crashed to $34,143, a drop of $10,705 compared to B01. In this plan 227 acres of corn, 402 acres of soybeans, 264 acres of diverted land, and 89 acres of turkey pasture are produced. As a consequence more corn is purchased and less sold in order to feed 27,100 turkeys and 406 feeder hogs.

The dotted line of Figure 12 traces out the decline in net profit as corn production is reduced. The slope is almost constant from 892 acres of corn down to 393 acres where twenty percent of the corn base acreage is placed into diverted land. The decision to participate further in the land diversion program involves a more than proportionate drop in profit.

Returning to Table 20, by observing columns B02, B08, and B15, we see the effect of hiring an additional hand. Perhaps the most noticeable difference is the increase in net profit of around $20,000 over the corresponding three labor unit plan. For B02 net profit is $64,897. Turkeys have entered at the maximum level of 43,000 birds requiring 142 acres of pasture. Corn occupies the remaining 840 acres. As with B07 weanlings for sale in period 2 come into the solution in this case at a level of 143 head. In addition the program specifies fattening 165 feeder hogs for sale in period 1. In plan B08 where total corn acreage is limited to a maximum of 600 acres net profit has declined from $64,897 to $62,845. Soybeans have substituted for corn. Since some labor is freed when this substitution occurs a greater quantity of feeders 1 enter the solution

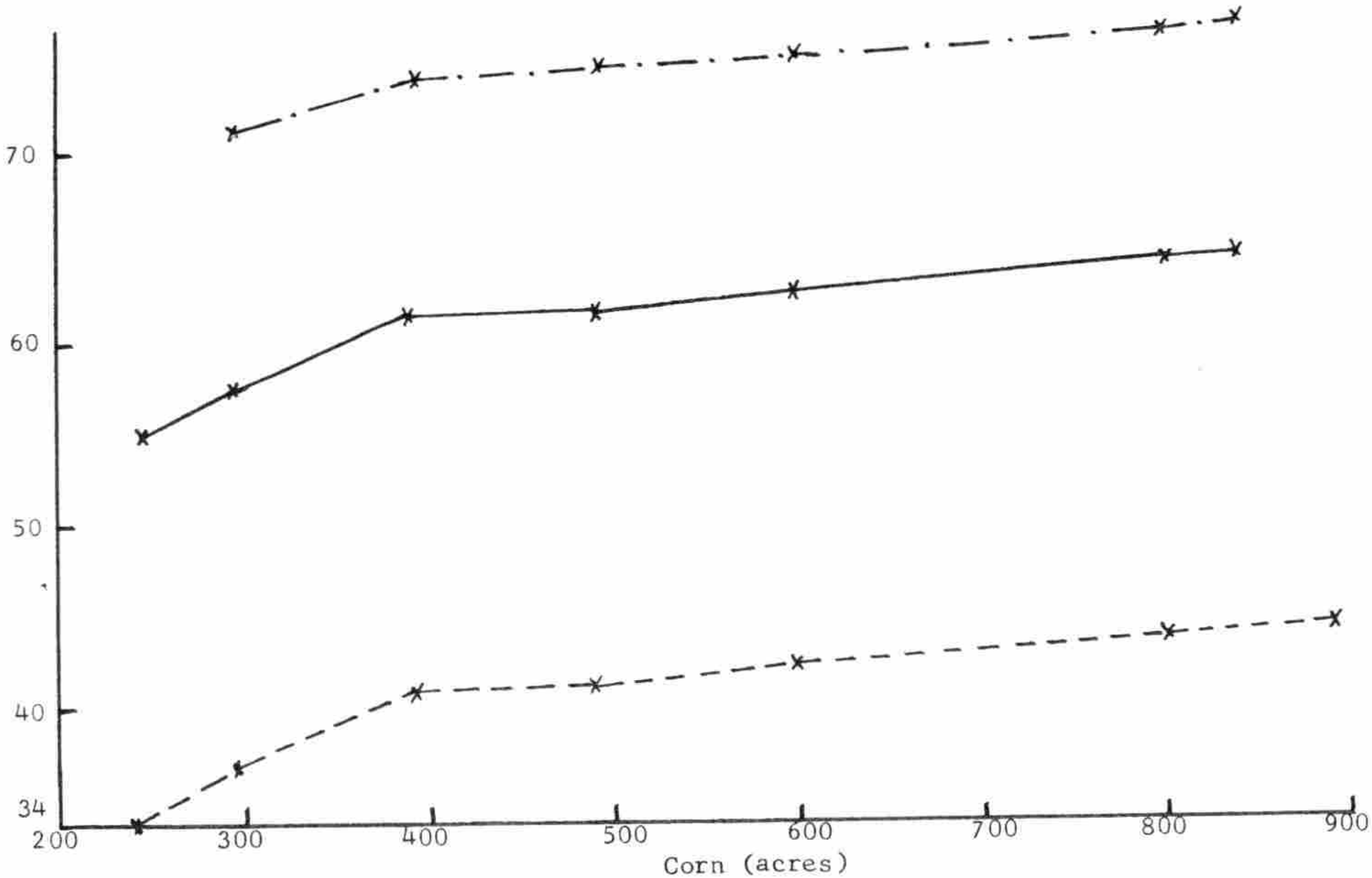

Figure 12. Net profit from optimum plans of model 2 (1040 acres) at different levels of corn production, with:
three units of labor ------,
four units of labor ______, and
five units of labor___ _ ___

(213 head) and 67 feeders for sale in period 4 also come in. Turkeys remain at the maximum level.

Referring to Figure 12 we note from the solid line that the decrease in profit as corn acreage is reduced is at the same rate as for the three labor unit case, being approximately constant down to 393 acres where twenty percent of the corn base acreage is diverted then falling at a rather steeper rate as the option to participate in land diversion at greater than twenty percent is taken.

The upper line of Figure 12 specifies the net profit at various corn acreages when five men are employed by the farm-firm. As we note the resultant increase in net profit by hiring an additional hand is \$12,500. The addition to net profit by having five men operate the farm-firm depicted by model 2 rather than three men is \$33,530.

Clearly the marginal value product of hiring extra labor is very large in this model but is, as we might expect, diminishing as extra units of labor are added. This is indicated by the smaller vertical distance between four and five labor units than between three and four labor units. It is extremely profitable for the operators to hire two full time men and the marginal value product of the last unit is still positive and large. We can therefore profitably hire more labor than this but since we can only hire labor in integer quantities and since we have not considered the case where a sixth man is hired, we cannot tell where the marginal value product of labor, expressed in net terms, equals zero.

Plans B03, B09, and B17 of Table 20 identify the level at which activities should be operated if the plan is to be practiced. We notice that the basic difference over previous plans is that larger numbers of weanlings are produced. Working hours have also been reduced in peak periods and increased in slack periods so that seasonal labor demand is more even. Labor is still scarce and therefore limiting in two periods. In period 2 labor has a shadow price of $40.16 per hour which is constant over the next 102 hours worked, and in labor period 4 the shadow price of labor of $9.67 per hour hold over the next 181 hours.

C. Model 3

The optimum results of nine separate plans are presented in Table 21. As with previous models each plan lists the optimum activity level when either different quantities of labor or different maximum corn acreages are placed in the model. In model 3 the land area considered is 1390 acres, 1285 acres being available for crop production.

The net profit resulting from plan B10 where three men are employed is $40,042. In this plan corn enters at 594 acres, 592 acres being allocated to corn grain production and two acres being used for corn silage production. Soybeans which require less labor per acre than corn come into the plan at 572 acres. Since labor is limiting, the program finds it profitable to reduce the acreage of corn and raise larger acreages of soybeans. Turkey pasture occupies 70 acres and the balance of 49 acres goes into diverted land.

For the first time in these models cattle have entered the solution. We find that the activity 'yearlings 42A' has come in at 36 head. This number is so small that it would be difficult for a farmer to justify the overheads of a system designed to fatten 36 head and we would probably find that an operator attempting to implement this plan would ignore the cattle raising activity adjusting the rest of his plan accordingly. The only other livestock that has entered are turkeys. The plan indicates that 21,264 head should be raised.

Because of the large acreages of soybeans and corn,grain storage is insufficient and the plan specifies that bins equivalent to 26,872 bushels of storage capacity be purchased.

Labor is a very limiting resource over the period March through August having a shadow price of \$30.39 in labor 2, \$27.42 in labor 3, and \$9.28 in labor 4. Land is also restrictive having a shadow price of \$57.71 on the next acre.

In plan B01 diverted acres were excluded from entering the solution and corn was free to enter at up to 1285 acres. As Table 21 indicates corn production falls from 594 to 442 acres, soybeans increase by 200 acres, turkey production decreases marginally by 884 birds, and net profit falls by \$1,568. Plan B01 would probably be rejected by a farmer since not only is net profit smaller but a greater acreage of crops using slightly more labor is required.

Plan B14 shows the optimum level of activities when fifty percent of the corn base acreage is forced into the plan. Net profit has declined by \$8,287 compared to plan B10. This is because the profitable activity of corn production has been curtailed by 273 acres and soybeans have been unable to increase because of the extra land in diverted pasture. Figure 13 (dotted line) indicates the magnitude of the decrease in net profit as corn acreage is reduced.

In plans B02, B08, and B15, four units of labor are employed. Since more labor is now available the high profit but high labor requiring activities of growing corn and raising turkeys are expanded over the three labor unit plans. In B02 corn production has increased to 1164 acres and turkey raising has jumped to 36,700 birds boosting net profit to $66,228 - a net increase of $17,754 over the corresponding three labor unit plan. That is, investing $8,000 in hiring an extra man has netted the farm-firm $17,754. No soybeans are produced nor land diverted in this plan. As with previous plans we find the grain merchandizing activities operating in such a manner that all bins are filled with grain, either produced or bought, in period 4. As livestock consume grain in successive periods so it is replaced by bought corn until period 3 when all that is remaining is sold leaving the bins empty for the new season's production.

Eleven yearling steers and 304 'weanlings 2' are raised under this plan. Again, a farmer implementing plan B02 would probably ignore the eleven head of cattle since it is such a small number and would not warrant the fixed investment in facilities required.

Labor is also restrictive in this plan in three labor periods having a shadow price very similar to that of plan B10. In labor 2 the shadow price is $30.87 for the marginal hour of labor worked, in labor 3 the shadow price is \$27.34, while in labor 4 the shadow price is \$6.35. Somewhat more hours of work over Fall and Winter are required in this plan compared to plan B10.

Plans B08 and B15 identify changes in profit and optimum activity levels when corn acreage is reduced and when diverted land is forced into the program. In plan B08 corn acreage is reduced to 800 acres, the balance being taken up by soybeans and turkey pasture. Turkey production has increased by 850 birds, weanlings 2 have left the plan and 133 feeders to be raised for sale in period 1 have entered. Net profit has fallen from \$66,228 (in B02) to \$63,540.

Fifty percent of the corn base acreage is placed into diverted land under the Federal Government Feed Grain Program in plan B15. This means that corn may only enter at a maximum of 321 acres while soybeans occupy 521 acres and turkey pasture requires 121 acres. Feeders 1 have increased to 270 head and feeders 4 have entered at 250 head. Turkey production has declined back to the B02 plan level of 36,700 birds.

Because of the greatly reduced corn acreage and the impossibility of fully compensating for this reduction by increasing other activities, net profit under plan B15 has subsided to \$51,930. The solid line of Figure 13 illustrates the interrelationship between net profit and total corn production when four labor units are employed. As may be seen the function decreases approximately monotonically from 1200 acres of corn down to 500 acres (where twenty percent of the corn base acreage is diverted) then falls at a greater rate as the option to participate further in the feed grain program is accepted.

The hiring of a fifth labor unit adds approximately $15,500 to the net profit of equivalent four labor unit plans, as shown in Figure 13. Since the marginal net profit between four and five labor unit plans is smaller than that between three and four labor unit plans (as found by the vertical distance between net profit lines at any point) we know that we are in a region of diminishing marginal productivity of labor. This is true since labor is the only parameter that has been altered. Its marginal productivity is still positive and large however even at the highest level we have considered.

Plans BO3, BO9, and B17 of Table 21 specify the optimum activity levels for various corn acreages when five labor units are engaged. The net profit resulting from plan BO3 is $81,688 which is generated from the production of 1139 acres of corn grain, 4 acres of corn silage, 43,000 turkeys, 1500 weanlings for sale in period 2, and 53 head of 'calves 22A'. The plan also indicates that a further 79,000 bushels of grain storage should be purchased.

With greater availability of labor and therefore the opportunity to produce more corn and turkeys, the shadow price of land has increased over earlier plans of model 3 and now stands at $74.30 on the marginal acre. Also labor is now only restrictive in two periods. In labor period 2 (March and April) the shadow price of labor is $40.12 per hour while in labor period 4 (July and August) it is $10.07.

Plans BO9 and B17 indicate that as corn acreage is reduced, being replaced by diverted land and soybeans, net profit declines - down to

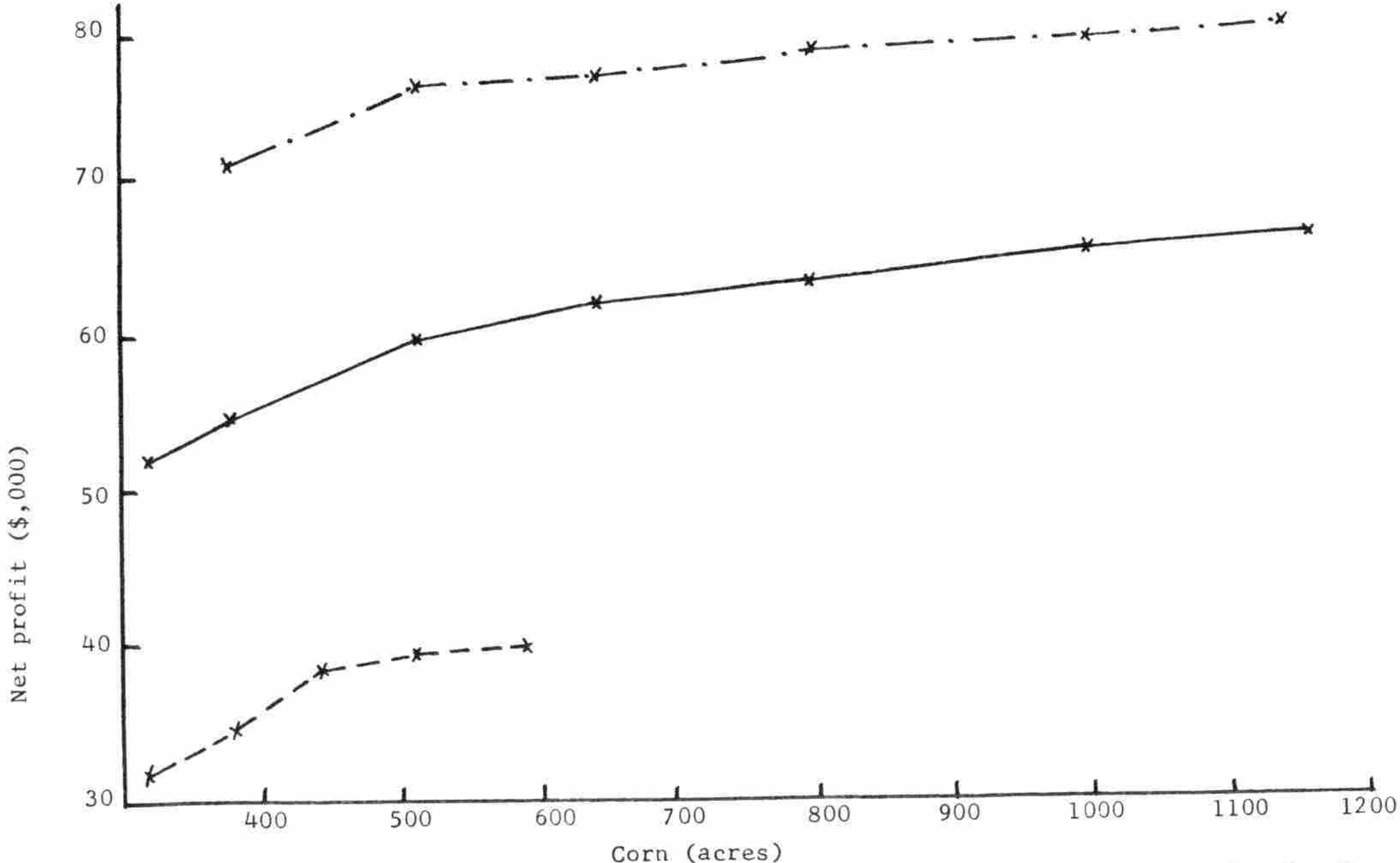

Figure 13. Net profit from optimum plans of model 3 (1285 acres) at different levels of vorn production, with;
three units of labor--------,
four units of labor__________, AND
five ynits of labor_____ - ___

$71,064 in plan B17. Turkey production is at its maximum and therefore cannot increase as more labor becomes available. Weanlings 2 have entered at a reduced level of 561 head and 'steers 42B' have come in at a practicable level of 348 head. Since less corn is being raised the need for grain storage is less so that by plan B17 it is not necessary to purchase any additional grain bins and bins reach maximum capacity only in period 1.

We shall now continue to an examination of the results of model 4.

D. Model 4

Table 22 details the optimum results of nine separate plans. As with previous models each plan lists the optimum activity level when either different quantities of labor or different maximum corn acreages are placed in the model. In model 4 the land area considered is 1680 acres, 1600 acres being available for crop production.

