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Inter-relationships among capital, technology and size in farm organization and income

John Donald Hutchinson
Iowa State University

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INTER-RELATIONSHIPS AMONG CAPITAL, TECHNOLOGY AND SIZE IN FARM ORGANIZATION AND INCOME

by

John Donald Hutchinson

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INTRODUCTION

Agricultural Progress

In recent decades the technological advances of the large and powerful American economy have had a very significant impact on the agricultural sector, and American farmers have been working in an environment marked by continued adjustment, change and growth. There have been substantial adjustments in the composition of the total inputs used by crop and livestock enterprises. These enterprises have been using larger proportions of inputs purchased from off-the-farm sources (e.g. purchased seeds), and less of those produced on the farm. Capital and technological progress have substituted for labor with this labor moving mainly to the large urban complexes; and capital and technological progress have substituted for land so that the effective land base per farm has been increased. In the last 10 years, technology has replaced approximately 55 million acres in the U.S.A.

The data in Table 5.5, Heady and Tweeten (13), identify absolute changes which have taken place in resource structure between the years 1910 and 1960. The substitution of technologically improved capital for conventional inputs has resulted in "savings" of annual inputs of approximately $17 billion. An aggregate of $10,380 million in annual machinery, power (4.6 million tractors), fertilizer and lime, and operating inputs substituted roughly for an annual input of $193 million in miscellaneous inputs, 20.8 million persons employed, 347 million acres of cropland, 46.6 million horses and mules and $49,108 million of physical real estate stock. Or, $10,380 million in annual inputs of the first category substituted for $27,817 million in annual inputs of the second category.

With this there has been a marked increase in total agricultural production - especially since 1935 when the effects of the dawning technological era were just beginning to be felt. Since 1940 the growth has been quite remarkable. From 1941-1960 total U.S. population has grown at 1.7 percent per year while agricultural output has more than kept pace with this with a growth rate for these two decades of 2.3 percent per year. From 1940 to 1965 total farm output increased by 67 percent while total 1965 labor output increased by 169 percent. Since the late 1950's, output per man hour in agriculture has gone up by 6.6 percent per year against 2.6 percent for non-farm industry(8). Increased efficiency in agriculture has been very significant.

Farm Organization

With these advances the management of farms has become considerably more involved and complicated. It has become more important to keep farm plans under constant revision - market prices and technology are continually changing and organization of the farm firm must be consistent with these, and with the scarce resources available.

Cornbelt farmers have been confronted with two important problems:

1. relatively low incomes resulting primarily from large output, low product prices and increasing input prices, and

2. pressure for larger enterprises and farms, due to the advance of technology and mechanization.

As a result, many farmers have been concerned with ways to expand their businesses, and successful adjustment to this technological advance includes: 1) expansion to allow larger volume and lower costs of production, and 2) adoption of the appropriate technological methods which will prove most efficient for a given farm situation.

Technological Change

The depression of the 1930's with its unfavorable relations between product and resource prices, plus the extreme restraint on capital and credit supply gave rise to great potential in technological change with the outset of World War II. Since the war, equity positions of farmers together with price relationships have favored an upsurge in this change which is still continuing (13). Technological change has occurred in approximately three stages:

1. The immediate post-war adjustment period - farmers' incomes had risen and the substitution of capital for labor began. The first round of mechanization on farms was completed and farmers began to apply chemicals in the form of fertilizers. Both the mechanical and chemical forms of capital representing innovations served to increase the productivity of crops and livestock. Demand for American farm products continued at a high rate as the war-torn nations sought to regain their feet. The typical American family farm was prospering as a result of this high demand, the rapid adoption of new technology, the increased use of capital and the more intensive use of land and labor.

2. The period of the mid 1950's - product prices in the United States were no longer so favorable because different nations began to accommodate their own agricultural needs. They no longer required such large supplies from the U.S. and U.S. exports dropped. So demand was now mainly dependent ongrowth of the U.S. population and of per capita income. Despite lower

prices farmers continued to adopt new technology - the ultimate effect of this was a continued increase in productivity with the resultant serious farm surplus problem. Some of the important technological advances during this period were:

a. improved crop varieties such as improved strains of hybrid corn, and a shift in emphasis in crops, e.g., the shift away from oats;

b. advances in the production and use of fertilizers such as the use of nitrogen on crops and the use of trace elements on livestock (e.g., copper, iodine);

c. increased mechanization and the use of larger machines;

d. improved erosion, drainage and flood control;

e. increased use of irrigation; and

f. new cultural practices such as summer fallow of wheat.

Broad estimates for the nation suggest that yield increases per annum for all crops in the United States to the end of the 1950's came to 10 percent from hybrid corn, 45 percent from fertilizer, 6 percent from irrigation and 37 percent from improved seeds, cultural practices and similar innovations (13).

3. The period of the 1960's - this period has possibly had the most rapid technological advances. Crop varieties are continually improving and more accurate knowledge is continually being found about the efficient use of the correct fertilizers for different crops on different soil types. Very high fertilizer applications are now being profitably applied. The use of herbicides and insecticides have increased yields in crops. Antibiotics have reduced death losses and increased growth rates in livestock. Crop

yields are also being increased by using closer row spacing and by increasing the plant population per acre. In some instances planes are being used to sow corn, and to spray crops for pests and diseases. Larger capacity machinery is being adopted, drying equipment is available to dry grain so that harvesting is not so dependent on the weather, and the automatic push-button method for self-feeding of livestock is now an accepted practice on larger farms. And there is the introduction of large corporation farms run along similar lines to businesses in the cities. Management ability now must be superior because decision making has become very skilled.

Sophisticated management planning techniques are being used to identify the appropriate allocation of scarce resources and the appropriate enterprise combinations that result in the optimum farm plans.

Farm Firm Growth

Factors affecting growth

Farm growth is another important aspect to be considered when managers are trying to allocate scarce resources to maximize profit. There are many factors which may affect farm firm growth, the main ones being:

1. the initial asset position of the firm,
2. the capital or credit use policies of the farm firm,
3. the nature of the variability of yields and prices,
4. consumption policies of the farm family,
5. management ability, and
6. technology.

Reasons for studying growth

The main reasons for studying firm growth appear to be:

1. As a goal in itself - especially for new and/or small firms - and to specify the farmer's goals, which as Renborg (26) stated, are not usually clearly expressed.

2. Because it is a managerial strategy to combat risk and uncertainty - as the farm grows larger it becomes less vulnerable to risk and uncertainty created by such hazards as time, weather, prices and yields, rising costs, government policy, availability of capital and the proportion of the housewife's budget spent on food.

3. Because the dynamics of growing firms is a more realistic setting to study resource allocation, production possibilities and other management problems such as: the acquisition of more land (the supply of land is inelastic while the demand is high), or the addition of machinery and labor (which are indivisible), or the effects of technological advances or the effect of varying amounts of operating capital.

4. Because practical experience has shown that large firms are generally more profitable than small ones, mainly because of economies of scale; and

5. Because of the unsatisfactory way that planning methods are used at the individual farm level.

Johnson (21) has stated: "Firm growth is one area in economics that has received little attention from economists." And Irwin (17) writes:

> ...one of the mainstays of industrial economic life has long been growth and merger. Farming has seen some of this, but on a much lesser scale. Yet, with growing farm-non-farm interdependence, it

is at least conceivable that the dominant historical theme of the last half of the 20th Century will be growth in size of production units.