The net profit resulting from plan B01 where three men are employed is $28,168. In this plan diverted land is excluded from entry but corn may enter up to the full acreage available. As we see the only corn produced in plan B01 is ten acres for use as silage. Instead of corn being the principal crop soybeans enter at 1557 acres. Turkey production is at a low level - 9,910 birds - and the only other livestock coming into the plan is 168 yearlings 42A. Obviously labor has become extremely restrictive in this plan as corn and turkey production (high labor requiring activities) are far less than in model 3. Indicative of the scarcity of labor is the shadow price on labor. In labor 4 the shadow price is $97.07 on the marginal hour, and $15.19 in labor 2. Contrarily, the shadow price on land is a mere $22.25 indicating that because labor is so limiting an additional acre of land is not a useful investment. (Although purchasing an additional acre of land would add $22.25 to gross returns it would also add in excess of $42.00 to fixed costs so that a net loss of approximately $20.00 would result from the transaction).

In plan B10 up to twenty percent of the corn base acreage of the farm may be placed in diverted land. When the plan finds it possible to do this as in plan B10 net profit increases by $6,316 to $34,484. Now corn grain production is at 291 acres, diverted land at 160 acres, soybeans occupy 1096 acres and turkey pasture uses 51 acres, allowing turkey production to increase to 15,580 birds. The eighteen yearlings 42A which are specified in the plan may be best excluded in practice for reasons given previously. Plan B10 of model 4 shows that only when acreage is so large as to make existing labor very scarce, is it profitable to participate in the feed grain program. All previous plans have recorded a loss in net profit when diverted land has been forced into the solution.

If fifty percent participation in the feed grain program is forced into the program as in plan B14 then profit falls compared to when twenty percent participation is chosen. Plan B14 gives a net profit of $28,789- $5695 less than plan B10. When such a large area of land (400 acres) is diverted as in B14 then sufficient labor is then available to allow a matching 400 acres of corn to be grown. The remaining land is used for soybean production (748 acres) and turkey pasture (52 acres). Cattle have left the plan entirely and have been replaced by 214 feeder hogs which are scheduled for sale in periods 1 and 4.

In this plan the shadow price on land has increased to \$65.92. For labor which is restrictive over spring and summer the shadow price is \$66.49 on the marginal hour on labor 2, \$.40 on labor 3, and \$5.92 on labor 4. The labor demand is very seasonal in this plan being at its peak over spring and summer, about six hours per day in fall, and averaging less than two hours per day in winter.

We note that the net profit of model 4 when three labor units are employed is less than that for model 2 and model 3 where smaller acreages were involved. The reason this is the case is because of the large fixed costs associated with owning the extra area of land and the inability of three labor units to farm it sufficiently intensively under the assumed technology and prices. That is, the resource labor is being spread too thinly over the land area in model 4 where only three men are employed.

Plans B02, B11, and B15 indicate the changes in optimum plans that occur when a fourth hand is hired. Net profit actually doubles going from \$28,168 in B01 to \$59,974 in B02. This serves to illustrate the high marginal productivity of additional labor and how restrictive labor must be in the three labor unit plans of model 4.

In B02 corn production is at 823 acres all except four acres being for corn-grain production. Soybeans occupy 678 acres and turkey pasture fills the remaining 99 acres. Turkey production has now expanded to 30,000 birds and the program states that 66 head of yearlings 42A should be fattened. Since a greater quantity of corn is now being produced it is also profitable to purchase a further 59,477 bushels of grain storage.

As with previous plans of model 4 the shadow price on labor is very high. In labor 2 the shadow price is \$21.53, in labor 3 it is \$8.23, while in labor 4 it is \$63.25 per hour. With such high shadow prices it is evident that labor is still very obstructive to greater profit even though an extra hand has been hired. This evidence is confirmed in plans BO3, B16, and B17 where a fifth permanent hand has been employed. The effect of this is to boost net profit of the farm-firm depicted by model 4 to \$85,250 in the case of plan BO3 - an increase of over \$25,000 compared to plan BO2. The marginal productivity of labor is still obviously very high although we are in a region of decreasing marginal productivity.

Plan BO3 specifies that 1452 acres of land should be used to raise corn grain, five acres should be for corn silage production, and 142 acres should be used for turkey pasture. Soybeans and diverted land do not enter although beans are close to entering as the penalty for producing an acre of them is only \$2.04. Turkey production reaches its maximum of 43,000 birds and weanlings 2, the only other livestock in the plan, enter at 433 head.

With five workers, labor becomes limiting in only two periods and with smaller shadow prices than previous plans of model 4. The shadow price in labor 2 is \$33.12 and in labor 4 is \$16.27.

Since labor was spread so thinly in plan BO2 an additional acre of land is not as valuable as in plan BO3 where five labor units are available. The shadow price of land in BO2 is \$33.86 while in BO3 it has risen to \$70.69.

Figure 14 illustrates the interaction of net profit and corn acreage in model 4. The solid line indicates that net profit falls rather rapidly once corn acreage is reduced below 1000 acres in the five labor unit case. Only three points are given for the four labor unit case as they extend over the total variability of all four labor unit plans. Again, profit falls as corn acreage declines. The vertical distance between the two lines gives the marginal net profitability of hiring an extra hand.

This concludes the presentation of the results of model 4. We shall now examine the results of model 5.

E. Model 5

The optimum results of nine separate plans of model 5 are given in Table 23. As with prior models each plan lists the optimum activity levels when either labor or maximum corn acreage is varied. In model 5 the land area considered is 2000 acres, 1920 acres being available for crop production.

Plans B10, B12, and B14 list the optimum activity levels of the 2000 acre farm when three men are employed. Net profit of these plans varies from $26,688 to $30,250. We would expect the net profit of these plans to be less than in models 2, 3, and 4 because in model 4, which has less land than model 5, net profit had begun to decline because of limiting labor and large fixed costs. That is, under the assumed technology, prices, possible farm activities, and available labor, we have exceeded the

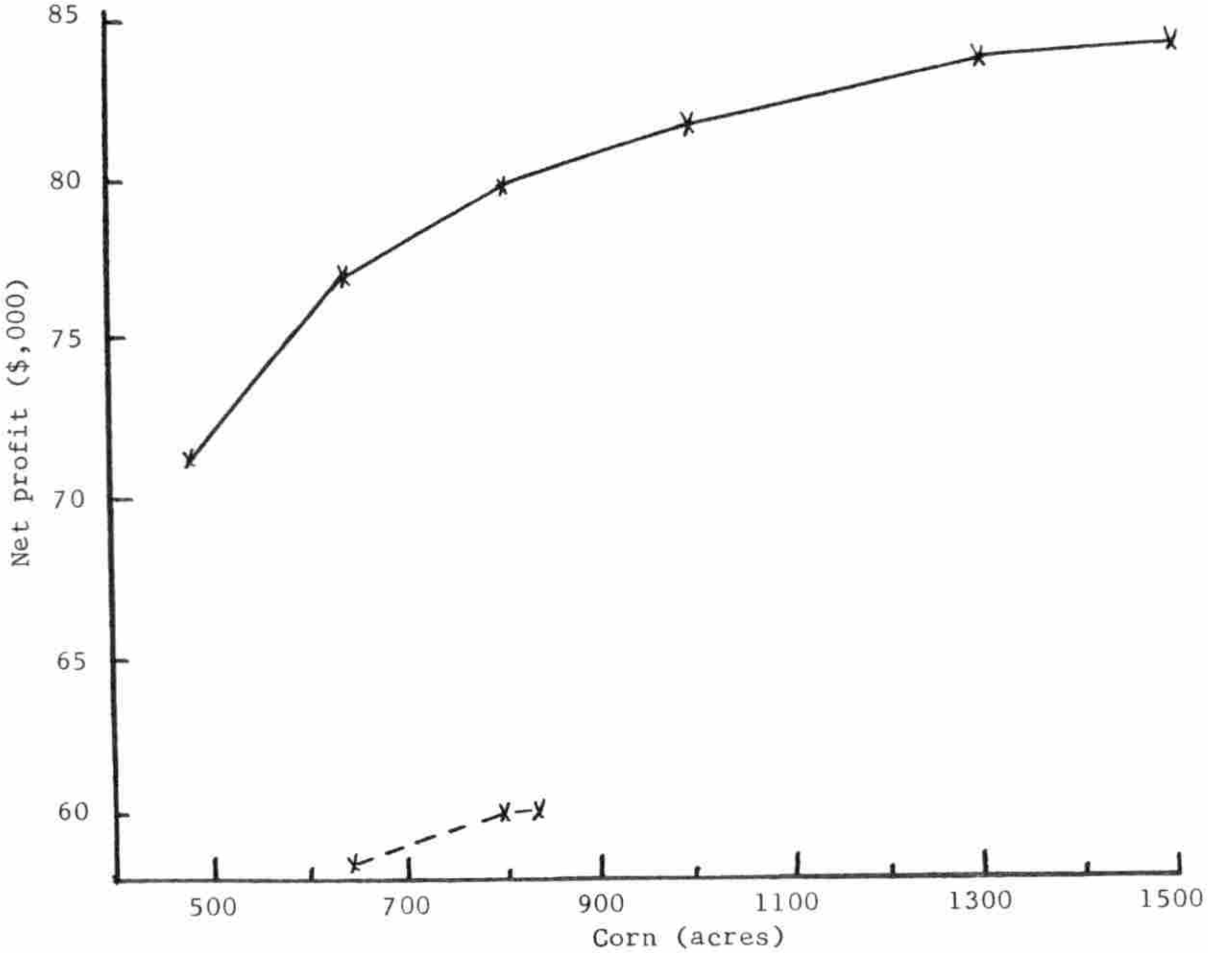

Figure 14. Net profit from optimum plans of model 4 (1680 acres) at different levels of corn production, with;
four units of labor-------, and
five units of labor______

optimal farm size. Since this is the case, the plans presented in B10, B12, and B14 do not represent advisable proposals in terms of practical farm recommendations and will therefore not be studied further at this juncture.

In plans B02, B11, and B15, where four labor units are utilized, net profit has almost doubled from previous plans of model 5 ranging from $48,073 in plan B15 to $59,071 in plan B11. The results of these plans, listed in Table 23 indicate that it is profitable to participate in the feed grain program up to the twenty percent diversion level although diverting more land than this involves some decrease in profit. Examining plan B11 we find that 760 acres of corn grain and one acre of corn silage is raised. Turkey pasture uses 84 acres while soybeans is the predominant crop requiring 882 acres. Diverted land enters at 192 acres (20% of the corn base acreage). Turkeys are the only livestock raised entering the program at 25,600 head. The twelve head of cattle that come in are best ignored for reasons given previously. Because of the large area in corn and beans it is profitable for the plan to purchase 60,347 bushels of additional corn storage bringing the farm-firms total storage capacity up to 130,000 bushels. The program specifies that corn remaining in period 3, approximately 84,000 bushels, should be sold before the end of period 3 while corn should be bought in periods 1, 2, and 4. The soybeans are stored for about nine months before being sold in period 3, while the 4000 bushels of oats harvested from turkey pasture are stored for sale in period 1.

Labor is the most limiting factor becoming restrictive in three labor periods. In labor 2 the shadow price of labor is $21.52 which is constant over the next 300 hours. The shadow price on labor 3 of $8.23 holds over the next 13 hours while in labor 4 labor has a very large shadow price of $63.25 on the marginal hour only.

The program indicates that the addition of land is not profitable. The shadow price of $33.86 on land which is constant on 45 additional acres, is insufficient to cover the fixed costs associated with land ownership. (If land is purchased at $700 per acre the annual interest charge on an acre at six percent is $42.00). In fact with the present resource structure we have an excess of land. The shadow price indicates that if we deduct an acre of land from the plan the gross returns (objective function) will be decreased by $33.86. This penalty remains true down to 1425 acres. However we have seen that an acre of land contributes in excess of $42.00 to fixed costs. Thus decreasing the land area of this plan by one acre increases net profit by at least $8.14 and this is constant until the land area has been reduced by more than 495 acres (1920 acres minus 1425 acres).

Plans B03, B16, and B17 tabulate optimum activity levels when five workers are engaged. The net profit of these plans varies from $72,036 to $83,535 depending on the area of corn raised. Net profit has increased by approximately $25,000 over the four labor unit plans indicating the gross shortage of labor experienced in these plans.

In plan B03 labor is still not sufficiently abundant to allow the two most profitable but most labor intensive activities of corn and turkey raising to enter the plan at their maximum level. Corn comes into the plan at 1188 acres of corn grain and 4 acres of corn silage while 39,378 head of turkeys are raised. Soybeans occupy the remaining 598 acres. Besides turkeys the only livestock raised in this plan are 74 yearlings 42A. With the large production of grains the program finds it profitable to more than double existing grain storage by adding bins which have a capacity of 102,000 bushels. This increases the total grain storage capacity of the farm-firm depicted by model 5 to 172,000 bushels.

Labor remains limiting in these plans over spring and summer. The shadow price on labor 2 is $21.52 and sensitivity analysis reveals that this is constant over the following 383 hours. In labor 3 the shadow price of $8.23 holds over 82 hours and the shadow price on labor 4 of $63.25 is stable up to an extra 65 hours. From this result we thus might conject that under the conditions assumed in this model five labor units are sub-optimal on a farm of 2000 acres. Alternatively we may state that the optimum sized farm for five labor units is less than 2000 acres. Our conjecture is confirmed when we examine the shadow price on land. As with plan B11 the shadow price of land is $33.86 which we have shown represents a penalty in excess of $8.00 per acre for having too much land. The shadow price remains constant over 138 acres indicating that we have <u>at least</u> 138 acres too many. That is, the marginal productivity of land has been driven below its price. Without recomputing the problem we cannot tell exactly how oversized our farm in model 5 is.

Plans B16 and B17 show how the optimum plan alters as corn acreage is reduced and diverted land forced in. Net profit subsides to $72,036 in B17 as forty percent of the corn base acreage is diverted. Soybeans increase by 200 acres and turkeys increase marginally. In addition feeder hogs begin to enter the plans reaching levels of 225 feeders 1 and 217 feeders 4 in plan B17. Since less corn grain is being raised the need for additional grain storage diminishes so that only 35,000 extra bushels are specified for B17.

Figure 15 illustrates the effect of corn acreage on net profit. With the exception of the five labor unit function the relationships shown do not bear the same resemblance and general shape as similar functions of other models. The reason that this is so is because the land area is too large in proportion to the available labor to be completely utilized in corn production.

In this chapter we have presented the optimum results of models 1 through 5. As mentioned in the preamble to this chapter, with the exception of emphasizing some obvious points no attempt to make recommendations, draw inferences, or reach conclusions has been made. These aspects will be covered in the subsequent chapter.

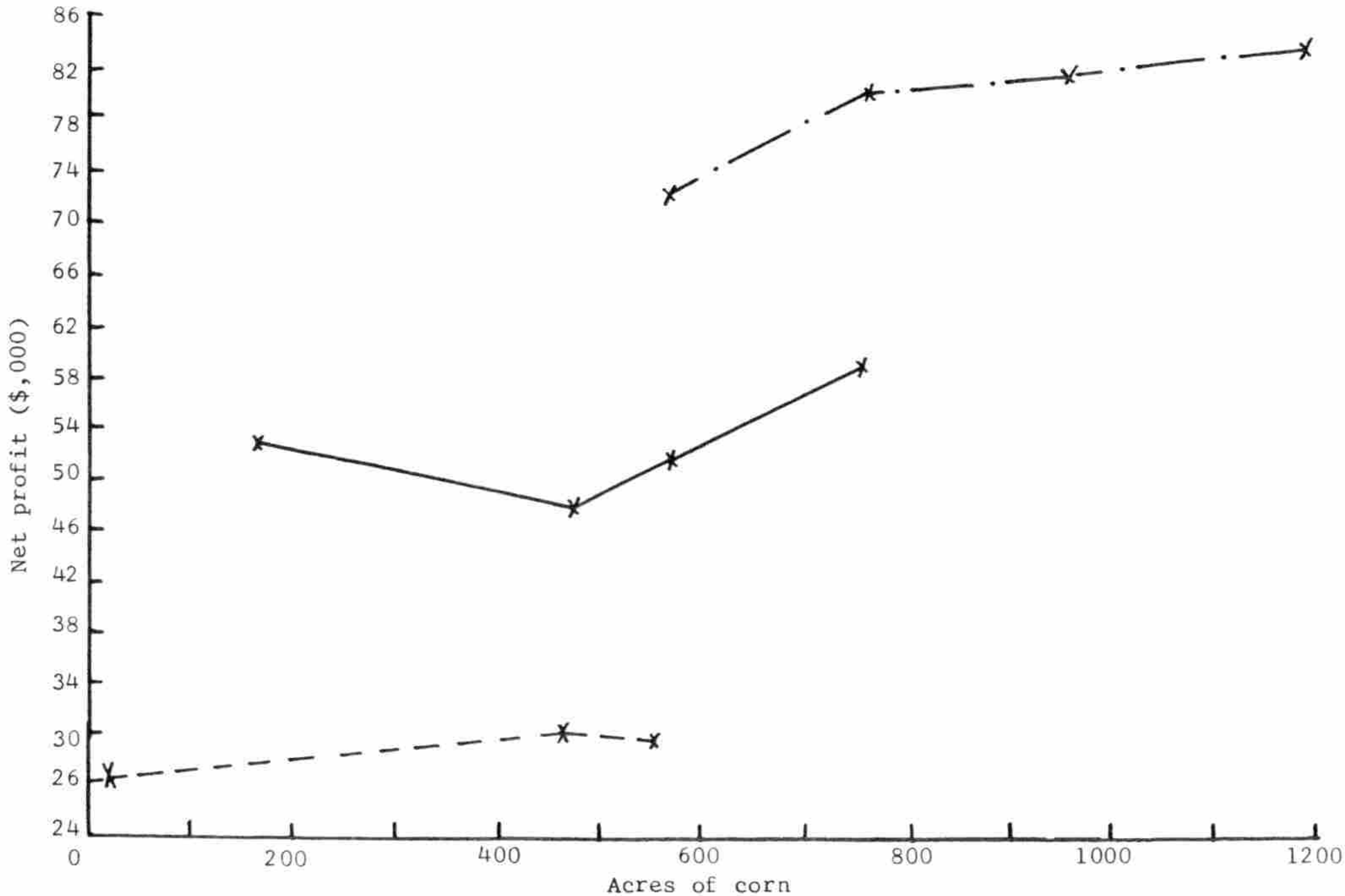

Figure 15. Net profit from optimum plans of model 5 (2000 acres) at different levels of corn production, with ;
3 labor units ------,
4 labor units_______, and
5 labor units___-___-

VII. RECOMMENDATIONS AND CONCLUSIONS, DISCUSSION, AND SUMMARY

In this chapter we shall attempt to make recommendations and draw conclusions from the results presented in Chapter VI. We shall return to model 1 and work through to model 5 bringing each model together in a comparative static framework in order to approximate a growth situation.