This study attempts to identify the income levels and the optimum farm plans for different farm sizes at different levels of operating capital in relation to recent technological advances and with respect to the probable growth in size of production units in North Central Iowa.

OBJECTIVES

This study is an application of a particular planning technique to provide information about the effects of certain technological developments on farm organization. Information is obtained about the optimum farm plans and net income that result with different levels of operating capital. And some knowledge is obtained about the possible growth potential of a typical sized farm in the Clarion-Webster soil area of North Central Iowa.

Within this over-all purpose specific objectives are:

1. To define a typical 280 acre farm model for this area, and the possible enterprise combinations which are appropriate for "1968 technological" levels[1] (see Model A1 in Table 15 of Appendix A).

2. To determine the optimum farm plans for this model that maximize net income in the short-run for different amounts of operating capital, (see Table 16 in Appendix A).

3. To determine the optimum farm plans when certain "new technological" developments are incorporated in this model at the different amounts of operating capital available (see Model A2 in Tables 15 and 16) and to compare these plans with those of model A1.

4. To determine the optimum farm plans for both the "1968" and the "new" technological levels with the different amounts of operating capital for each of four additional and different sized farms: 460, 640, 960 and 1280 acres, (see Models B, C, D and E in Tables 15 and 16).

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[1] Data were not available in all instances for 1968, but they were for 1967 and Tables in Appendix A reflect values for this year. However it is assumed that technologies in 1968 are the same as those in 1967 since little change will have taken place between these two years.

5. To determine the optimum farm plans when the hired labor restraint at the maximum capital levels for each farm model is released.

6. To compare the net income and net return for all of these different sized farms at the two technological levels with the different amounts of operating capital.

SETTING OF STUDY

Situation

Because problems on farms in the Corn Belt are similar, although they may be handled in different ways, it can be expected that results from a particular soil area within a given state may apply equally as well to other soil areas within that state, and even to soil areas in bordering states. For this reason a typical farm was selected for this study in the Clarion-Webster soil area located in North Central Iowa. The distribution (33) of farms in the area by size for the two years 1959 and 1964 was:

	1959	1964
70-179 acres	45%	36%
180-259 acres	27%	25%
260-499 acres	25%	34%
500-999 acres	3%	5%

It can be seen that the largest percentage of farms in 1964 is in the 70-179 acre group - however as the 1959 figure of 45 percent shows, these smaller farms are on the way out. Therefore the typical farm is selected from the 260-499 acre group; in fact the average farm size in 1967 was 275-280 acres with approximately 10 percent taken up with buildings, waste land and permanent pasture (33); the remainder is approximately 67 percent Webster-Nicollet soil types, and 33 per cent Clarion soil type.

The Webster-Nicollet soils are a loam with high organic matter, poor natural drainage, and a slope of 0-2.5 per cent; the Clarion soil is also a loam but with medium organic matter, good natural drainage, and a slope of

2.5-5 percent with slight erosion problems.

Because we are interested ultimately in how farms will grow we have chosen a farmer who is assumed to be 30 years old, with a 20 year planning horizon. He is assumed to be married with two children, the oldest being less than 5 years of age (33). He is average to slightly above average in management ability; and his short-run objective function is to maximize his profit.

Average weather conditions are assumed for the study.

Resources

Having selected this typical farm other resources used must be defined. These are:

Land

A 280 acre farm is taken as the starting point in this study. After this, land is varied by discrete amounts to 460, 640, 960 and 1280 acres, and the short-run models in Table 15 of Appendix A are evaluated. It is assumed that 10 percent of the total land area in models A, B and C and 8 percent in models D and E is waste land, buildings, roads, etc., and this is deducted from the total. The remainder is automatically subdivided into two classes depending on the soil type: 67 percent being Webster-Nicollet soils and 33 percent being Clarion soil. However it is assumed that the same cropping systems can be grown on both.

Labor

The average farm in 1966-'67 had 11.8 months of operator labor and 0.6 months of family labor (33). This is a little over 2900 hours per year. In this study operator labor is divided into 5 time periods with the distribution shown in Table 1, [where abbreviations represent the months of the year respectively: December (D), January (J), February (F), March (M), April (A), May (M), June (J), July (J), August (A), September (S), October (O), and November (N)]:

Table 1. Distribution of owner-operator labor supply (10)

Period	Working days	Hours/day	Total hours
D.J.F.	78	8.0	624
M.A.	52	8.5	442
M.J.	52	13.0	676
J.A.	52	10.0	520
S.O.N.	78	8.5	663
Totals	312		2925

Up to 150 hours of hired labor at a cost of $1.50 per hour are available to the 280 acre farm in three periods when owner-operator labor might well be restricting because of planting and harvesting of crops and feeding stock: M.A., M.J., and S.O.N. The 480 and 640 acre farms (see Table 15) have 1 hired man each for 12 months; the 960 acre farm has 2 hired men for 12 months and the 1280 acre farm has 4 hired men for 12 months. Each hired man has a total fixed cost of $5500 (which covers wages and subsidiary costs such as meat, milk and housing) and represents 2925 hours with similar distribution to that of owner-operator labor. In the optimal solution, at the maximum capital level, with new technology for each farm size, no restriction is placed on the amount of hired labor available in any period.

The labor requirements in each model are those demanded directly for each time period by the different possible enterprises.

Buildings

Machinery and hay and grain storage space are assumed adequate for the size of crop enterprises permitted by resource constraints in this study for all capital and acreage amounts. Fixed costs are deducted for facilities (see Table 17).

Housing space for the following numbers of livestock is assumed to be available at the outset:

1. The floor area of the farrowing unit for hogs = 1300 sq. ft., which is sufficient to house 20 sows and their litters at any one time.

2. The floor area of an open-front growing and finishing unit = 200 sq. ft., which is sufficient to house 200 pigs.

3. The floor area of the open-front building for cattle = 200 sq. ft., which is sufficient to house 100 calves, or 80 yearling cattle, or 67 2 year old cattle or 40 beef cows.

4. Expansion of hog facilities to house extra sows and their litters is possible (see Table 63 for costs); and expansion for cattle facilities to house more cattle is also possible (see Table 58 for costs). Refer to Table 15 for the expansion restraints in the different short-run models.

Capital

In setting up the programming model it is realized that an established farmer must have sufficient capital to invest in real estate with improvements, crop machinery and other equipment. He must also be able to pay annual fixed costs which account for example for depreciation, interest and taxes on personal property and real estate.

In this study the farmer is assumed to have 100 percent equity, i.e. to have adequate overhead capital already invested in the land, the necessary improvements, buildings, livestock, crop machinery and other equipment. However at the end of this study return on capital value is also estimated for equity values of 50 percent and 25 percent. Tables 2 - 3 show the capital value of the land and its improvements (such as water and fencing), the buildings, the machinery and the livestock for the different sized farms. The capital managed by the farmer in this study is simply "operating capital" used to pay annual variable cash expenses such as electricity, oil, fuel, seed, fertilizer and supplements and to pay for the investment in livestock. The annual fixed costs are automatically deducted from the net profit in each model to give the farm's net income. The operating capital available to the farmer at the beginning of the year in each model is varied as shown in Table 16 in Appendix A.

The operating capital required by each activity is estimated for each of the possible programs for each of four time periods: 1) D.J.F., 2) M.A.M., 3) J.J.A., and 4) S.O.N. The coefficients in each of these time periods will depend on the amount of variable costs to be paid for the particular enterprises; and they will depend on the cash returns from the sale of any produce or livestock. Income generated by an enterprise is automatically available along with the operating capital, to pay costs as they occur.

Table 2 . Total initial capital value for land and improvements, buildings, machinery and livestock for the 280, 460, 640, 960 and 1280 acre farms with 1968 technology

Item	Source	Value - dollars				
		280 acres	460 acres	640 acres	960 acres	1280 acres
Land and improvements at $548/acre		$153,440.00	$252,080.00	$350,720.00	$526,080.00	$701,440.00
Buildings[a]						
machinery[b]	(19)	2,200.00	2,889.92	3,520.44	5,279.12	7,039.34
corn cribs	(19)	600.00	985.20	1,371.60	2,056.80	2,742.60
cattle (+ equipment)[c]	Tables 53-56	6,711.50	6,711.50	6,711.50	6,711.50	6,711.50
hogs (+ equipment)[c]	Table 60	16,068.25	16,068.25	16,028.25	16,028.25	16,028.25
Machinery[a,b]	Table 19	13,437.05	17,650.80	21,501.83	32,243.40	42,994.35
Livestock						
cattle	Tables 66-70	5,184.00	21,048.00	13,440.00	16,632.00	62,928.00
hogs	Tables 66-70	4,800.00	7,140.00	7,200.00	9,480.00	14,040.00
Total capital value		$202,440.80	$324,573.67	$420,493.62	$614,511.07	$853,924.04

[a]These figures represent the average value = 55% of purchase price.

[b]Machinery cost/unit is reduced to 80% for the 460 acre farm and 70% for the 640, 960 and 1280 farms due to economies of scale with increasing farm size (23).

[c]All farms start with housing facilities for 20 units of hogs and 100 units of cattle.

Table 3 . Total initial capital value for land and improvements, buildings, machinery and livestock for the 280, 460, 640, 960 and 1280 acre farms with new technology

Item	Source	Value - dollars				
		280 acres	460 acres	640 acres	960 acres	1280 acres
Land and improvements at $548/acre		$153,440.00	$252,080.00	$350,720.00	$526,080.00	$701.440.00
Buildings[a]						
machinery[b]	(19)	2,200.00	2,889.92	3,520.44	5,279.12	7,039.34
corn cribs	(19)	600.00	985.20	1,371.60	2,056.80	2,742.60
cattle (+equipment)[c]	Tables 53-57	6,513.19	6,513.19	6,513.19	6,513.19	6,513.19
hogs (+equipment)[c]	Table 61	22,690.25	22,690.25	22,690.25	22,690.25	22,690.25
Machinery[a,b]	Table 38	25,977.05	34,143.04	41,565.30	62,347.60	83,130.60
Livestock						
cattle	Tables 66-70	5,184.00	21,048.00	13,440.00	16,632.00	62,928.00
hogs	Tables 66-70	4,800.00	7,140.00	7,200.00	9,480.00	14,040.00
Total capital value		$ 221,404.49	$ 347,489.60	$ 447,020.78	$ 651,078.96	$ 900,523.98

[a,b,c]See footnotes Table 2 .

Borrowed capital restraint : Capital can be borrowed at the rate of $1.25 for $1.00 equity value,[1] at an interest rate of 7 per cent. Special borrowing facilities are available for cattle feeder stock - an unlimited amount of borrowed capital can be obtained at 6 per cent if the farm does not have the necessary finance available to purchase the cattle.

Management

The owner operator in 1968 is considered to be average to slightly above average, i.e. his timing of operations and other management practices, such as insect and weed control, selection of corn varieties and obtaining stands consistent with soil moisture and fertilization levels are approximately 'right' or 'optimum', though not completely optimum. He is not considered to be more skilful in any particular phase of farming than any other. With the adoption of new technology he is considered to be well above average, i.e. a 'superior' manager whose timing of operations, and whose various cropping and livestock practices are similar to those found on the best commercial farms.

Livestock

The appropriate breeding stock and feeder pigs and feeder cattle are assumed to be on the farm at the start of the period. The optimum program will determine the numbers and the type of livestock being carried on the farm.

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[1]Independent investigation.

Machinery

Adequate machinery for cropping and livestock activities is assumed to be on the farm; as the farm size increases and new machinery is added economies of scale are included based on work done by Krenz (23), who used an approximation of the relevant points selected from the separate short-run curves of eight different sets of machinery. See Table 15.

Prices used

The procedure in this study has been to determine optimum plans of farm organization under various sets of conditions to maximize net operating income for the prices and costs given in Table 4. All prices are for stock and produce either bought or sold on the farm. Prices for products are averaged for the 10 year period 1957-67 and so long as these long-run price ratios between commodities remain unchanged (i.e. the historic relationship continues), the farm plan which maximizes profit will be the same, regardless of the absolute price level. Naturally net income will vary with the price level.

Machinery, buildings and other capital investment prices and costs are the 1967 values. Costs that could not be obtained for 1967 but which had been calculated for some previous period were inflated by using the production index of agricultural prices (37).

Costs

Input costs are divided into:

Fixed costs: annual fixed costs are those that are incurred irrespective of the level of production, i.e. those which do not vary with acreage,

Table 4. Summary of prices used in this study for seed, fertilizer, livestock and land

Item	Unit	Cost	Unit	Cost
Seed[a]		$		$
Hybrid corn (C)	per bu	12.03		
Soybeans (Sb)	" "	3.69		
Oats (O)	" "	1.50		
Cert. alfalfa	per lb	.55		
Red clover	" "	.44		
Orchard grass	" "	.35		
Corn bought	per bu	1.20		
Corn sold	" "	1.00		
Sb sold	" "	2.50		
Fertilizer				
N	per lb	.06		
P_2O_5	" "	.09		
K_2O	" "	.045		
Lime	1 ton	3.25		
Cattle[a]				
	Purchase		Sale	
Enterprize				
1	1 cwt	26.67	1 cwt	25.94
2	"	27.66	"	26.22
3	"	24.89	"	24.18
4	"	26.67	"	26.47
5	"	26.67	"	26.67
6	"	23.87	"	25.29
7	"	23.00	"	23.44
8	"	23.76	"	24.28
9	"	25.60	"	26.65
10	"	23.76	"	23.94
Pigs[a]	Hogs		Sows	
Feb	1 cwt	17.66	1 cwt	15.01
March	"	17.20	"	15.03
April	"	16.92	"	15.06
June	"	19.05	"	15.84
Aug	"	19.23	"	16.32
Sept	"	18.10	"	15.95
Oct	"	17.39	"	15.66
Dec.	"	17.18	"	14.18
Land	1 acre	548.00		

[a]Average of 1957-'67 time period; source: (38, 39).

or the number of livestock, or the output. For example: machinery depreciation, property taxes, insurance and interest. They are all divided evenly between the 4 capital time periods and paid accordingly, except for property taxes which are paid only in periods 2 and 4. So fixed costs are deducted (within the program) from the net profit to give the net income. Fixed costs for the respective enterprize combinations are computed in the following way:

1. Interest: in a study by Stoneberg _et al_. (34) interest is calculated at 3 percent per annum on buildings and in a study by Krenz (23) at 7 percent on 90 percent[1] of the new value of machinery. These were the rates used in this study.