A. Recommendations and Conclusions

This study is an attempt to formulate optimum resource use and activity levels for a specific farm-firm under stated assumptions regarding farm size and labor utilization. For this reason it is pertinent that the results be presented as a series of general recommendations which entrepreneurs of the farm-firm may use as a basis on which to make future decisions concerning the growth or expansion of their farm-firm.

From model 1 we have seen that it is possible and profitable for the operators to raise corn on a continuous basis up to the limit of land available after turkey pasture has been deducted. Although the most profitable plan is one where 614 acres of corn and 66 acres of turkey pasture are produced, Figure 11 indicates that the loss in revenue if limited quantities of soybeans are planted is not large. The recommendation therefore is that if maximum profit is desired the operators of the 720 acre farm-firm depicted by model 1 should produce corn to the maximum acreage possible after 66 acres of turkey pasture has been sown. If, because of adverse weather or the emergence of a pest problem, the full 614 acres of corn cannot be planted then the loss in revenue caused by a reduction of 120 acres of corn is not large - about $700 net. If the operators desire to produce more soybeans than this or participate in the feed grain program then they must be prepared to accept the drop in net profit resulting from such sub-optimal plans as shown in Figure 11.

A further recommendation that may be made from model 1 is that regardless of the plan implemented it is only marginally profitable to hire an additional hand. The gross margin resulting from taking this action is approximately $8,800. In all models we have assumed that the fixed cost of hiring a permanent man is $8000, so that in model 1 the marginal net profit derived from utilizing an extra hand is only $800. To the extent that the entrepreneurs of the farm-firm (a) can hire a permanent hand at a smaller or greater price, (b) prefer to have more leisure time letting the hired hand do more work, and (c) are prepared to assume the responsibility of supervising a hired man, so their decision on this matter will be made.

The results of model 2 show that expansion of the farm-firm by the aquisition of an additional half section of land is a very profitable adjustment. From Figure 16 we find that with three labor units net profit has increased by $15,295 over model 1 to $44,848. The figure also indicates that under the assumed conditions the land base should not be expanded beyond 1040 acres. In other words, optimum farm size when three men are employed under the technology, prices, resources, and possible activities assumed here is in the order of 1040 acres. If the farm-firm

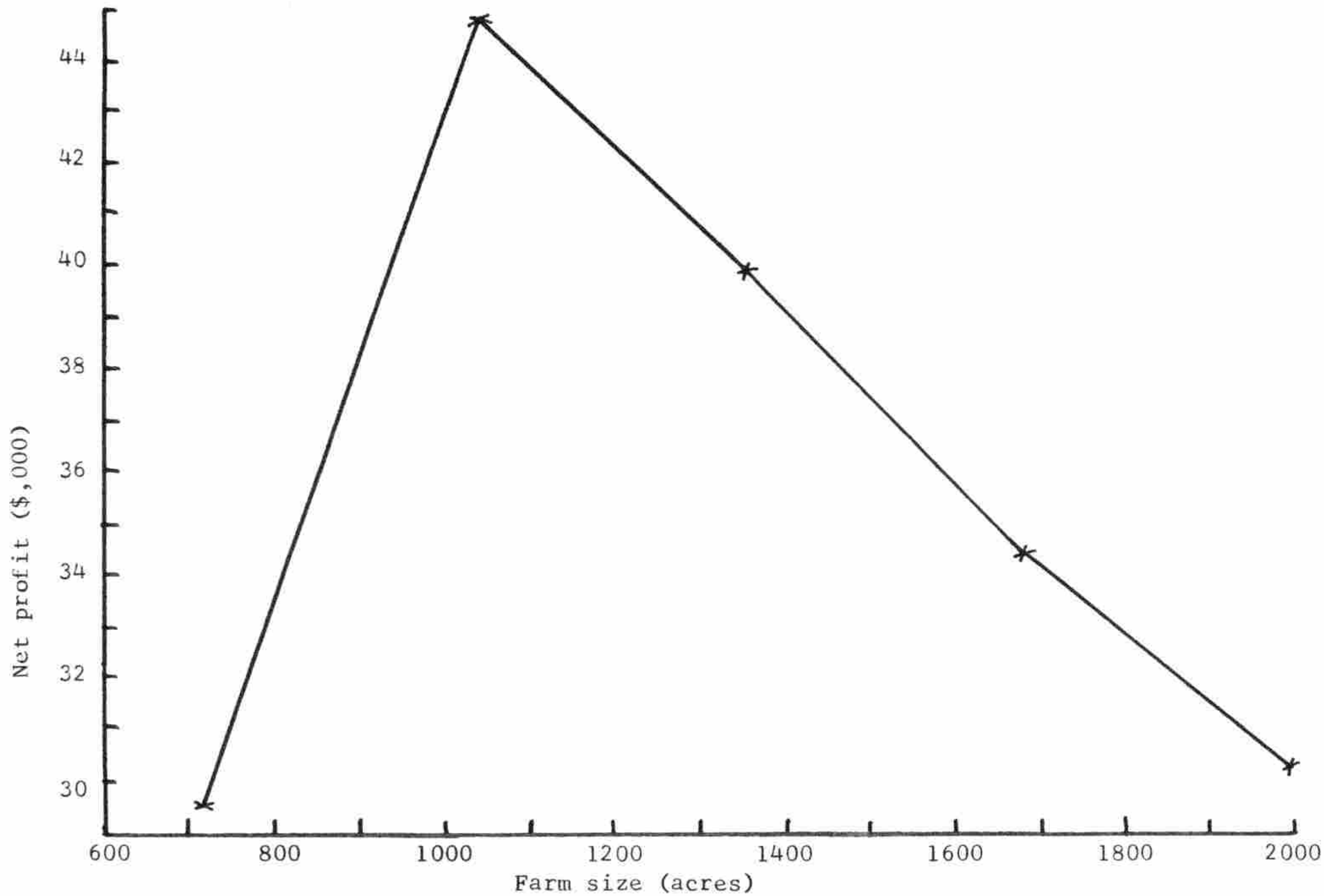

Figure 16. Net profit versus farm size of models 1 through 5 when three units of labor are employed

attempts to expand beyond this by merely increasing its land base then it will experience a decrease in net profit.

With regard to activity levels of three labor unit plans of model 2 we can make the same recommendations as for model 1. After excluding 90 acres of land for turkey pasture the balance of land should be planted in corn. The forfeit for not doing this is relatively small however as Figure 12 attests. If corn production is decreased by 300 acres net profit falls by only five percent to \$42,493.

In model 2 there is no question as to the advisability of hiring a fourth hand. Gross profit increases by \$28,000 over three labor unit plans. In net terms if hiring an extra hand costs \$8,000 as assumed here, then the increase in net profit is \$20,000. The magnitude of marginal net profit when an extra labor unit is added is indicative of the sub-optimal labor use in the three labor unit plans of model 2. It is sub-optimal in the sense that its marginal value product is extremely high.

As Table 20 indicates, we can recommend that a fifth labor unit be added to the farm-firm since the incremental net profit from doing so is \$12,500. Although the marginal value product of labor has decreased it is still positive and far exceeds its price. That is, we have not yet driven the marginal value product of labor to its optimum level - where it equals the price of hiring an additional hand. When the farm-firm has five men employed on it net profit rises to \$77,379.

Previous recommendations of model 2 concerning activity levels remain true in the case of five labor units. The most profitable plan is where the maximum number of turkeys are produced and the maximum acreage of corn is raised. The opportunity cost of not adhering entirely to corn but planting beans or participating up to twenty percent in the feed grain program is not large as is shown in Figure 12. The operators may prefer to accept the small decrease in profit in order to diversify their operations.

The decision of the entrepreneurs of the farm-firm to purchase another 320 acres to bring total acreage up to 1360 acres as has been done in model 3, must be accompanied by the decision to employ at least four men. As Figure 16 shows, to attempt to operate a farm of 1360 acres with only three men under present technology would reduce net profit. Figure 17 however indicates that net profit will increase from $64,897 in model 2 to $66,228 in model 3 when four men are employed. Figure 17 also indicates that a farm of 1360 acres gives the maximum net profit of all farm sizes considered under the assumptions of the models. That is, the optimum farm size under technology, prices, resources, and activities assumed in the study for a four man operation is around 1360 acres. If the entrepreneurs attempt to expand the land base only beyond this point they will experience a decrease in net profit.

The optimum activities of four labor unit plans of model 3 are essentially the same as model 2. Turkeys enter at 36,000 birds and corn occupies the remaining land. The opportunity cost of substituting soybeans for corn is relatively small being only $2,800 or four percent if 364 acres of soybeans replace corn. If the operator wishes to divert twenty percent of his corn base acreage then the opportunity cost compared to planting all corn is $6,400, or a decrease of ten percent.

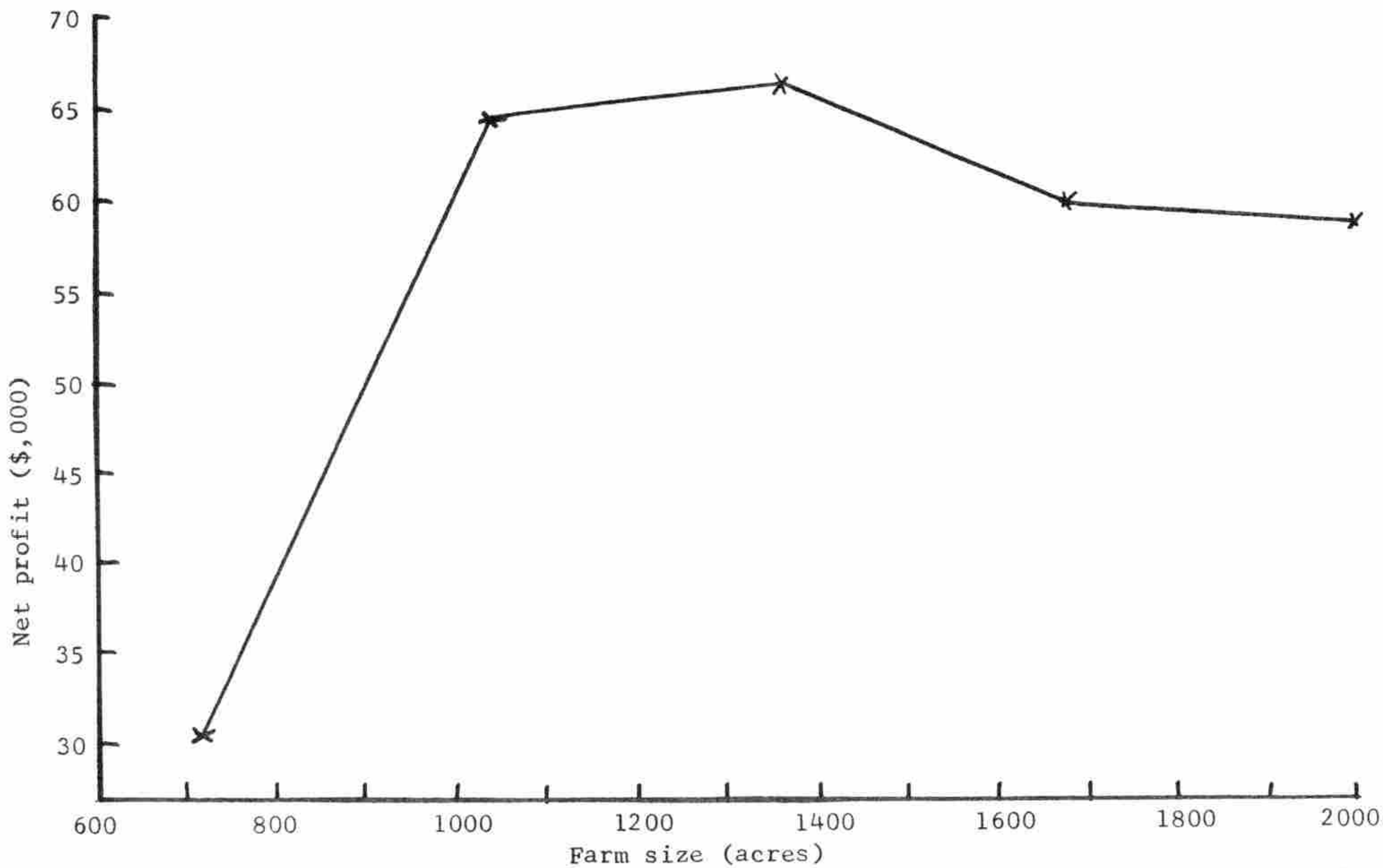

Figure 17. Net profit versus farm size of models 1 through 5 when four labor units are employed

The results of model 3 listed on Table 21 indicate that it is very profitable to hire a fifth permanent worker. By doing so net profit of the farm-firm represented by model 3 is increased from $66,229 to $81,688 - a net increase of $15,440.

With respect to activity levels of model 3 when five labor units are employed, the same recommendations as for four labor unit plans are true. Corn and turkeys remain the most profitable activities. If the operators wish or find it necessary to plant soybeans then the decrease in net profit is of a small magnitude - reducing corn by 343 acres and replacing it with soybeans decreases net profit by less than 3% to $79,316. If twenty percent of the corn base acreage of the farm is diverted the decrease in profit is somewhat larger being eight percent or $3,500.

We have already seen from Figures 16 and 17 that net profit is declining when three or four labor units are employed on defined farms larger than 1360 acres. Thus in model 4 where farm size is 1680 acres the only profitable labor combination considered is five men. If the operators desire to own 1680 acres they will require at least five men to operate the farm-firm at a level more profitable than that depicted by model 3. Even so, net profit has only increased marginally by $3,500 to $85,250. This represents a mere four percent increase in net profit.

As Figure 14 indicates previous recommendations with respect to corn acreage remain in force. The most profitable plan is where the highest proportion of corn is planted. As corn acreage declines net profit falls.

Model 5 represents a farm of 2000 acres. Figure 18 indicates that if we attempt to expand to this farm size under the assumptions and with five or fewer labor units, net profit will decline in comparison to smaller operations. Since we are only considering five, four, or three labor units we cannot recommend that under the present technology a farm of this size be operated. Figure 18 reveals that the optimum farm size with five men and other assumptions made is in the vicinity of 1680 acres.

As an overall recommendation for profit maximization we would advise the operators that subject to present technology, prices, resources, and activity possibilities considered in this study, the most profitable structure is one where five units of labor resource are used to operate a land base of around 1680 acres in the manner specified in plans B03, B06, or B16 of model 4.

B. Discussion

In the United States, the objective of farm management and production economics research is typically stated in terms of developing information useful to decision making by individual farmers (1). This study claims to meet that objective by providing advice, based on a particular entrepreneur's aims, pertaining to the optimization of a farm-firm. We have studied several alternative static models and from these have made recommendations concerning the optimum combination of resources with activities to give a restrained profit maximization solution. We have attempted to incorporate non-economic aspects of the entrepreneurs objectives by limiting the number of hours that the operators may work per week and by the

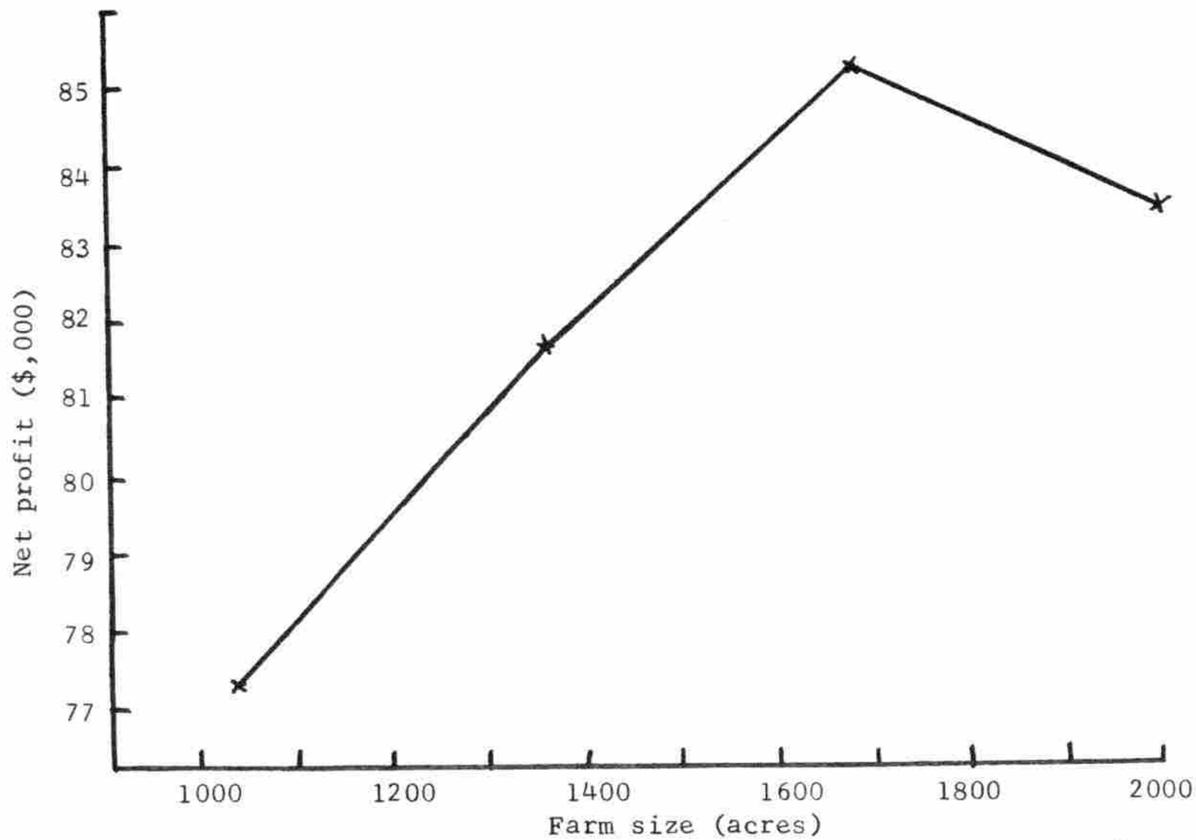

Figure 18. Net profit versus farm size of models 1 through 5 when five labor units are employed

maximum levels set on several activities.