2. Taxes and insurance: these are calculated at $2\frac{1}{2}$ percent per annum (14) of the new cost of machinery and at $1\frac{1}{2}$ percent for buildings (23).

3. Depreciation: this is generally found by the straight-line method (5) - machinery is obtained by dividing 90 percent of the purchase price by the estimated number of years of service (23, 5). Depreciation on buildings is estimated at 5 percent per annum of their average value (see Table 19) and on other equipment at 6.6 percent per annum of their average value (34).

4. Other fixed costs, e.g. land tax and living expenses are found independently; they are listed in Table 17.

Note: fixed costs for the 460, 640, 960, and 1280 acre farms are simply the appropriate multiples for those in the 280 acre farm.

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[1]Allowing 10 percent for salvage value.

Variable costs: annual variable costs are those that will vary with the number of units of the particular activity that enter into the program. They will include: building repairs, machinery repairs and fuel, crop seed, spray and fertilizer. Machinery variable repairs are calculated at 3 percent per annum of new cost and building variable repairs at 1½ percent of new cost (14). Other variable costs are calculated independently. All variable costs are divided among the 4 capital time periods depending on the time of the year in which they are paid.

METHOD OF ANALYSIS

General

Decision making in farm organization and management is concerned mainly with problems of 1) production and allocation, e.g. how to get land, how to combine resources, what to produce, what scale of production and what type of machinery, buildings and equipment, 2) administration, e.g. acquiring capital and credit, supervision of work, operational timing, production and performance records and hiring labor, and 3) marketing, e.g. when, what, how and from whom to buy, and when, what, how and to whom to sell. There are various tools available to help the farm manager and other decision makers make rational decisions involving optimum resource allocation of scarce land, labor, capital and other necessary resources. Some of the important tools include: improved budgets, supply forecasting, planning guides, management consulting firms, commercial servicing, meteorological forecasting, market forecasting and interpretation, supply and demand forecasting, research and extension publications, electronic accounting and data processing, linear programming, and operations research.

In this study linear programming is used to solve simultaneously the hundreds of possible production alternatives, given the particular objective function of maximizing profit, the particular constraints, the particular input-output coefficients and the particular prices to give efficient allocation of scarce resources.

Procedure Used

Collection of data

Coefficients for this study were developed from 2 sources: a) data that are available in the results of research studies and b) personal investigation with agronomy specialists, animal husbandry specialists, and machinery specialists, and on-the-farm visits with farmers. These coefficients are presented in Appendix A.

Method of analysis

The simplex method of linear programming was used to determine the optimum farm plans for varying amounts of operating capital, and for varying farm sizes. The simplex method is an algorithm that uses mathematical procedures in a particular sequential way to solve lengthy problems involving a greater number of unknowns (variables) than there are equations (2). This algorithm was solved using the computer and a special computer routine called Mathematical Programming System/360 (or M.P.S./360) - of which linear programming is a subset. The theory behind linear programming, and its application to farm planning where there are many production possibilities for the available resources is thoroughly explained and illustrated in Heady and Candler (9) and in Beneke (2). Various farm management studies have used this technique, notably references (12, 24, 25, 31).

The following summary steps were taken in this analysis:

1) the formulation of the models,

2) the programming computations to obtain the profit-maximizing plans for the various models, and

3) the presentation and interpretation of each plan for each model at each capital level.

Method of Presentation

The optimum profit-maximizing plans for the various short-run models in Tables 15 and 16, Appendix A, with the various technological possibilities and varying amounts of operating capital and land sizes are presented in Tables 66 - 70 in Appendix B, and analyzed in Chapters 7 and 8.

Existing farm organizations can then be compared with these results to determine how income might be increased in an individual situation. It must be realized that no one system will be best in all cases because variations in 1) quantities of physical resources available, 2) managerial ability of the operator, and 3) other production alternatives, will influence the selection of the most profitable system.

LEVELS OF TECHNOLOGY USED

Crops

1968 farm models

These models are based on the knowledge and methods that farmers were using in 1968; they are methods that have been proven as 'sound' and 'acceptable' by past experience. These methods include:

1) Row width - corn and soybeans are planted in the normal 40" rows. To obtain about 15,000 plants/acre corn is sown at 12 lbs/acre. Soybeans are sown at the rate of 50 lbs/acre.

2) Fertilizer - two levels of application are considered: medium and high. If capital is an extremely limiting resource then the program is able to allocate it to a lower capital-demanding, medium fertilizer level using crop. When capital is not such a limiting resource the program is able to allocate it to a higher capital-demanding, but also higher yielding, high fertilizer level using crop.

3) Machinery - it is assumed that machinery which is typical of that used on farms for the past few seasons is on the farm (Table 19). Silage is harvested by custom while corn can be harvested in various ways. a) Shelled corn can be harvested for grain by a picker-sheller. A cost (see Table 36) is then charged for drying this; it is then stored in a bin, fed to cattle as such, or fed to hogs after it has been through the grinder. b) Ear corn can be harvested by a picker. It is then stored in a crib, shelled and fed to cattle, or shelled, ground and fed to hogs. c) Corn can be harvested for silage.

4) Management - the farm manager is assumed to be average to slightly above average, as defined previously under 'resources'.

Models with new technology

1) Row width - both corn and soybeans are planted in 30" rows with an assumed yield increase of 8 percent and 10 percent respectively (27, 28).

2) Seed variety - a) corn: to obtain 21-22,000 plants per acre at harvest allowing 15 percent mortality, 17 lbs of seed will need to be planted per acre. This seed will be the best hybrid seed available; it is approximately 3 times as expensive as 4 way cross seed (see Table 45) and has an average yield increase of 6 percent, (20, 3). b) Soybeans: by planting one of the latest varieties at 60 lbs/acre soybean yield is increased by an average of 7.5 percent (28).

3) Fertilizer is increased by the recommended amounts to cope with the increased plant populations. Thirty lbs of nitrogen (N), 20 lbs of P_2O_5 and 20 lbs of K_2O are added to the 'high' level shown in Table 29, for corn, to give the results in Table 37.

4) Machinery - the appropriate machinery that is required to cope with these changes is now assumed to be on the farm and a drier is purchased. (See Table 38). There is now no direct cost to the farm for drying as such, however labor is increased to take this new machine into account. Because of the new machinery now on the farm fixed costs are adjusted accordingly (see Table 17 in Appendix A).

5) Management - superior management similar to that found on the best commercial farms is now assumed to be controlling the farm operations.

6) Labor is adjusted to incorporate the changes due to narrower rows, the more modern machinery and the increased yields (see Tables 39-44).