In order that we keep the results of this study in correct perspective it may be helpful to restate the assumptions in explicit form.

1. Because of the linearity assumption no consideration has been given to rising costs and time associated with travelling distances between land holdings as farm-firm size increases. The magnitude of these costs obviously depends on the distance between blocks of land operated by the farm-firm.

2. We have assumed that land added to successive models is immediately available in the right quantity and correct locality. This assumption is probably reasonable when we consider that the area of land within a four mile radius of the farm-firm headquarters is 25,600 acres and that over 1000 acres of that has been for sale over the past six months.[1]

3. The linear programming models used in this study are deterministic. Prices and yields are given and assumed to be known with certainty.

4. As a series of comparative static models, the study fails to take account of possible technological advances that will inevitably occur in future years. The models merely portray one year in a farm-firm's operation. They are static equilibrium models. The use of a dynamic model to trace an optimal expansion path was not employed for two reasons. Firstly, in a real world situation it is only possible for an entrepreneur to purchase additional land as it comes onto the market. The entrepreneur

---

[1]Personal communication with the farm-firm operator.

must then usually purchase the farm as a whole entity. It is therefore not realistic to ask a dynamic program "when and how much additional land should be purchased." Secondly, given the fact that the farm-firm being studied does not face a capital limitation problem, if it is profitable to add land and improvements to the operation then a dynamic program would probably specify that the changes be made immediately. For these reasons static models were used.

Glenn Johnson wrote that "Static economics defines the problem of managing a farm as dealing essentially (1) with resource combinations, (2) with enterprise combinations, and (3) with levels of input and, hence, of output. As the academician looks at the management process in operation on farms he realizes that the list of problems solved by static economics is far too narrow" (31, p. 445). This study succumbs to Johnson's criticism but we defend the methodology used by asserting that the results of the study go far in aiding the entrepreneurs of the farm-firm to make knowledgeable decisions. The study makes no claim to interdisciplinary breadth which we saw from Chapter I is required to support the increasingly broad concept of management, but rather claims to have answered specific questions regarding profitable adjustments of the farm-firm. As such the production economics approach used here has surely contributed to the management of the farm-firm and may represent a small but perhaps significant step in the extension of production economics principles from their "practical application" to "commercial adoption."

C. Summary

The first chapter of this study dealt with the role of farm management and management decisions in successful farming. We mentioned the complexity of the entire decision making process and pointed out that social scientists, until recently, have had little success in faithfully simulating decision processes in mechanistic models. We then suggested linear programming as a tool available to economists which is capable of overcoming some of the difficulties associated with combining resources and enterprises.

After defining the objectives of the study and describing the present farm-firm structure, we continued to review four production economics principles as applied to linear programming and examine the technique, model, and methodology of linear programming.

In Chapter V the models used to depict five farm-firm situations were described. We saw how the program was constructed to handle the problem of varying returns on diverted land, and how the grain inventory problem was integrated with the general model to give a coordinated solution.

The results of the models were presented in Chapter VI and the implications of them were given in the first part of Chapter VII. Results showed that a considerable increase in profit was possible in model 1 (720 acre farm) by increasing corn production. From a net profit of $7,750 under present production patterns of the farm-firm studied, the potential increase in net profit by reorganizing activities within present resource restraints to include more corn and turkeys, is in the order of

$20,000. Model 1 further showed that the addition of a hired man increased net profit marginally (only $800).

Other models confirmed the finding of model 1 that corn and turkey production were the most profitable enterprises and where not restrained by labor the program specified that they be produced at their respective maximum levels. Only when labor became severely limiting (such as when three labor units were employed on a 2000 acre farm) did it become profitable for the farm-firm to participate in the Federal Government Feed Grain Program by diverting land out of corn production.

As farm size increased the models showed how marginal net profit from hiring extra labor increased. In all models which had a land base of 1040 acres or greater it was profitable to hire two extra labor units bringing to five the total number of men employed on the farm-firm.

Finally, the results of the study showed that under the activities, restraints, and coefficients considered, optimum farm size when three labor units are employed is in the vicinity of 1040 acres. When four labor units are utilized optimum farm size increases to approximately 1360 acres, and when a fifth man is engaged optimum farm size is in the order of 1680 acres.

In Chapter VII we returned to review and conclude the objectives of the study.

VIII. LITERATURE CITED

1. Ackerman, Joseph. Evaluation of N.C.R.-4, North Central Farm Management Committee: 1965. Unpublished mimeographed paper. Farm Foundation, Chicago, Ill. 1965.

2. Beale, E. M. L. On optimizing a convex function subject to linear inequalities. J. Royal Statistical Society 17: 173-185. 1955.

3. Beneke, R. R. Linear programming applications to farm planning. Revised. Department of Economics, Iowa State University, Ames, Iowa. 1968.

4. Blosser, R. H. and Doster, D. H. Hog costs from weaning to slaughter. Ohio Report on Research and Development 51, No. 2: 27-29. 1966.

5. Candler, Wilfred. Linear programming with stochastic yields. Unpublished Ph.D. thesis. Library, Iowa State University, Ames, Iowa. 1957.

6. Candler, Wilfred and Musgrave, W. F. A practical approach to the profit maximization problem in farm management. J. of Agricultural Economics 14: 510-517. 1960.

7. Cyert, Richard M. and March, James G. A behavioral theory of the firm. Englewood Cliffs, N.J., Prentice-Hall Inc. 1963.

8. Dantzig, G. B. Linear programming and extensions. Princeton, N.J., Princeton University Press. 1963.

9. Dantzig, G. B. The programming of interdependent activities: Mathematical model. In Koopmans, Tjalling C., editor. Activity analysis of production and allocation. 19-32. John Wiley and Sons, Inc., New York, N.Y. 1951.

10. Detailed cost report for central and western Illinois, 1964, and 1965. Illinois Agr. Expt. Sta. Res. Report A.E.R.R.-85. 1967.

11. Dorfman, Robert. Application of linear programming to the theory of the firm. University of California Press, Berkeley, Calif., 1951.

12. Dorfman, Robert, Samuelson, P. A. and Solow, R. M. Linear programming and economic analysis. McGraw Hill, New York, N.Y. 1956.

13. Ferguson, C. E. Microeconomic theory. Richard D. Irwin, Inc., Homewood, Illinois. 1966.

14. Gibbens, J. M. Income possibilities of basic alternative adjustment programs for small farms on Tama-Muscatine soils in Iowa. Unpublished Ph.D. thesis. Library, Iowa State University, Ames, Iowa. 1964.

15. Gibbons, J. R. Costs, economies of scale and alternative production methods in steer feeding in relation to overall farm resource use. Unpublished Ph.D. thesis. Library, Iowa State University, Ames, Iowa. 1963.

16. Gomory, R. E. An all-integer integer programming algorithm. I.B.M. Research Report, R.C. 189. 1960.

17. Gomory, R. E. Outline of an algorithm for integer solutions to linear programs. American Mathematical Society Bul. 64. 1958.

18. Heady, E. O. Economics of agricultural production and resource use. Englewood Cliffs, N.J., Prentice-Hall, Inc. 1952.

19. Heady, E. O. and Candler, W. Linear programming methods. Iowa State University Press, Ames, Iowa. 1958.

20. Heady, E. O. and Gilson, J. C. Optimum combinations of livestock enterprises and management practices on farms including supplementary dairy and poultry enterprises. Iowa Agr. Expt. Sta. Res. Bul. 437. 1956.

21. Heady, E. O. and Jensen, H. R. Farm management economics. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1954.

22. Heady, E. O., McAlexander, R., and Stoneberg, E. G. Plans for beginning farmers in south-west Iowa with comparison of farm and non farm income opportunities. Iowa Agr. Expt. Sta. Res. Bul. 456. 1958.

23. Henderson, J. M. and Quant, R. E. Microeconomic theory. McGraw Hill, New York, N.Y. 1958.

24. Hildreth, C. and Reiter, S. On the choice of a crop rotation plan. In Koopmans, Tjalling, C., editor. Activity analysis of production and allocation. 177-188. John Wiley and Sons, Inc., New York, N.Y. 1951.

25. Hoglund, C. R. Investment and annual costs for alternative beef cattle feeding systems. Michigan Agr. Expt. Sta. Farm Science Res. Report 7. 1965.

26. Hull, D. A., Hull, A. D. and Caldwell, M. G. 1968 Costs for field work. Iowa Farm Science 22, No. 7: 20-136. 1968.

27. Hutchinson, J. D. Interrelationships among capital, technology and size in farm organization and income. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa. 1969.

28. Iowa Farm Science. Prices of Iowa Farm Products 1930-1968. F. S. 1313. Iowa Agr. Expt. Sta. 1969.

29. Iowa turkey demonstration flock report (1964). Iowa State University Coop. Ext. Service. [Publication] 8305 A. 1965.

30. James, S. C., editor. Midwest farm planning manual. 2nd edition. Iowa State University Press, Ames, Iowa. 1968.

31. Johnson, Glenn L. Agricultural Economics, Production Economics, and the field of Farm Management. Journal of Farm Economics 39, No. 3: 441-450. 1957.

32. Koopmans, Tjalling C. Optimum utilization of the transport system. Proceedings of the International Statistical Conferences, 1947. Washington. Vol. 5 (Reprinted as a supplement to Econometrica 17: 136-146.) 1949.

33. Koopmans, Tjalling C., editor. Activity analysis of production and allocation. John Wiley and Sons, Inc., New York, N.Y. 1951.

34. Kopetz, H. On the application of operations research techniques in agricultural economics. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa. 1966.

35. Samuelson, P. A. Foundations of economic analysis. Harvard University Press, Boston, Mass. 1953.

36. Shechter, Mordechai. Empirical decision rules for agricultural policy: A simulation analysis of the feed grain program. Unpublished Ph.D. thesis. Library, Iowa State University, Ames, Iowa. 1968.

37. Smith, Adam. The wealth of nations. Henry Regney Company, Chicago, Illinois. 1953.

38. Summary of results of Nebraska tests. University of Nebraska, Dept. of Agric. Engineering [Publication] 1965.

39. Trede, C. E. Swine production systems as related to business management on north-central Iowa farms. Unpublished M.S. thesis. Library, Iowa State University, Ames, Iowa. 1968.

40. U.S. Department of Agriculture. Partitioning financial returns: an application to the growth of farm firms. U.S.D.A. Economic Research Service 390. 1969.

41. Van Arsdall, R. N. Labor requirements, machinery investments, and annual costs, for the production of selected field crops in Illinois, 1965. Illinois Agr. Expt. Sta. A.E. 4112. ca. 1966.

42. Wood, M. K. and Dantzig, G. B. The programming of interdependent activities. I. In Koopmans, Tjalling C., editor. Activity analysis of production and allocation. 15-19. John Wiley and Sons, Inc., New York, N.Y. 1951.

IX. ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance given by Professor Earl O. Heady.

A sincere debt of gratitude is owing to Dr. Robert J. Townsley, a former fellow graduate student, for his counsel, advice, and suggestions throughout the entirety of this study.

Thanks are also due to Gary D. Harter for his help in deriving cattle data and many other miscellaneous matters.

X. APPENDIX A

Table 4. Tractor operating costs (38)

Tractor size	Fuel consumption per hour[a]	Fuel cost per hour[b]	Oil con-consumption per hour	Oil cost per hour[c]	Total operating cost per hour
	gallons	$	gallons	$	$
55 h.p. deisel	3.3	.544	.008	.013	.557
85 h.p. deisel	4.5	.743	.01	.016	.759
115 h.p. deisel	5.8	.957	.012	.019	.976

[a]Based on the tractor working at 62% of its maximum load.

[b]Based on a cost of $.165 per gallon for deisel.

[c]Based on a cost of $1.60 per gallon for lubricating oil.

Table 5. Cropping machinery: capital requirements, useful life, and annual fixed costs (as reported by operators)

Machine	Replacement cost	Life (years)	Annual depreciation	Repair cost[a]	Taxes and insurance[b]	Total fixed costs
Tractor (110 h.p.)	$6,000	8	$750	$180	$120	$1,050
Tractor (60 h.p.)	5,000	10	400	120	80	600
Truck (2½ ton)	2,000	8	250	60	40	350
Truck (3/4 ton)	2,500	6	416	75	50	541
Feed carrier	600	20	30	18	12	60
Plow (8 bottom)	2,000	18	111	60	40	211
Spring tooth harrows (30 ft)	540	18	30	16	11	57
Spike harrows (30 ft)	108	18	6	3	2	11
Sprayer	425	15	28	13	8	49
Mower	600	18	33	18	12	63
Rotary shredder	690	6	6	20	14	40
Side rake	600	12	50	18	12	80
Discs (21 ft)	1,500	10	150	45	30	225
2 augers (40 ft)	540	18	30	16	11	57
Rotary hoe	1,160	8	144	36	23	203
Combine (6 row)	5,600	6	934	168	112	1214
Elevator (52 ft)	1,040	8	130	30	20	180
Spreader (manual)	480	16	30	15	9	54
Corn planter (6 row)	2,640	10	264	78	52	394
Total	33,023					5439
Av. value[c]	16,511	at 5% interest = $825				825
Total annual fixed costs including interest on capital						$6264.00

[a]Annual repair costs calculated at 3% of replacement cost.

[b]Taxes and insurance calculated as 2% of replacement cost.

[c]Average value is 50% of replacement cost.

Table 6. Variable costs of crops (per acre) 1968[a]

Variable cost per acre	Corn	Oats	Soybeans	Oats and alfalfa	Diverted land	Corn silage
Fertilizer	$20.25	$6.00	$3.20	0	0	$20.55
Therapeutant	2.80	0	0	0	0	2.80
Herbacide	3.82	0	4.70	0	0	3.82
Seed	4.34	4.40	3.10	0.54	1.64	4.34
Op. costs (85 h.p. tractor)	3.53	2.06	2.86	3.07	.81	-
Op.costs (110 h.p. tractor)	3.04	1.65	2.40	2.51	.68	11.32
Total (85 h.p. tractor)	34.74	12.46	13.86	9.61	2.45	-
Total (110 h.p. tractor)	34.25	12.05	13.40	9.05	2.32	42.83

[a]Source: Table 4 and (41).

Table 7. Hogs: feed fed, cash expenses and net revenue per hog from birth to slaughter (1968)[a]

Item	Units
Weight at marketing	220 lb
Price per cwt.	$17.00
Gross value	$37.40
Culled sow weight/hog sold	5.34 lb
Sow value/hog sold	$ .80
Gross receipts	$38.20
Feed fed	
Corn	10.02 bu.
Supplements	$8.95
Annual cash expenses	
Feed supplements	$8.95
Power and machinery	1.18
Veterinary and med.	1.00
Taxes (livestock and feed) and interest on livestock	.56
Replacement boar	1.02
Total expenses	12.71
Net revenue	$25.49

[a]Source: Farm accounts and records, and (4).

Table 8. Feeder swine: food fed, cash expenses and net revenue, per feeder pig for growing-finishing (1968)[a]

Item	Unit
Weight at marketing	220 lb
Weight when purchased	40 lb
Price of weanlings	$17.40
Gross receipts at $.17/lb	$37.40
Feed fed	
Corn	9.71 bu.
Supplements	$4.75
Annual cash expenses	
Feed supplements	$4.75
Power and machinery	.59
Veterinary and med.	.23
Taxes (livestock and feed) and interest on livestock	.23
Price of weanling	17.40
Replacement boar	1.02
Total expenses	$24.22
Net revenue	$13.18

[a]Source: farm accounts and records, and (4).

Table 9. Weanling hogs: feed fed, cash expenses, and net revenue per hog (1968)[a]

Item	Unit
Weight at sale (weaning)	40 lb
Price per weanling	$16.60
Gross receipts	$16.60
Feed fed	
Feed supplements[b]	5.20
Corn	.322 bu
Cash expenses	
Feed supplements	$5.20
Power and machinery	.64
Veterinary and med.	.87
Taxes (livestock and feed) and interest on livestock	.33
Replacement boar	1.02
Total expenses	8.96
Net revenue	$8.54

[a]Source: Farm accounts and records and (4).

[b]Includes feed fed to sows and boars per piglet.

Table 10. Turkeys: Feed fed, cash expenses, and net revenue per turkey[a]

Item	Unit (per 10 birds)
Weight at marketing	280 lb
Price per lb	$ .20
Gross value	56.00
Feed fed	
Corn	11.35 bushels
Supplements	$14.87
Annual cash expenses	
Feed supplements[b]	$14.87
Poults at $.80 each[c]	8.00
Total expenses	$22.87
Net revenue	$33.13

[a]Source: Farm accounts and records.

[b]Feed supplements include the cost of medication added to the feed.

[c]$.10 has been added to the cost of each poult to allow for death loss.

Table 11. Buildings and equipment: capital requirements, useful life, and fixed costs[a]

Item	Repl. cost $	Life (yrs)	Annual depr.	Av. repair costs (1.5%)	Taxes and insurance (1.3%)	Total fixed costs
Corn crib (5000 bu)	$ 3,000	16	$187.50	$ 45.00	$ 29.04	
Grain bins(20)(65000 bu)	18,000	14	1285.00	270.60	234.00	
Aeration ducts	931	10	93.10	13.96	12.10	
Grain driers (2)	1,230	8	153.75	18.45	16.00	
Augers and motors	820	12	68.33	12.30	10.60	
Store and dry unit	400	10	40.00	6.00	5.72	
Grain leveller	400	10	40.00	6.00	5.72	
Grain mill and mixer	1,000	15	66.60	15.00	13.00	
Total corn equip.	25,781		1934.28	387.31	336.20	$2657.80
Average value	12,890	Interest on average value		=		644.50
						3302.30
Tiles (14,000 ft)	7,800	20	390.00	0	1	390.00
Average value	3,900	Interest on average value		=		195.00
						585.00
Hog Buildings and Equipment						
20 stall farrowing unit	5,600	15	373.50	84.00	72.80	
Equipment for above	3,600	15	240.00	54.00	46.80	
500 head growing-finish.	4,920	15	328.00	73.80	64.00	
Equipment for above	1,500	15	100.00	22.50	19.50	
Total	14,620		1041.50	234.30	203.10	1478.90
Average value	7,310	Interest on average value		=		365.50
						1844.40

[a] Source: Farm depreciation schedule, farm records, Tables 12, 13, 14.

Table 11. (Continued)

Item	Repl. cost $	Life (yrs)	Annual depr.	Av. repair costs (1.5%)	Taxes and insurance (1.3%)	Total fixed costs
Turkey Buildings and Equipment						
6000 bird brooding building	$4,500	15	300.00	67.00	60.00	
Equipment for above	5,900	15	393.30	89.00	78.00	
Range shelters and feeders	600	10	60.00	9.00	8.00	
Total	11,000		753.30	165.00	146.00	1064.30
Average value	5,500		Interest on average value		=	275.00
						1339.30
Other						
Houses (3)	45,000	20	2250.00	675.50	600.00	
Two way radios (5)	400	10	40.00	6.00	5.20	
LP tank and line	500	15	33.33	7.50	6.50	
Generator (auxilliary power)	653	10	65.30	9.79	8.49	
Welder	335	10	33.50	5.03	4.35	
Well and water system	1,500	20	75.00	22.50	19.50	
Misc. tools	300	20	15.00	4.50	3.90	
Machine shed and garage(2300 ft^2)	3,000	20	150.00	45.00	39.00	
Fences	1,800	10	180.00	27.00	23.34	
Total	53,488		2842.13	802.32	710.28	4354.73
Average value	26,744		Interest on average value		=	1337.20
						5691.93

Table 12. Approximate replacement cost of a twenty stall farrowing unit and related equipment, 1967[a]

Item	Cost		
I Building shell			
A. Site preparation	$ 50.00		
B. Building shell[b]	3825.00		
C. Utilities[c]	1725.00		
		5600.00	
II Equipment			
A. Steel farrowing stalls	$2400.00		
B. Electric floor heaters	600.00		
C. Ventilation system	150.00		
D. Self feeder for gestating sows	250.00		
E. Heaters	200.00		
		3600.00	
			9200.00

[a]Source: adapted from Trede (39).

[b]Includes concrete foundations and floor, insulated walls and roof.

[c]Includes water supply, electrical outlets and sewage drains.

Table 13. Approximate replacement cost of a 500 head open front growing-finishing building for hogs, 1967[a]

Item	Cost		
I Building Shell			
A. Site preparation	$ 120.00		
B. Building shell[b]	4400.00		
C. Utilities[c]	400.00		
		4920.00	
II Equipment			
A. Self feeders	800.00		
B. Automatic heated waterers	400.00		
C. Interior partitions	300.00		
		1500.00	
			6420.00

[a]Source: adapted from Trede (39).

[b]Includes concrete foundations and floor, insulated walk and roof.

[c]Includes water supply, electrical outlets and sewage drains.

Table 14. Approximate replacement costs of turkey facilities of 6,000 bird capacity (1967)[a]

Item	Cost
A. Brooding building[b]	$ 4,500
B. Equipment for above[c]	5,900
C. Range shelters and feeders	600
	$11,000.00

[a]Replacement costs were developed in consultation with Mr. Wallace Ross, Department of Poultry Science, Iowa State University.

[b]Includes site preparation, concrete floor and foundation, insulated walls and roof.

[c]Includes automatic feeders and waterers, gas heaters, thermostatically controlled ventilation, electric outlets and lights, and wire netting brooding frames.

Table 15. Cattle: input-output coefficients, variable costs, and net returns, using a self unloading wagon system[a]

Cattle enterprise	1 Steer calves	2 Steer calves	3 Yearling steers	4 Yearling steers	5 Yearling steers	6 Yearling steers	7 Yearling steers of	8 Yearling steers of
Unit:	1 steer	1 steer	1 steer	1 steer	1 steer	1 steer	2 steers	2 steers
Basic data:								
Purch. date	Nov	Nov	Oct	Oct	April	April	Oct.Apr.	Oct.Apr.
Markt. date	Aug	Aug	Apr	Apr	Sept	Sept	Apr.Sept.	Apr.Sept.
Days fed	270	270	190	190	145	145	335	335
Init. weight(lb)	450	450	600	600	700	700	1300	1300
Mkt weight (lb)	1050	1050	1050	1050	1050	1050	2100	2100
Net gain (lb)	600	600	450	450	350	350	800	800
Gain/day	2.22	2.22	2.37	2.37	2.42	2.42		
Death loss (%)	1.10	1.10	.75	.75	.75	.75	.75	.75
Meat sold (lb)	1020	1020	1020	1020	1020	1020	2040	2040
Feed fed:								
Corn (bu)	44.4	43.7	47.6	44.5	36.25	37.03	83.85	81.53
Suppl. (lb)	194.4	37.8	89.3	43.7	68.15	33.35	157.45	77.05
Haylage (tons)	0	.742	0	.294	0	.224	0	.518
Silage (tons)	2.632	1.620	1.710	1.197	1.305	.913	3.015	2.110
Labor 1	1.82	1.82	1.78	1.78	0	0	1.78	1.78
Labor 2	1.20	1.20	.98	.98	.47	.47	1.45	1.45
Labor 3	.95	.95	0	0	1.36	1.36	1.36	1.36
Labor 4	.35	.35	0	0	1.36	1.36	1.36	1.36
Labor 5	.12	.12	.14	.14	.43	.43	.57	.51

[a]Source: (27) and private communication with G. D. Harter.

Table 15. (Continued)

Cattle enterprise	1 Steer calves	2 Steer calves	3 Yearling steers	4 Yearling steers	5 Yearling steers	6 Yearling steers	7 Yearling steers of	8 Yearling steers of
Variable costs:								
Suppl.(5¢/lb)	9.72	1.89	4.46	2.19	3.41	1.66	7.87	3.85
Power and machinery	4.63	4.63	1.51	1.51	1.08	1.08	2.59	2.59
Taxes on LS	.97	.97	.97	.97	.88	.88	1.85	1.85
Vet and med.	4.50	4.50	1.20	1.20	.85	.85	2.05	2.05
Transport	4.85	4.85	5.00	5.00	5.00	5.00	10.00	10.00
Feeder stock	129.62	129.62	160.80	160.80	174.19	174.19	334.99	334.99
Interest on LS	6.28	6.28	6.42	6.42	6.33	6.33	12.75	12.75
Cost of feedlot/ steer/yr:								
0-350 head	6.44	6.44	6.44	6.44	6.44	6.44	3.22	3.22
351-500 head	5.98	5.98	5.98	5.98	5.98	5.98	2.99	2.99
500-750 head	5.22	5.22	5.22	5.22	5.22	5.22	2.61	2.61
Total variable costs								
0-350 head capac.	167.01	159.18	186.80	184.53	198.18	196.43	375.32	371.30
351-500 " "	166.55	158.72	186.34	184.07	197.72	195.97	375.09	371.07
500-750 " "	165.79	157.96	185.58	183.31	196.96	195.21	374.71	370.69
Gross receipts	278.50	278.50	274.60	274.60	271.80	271.80	546.40	546.40
Net revenue								
0-350 head unit	111.49	119.32	87.80	90.07	73.62	75.37	171.08	175.10
351-500 " "	111.95	119.78	88.26	90.53	74.09	75.83	171.31	175.33
500-750 " "	112.71	120.54	89.02	91.29	74.84	76.59	171.69	175.71

Table 16. Cattle: input-output coefficients, variable costs, and net returns using an auger feeding system[a]

Cattle enterprise	Calf 1	Calf 2	Yrling 3	Yrling 4	Steer 5	Steer 6	Yrling 8	Yrling 9
Basic data:								
Feed fed	As for the respective columns in Table 15							
Variable costs excluding F.C.								
Labor 1	1.26	1.26	1.44	1.44	0	0	1.44	1.44
2	.95	.95	.79	.79	.33	.33	1.12	1.12
3	.72	.72	0	0	1.17	1.17	1.17	1.17
4	.26	.26	0	0	1.17	1.17	1.17	1.17
5	.08	.08	.11	.11	.30	.30	.41	.41
Cost of feedlot/steer/yr								
0 - 350 head	7.07	7.07	7.07	7.07	7.07	7.07	3.53	3.53
351 - 500 "	6.49	6.49	6.49	6.49	6.49	6.49	3.24	3.24
Total variable costs								
0 - 350 hed capacity	167.64	159.81	187.43	185.16	198.81	197.06	375.63	371.61
351 - 500 " "	167.06	159.23	186.85	184.58	198.23	196.48	375.34	371.32
Gross receipts	278.50	278.50	274.60	274.60	271.80	271.80	546.40	546.40
Net revenue								
0 - 350 head unit	110.86	118.69	87.17	89.44	72.99	74.74	170.77	174.79
351 - 500 head unit	111.44	119.27	87.75	90.02	73.57	75.32	171.06	175.08

Table 17. Annual fixed costs of various sized farms used in the study[a]

Item	Farm size in acres				
	720	1040	1360	1680	2000
Property taxes	4,932.50	7,966.00	10,999.47	13,845.53	17,071.38
Int. on land[b]	21,840.00	35,280.00	48,720.00	61,320.00	75,600.00
Rent	4,230.00	4,230.00	4,230.00	4,230.00	4,230.00
Machinery	6,264.00	9,764.00	9,764.00	12,832.00	12,832.00
Corn cribs, grinder-mixer etc.	3,302.50	3,302.50	4,649.81	4,649.81	4,649.81
Hog bldgs and equip.	1,844.40	1,844.40	1,844.40	1,844.40	1,844.40
Turkey "	1,339.30	1,339.30	1,339.30	1,339.30	1,339.30
Houses, sheds and misc.	5,691.93	5,691.93	5,920.40	6,854.14	6,856.14
Tiles	585.00	944.77	1,304.55	1,638.00	2,024.10
Labor(3 units)	37,300.00	37,300.00	37,300.00	37,300.00	37,300.00
Labor(4 units)	45,300.00	45,300.00	45,300.00	45,300.00	45,300.00
Labor(5 units)	-	-	53,300.00	53,300.00	53,300.00
Total(3 lab. units)	87,329.63	107,662.90	126,071.93	145,853.18	163,745.13
Total (4 ")	95,329.63	115,662.90	134,071.93	153,853.18	171,745.13
Total (5 ")	-	-	142,071.93	161,853.18	179,745.13

[a]Farm records, Tables 9, 15.

[b]Calculated as: Total acreage less 200 rented acres, at 6% per annum.

XI. APPENDIX B

Table 18. Optimum plans for Model 1 (720 acres)

Activity \ Name	BJ1	BJ5	BJ7	BJ2	BJ6	BJ8	Units
Gross returns	116,882	114,211	111,792	125,678	123,009	120,544	$
Net profit	29,554	26,883	24,485	30,350	27,681	25,237	$
Labor units	3	3	3	4	4	4	men
Corn	614	420	280	614	420	280	acres
Turkey land	66	66	66	66	66	66	"
Soybeans	0	194	264	0	194	264	"
Diverted land	0	0	70	0	0	70	"
Buy corn 1	210	6,228	4,708	1,954	7,803	7,372	bushels
Buy corn 2	2,496	7,955	0	2,600	8,351	0	"
Buy corn 4	2,485	9,238	18,786	4,215	10,940	20,445	"
Sell corn 3	58,520	52,500	35,000	58,375	52,500	35,000	"
Sell oats 3	3,102	0	0	3,102	0	0	"
Sell oats 4	0	3,102	3,102	0	3,102	3,102	"
Sell soybeans 3	0	3,102	3,102	0	3,102	3,102	"
Sell soybeans 4	0	4,658	7,458	0	4,658	7,458	"
Sell hay	50.8	50.8	50.8	50.8	50.8	50.8	tons
Hogs 1	0	0	0	0	340	418	head
Weanlings 1	355	345	500	500	500	500	"
Weanlings 2	500	500	500	500	500	500	"
Weanlings 3	66	55	0	280	290	290	"
Weanlings 4	138	160	216	154	160	82	"
Turkeys	20,000	20,000	20,000	20,000	20,000	20,000	"
Cap. transfer 1	50,925	53,643	40,590	52,919	55,949	42,549	$
Cap. transfer 2	0	0	0	0	0	0	"
Cap. transfer 3	78,780	78,207	37,946	78,554	78,270	37,728	"
Cap. transfer 4	99,799	106,270	63,835	93,889	100,609	56,554	"
Labor 1	4.8	3.3	2.3	3.5	3.5	3.5	hours/day
Labor 2	8.0	8.0	8.0	8.0	8.0	8.0	"
Labor 3	11.5	11.5	11.4	10.3	8.9	10.0	"
Labor 4	8.5	8.5	8.5	8.5	8.5	8.8	"
Labor 5	8.5	7.6	7.4	7.6	7.1	6.7	"

Table 19. Optimum plans for model 1 when 620 acres of land are rented out at $50 per acre

Activity / Name	BJIR	BJ2R	Units
Labor units	3	4	Men
Gross returns	102,294	111,523	$
Net profit	23,494	24,723	$
Rented land	620	620	acres
Turkey pasture	80	80	"
Buy corn 4	33,871	39,925	bushels
Sell oats 3	3,760	3,760	"
Sell hay	61.6	61.6	tons
Hogs 1	327	420	head
Hog expansion 1	0	281	head
Hog expansion 3	233	448	"
Weanlings 1	500	500	"
Weanlings 2	500	500	"
Turkeys	20,000	20,000	"
Turkey expansion	4,240	4,240	"
Capital transfer 1	35,878	39,492	$
Capital transfer 3	24,638	29,056	"
Capital transfer 4	25,390	18,835	"
Labor 1	3.8	4.4	hours/day
Labor 2	8.0	8.0	"
Labor 3	9.6	9.0	"
Labor 4	8.5	8.5	"
Labor 5	6	5.9	"

Table 20. Optimum plans for model 2 (1040 acres)

Activity	BO1	BO7	B14	BO2	BO8
Labor units	3	3	3	4	4
Gross return	152,766	150,588	141,727	180,938	179,150
Net profit	44,848	42,493	34,143	64,897	62,845
Corn	892	600	227	840	600
Turkey pasture	90	92	89	142	142
Soybeans	0	290	402	0	240
Diverted land	0	0	264	0	0
Buy corn 1	318	656	0	799	1,032
Buy corn 2	3,397	3,323	0	5,042	5,001
Buy corn 4	12,520	13,120	34,706	20,567	20,833
Sell corn 3	95,944	59,152	28,375	80,342	50,296
Sell oats 2	4,227	4,311	4,204	6,669	6,669
Sell beans 3	0	11,609	16,062	0	9,604
Sell haylage	94.7	97	98.4	156	156
Feeders 1	0	78	205	165	213
Feeders 4	0	0	201	0	67
Turkeys	13,000	13,000	13,000	13,000	13,000
Turkey expansion	14,250	14,790	14,100	30,000	30,000
Weanlings 1	0	0	0	0	0
Weanlings 2	172	0	0	143	83
Weanlings exp. 2	0	0	0	0	0
Cap. transfer 1	64,715	62,306	45,625	84,612	81,260
Cap. transfer 3	66,568	56,769	54,078	139,863	44,258
Cap. transfer 4	59,579	83,751	62,074	107,056	101,125
Labor 1	1.9	1.3	1.1	1.4	1.3
Labor 2	8.0	8.0	8.0	8.0	8.0
Labor 3	11.5	11.5	11.5	11.5	11.5
Labor 4	8.5	8.5	8.5	8.5	8.5
Labor 5	6.8	6.0	5.0	5.9	4.4
Buy grain bins	41,398	12,200	0	35,012	7,935