7) Spray costs are assumed to remain the same except for Atrazine and Bux 10 which increase because they are band sprayed (Table 46).

8) Twine and lime costs will not change.

9) Operating costs and custom harvesting costs will naturally increase with the increased yields; but they are reduced by the more sophisticated machinery that is purchased. These are taken into account in Tables 47 and 48.

Corn now has a total yield which is increased by 14 percent to 128.8 bushels per acre on the average while the yield from soybeans has increased by 17.5 per cent to a total of 41.2 bushels per acre average.

Cattle

The cattle enterprise and the method of feeding adopted on any particular farm must be inter-related with the rest of the activities. In particular the feeding method cannot be chosen apart from the best use of the resources on the entire farm. It must supplement these other farm operations and not conflict with the efficient operation of the farm as a whole. A particular system is not necessarily best for all cases, so 3 different feeding methods are incorporated in this study.

Farm models 1968

Feeding method A   Cattle are fed using a wagon-scoop feeding system similar to method II in Gibbons' study (5) (see Table 50) - an open-front building is available (Table 53) but the cattle can be moved around the farm.

Feeding method B   Cattle are fed using a self-unloading wagon system similar to that outlined by Gibbons (5), in his method III. An open-front building is available. Labor is assumed to decrease by 0.7120 percent[1] over method A and variable costs are assumed to change by 1.0316 percent.[1] Total feed consumed is assumed to remain virtually constant except that only a little pasture would be fed when stock arrive on the farm; following this they are fed in the drylot and no pasture would be given to them - this decrease is compensated for by an increase in their hay consumption.

Farm models with new technology - feeding method C

A mechanical feeding system similar to method IV in Gibbons' study (5) is introduced. An open-front building is beside the feedlots which are used all the time by the cattle. This more elaborate system minimizes the labor required. However in comparison to method A it increases the capital investment, while it decreases it in comparison to method B (see Tables 52 and 57). In this model labor is assumed to decrease by 0.5785 percent[1] over method A and variable cash expenses are assumed to change by 1.0039 percent.[1] Total feed consumption and the amounts of the different feeds consumed are the same as those for method B.

Hogs

Trede (36) points out that there are several important factors in successful hog production: the appropriate farrowing system will depend on the time of farrowing and the type of housing; the appropriate growing and finishing system will depend on the amount of confinement and the type of

[1]These represent the percentage changes at the 100 calf level in Gibbons' study (5).

housing; and the appropriate manure disposal method will depend on the method of flushing effluent from the buildings and on the method used to decompose the waste in the storage pit or lagoon. The levels of technology for hog enterprises used in this study are as follows.

1968 farm models

These models have an adequate central farrowing house with a concrete floor and an adequate growing-finishing unit which is partially environmentally controlled (see Table 60). Liquid manure is flushed from the buildings and stored in a storage pit. This manure is drained regularly and spread on the land.

Farm models with new technology

These models have a farrowing house with a concrete floor and almost complete environmental control with a nursery unit and a completely enclosed growing and finishing unit nearby, both with good environment control. (See Table 61). Manure disposal involves liquid manure handling facilities and the recycle system (36, 41). The treated wastes from the hog buildings are transferred to a small aerobic storage pit (this is not a large lagoon) which introduces air mechanically by means of a paddle wheel. This substitutes for the large land area previously required in the lagoon, or large oxidation ponds, used in earlier methods. From the storage pit it is returned to the hydraulic flushing system.

Only 4 and 6 litter systems are considered, (Table 65) with 8.5 pigs weaned per litter and a 2.5 percent death-loss, compared with 7.45 pigs weaned per litter and a 3.0 percent death-loss for these two systems under the old technology. With this new technology coefficients for variable costs, for net revenue and for grain consumption increase, but the hours of labor are assumed to remain the same - which in effect implies higher efficiency due to the superior management which now handles a larger number of pigs.

ENTERPRISES

Crop Enterprises

The same crop production plans were used with the two levels of fertilization under 1968 technology, and with the very high level of fertilization under new technology. These plans involve different rotations of corn (C), oats (O), soybeans (Sb) and meadow (M), which were selected to meet the overall requirements of the farm plan. Rotations, and not the individual crops, were selected as the appropriate activities in the program, because rotations incorporate the effect that each crop has on the soil fertility level and therefore on the crop that follows in the sequence. Many farmers do not follow a specific rotation of crops from year to year - instead they produce those crops that will maximize profits for that year. However this is not considered to be the most efficient or the most practical method of handling the cropping activities, for the manager in this study. It is to be noted as Shrader et al. (29) state in their article on crop rotations, that a particular rotation or land use system cannot be recommended as final for all time. Crops may become obsolete and new ones may take their place because of relative changes in prices and costs, or the introduction of new production methods, or insect and weed control for example.

The crop rotations considered suitable to the area and used in this study are:

1) CCCC
2) CCSb
3) CO
4) CSbCOM
5) CCOMM.

Table 29 in Appendix A identifies these rotations under 1968 technology with the medium and high fertilizer applications and the yields obtained. Corn can be harvested for grain which is either utilized on the farm as grain or sold at $1.00/bushel (bu.); or grain is harvested by custom for silage; grain can also be bought at $1.20/bu. Oats are converted to grain equivalent (2 bu. of oats are assumed equivalent to 1 bu. of corn); soybeans are sold at $2.50/bu. Meadow may be grazed as pasture or harvested as hay; hay was not bought or sold. Crop yields are consistent with yields obtained by many farmers although it is realized that some farmers still do much better. However this study is interested in the typical yields.

It should be emphasized that fertilization recommendations are assumed for average to slightly above average management. The recommended high level of fertilization would tend to maximize the return per acre of a given land area. The low level of fertilization is a minimum recommendation for farmers with minimum levels of operating capital available.

Table 37 identifies the fertilizer applications and costs and the crop yields achieved for the various rotations using new technology. It can be seen that the rates applied and the yields obtained have increased significantly over the already high figures for high fertilization applications under 1968 technology (Table 29).

Cattle Enterprises

Calves

Good-choice feeder steer calves Good-choice steer calves are bought in October-November at about 450 pounds weight. They are wintered on roughage, silage and hay, then put on a full feed in a drylot in early summer. They are fed out to grade choice and are marketed about the end of September at an average weight of 1100 pounds. Death loss is 3 percent of purchase weight.

Feeder steer calves deferred - fed on pasture Good to choice steer calves are purchased in September-October at a weight of 450 pounds and fed on pasture. They are wintered on roughage, silage, and limited grain, and put out on pasture the following spring - early summer. By August 1 they are transferred to the drylot and full-fed on ground ear corn until they are marketed in September-October at about 1010 pounds. Death loss is 3 percent of purchase weight.

Good-choice heifer calves Good to choice heifer calves weighing about 420 pounds are purchased at the beginning of November. They are fed pasture then full-fed hay, silage, and limited grain. This grain is increased when they are put on the drylot at the beginning of April. They are sold in June at about 850 pounds. Death loss is 3 percent of purchase weight.

Yearlings

Good choice long fed yearling steers These are purchased at about 630 pounds weight in October and kept on the farm until August. They are fed some pasture in the late fall, and then wintered on high roughage, then they are put on a full feed of grain about April 1. They are marketed at 1150 pounds liveweight. Death loss is 1 percent of purchase weight.

Good choice short fed yearling steers - Fall These are similar to those described in the previous group; however, they are put on full feed immediately and sold about the middle of May at about 1100 pounds.

Good choice steers - short fed spring These are purchased at 700 pounds in February and kept on the farm until June. A heavy grain ration is fed with some pasture, silage and hay. They are sold at 1050 pounds weight. Death loss is 1% of purchase weight.

Medium yearling steers - drylot finished Medium yearling steers purchased at 600 pounds in September-October, fed pasture for three months and then fed grain, hay and some silage in the drylot through the winter. The grain is increased towards the end of May and the cattle are sold at 1050 pounds weight by the end of June. Death loss is 1 percent of purchase weight.

Good choice yearling heifers Good choice heifers are bought October-November at about 570 pounds weight. They are fed pasture for the remainder of the fall, wintered on grain, silage and hay and then finished off in a drylot in the spring on grain. They are sold at an average of 1000 pounds weight in May. Death loss is 1 percent of purchase weight.

Two year old steers

Good choice short fed Good choice steers are purchased at a weight of 800 pounds in October-November. They are put on a grain ration immediately with some pasture, hay and silage, and fed for 4½ months until they are sold at 1150 pounds in March. Death loss is 1 percent of purchase weight.

Beef cows

Calf sold The cows calve in the spring with most of the calves being born between March 15 and June 1. The calves are weaned after 230 days and weigh about 480 pounds on the average when sold in October, November and December.

Calves are fed grain and some mineral and salt before weaning. The cows get roughage such as harvested cornfields, aftermath top growth left on pastures and hay fields during winter months plus considerable silage. A cow's productive life is taken as 5.5 years. Death loss is 1 percent of initial weight.

General

The basic restrictions on cattle activities have already been described in the section on buildings. The input-output data for the various cattle enterprises under feeding method A, 1968 technology, may be found in Tables 50 and 51, Appendix A; for these enterprises under feeding method B, 1968 technology, the data may be found in Table 52 of Appendix A; and for these enterprises under feeding method C, new technology, the data may also be found in Table 52, Appendix A.

Expansion of cattle facilities   Cattle facilities can be expanded to allow more stock to enter the farm plan if the program decides this is profitable. A linear relationship is assumed to exist, i.e. increasing or decreasing returns to scale are not allowed for. Table 15, Appendix A lists the expansion restrictions for the different models. Table 58 shows the calculations required to find the total annual charge to each extra unit of activity that enters the program for feeding methods A, B, and C.

Hog Enterprises

As indicated in Table 59, 6 hog enterprises were considered in the program to compete for the resources available on the farm.

1. Spring pigs: (unit = 1 sow and 1 litter): The sows are farrowed in the central farrowing house in April. They are fed out on pasture 2 weeks later and the pigs are weaned at 6-8 weeks old and sold in October at a weight of 230 pounds. One gilt is saved for the following year. Litters average 7.5 pigs weaned per sow.

2. Spring and fall pigs: (1 sow and 2 litters): This hog system includes spring and fall litters farrowed in a central farrowing unit in April and October. Spring pigs are fed out on pasture for growing and finishing and are marketed at 230 pounds in October. Litters average 7.5 pigs weaned per sow.

Fall pigs are fed and finished in an open front growing and finishing building with an attached concrete floor and marketed at a weight of 230 pounds in early April. Litters average 7.4 pigs weaned/sow. Sows farrow 2 litters and are sold after fall farrowings. One gilt is saved from the August litter for the following year.

3. Winter-summer pigs (a): (1 sow and 2 litters): In this enterprise sows are farrowed twice during the year: once in June-July on pasture using 'A houses'; and once in December-January in the central farrowing house. The winter pigs are moved to the open front growing-finishing unit with the attached concrete floor and are kept there until they are sold in June. The summer pigs are weaned at 6-8 weeks, kept on pasture and sold in December. All pigs are sold weighing 230 pounds.

In winter 7.4 pigs are weaned/litter and in summer 7.5 pigs are weaned/litter. One gilt is saved as a replacement from winter litters.

4. Winter-summer pigs (b): (1 sow and 2 litters): This is similar to the previous enterprise except that the summer pigs are also farrowed in the central farrowing house and finished in the finishing unit.

5. 4 litter system: (2 sows and 4 litters): Two groups of sows are farrowed twice a year in the central farrowing house (i.e. 4 litters are produced). One group farrows in February and August and the other group farrows in June and December. This system has the advantage of avoiding heavy labor requirements for hogs during the busy spring and fall crop season. The pigs are weaned at 5 weeks - the spring pigs are put in the enclosed and partially controlled growing and finishing unit and sold at 230 pounds in August and October; the fall pigs are fed in the enclosed and partially controlled growing and finishing unit and sold at the same weight in February and April.

All litters average 7.45 pigs weaned per sow. Replacement gilts are kept in June and August.

6. 6 litter system: (3 sows and 6 litters): Three groups of sows farrow twice a year (i.e., 6 litters are produced) in this enterprise, with one group farrowing every second month so pigs are produced during 6 months of the year. Litters and sows remain in the farrowing house for 3 weeks. The pigs are then weaned and moved to the nursery for 2-3 weeks; then they are taken to the growing-finishing units and kept in confinement on concrete until they are sold. The sows are moved to the sow colony. Pigs are sold at 230 pounds liveweight; 7.45 pigs are weaned per litter and 3

replacement gilts are kept. Table 5 shows the use of the facilities through the year.

General

The one and two litter systems use rotated pasture extensively, while multiple farrowing has become associated with the confinement-on-concrete system of technology. The volume of any hog enterprise can be increased by expanding the conventional system or by adopting multiple farrowing (18). Multiple farrowing distributes fixed costs and investment over a larger output by using facilities more fully. Labor is more evenly distributed through the year, though the quality must be higher. However, selection of the particular hog system must be made in association with the best use of the resources for the entire farm.

Basic input-output data for 1968 technology may be found in Table 59; and for advanced technology the new input output coefficients can be found in Table 65.

Expansion of hog facilities As with cattle the program can select additional hog facilities if this would be profitable. The expansion restrictions are listed in Table 15 for the different models and the cost per unit per year is found in Table 63 for both levels of technology.

Miscellaneous

The linear program does contain additional restrictions and activities. A haymaking activity is included and the labor and costs are found in Tables 27 and 26. A standing meadow transfer row transfers standing meadow into either pasture for grazing or hay for consumption by livestock. Silage can be produced from the grain in any of the crop rotations and the appropriate labor and cost coefficients are shown in Tables 36 and 49 for the 1968 and new technology levels respectively.

Transfer rows enable capital to be transferred between time periods through the year and surplus operating capital can be transferred for the purchase of feeder stock.

An outside investment activity which has a 5 percent return is included in the program - thus the activities entering the program must return 5 percent per annum or the farm will invest surplus finance outside the farm for 12 months at 5 percent; for the last 9 months at 3.75 percent; for the last 6 months at 2.5 percent; and for the last 3 months at 1.25 percent.