B15	B03	B09	B17	Units
4	5	5	5	Men
170,442	201,444	199,889	194,045	$
54,876	77,379	75,557	70,406	$
227	840	600	294	Acres
139	142	142	142	"
352	0	240	349	"
264	0	0	197	"
4,290	1,204	819	7,389	Bushels
	8,283	8,299	5,636	"
49,737	20,308	20,364	39,387	"
28,375	77,493	47,559	36,533	"
6,548	6,669	6,669	6,669	"
14,067	0	9,579	13,960	"
153	156	156	156	Tons
350	0	0	0	Head
280	0	0	64	"
13,000	13,000	13,000	13,000	"
29,220	30,000	30,000	30,000	"
0	0	0	500	"
0	500	500	500	"
0	1,008	1,006	1,050	"
60,222	89,137	88,211	56,004	$
50,800	152,740	134,228	48,710	$
77,588	127,419	121,680	84,203	$
0.9	6.0	6.0	6.0	hours/day
8.0	8.0	8.0	8.0	"
11.5	10.1	10.1	10.0	"
8.5	8.5	8.5	8.5	"
4.6	10.2	10.2	10.2	"
0	32,448	7,442	0	bushels

Table 21. Optimum plans for Model 3 (1360 acres)

Activity	BO1	B10	B14	BO2	BO8
Labor units	3	3	3	4	4
Gross return	164,546	166,113	157,759	200,300	197,612
Net profit	38,474	40,042	31,755	66,228	63,540
Corn grain	439	592	321	1,163	799
Corn silage	3	2	0	0.6	0.7
Turkey pasture	67	70	71	121	124
Soybeans	775	572	571	0	361
Diverted land	0	49	322	0	0
Buy corn 1	1,284	797	611	246	826
Buy corn 2	6,093	6,109	12,807	10,234	10,299
Buy corn 3	9,930	19,067	11,209	16,761	17,756
Sell corn 3	46,520	65,246	37,456	130,282	84,400
Sell oats 1	3,160	3,298	3,346	5,693	5,840
Sell beans 3	30,997	22,867	22,832	0	14,428
Sell haylage	57	66.6	78.3	130	133
Feeders 1	0	0	126	0	113
Feeders 4	0	0	170	0	0
Weanlings 2	0	0	0	304	0
Weanling exp. 2	0	0	0	0	0
Turkeys	13,000	13,000	13,000	13,000	13,000
Turkey expansion	7,380	8,264	8,573	23,700	24,654
Yearlings 42A	58	36	0	11	13
Steers 42B	0	0	0	0	0
Calves 22A	0	0	0	0	0
Cap. transfer 1	57,283	64,867	102,742	98,554	95,630
Cap. transfer 3	95,468	97,899	120,356	104,888	96,053
Cap. transfer	89,721	97,097	129,429	133,419	125,910
Labor 1	1.6	1.8	1.2	2.1	1.3
Labor 2	8.0	8.0	8.0	8.0	8.0
Labor 3	11.5	11.5	11.5	11.5	11.5
Labor 4	8.5	8.5	8.5	8.5	8.5
Labor 5	6.3	6.2	5.4	6.9	6.0
Buy grain bins	15,910	26,872	0	81,093	44,338

B15	BO3	BO9	B17	Units
4	5	5	5	Men
185,902	223,760	221,388	213,136	$
51,930	81,688	79,316	71,064	"
321	1,139	799	386	acres
0	4	0.6	0	"
121	142	142	142	"
521	0	343	499	"
322	0	0	257	bushels
1,309	901	120	351	"
18,885	13,448	13,131	17,542	"
19,138	19,698	19,509	42,090	"
32,841	124,085	82,161	25,447	"
5,690	6,669	6,669	6,669	"
20,837	0	13,723	19,948	tons
133	116	151	78	head
270	0	0	72	"
250	0	0	0	"
0	500	500	500	"
0	1,004	1,007	61	"
13,000	13,000	13,000	13,000	"
23,688	30,000	30,000	30,000	"
0	0	0	0	"
0	0	0	348	"
0	53	7	0	"
143,914	183,881	92,783	225,402	$
132,625	186,905	85,382	124,506	"
167,880	227,303	127,552	255,014	"
1.0	4.9	5.4	1.9	hours/day
8.0	8.0	8.0	8.0	"
11.5	10.1	10.1	11.5	"
8.5	8.5	8.5	8.5	"
5.0	7.9	7.9	5.1	"
0	79,000	43,652	0	bushels

Table 22. Optimum plans for Model 4 (1680 acres)

Activity	B01	B10	B14	B02
Labor units	3	3	3	4
Gross return	174,024	180,340	176,586	213,830
Net profit	28,168	34,484	28,789	59,974
Corn grain	0	291	400	819
Corn silage	9.6	1	0	4
Turkey pasture	33	51	52	99
Soybeans	1,557	1,096	748	678
Diverted land	0	160	400	0
Buy corn 1	7,373	403	248	1,455
Buy corn 2	4,836	4,393	4,253	8,755
Buy corn 4	6,524	7,278	8,125	14,355
Sell corn 3	0	30,006	42,770	90,005
Sell oats 1	1,537	2,416	2,442	4,643
Sell beans 3	62,282	43,843	29,921	27,140
Sell haylage	0	51	57	89
Buy haylage	13.5	0	0	0
Feeders 4	0	0	153	0
Feeders 1	0	0	61	0
Weanlings 2	0	0	0	0
Weanling exp. 2	0	0	0	0
Turkeys	9,910	13,000	13,000	13,000
Turkey expansion	0	2,580	2,745	10,938
Yearlings 42A	168	18	0	66
Steers 42B	0	0	0	0
Cap. transfer 1	19,419	63,144	64,078	81,833
Cap. transfer 3	113,210	111,645	105,204	120,717
Cap. transfer 4	64,577	99,404	98,554	122,990
Labor 1	2.9	1.6	1.3	1.7
Labor 2	8.0	8.0	8.0	8.0
Labor 3	11.0	11.5	11.5	11.5
Labor 4	8.5	8.5	8.5	8.5
Labor 5	5.9	6.0	5.8	6.3
Buy grain bins	0	10,267	9,922	59,477

B11	B15	B03	B16	B17	Unit
4	4	5	5	5	men
213,643	202,759	247,106	242,240	232,950	$
59,787	48,996	85,250	80,384	71,188	"
796	400	1,452	800	480	acres
4	0	5	0	0	"
99	102	142	142	142	"
701	698	0	658	658	"
0	400	0	0	320	"
1,458	945	1,177	17	882	bushels
8,748	8,336	12,772	12,595	12,494	"
14,365	16,053	19,764	19,759	21,813	"
87,206	36,160	163,127	81,486	40,163	"
4,643	4,786	6,669	6,669	6,669	"
28,038	27,926	0	0	26,316	"
90	112	104	147	145	tons
0	0	0	0	0	"
0	223	0	0	232	"
0	182	0	3	182	head
0	0	433	500	500	"
0	0	0	306	0	"
13,000	13,000	13,000	13,000	13,000	"
16,938	17,860	30,000	30,999	30,000	"
65	0	0	0	0	"
0	0	0	40	50	"
81,660	82,899	209,556	116,442	107,129	$
120,165	95,011	228,830	108,621	87,034	"
122,603	114,543	262,550	155,779	140,270	"
1.7	1.2	2.5	2.8	2.0	hours/day
8.0	8.0	8.0	8.0	8.0	"
11.5	11.5	11.2	11.5	11.5	"
8.5	8.5	8.5	8.5	8.5	"
6.3	5.3	7.0	6.6	5.6	"
57,575	7,926	118,225	56,317	16,316	bushels

Table 23. Optimum plans for Model 5 (2000 acres)

Activity	B10	B12	B14	B02
Labor units	3	3	3	4
Gross return	190,436	193,998	191,239	224,660
Net profit	26,688	30,250	27,532	52,918
Corn grain	0	465	480	161
Corn silage	8	0	0	6
Turkey pasture	16	33	32	73
Soybeans	1,704	1,038	928	1,680
Diverted land	192	384	480	0
Buy corn 1	3,036	0	0	2,178
Buy corn 2	4,665	2,720	2,654	6,974
Buy corn 4	3,827	4,563	4,945	11,206
Sell corn 3	0	53,592	55,459	11,007
Sell oats 1	744	1,562	1,524	3,430
Sell beans 3	68,153	41,518	37,103	67,204
Sell haylage	0	36	36	51
Buy haylage	23	0	0	0
Feeders 1	0	0	0	0
Feeders 4	0	0	102	0
Turkeys	4,795	10,070	9,825	13,000
Turkey expansion	0	0	0	9,116
Yearlings 42A	137	0	0	0
Cap. transfer 1	26,039	66,795	92,072	62,035
Cap. transfer 3	128,688	133,485	156,976	127,417
Cap. transfer 4	71,327	108,613	133,762	107,214
Labor 1	2.7	1.6	1.5	2.0
Labor 2	8.0	8.0	8.0	8.0
Labor 3	10.5	11.0	11.1	11.5
Labor 4	8.5	8.5	8.5	8.5
Labor 5	6.0	6.4	6.2	5.8
Buy grain bins	128	29,619	27,103	17,320

B11	B15	B03	B16	B17	Unit
4	4	5	5	5	Men
230,819	219,735	263,283	261,355	251,697	$
59,071	48,073	83,535	81,607	72,036	"
760	480	1,188	956	576	Acres
1	0	4	4	0	"
84	82	130	130	133	"
882	878	598	830	827	"
192	480	0	0	384	"
268	576	1,638	1,667	1,090	bushels
7,038	6,736	11,388	11,316	10,921	"
11,743	12,921	18,731	18,835	20,461	"
84,507	48,680	132,256	103,303	54,291	"
3,971	3,868	6,108	6,108	6,271	"
35,294	35,108	23,910	33,191	33,063	"
89	90	121	123	147	tons
0	0	0	0	0	"
0	119	0	39	225	head
0	216	0	0	217	"
13,000	13,000	13,000	13,000	13,000	"
12,600	11,940	26,378	26,383	27,435	"
12	0	74	67	0	"
91,803	131,127	105,531	103,743	178,083	$
136,961	166,417	144,442	150,925	186,611	"
136,966	170,350	154,927	138,733	216,130	"
1.5	1.3	1.7	1.6	1.2	hrs/day
8.0	8.0	8.0	8.0	8.0	"
11.5	11.5	11.5	11.5	11.5	"
8.5	8.5	8.5	8.5	8.5	"
6.3	5.6	6.4	6.2	5.4	
60,347	25,108	102,386	82,716	35,063	bushels

X. APPENDIX C

TABLE 24. COMPUTER PRINTOUT OF MODEL 5.

```
ROWS
 N  RETURNS
 L  LANDA
 L  LANDB
 L  LANDC
 L  RHSA
 L  RHSB
 L  RHSC
 L  RHSD
 L  TURKLAND
 L  CORNPROD
 L  CORNSIL
 L  OATGRN
 L  BEANS
 L  HAYL
 L  LABOR1
 L  LABOR2
 L  LABOR3
 L  LABOR4
 L  LABOR5
 L  CAPSPLY1
 L  CAPSPLY2
 L  CAPSPLY3
 L  CAPSPLY4
 E  FCOSTS1
 E  FCOSTS2
 E  FCOSTS3
 E  FCOSTS4
 E  PERIOD1
 E  PERIOD2
 E  PERIOD3
 E  PERIOD4
 E  PERIOD1A
 E  PERIOD2A
 E  PERIOD3A
 E  PERIOD4A
 E  PERIOD11
 E  PERIOD22
 E  PERIOD33
 E  PERIOD44
 L  GSTRMAX1
 L  GSTRMAX2
 L  GSTRMAX3
 L  GSTRMAX4
 L  TURKMAX1
 L  TURKMAX2
 L  FARCMAX1
 L  FARCMAX2
 L  FARCMAX3
```

TABLE 24. (CONTINUED).

L FARCMAX4
L FEEDMAX1
L FEEDMAX2
L FEEDMAX3
L FEEDMAX4
COLUMNS

CORNG	RETURNS	-34.740	LANDA	1.000
CORNG	LABOR1	.280		
CORNG	LABOR2	.430	LABOR3	.780
CORNG	LABOR4	.790	LABOR5	1.160
CORNG	CAPSPLY1	.240	CAPSPLY2	25.130
CORNG	CAPSPLY3	4.110	CAPSPLY4	5.260
CORNG	PERIOD44	-125.000	CORNPROD	-125.000
CORNS	RETURNS	-42.770	LANDA	1.000
CORNS	CORNSIL	-21.000	LABOR1	.190
CORNS	LABOR2	.430	LABOR3	1.270
CORNS	LABOR4	3.810	LABOR5	7.120
CORNS	CAPSPLY1	.270	CAPSPLY2	23.800
CORNS	CAPSPLY3	8.800	CAPSPLY4	9.900
PASTURE	RETURNS	-9.050	LANDC	1.000
PASTURE	TURKLAND	-1.000	OATGRN	-47.000
PASTURE	HAYL	-1.100	LABOR1	.130
PASTURE	LABOR2	.340	LABOR3	.420
PASTURE	LABOR4	1.940	LABOR5	.270
PASTURE	CAPSPLY1	.230	CAPSPLY2	7.750
PASTURE	CAPSPLY3	.810	CAPSPLY4	.260
PASTURE	PERIOD3A	-47.000		
OATS	RETURNS	-12.050	LANDC	1.000
OATS	OATGRN	-95.000	LABOR1	.270
OATS	LABOR2	.680	LABOR3	.250
OATS	LABOR4	.860	LABOR5	.350
OATS	CAPSPLY1	.210	CAPSPLY2	10.800
OATS	CAPSPLY3	.790	CAPSPLY4	.250
OATS	PERIOD3A	-95.000		
SOYBNS	RETURNS	-14.860	LANDC	1.000
SOYBNS	BEANS	-40.000	LABOR1	.200
SOYBNS	LABOR2	.460	LABOR3	.780
SOYBNS	LABOR4	.650	LABOR5	.680
SOYBNS	CAPSPLY1	.160	CAPSPLY2	9.430
SOYBNS	CAPSPLY3	4.560	CAPSPLY4	.710
SOYBNS	PERIOD4A	-40.000		
DL20	RETURNS	79.680	LANDB	1.000
DL20	LANDC	1.000	LABOR1	.010
DL20	LABOR2	.530	LABOR3	.210
DL20	LABOR4	.010	CAPSPLY2	-10.390
DL20	CAPSPLY3	-61.290	RHSB	1.000
DL40	RETURNS	70.250	LANDB	1.000
DL40	LANDC	1.000	LABOR1	.010
DL40	LABOR2	.530	LABOR3	.210

TABLE 24. (CONTINUED).

DL40	LABOR4	.010	CAPSPLY2	-16.030
DL40	CAPSPLY3	-54.220	RHSC	1.000
DL50	RETURNS	68.570	LANDB	1.000
DL50	LANDC	1.000	LABOR1	.010
DL50	LABOR2	.530	LABOR3	.210
DL50	LABOR4	.010	CAPSPLY2	-15.610
DL50	CAPSPLY3	-52.960	RHSD	1.000
CLS1	LANDA	-1.000	LANDB	1.000
CLS1	LANDC	1.000		.
CLS2	LANDA	-1.000	LANDC	1.000
CLS2	RHSA	1.000		.
BUYCORN1	RETURNS	-1.060		
BUYCORN1	CAPSPLY1	1.060	PERIOD1	-1.000
BUYCORN2	RETURNS	-1.090		
BUYCORN2	CAPSPLY2	1.090	PERIOD2	-1.000
BUYCORN3	RETURNS	-1.170		
BUYCORN3	CAPSPLY3	1.170	PERIOD3	-1.000
BUYCORN4	RETURNS	-1.04		
BUYCORN4	CAPSPLY4	1.040	PERIOD4	-1.000
SELCORN1	RETURNS	1.020		
SELCORN1	CAPSPLY1	-1.020	PERIOD11	1.000
SELCORN1	CORNPROD	1.000		
SELCORN2	RETURNS	1.050		
SELCORN2	CAPSPLY2	-1.050	PERIOD22	1.000
SELCORN2	CORNPROD	1.000		
SELCORN3	RETURNS	1.130		
SELCORN3	CAPSPLY3	-1.130	PERIOD33	1.000
SELCORN3	CORNPROD	1.000		
SELCORN4	RETURNS	1.000		
SELCORN4	CAPSPLY4	-1.000	PERIOD44	1.000
SELCORN4	CORNPROD	1.000		
SELLOAT1	RETURNS	.680	OATGRN	1.000
SELLOAT1	CAPSPLY1	-.680	PERIOD1A	1.000
SELLOAT2	RETURNS	.700	OATGRN	1.000
SELLOAT2	CAPSPLY2	-.700	PERIOD2A	1.000
SELLOAT3	RETURNS	.640	OATGRN	1.000
SELLOAT3	CAPSPLY3	-.640	PERIOD3A	1.000
SELLOAT4	RETURNS	.600	OATGRN	1.000
SELLOAT4	CAPSPLY4	-.600	PERIOD4A	1.000
SELLSBS1	RETURNS	2.500	BEANS	1.000
SELLSBS1	CAPSPLY1	-2.500	PERIOD1A	1.000
SELLSBS2	RETURNS	2.550	BEANS	1.000
SELLSBS2	CAPSPLY2	-2.550	PERIOD2A	1.000
SELLSBS3	RETURNS	2.710	BEANS	1.000
SELLSBS3	CAPSPLY3	-2.710	PERIOD3A	1.000
SELLSBS4	RETURNS	2.400	BEANS	1.000
SELLSBS4	CAPSPLY4	-2.400	PERIOD4A	1.000
SELLHAYL	RETURNS	9.650	HAYL	1.000
SELLHAYL	CAPSPLY3	-9.650		

TABLE 24. (CONTINUED).