Table 5 . Use of hog facilities for the 6 litter system[a]

Sow group	Farrowing house	Nursery unit	Growing finishing 1	Growing finishing 2	Sow colony 1	Sow colony 2
1	Jan 1-Feb 15	Feb 1-Mar 15	Mar 15-June 15		Mar 15-July 1	
2	Mar 1-Apr 15	Apr 1-May 15		May 15-Aug 15		May 15-Sept 1
3	May 1-June 15	June 1-July 15	July 15-Oct 15		July 15-Nov 1	
1a	July 1-Aug 15	Aug 1-Sept 15		Sept 15-Dec 15		Sept 15-Jan 1
2a	Sept 1-Oct 15	Oct 1-Nov 15	Nov 15-Feb 15		Nov 15-Mar 1	
3a	Nov 1-Dec 15	Dec 1-Jan 15		Jan 15-Apr 15		Jan 15-May 1

[a]Source: (18, p. 21).

PRESENTATION AND ANALYSIS OF THE OPTIMUM PLANS FOR EACH MODEL

The optimum plans at the various capital levels (in Table 16) for the models in Table 15, are presented in Tables 66 - 70 in Appendix B. Column 1 indicates the amount of owner operating capital (operating capital does not include fixed capital) used by each plan; column 2 indicates the amount of operating capital borrowed for each 3 month period; column 3 indicates the net income that results after fixed costs have been deducted from the farm's net profit; the fourth column indicates the crop rotations and the stock enterprises that are optimal for each capital level, and the levels at which they enter the solution.

Column 5 identifies which resources are limiting and their shadow prices. The scarce limiting resources most profitable for the firm to acquire for each of the alternative programs are indicated by their shadow prices. Shadow prices are valuable because they estimate returns the firm may gain from the acquisition of another unit of a scarce resource. Thus, they assist in determining the advisability of plans to acquire more resources in order to increase the firm's net income. A zero shadow price for a resource indicates that it is not a limiting resource to a computed program's optimal solution. An additional unit of a resource that is limiting will bring a return to net income equivalent to the indicated shadow price. They provide insight as to the wisdom of procuring added amounts of resources beyond the initial resource supply of the firm considering expansion, in order to increase its net operating income.

The sixth column indicates the amount of grain sold (+) or bought (-); the seventh column shows the amount of capital invested and the length

Table 6 . Partial key of abbreviations and terms used in the analysis

Crop rotation enterprises

Term	Term
$CCCC_{jg}$	$CSbCOM_{jg}$
$CCCC_{js}$	$CSbCOM_{js}$
$CCSb_{jg}$	$CCOMM_{jg}$
$CCSb_{js}$	$CCOMM_{js}$
CO_{jg}	
CO_{js}	

Where:

C = Corn
O = Oats
Sb = Soybeans
M = Meadow

and:

j = 1 is medium fertilizer
j = 2 is high fertilizer
j = 3 is New Technology

and

g = grain
S = silage

Cattle enterprises

Term	Definition
1. $SCGD_i$	= Steer calves, good choice, drylot fed
2. $SCGP_i$	= Steer calves, good choice, pasture fed
3. HCG_i	= Heifer calves, good choice
4. $SYGL_i$	= Steer, yearlings, good choice, long fed.
5. $SYGSF_i$	= Steer, yearlings, good choice, short fed, fall.
6. $SYGSS_i$	= Steer, yearlings, good choice, short fed, spring.
7. $SYMD_i$	= Steer, yearlings, good choice, medium, drylot fed.
8. HYG_i	= Heifer yearlings, good choice.
9. $2SGS_i$	= Steers, 2 years, good choice, short fed.
10. BC_i	= Beef cows, calf sold.

Where:

i = 1 is feeding method A (i.e. bucket and scoop system)
i = 2 is feeding method B (i.e. self-unloading wagon system)
i = 3 is feeding method C = New Technology (i.e. auger system)

Table 6. (Continued)

Term	Hog enterprises Definition
1L	= Spring pigs
2L	= Spring and Fall pigs.
2L(1)	= Winter-Summer pigs, (1)
2L(2)	= Winter-Summer pigs, (2)
4L	= 4 litter system - 1968 technology
6L	= 6 litter system - 1968 technology
4LNT	= 4 litter system - 1968 technology + new technology
6LNT	= 6 litter system - 1968 technology + new technology

Net income = farm net profit - fixed costs. It includes the return to the owner for his labor and management.

$$\text{Net return} = \frac{\text{Net income + the fixed cost of interest on land inv.}}{\text{Total initial capital value}}$$

of time it is invested for; while the last column indicates the amount of hired labor. Tables 6 and 15 list the abbreviations and terms (with their definitions) used in this analysis.

280 Acre Farm (Table 66, Appendix B)

Model A1

In this model land, labor in period 1 (labor 1), hired labor in period 5 (hired labor 5), hog housing expansion, operating capital and borrowed capital, are the main limiting resources in the optimal solution for plan 1. The shadow price is greatest for hog housing - another unit of housing would increase profit by $45. For land it is $43/acre, for labor 1 it is $5/hour and for hired labor 5 it is $20/hour.

At this low level of operating capital ($5000) the rotation corn-corn-soybeans for grain at the high fertilizer level (CCSb2G) is planted on 234 acres. Of the remaining 19 acres, 12 acres are planted in corn-corn-oats-meadow-meadow for grain (CCOMM2G) and 7 acres in CCOMM for silage (CCOMM2S)--both at high fertilizer levels. The rotation CCSb is the optimum rotation given the seriously limiting restrictions on land, labor and capital; and CCOMM is the most efficient rotation to produce the pasture and hay required by the livestock. Soybeans are sold; so are all but 2770 bushels of grain at $1.00/bushel - this is more profitable than investing them in additional stock. To do this would require extra capital and labor.

For maximum profit 25 steer calves, good choice drylot fed with the self-unloading wagon feeding method (SCGD2) enter the program in plan 1 -

these require a large amount of labor in each period, a large amount of silage, not very much pasture (which is important with land limiting), and only an average amount of hay. They have a very high profit ($116) margin/steer. Because hired labor is so limiting in period 5, 13 yearling steers, good choice, short fed in the fall, with the low capital - requiring bucket and scoop method of feeding (SYGSF1) also enter. These are a good profit/steer ($85) enterprise requiring very little (.2 hour) labor in period 5 when it is limiting most, and they do not eat very much hay or pasture.

Neither of the hog activities that enter require any pasture - the 4L (4 litter, 1968 technology) system is a very high profit enterprise ($817/unit) requiring a considerable amount of labor. The 2 litter winter-summer pigs with 1968 technology (2L(2)), on the other hand, is a low profit enterprise which uses considerably less labor in periods 1 and 5. All available hog shelter and hog expansion facilities are used up.

Plan 1 has a net income of $10,305. Net income is the 'net' figure after the fixed costs listed in Table 17 have been deducted from the farm's net profit. Out of this net income figure must come the reward to the operator for his labor and management. As well as incorporating family living expenses, property taxes and depreciation on buildings and machinery for example, fixed costs also include interest at 5 percent per annum on the investment in the land. With this interest added to the net income the farm's net revenue is $17,977 which is a net return of 8.88 percent on the farmer's total investment with the value of his land at $548/acre (15). This would appear to be a very reasonable return when compared to market interest rates.