BUYHAYL	RETURNS	-10.750	HAYL	-1.000
BUYHAYL	CAPSPLY3	10.750		
HOGS1	RETURNS	26.650		
HOGS1	LABOR1	.560	LABOR2	.510
HOGS1	LABOR3	.560	LABOR4	.770
HOGS1	LABOR5	.880	CAPSPLY1	-32.980
HOGS1	FEEDMAX1	1.000	FEEDMAX4	.500
HOGS1	CAPSPLY4	6.330	PERIOD1	4.850
HOGS1	PERIOD2	.430	PERIOD3	.190
HOGS1	PERIOD4	4.850	FARDMAX4	1.000
HOGS2	RETURNS	23.220		
HOGS2	LABOR1	.880	LABOR2	.560
HOGS2	LABOR3	.510	LABOR4	.550
HOGS2	LABOR5	.770	CAPSPLY1	6.380
HOGS2	FEEDMAX1	.500	FEEDMAX2	1.000
HOGS2	CAPSPLY2	-29.600	PERIOD1	4.850
HOGS2	PERIOD2	4.850	PERIOD3	.430
HOGS2	PERIOD4	.190	FARDMAX1	1.000
HOGS3	RETURNS	29.680		
HOGS3	LABOR1	.770	LABOR2	.880
HOGS3	LABOR3	.560	LABOR4	.510
HOGS3	LABOR5	.550	CAPSPLY2	6.380
HOGS3	FEEDMAX2	.500	FEEDMAX3	1.000
HOGS3	CAPSPLY3	-36.060	PERIOD1	.190
HOGS3	PERIOD2	4.850	PERIOD3	4.850
HOGS3	PERIOD4	.430	FARDMAX2	1.000
HOGS4	RETURNS	25.070		
HOGS4	LABOR1	.550	LABOR2	.770
HOGS4	LABOR3	.880	LABOR4	.560
HOGS4	LABOR5	.510	CAPSPLY3	6.330
HOGS4	FEEDMAX3	.500	FEEDMAX4	1.000
HOGS4	CAPSPLY4	-31.400	PERIOD1	.430
HOGS4	PERIOD2	.190	PERIOD3	4.850
HOGS4	PERIOD4	4.850	FARDMAX3	1.000
FEEDER1	RETURNS	15.280		
FEEDER1	LABOR1	.310	LABOR4	.860
FEEDER1	LABOR5	.610	CAPSPLY1	-26.890
FEEDER1	FEEDMAX4	.500		.
FEEDER1	CAPSPLY4	11.610	PERIOD1	4.850
FEEDER1	PERIOD4	4.850	FEEDMAX1	1.000
FEEDER2	RETURNS	12.420		
FEEDER2	LABOR1	.860	LABOR2	.620
FEEDER2	LABOR3	.310	CAPSPLY1	11.400
FEEDER2	FEEDMAX2	1.000		.
FEEDER2	CAPSPLY2	-25.820	PERIOD1	4.850
FEEDER2	PERIOD2	4.850	FEEDMAX1	.500
FEEDER3	RETURNS	16.580		
FEEDER3	LABOR2	.860	LABOR3	.620
FEEDER3	LABOR4	.310	CAPSPLY2	12.500

TABLE 24. (CONTINUED).

FEEDER3	FEEDMAX3	1.000		.
FEEDER3	CAPSPLY3	-29.080	PERIOD2	4.850
FEEDER3	PERIOD3	4.850	FEEDMAX2	.500
FEEDER4	RETURNS	14.550		
FEEDER4	LABOR3	.860	LABOR4	.620
FEEDER4	LABOR5	.310	CAPSPLY3	11.010
FEEDER4	FEEDMAX4	1.000		.
FEEDER4	CAPSPLY4	-25.960	PERIOD3	4.850
FEEDER4	PERIOD4	4.850	FEEDMAX3	.500
WEANER1	RETURNS	8.680		
WEANER1	LABOR1	.120	LABOR2	.100
WEANER1	LABOR3	.200	LABOR4	.550
WEANER1	LABOR5	.770	CAPSPLY1	-7.860
WEANER1	FAROMAX1	1.000		.
WEANER1	CAPSPLY2	-.820	PERIOD1	.680
WEANER2	RETURNS	8.450		
WEANER2	LABOR1	.770	LABOR2	.120
WEANER2	LABOR3	.100	LABOR4	.200
WEANER2	LABOR5	.550	CAPSPLY2	-7.700
WEANER2	FAROMAX2	1.000		.
WEANER2	CAPSPLY3	-.750	PERIOD2	.680
WEANER3	RETURNS	9.600		
WEANER3	LABOR1	.550	LABOR2	.770
WEANER3	LABOR3	.120	LABOR4	.100
WEANER3	LABOR5	.200	CAPSPLY3	-8.750
WEANER3	FAROMAX3	1.000		.
WEANER3	CAPSPLY4	-.850	PERIOD3	.680
WEANER4	RETURNS	7.780		
WEANER4	LABOR1	.200	LABOR2	.550
WEANER4	LABOR3	.770	LABOR4	.120
WEANER4	LABOR5	.100	CAPSPLY1	-.780
WEANER4	FAROMAX1	1.000		
WEANER4	CAPSPLY4	-7.000	PERIOD4	.680
TURKEYS	RETURNS	33.130	TURKLAND	.033
TURKEYS	LABOR2	.258		
TURKEYS	LABOR3	.332	LABOR4	.113
TURKEYS	LABOR5	.117	CAPSPLY2	7.270
TURKEYS	CAPSPLY3	-16.570	CAPSPLY4	-23.830
TURKEYS	PERIOD2	1.150	PERIOD3	5.670
TURKEYS	PERIOD4	4.530	TURKMAX1	1.000
HOGSEX1	RETURNS	24.970		
HOGSEX1	LABOR1	.560	LABOR2	.510
HOGSEX1	LABOR3	.560	LABOR4	.770
HOGSEX1	LABOR5	.880	CAPSPLY1	-32.410
HOGSEX1	CAPSPLY4	7.440	PERIOD1	4.850
HOGSEX1	PERIOD2	.430	PERIOD3	.190
HOGSEX1	PERIOD4	4.850		.
HOGSEX2	RETURNS	21.540		
HOGSEX2	LABOR1	.880	LABOR2	.560

TABLE 24. (CONTINUED).

HOGSEX2	LABOR3	.510	LABOR4	.550
HOGSEX2	LABOR5	.770	CAPSPLY1	7.490
HOGSEX2	CAPSPLY2	-29.030	PERIOD1	4.850
HOGSEX2	PERIOD2	4.850	PERIOD3	.430
HOGSEX2	PERIOD4	.190		.
HOGSEX3	RETURNS	28.000		
HOGSEX3	LABOR1	.770	LABOR2	.880
HOGSEX3	LABOR3	.560	LABOR4	.510
HOGSEX3	LABOR5	.550	CAPSPLY2	7.490
HOGSEX3	CAPSPLY3	-35.490	PERIOD1	.190
HOGSEX3	PERIOD2	4.850	PERIOD3	4.850
HOGSEX3	PERIOD4	.430		.
HOGSEX4	RETURNS	23.290		
HOGSEX4	LABOR1	.550	LABOR2	.770
HOGSEX4	LABOR3	.880	LABOR4	.560
HOGSEX4	LABOR5	.510	CAPSPLY3	7.440
HOGSEX4	CAPSPLY4	-30.730	PERIOD1	.430
HOGSEX4	PERIOD2	.190	PERIOD3	4.850
HOGSEX4	PERIOD4	4.850		.
FEEDEX1	RETURNS	14.670		
FEEDEX1	LABOR1	.310	LABOR4	.860
FEEDEX1	LABOR5	.610	CAPSPLY1	-26.730
FEEDEX1	CAPSPLY4	12.060	PERIOD1	4.850
FEEDEX1	PERIOD4	4.850		.
FEEDEX2	RETURNS	11.820		
FEEDEX2	LABOR1	.860	LABOR2	.620
FEEDEX2	LABOR3	.310	CAPSPLY1	11.850
FEEDEX2	CAPSPLY2	-23.670	PERIOD1	4.850
FEEDEX2	PERIOD2	4.850		.
FEEDEX3	LABOR2	.860	LABOR3	.620
FEEDEX3	RETURNS	15.980		
FEEDEX3	LABOR4	.310	CAPSPLY2	12.950
FEEDEX3	CAPSPLY3	-28.930	PERIOD2	4.850
FEEDEX3	PERIOD3	4.850		.
FEEDEX4	RETURNS	13.950		
FEEDEX4	LABOR3	.860	LABOR4	.620
FEEDEX4	LABOR5	.310	CAPSPLY3	11.860
FEEDEX4	CAPSPLY4	-25.810	PERIOD3	4.850
FEEDEX4	PERIOD4	4.850		.
WEANEX1	RETURNS	7.300		
WEANEX1	LABOR1	.120	LABOR2	.100
WEANEX1	LABOR3	.200	LABOR4	.550
WEANEX1	LABOR5	.770	CAPSPLY1	-7.620
WEANEX1	CAPSPLY2	-.180	PERIOD1	.680
WEANEX2	RETURNS	7.570		
WEANEX2	LABOR1	.770	LABOR2	.120
WEANEX2	LABOR3	.100	LABOR4	.200
WEANEX2	LABOR5	.550	CAPSPLY2	-7.480
WEANEX2	CAPSPLY3	-.090	PERIOD2	.680

TABLE 24. (CONTINUED).

WEANEX3	RETURNS	8.720		
WEANEX3	LABOR1	.550	LABOR2	.770
WEANEX3	LABOR3	.120	LABOR4	.100
WEANEX3	LABOR5	.200	CAPSPLY3	-8.530
WEANEX3	CAPSPLY4	-.190	PERIOD3	.680
WEANEX4	RETURNS	6.900		
WEANEX4	LABOR1	.200	LABOR2	.550
WEANEX4	LABOR3	.770	LABOR4	.120
WEANEX4	LABOR5	.100	CAPSPLY1	-.120
WEANEX4	CAPSPLY4	-6.780	PERIOD4	.680
TURKEX	RETURNS	32.160	TURKLAND	.033
TURKEX	LABOR2	.258		
TURKEX	LABOR3	.332	LABOR4	.113
TURKEX	LABOR5	.117	CAPSPLY2	8.240
TURKEX	CAPSPLY3	-16.570	CAPSPLY4	-23.830
TURKEX	PERIOD2	1.150	PERIOD3	5.670
TURKEX	PERIOD4	4.530	TURKMAX2	1.000
CTR1	CAPSPLY1	1.000	CAPSPLY2	-1.000
CTR2	CAPSPLY2	1.000	CAPSPLY3	-1.000
CTR3	CAPSPLY3	1.000	CAPSPLY4	-1.000
CTR4	CAPSPLY1	-1.000	CAPSPLY4	1.000
FCPA1	CAPSPLY1	1.000	FCOSTS1	1.000
FCPA2	CAPSPLY2	1.000	FCOSTS2	1.000
FCPA3	CAPSPLY3	1.000	FCOSTS3	1.000
FCPA4	CAPSPLY4	1.000	FCOSTS4	1.000
CONSTOR1	PERIOD11	1.000	PERIOD22	-1.000
CONSTOR1	GSTRMAX1	1.000		.
CONSTOR2	PERIOD22	1.000	PERIOD33	-1.000
CONSTOR2	GSTRMAX2	1.000		.
CONSTOR3	PERIOD33	1.000	PERIOD44	-1.000
CONSTOR3	GSTRMAX3	1.000		.
CONSTOR4	PERIOD11	-1.000	PERIOD44	1.000
CONSTOR4	GSTRMAX4	1.000		.
CRNTRAN1	PERIOD4	-1.000	PERIOD44	1.000
CRNTRAN2	PERIOD3	-1.000	PERIOD33	1.000
CRNTRAN3	PERIOD2	-1.000	PERIOD22	1.000
CRNTRAN4	PERIOD1	-1.000	PERIOD11	1.000
BCNSTOR1	PERIOD1	1.000	PERIOD2	-1.000
BCNSTOR1	GSTRMAX1	1.000		
BCNSTOR2	PERIOD2	1.000	PERIOD3	-1.000
BCNSTOR2	GSTRMAX1	1.000		
BCNSTOR3	PERIOD3	1.000	PERIOD4	-1.000
BCNSTOR3	GSTRMAX1	1.000		
BCNSTOR4	PERIOD1	-1.000	PERIOD4	1.000
BCNSTOR4	GSTRMAX1	1.000		
GRNSTOR1	PERIOD1A	1.000	PERIOD2A	-1.000
GRNSTOR1	GSTRMAX1	1.000		.
GRNSTOR2	PERIOD2A	1.000	PERIOD3A	-1.000
GRNSTOR2	GSTRMAX2	1.000		.

TABLE 24. (CONTINUED).

GRNSTOR3	PERIOD3A	1.000	PERIOD4A	-1.000
GRNSTOR3	GSTRMAX3	1.000		.
GRNSTOR4	PERIOD1A	-1.000	PERIOD4A	1.000
GRNSTOR4	GSTRMAX4	1.000		.
BUYGRNST	RETURNS	-.056	GSTRMAX1	-1.000
BUYGRNST	GSTRMAX2	-1.000	GSTRMAX3	-1.000
BUYGRNST	GSTRMAX4	-1.000	CAPSPLY1	.056
CALF12A	RETURNS	111.930	LANDC	.004
CALF12A	CORNSIL	2.632		
CALF12A	LABOR1	1.820	LABOR2	1.200
CALF12A	LABOR3	.950	LABOR4	.350
CALF12A	LABOR5	.120	CAPSPLY1	135.780
CALF12A	CAPSPLY2	23.220	CAPSPLY3	-270.930
CALF12A	PERIOD1	17.200	PERIOD2	12.600
CALF12A	PERIOD3	10.400	PERIOD4	4.200
CALF22A	RETURNS	119.780	LANDC	.004
CALF22A	CORNSIL	1.620		
CALF22A	HAYL	.742	LABOR1	1.820
CALF22A	LABOR2	1.200	LABOR3	.950
CALF22A	LABOR4	.350	LABOR5	.120
CALF22A	CAPSPLY1	126.560	CAPSPLY2	19.440
CALF22A	CAPSPLY3	-265.780		
CALF22A	PERIOD1	16.900	PERIOD2	12.400
CALF22A	PERIOD3	10.300	PERIOD4	4.100
YRLG32A	RETURNS	88.260	LANDC	.004
YRLG32A	CORNSIL	1.710		
YRLG32A	LABOR1	1.780	LABOR2	.980
YRLG32A	LABOR5	.140	CAPSPLY1	19.510
YRLG32A	CAPSPLY2	-266.260	CAPSPLY4	138.490
YRLG32A	PERIOD1	24.100	PERIOD2	11.300
YRLG32A	PERIOD4	12.200		.
YRLG42A	RETURNS	90.530	LANDC	.004
YRLG42A	CORNSIL	1.197		
YRLG42A	HAYL	.294	LABOR1	1.780
YRLG42A	LABOR2	.980	LABOR5	.140
YRLG42A	CAPSPLY1	9.890	CAPSPLY2	-265.530
YRLG42A	CAPSPLY4	165.110		
YRLG42A	PERIOD1	22.200	PERIOD2	10.200
YRLG42A	PERIOD4	12.100		.
STEER32A	RETURNS	74.090	LANDC	.004
STEER32A	CORNSIL	1.305		
STEER32A	LABOR2	.470	LABOR3	1.360
STEER32A	LABOR4	1.360	LABOR5	.430
STEER32A	CAPSPLY2	168.190	CAPSPLY3	18.810
STEER32A	CAPSPLY4	-261.090		
STEER32A	PERIOD2	10.400	PERIOD3	19.550
STEER32A	PERIOD4	6.300		.
STEER42A	RETURNS	75.830	LANDC	.004
STEER42A	CORNSIL	.913		

TABLE 24. (CONTINUED).

STEER42A	HAYL	.224	LABOR2	.470
STEER42A	LABOR3	1.360	LABOR4	1.360
STEER42A	LABOR5	.430	CAPSPLY2	166.190
STEER42A	CAPSPLY3	15.810	CAPSPLY4	-259.830
STEER42A	PERIOD2	10.700	PERIOD3	19.830
STEER42A	PERIOD4	6.500		
BOTH32A	RETURNS	171.310	LANDC	.004
BOTH32A	CORNSIL	3.015		
BOTH32A	LABOR1	1.780	LABOR2	1.450
BOTH32A	LABOR3	1.360	LABOR4	1.360
BOTH32A	LABOR5	.570	CAPSPLY1	19.510
BOTH32A	CAPSPLY2	-98.060	CAPSPLY3	17.810
BOTH32A	CAPSPLY4	-101.600	PERIOD1	24.100
BOTH32A	PERIOD2	21.700	PERIOD3	19.550
BOTH32A	PERIOD4	18.500		
BOTH42A	RETURNS	175.330	LANDC	.004
BOTH42A	CORNSIL	2.110		
BOTH42A	HAYL	.518	LABOR1	1.780
BOTH42A	LABOR2	1.450	LABOR3	1.360
BOTH42A	LABOR4	1.360	LABOR5	.570
BOTH42A	CAPSPLY1	9.890	CAPSPLY2	-97.340
BOTH42A	CAPSPLY3	14.810	CAPSPLY4	-93.720
BOTH42A	PERIOD1	22.200	PERIOD2	20.900
BOTH42A	PERIOD3	19.830	PERIOD4	18.600
CALF12B	RETURNS	111.440	LANDC	.004
CALF12B	CORNSIL	2.632		
CALF12B	LABOR1	1.820	LABOR2	1.200
CALF12B	LABOR3	.950	LABOR4	.350
CALF12B	LABOR5	.120	CAPSPLY1	135.780
CALF12B	CAPSPLY2	24.220	CAPSPLY3	-271.440
CALF12B	PERIOD1	17.200	PERIOD2	12.600
CALF12B	PERIOD3	10.400	PERIOD4	4.200
CALF22B	RETURNS	119.270	LANDC	.004
CALF22B	CORNSIL	1.620		
CALF22B	HAYL	.742	LABOR1	1.820
CALF22B	LABOR2	1.200	LABOR3	.950
CALF22B	LABOR4	.350	LABOR5	.120
CALF22B	CAPSPLY1	126.560	CAPSPLY2	20.440
CALF22B	CAPSPLY3	-266.270	PERIOD1	16.900
CALF22B	PERIOD2	12.400	PERIOD3	10.300
CALF22B	PERIOD4	4.100		
YRLG32B	RETURNS	87.750	LANDC	.004
YRLG32B	CORNSIL	1.710		
YRLG32B	LABOR1	1.780	LABOR2	.980
YRLG32B	LABOR5	.140	CAPSPLY1	19.510
YRLG32B	CAPSPLY2	-265.750	CAPSPLY4	158.490
YRLG32B	PERIOD1	24.100	PERIOD2	11.300
YRLG32B	PERIOD4	12.200		
YRLG42B	RETURNS	90.020	LANDC	.004

TABLE 24. (CONTINUED).

YRLG42B	CORNSIL	1.197		
YRLG42B	HAYL	.294	LABOR1	1.780
YRLG42B	LABOR2	.980	LABOR5	.140
YRLG42B	CAPSPLY1	15.510	CAPSPLY2	-264.020
YRLG42B	CAPSPLY4	158.490	PERIOD1	22.200
YRLG42B	PERIOD2	10.200	PERIOD4	12.100
STEER32B	RETURNS	73.570	LANDC	.004
STEER32B	CORNSIL	1.305		
STEER32B	LABOR2	.470	LABOR3	1.360
STEER32B	LABOR4	1.360	LABOR5	.430
STEER32B	CAPSPLY2	168.190	CAPSPLY3	15.810
STEER32B	CAPSPLY4	-257.570	PERIOD2	10.400
STEER32B	PERIOD3	19.550	PERIOD4	6.300
STEER42B	RETURNS	75.320	LANDC	.004
STEER42B	CORNSIL			
STEER42B	HAYL	.224	LABOR2	.470
STEER42B	LABOR3	1.360	LABOR4	1.360
STEER42B	LABOR5	.430	CAPSPLY2	168.190
STEER42B	CAPSPLY3	14.810	CAPSPLY4	-258.320
STEER42B	PERIOD2	10.700	PERIOD3	19.830
STEER42B	PERIOD4	6.500		
BOTH32B	RETURNS	171.060	LANDC	.004
BOTH32B	CORNSIL	3.015		
BOTH32B	LABOR1	1.760	LABOR2	1.450
BOTH32B	LABOR3	1.360	LABOR4	1.360
BOTH32B	LABOR5	.570	CAPSPLY1	19.550
BOTH32B	CAPSPLY2	-97.600	CAPSPLY3	15.810
BOTH32B	CAPSPLY4	-99.080	PERIOD1	24.100
BOTH32B	PERIOD2	21.700	PERIOD3	19.550
BOTH32B	PERIOD4	18.500		
BOTH42B	RETURNS	175.080	LANDC	.004
BOTH42B	CORNSIL	2.110		
BOTH42B	HAYL	.518	LABOR1	1.760
BOTH42B	LABOR2	1.450	LABOR3	1.360
BOTH42B	LABOR4	1.360	LABOR5	.570
BOTH42B	CAPSPLY1	15.510	CAPSPLY2	-95.830
BOTH42B	CAPSPLY3	14.810	CAPSPLY4	-99.830
BOTH42B	PERIOD3	19.830	PERIOD4	18.000
BOTH42B	PERIOD1	22.200	PERIOD2	20.900
RIGHT HAND SIDES				
BC1	LANDC	1920.000	RHSA	1920.000
BC1	LABOR1	1296.000	LABOR2	1152.000
BC1	LABOR3	1056.000	LABOR4	1224.000
BC1	LABOR5	2160.000	GSTRMAX1	70000.000
BC1	GSTRMAX2	70000.000	GSTRMAX3	70000.000
BC1	GSTRMAX4	70000.000	TURKMAX1	1300.000
BC1	TURKMAX2	3000.000	FAROMAX1	500.000
BC1	FAROMAX2	500.000	FAROMAX3	500.000
BC1	FAROMAX4	500.000	FEEDMAX1	420.000

TABLE 24. (CONTINUED).

B01	FEEDMAX2	420.000	FEEDMAX3	420.000
B01	FEEDMAX4	420.000		
B01	FCOSTS1	40937.000	FCOSTS2	40937.000
B01	FCOSTS3	40937.000	FCOSTS4	40937.000
B02	LANDC	1920.000	RHSA	1920.000
B02	LABOR1	1728.000	LABOR2	1536.000
B02	LABOR3	2208.000	LABOR4	1632.000
B02	LABOR5	2880.000	GSTRMAX1	70000.000
B02	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B02	GSTRMAX4	70000.000	TURKMAX1	1300.000
B02	TURKMAX2	3000.000	FAROMAX1	500.000
B02	FAROMAX2	500.000	FAROMAX3	500.000
B02	FAROMAX4	500.000	FEEDMAX1	420.000
B02	FEEDMAX2	420.000	FEEDMAX3	420.000
B02	FEEDMAX4	420.000		
B02	FCOSTS1	42937.000	FCOSTS2	42937.000
B02	FCOSTS3	42937.000	FCOSTS4	42937.000
B03	LANDC	1920.000	RHSA	1920.000
B03	LABOR1	2160.000	LABOR2	1920.000
B03	LABOR3	2760.000	LABOR4	2040.000
B03	LABOR5	3600.000	GSTRMAX1	70000.000
B03	GSTRMAX4	70000.000	TURKMAX1	1300.000
B03	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B03	TURKMAX2	3000.000	FAROMAX1	500.000
B03	FAROMAX2	500.000	FAROMAX3	500.000
B03	FAROMAX4	500.000	FEEDMAX1	420.000
B03	FEEDMAX2	420.000	FEEDMAX3	420.000
B03	FEEDMAX4	420.000		
B03	FCOSTS1	44937.000	FCOSTS2	44937.000
B03	FCOSTS3	44937.000	FCOSTS4	44937.000
B04	LANDC	1920.000	RHSA	1600.000
B04	LABOR1	1296.000	LABOR2	1152.000
B04	LABOR3	1656.000	LABOR4	1224.000
B04	LABOR5	2160.000	GSTRMAX1	70000.000
B04	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B04	GSTRMAX4	70000.000	TURKMAX1	1300.000
B04	TURKMAX2	3000.000	FAROMAX1	500.000
B04	FAROMAX2	500.000	FAROMAX3	500.000
B04	FAROMAX4	500.000	FEEDMAX1	420.000
B04	FEEDMAX2	420.000	FEEDMAX3	420.000
B04	FEEDMAX4	420.000		
B04	FCOSTS1	40937.000	FCOSTS2	40937.000
B04	FCOSTS3	40937.000	FCOSTS4	40937.000
B05	LANDC	1920.000	RHSA	1600.000
B05	LABOR1	1728.000	LABOR2	1536.000
B05	LABOR3	2208.000	LABOR4	1632.000
B05	LABOR5	2880.000	GSTRMAX1	70000.000
B05	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B05	GSTRMAX4	70000.000	TURKMAX1	1300.000

TABLE 24. (CONTINUED).

BO5	TURKMAX2	3000.000	FARDMAX1	500.000
BO5	FARDMAX2	500.000	FARDMAX3	500.000
BO5	FARDMAX4	500.000	FEEDMAX1	420.000
BO5	FEEDMAX2	420.000	FEEDMAX3	420.000
BO5	FEEDMAX4	420.000		
BO5	FCOSTS1	42937.000	FCOSTS2	42937.000
BO5	FCOSTS3	42937.000	FCOSTS4	42937.000
BO6	LANDC	1920.000	RHSA	1600.000
BO6	LABOR1	2160.000	LABOR2	1920.000
BO6	LABOR3	2760.000	LABOR4	2040.000
BO6	LABOR5	3600.000	GSTRMAX1	70000.000
BO6	GSTRMAX2	70000.000	GSTRMAX3	70000.000
BO6	GSTRMAX4	70000.000	TURKMAX1	1300.000
BO6	TURKMAX2	3000.000	FARDMAX1	500.000
BO6	FARDMAX2	500.000	FARDMAX3	500.000
BO6	FARDMAX4	500.000	FEEDMAX1	420.000
BO6	FEEDMAX2	420.000	FEEDMAX3	420.000
BO6	FEEDMAX4	420.000		
BO6	FCOSTS1	44937.000	FCOSTS2	44937.000
BO6	FCOSTS3	44937.000	FCOSTS4	44937.000
BO7	LANDC	1920.000	RHSA	1300.000
BO7	LABOR1	1296.000	LABOR2	1152.000
BO7	LABOR3	1656.000	LABOR4	1224.000
BO7	LABOR5	2160.000	GSTRMAX1	70000.000
BO7	GSTRMAX2	70000.000	GSTRMAX3	70000.000
BO7	GSTRMAX4	70000.000	TURKMAX1	1300.000
BO7	TURKMAX2	3000.000	FARDMAX1	500.000
BO7	FARDMAX2	500.000	FARDMAX3	500.000
BO7	FARDMAX4	500.000	FEEDMAX1	420.000
BO7	FEEDMAX2	420.000	FEEDMAX3	420.000
BO7	FEEDMAX4	420.000		
BO7	FCOSTS1	40937.000	FCOSTS2	40937.000
BO7	FCOSTS3	40937.000	FCOSTS4	40937.000
BO8	LANDC	1920.000	RHSA	1300.000
BO8	LABOR1	1728.000	LABOR2	1536.000
BO8	LABOR3	2208.000	LABOR4	1632.000
BO8	LABOR5	2880.000	GSTRMAX1	70000.000
BO8	GSTRMAX2	70000.000	GSTRMAX3	70000.000
BO8	GSTRMAX4	70000.000	TURKMAX1	1300.000
BO8	TURKMAX2	3000.000	FARDMAX1	500.000
BO8	FARDMAX2	500.000	FARDMAX3	500.000
BO8	FEEDMAX2	420.000	FEEDMAX3	420.000
BO8	FARDMAX4	500.000	FEEDMAX1	420.000
BO8	FEEDMAX4	420.000		
BO8	FCOSTS1	42937.000	FCOSTS2	42937.000
BO8	FCOSTS3	42937.000	FCOSTS4	42937.000
BO9	LANDC	1920.000	RHSA	1300.000
BO9	LABOR1	2160.000	LABOR2	1920.000
BO9	LABOR3	2760.000	LABOR4	2040.000

TABLE 24. (CONTINUED).

B09	LABOR5	3600.000	GSTRMAX1	70000.000
B09	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B09	GSTRMAX4	70000.000	TURKMAX1	1300.000
B09	TURKMAX2	3000.000	FAROMAX1	500.000
B09	FAROMAX2	500.000	FAROMAX3	500.000
B09	FAROMAX4	500.000	FEEDMAX1	420.000
B09	FEEDMAX2	420.000	FEEDMAX3	420.000
B09	FEEDMAX4	420.000		
B09	FCOSTS1	44937.000	FCOSTS2	44937.000
B09	FCOSTS3	44937.000	FCOSTS4	44937.000
B10	LANDB	960.000		
B10	LANDC	1920.000	RHSB	192.000
B10	LABOR1	1296.000	LABOR2	1152.000
B10	LABOR3	1656.000	LABOR4	1224.000
B10	LABOR5	2160.000	GSTRMAX1	70000.000
B10	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B10	GSTRMAX4	70000.000	TURKMAX1	1300.000
B10	TURKMAX2	3000.000	FAROMAX1	500.000
B10	FAROMAX2	500.000	FAROMAX3	500.000
B10	FAROMAX4	500.000	FEEDMAX1	420.000
B10	FEEDMAX2	420.000	FEEDMAX3	420.000
B10	FEEDMAX4	420.000		
B10	FCOSTS1	40937.000	FCOSTS2	40937.000
B10	FCOSTS3	40937.000	FCOSTS4	40937.000
B11	LANDC	1920.000	RHSB	192.000
B11	LANDB	960.000		
B11	LABOR1	1728.000	LABOR2	1536.000
B11	LABOR3	2208.000	LABOR4	1632.000
B11	LABOR5	2880.000	GSTRMAX1	70000.000
B11	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B11	GSTRMAX4	70000.000	TURKMAX1	1300.000
B11	TURKMAX2	3000.000	FAROMAX1	500.000
B11	FAROMAX2	500.000	FAROMAX3	500.000
B11	FAROMAX4	500.000	FEEDMAX1	420.000
B11	FEEDMAX2	420.000	FEEDMAX3	420.000
B11	FEEDMAX4	420.000		
B11	FCOSTS1	42937.000	FCOSTS2	42937.000
B11	FCOSTS3	42937.000	FCOSTS4	42937.000
B12	LANDB	960.000		
B12	LANDC	1920.000	RHSC	384.000
B12	LABOR1	1296.000	LABOR2	1152.000
B12	LABOR3	1656.000	LABOR4	1224.000
B12	LABOR5	2160.000	GSTRMAX1	70000.000
B12	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B12	GSTRMAX4	70000.000	TURKMAX1	1300.000
B12	TURKMAX2	3000.000	FAROMAX1	500.000
B12	FAROMAX2	500.000	FAROMAX3	500.000
B12	FAROMAX4	500.000	FEEDMAX1	420.000
B12	FEEDMAX2	420.000	FEEDMAX3	420.000

TABLE 24. (CONTINUED).

B12	FEEDMAX4	420.000		
B12	FCOSTS1	40937.000	FCOSTS2	40937.000
B12	FCOSTS3	40937.000	FCOSTS4	40937.000
B13	LANDB	960.000		
B13	LANDC	1920.000	RHSC	384.000
B13	LABOR1	1728.000	LABOR2	1536.000
B13	LABOR3	2208.000	LABOR4	1632.000
B13	LABOR5	2880.000	GSTRMAX1	70000.000
B13	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B13	GSTRMAX4	70000.000	TURKMAX1	1300.000
B13	TURKMAX2	3000.000	FARCMAX1	500.000
B13	FARCMAX2	500.000	FARCMAX3	500.000
B13	FARCMAX4	500.000	FEEDMAX1	420.000
B13	FEEDMAX2	420.000	FEEDMAX3	420.000
B13	FEEDMAX4	420.000		
B13	FCOSTS1	42937.000	FCOSTS2	42937.000
B13	FCOSTS3	42937.000	FCOSTS4	42937.000
B14	LANDB	960.000		
B14	LANDC	1920.000	RHSD	480.000
B14	LABOR1	1296.000	LABOR2	1152.000
B14	LABOR3	1656.000	LABOR4	1224.000
B14	LABOR5	2160.000	GSTRMAX1	70000.000
B14	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B14	GSTRMAX4	70000.000	TURKMAX1	1300.000
B14	TURKMAX2	3000.000	FARCMAX1	500.000
B14	FARCMAX2	500.000	FARCMAX3	500.000
B14	FARCMAX4	500.000	FEEDMAX1	420.000
B14	FEEDMAX2	420.000	FEEDMAX3	420.000
B14	FEEDMAX4	420.000		
B14	FCOSTS1	40937.000	FCOSTS2	40937.000
B14	FCOSTS3	40937.000	FCOSTS4	40937.000
B15	LANDB	960.000		
B15	LANDC	1920.000	RHSD	480.000
B15	LABOR1	1728.000	LABOR2	1536.000
B15	LABOR3	2208.000	LABOR4	1632.000
B15	LABOR5	2880.000	GSTRMAX1	70000.000
B15	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B15	GSTRMAX4	70000.000	TURKMAX1	1300.000
B15	TURKMAX2	3000.000	FARCMAX1	500.000
B15	FARCMAX2	500.000	FARCMAX3	500.000
B15	FARCMAX4	500.000	FEEDMAX1	420.000
B15	FEEDMAX2	420.000	FEEDMAX3	420.000
B15	FEEDMAX4	420.000		
B15	FCOSTS1	42937.000	FCOSTS2	42937.000
B15	FCOSTS3	42937.000	FCOSTS4	42937.000
B16	LANDB	960.000		
B16	LANDC	1920.000	RHSB	192.000
B16	LABOR5	3600.000	GSTRMAX1	70000.000
B16	LABOR3	2760.000	LABOR4	2040.000

TABLE 24. (CONTINUED).

B16	LABOR1	2160.000	LABOR2	1920.000
B16	GSTRMAX4	70000.000	TURKMAX1	1300.000
B16	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B16	TURKMAX2	3000.000	FAROMAX1	500.000
B16	FAROMAX2	500.000	FAROMAX3	500.000
B16	FAROMAX4	500.000	FEEDMAX1	420.000
B16	FEEDMAX2	420.000	FEEDMAX3	420.000
B16	FEEDMAX4	420.000		
B16	FCOSTS1	44937.000	FCOSTS2	44937.000
B16	FCOSTS3	44937.000	FCOSTS4	44937.000
B17	LANDB	960.000		
B17	LANDC	1920.000	RHSC	384.000
B17	LABOR5	3600.000	GSTRMAX1	70000.000
B17	LABOR3	2760.000	LABOR4	2640.000
B17	LABOR1	2160.000	LABOR2	1920.000
B17	GSTRMAX4	70000.000	TURKMAX1	1300.000
B17	GSTRMAX2	70000.000	GSTRMAX3	70000.000
B17	TURKMAX2	3000.000	FAROMAX1	500.000
B17	FAROMAX2	500.000	FAROMAX3	500.000
B17	FAROMAX4	500.000	FEEDMAX1	420.000
B17	FEEDMAX2	420.000	FEEDMAX3	420.000
B17	FEEDMAX4	420.000		
B17	FCOSTS1	44937.000	FCOSTS2	44937.000
B17	FCOSTS3	44937.000	FCOSTS4	44937.000

ENDATA