When $10,000 of operating capital is available to the farm the number of calves increases to 33 at the expense of the less profitable yearlings which decrease to 4. In plan 1 capital was limiting and so the SYGSF1 yearlings which do not use any capital in period 3 (late spring-summer) enter the optimal solution. The SCGD2 calves however do use capital in this period. But capital is no longer limiting in plan 2 and so these more profitable calves increase at the expense of the yearlings. There is a slight increase in the silage produced to feed the extra calves and there is a 3 hour increase to 81 hours, of hired labor in period 3.

As more capital is added in further plans no change takes place in the optimal solution. The small additional net income is due to the increased amount of capital invested off the farm. This investment is, in fact, an outside investment activity incorporated in the model so that if, in any particular time period, there are no activities which will return 5 percent per annum, surplus finance is 'loaned' off the farm at this rate. Hence activities that enter the optimum solutions must return this amount on the operating capital invested in them. In plan 1, $6998 are invested off-the-farm for 12 months and $6271 for 6 months, while in plan 4 $25,652 are invested for 12 months and only $2694 for 3 months. Net return has increased from 8.88 percent in plan 1 to 9.26 percent in plan 4.

The capital borrowing activity simply makes finance available to the farmer at 7 percent per annum from his bank (or a lending institution) to help him through any particular 3 month period when he is short of operating capital. In this model the maximum amount is borrowed in plan 1, during period 2 - and in subsequent plans less than the maximum amount is borrowed, i.e. borrowed capital is no longer a limiting resource. This borrowing activity does not conflict with the 'lending' or 'investment' activity. They both merely increase the versatility of the borrowing and lending facilities available to the farmer.

Because of the large shadow prices on land, hired labor 5, and on hog housing expansion the farmer should investigate the possibilities of investing his surplus capital in additional units of these particular limiting inputs, to increase his net returns on his total capital investment.

Model A2

When the activities containing the new technologies were added to the program the shadow prices on land, labor 1 and hired labor 5 increase in comparison to 1968 technology (model A1 plan 1), i.e. these resources become more restricting, while the shadow price for hog housing expansion is reduced very significantly to zero. In effect the new technology has substituted for hog buildings and equipment. And the amount of hired labor in period 3 (at a cost of $1.50 per hour) is reduced by 34 hours to 44 hours (in comparison to plan 1 A1) - in effect there has been a substitution of technology for labor in this period.

In the optimal solution for plan 1 the more efficient labor saving activities using new technology enter with 2 exceptions. The rotation CCOMM for silage remains at a high fertilizer level only, since new silage harvesting techniques were not considered as a part of the new technology, and only a small amount of extra silage is produced. And the one litter hog system under the old technology (1L) enters because only hog systems 4LNT and 6LNT were considered with new technology. However there is still a small amount of hog housing over: the hog housing expansion is no longer limiting (as it was in A1). The 1L hog system with its small labor and housing demand is best suited to fill this purpose and it replaces the 2L(2) hogs in A1 plan 1.

The number of litters produced under the 4LNT hog system increases to 136. The number of SCGD3 steer calves with new technology goes up slightly to 26. The rotation CCOMM for grain using new technology (CCOMM3G) increases to provide the extra pasture for the 1L hogs and the activity SCGD3, and the grain surplus sold increases to 2816 bushels. The most notable change perhaps, is from 13 yearling steers at the bucket and scoop feeding level (SYGSF1) to 21 SYGSF with the auger feeding system (SYGSF3) - a direct substitution of new technology for the now more limiting land and labor. Net income is reduced to $9790, which together with interest on land investment equals a net return of 7.89 percent on the farmer's total initial capital investment in his property. Out of this must come the reward to labor and management.

With higher capital levels more money is invested in off-the-farm activities, and income increases due to the extra interest received, as in A1.

The most significant feature of Models A1 and A2 when compared, is that the new technologies while entering the program, are not profitable because of the extra amount of fixed costs which have to be deducted (see Table 66 , footnote (b)) - the net income in A2 has been reduced below those in A1.

However Plan 5 in A2 represents the optimal solution for $20,000 of operating capital with no restrictions on hired labor in periods 1-5. The rotation CCSb3G and the cattle activity SYGSF3 both leave the solution. A total of 204 acres of corn-corn-corn-corn for grain under new technology (CCCC3G) enters for the first time - this is a highly productive, but also a high labor demanding rotation. There is no surplus grain and none is purchased. Beef cows with new technology enter (68 BC3) - a new enterprise with a high capital and labor demand and a very low grain requirement. The most interesting change has been the inclusion of 240 litters of 6 litter new technology hogs (6LNT), and the exclusion of both the 1L and 4L hog systems. The activity 6LNT is a high labor demanding activity - but it has a very high profit margin of $1339 per unit of 3 sows and 6 litters. The net effect of this has been to raise the shadow price on hog housing expansion to $503/unit. Land is the only other seriously limiting resource with a shadow price of $94/acre.

Hired labor in periods 1-5 respectively has become 494, 406, 391, 158 and 599 hours. These increases illustrate how restricting labor was during these periods in the previous plans. This extra labor totals 2048 hours or approximately an additional two-thirds of a hired man.

In period 1 the farm invests $24,341 for the 12 months, in period 2 it borrows $8752 for 3 months, period 3 it invests $3938 for 6 months and in period 4 it borrows $9560 for 3 months. The net effect of all these operations in this plan is an increase in net income to $19,786; this represents a return on the farmer's investment of 12.4 percent when interest on land is included. Under these conditions the new technology is a profitable investment.

460 Acre Farm (Table 67, Appendix B)

Model B1

Interesting developments in plan 1 for this model over plan 1 in model A1 are the introduction of 37 acres of the more expensive, but very high grain producing rotation, corn-corn-corn-corn for grain at a high fertilizer level (CCCC2G); and the increase in the shadow price for land to $54/acre - it has become a more limiting factor in the optimal solution. The rotation, CCSb2G, which is not an expensive rotation, has increased to 300 acres with a corresponding increase in soybeans sold. CCOMM2G and CCOMM2S have both increased considerably to 52 and 24 acres respectively to produce the extra pasture and hay required by the large increase in the very profitable SCGD2 cattle to 111 head. And interestingly enough 46 SYGSF cattle with the bucket and scoop method of feeding have entered the program as in A1 - they do not use any labor in July and August (period 4) and they only use 0.2 hours in period 5 when it is limiting most of all. The high profit 4L hog system has increased to 184 litters.

The full $6250 are borrowed at 7 percent per annum (p.a.) in period 2; and $10,062 are invested at 5 percent per annum for 12 months and $13,677 for 6 months. The net result of this plan is a considerable increase in net income (which must cover the operator's labor and management) to $19,354. It should be noted that fixed costs now also include a cost of $5500 for hired labor. When interest on the investment in the land, of $12,604 is added on, the farmer's net revenue becomes $31,958. This represents a net return of 9.85 percent on the farmer's initial investment in the property. A substantial factor in this increased proportional return is due to the economies of scale due to the larger farm - fixed machinery costs/unit are reduced by 80 percent (see Table 15).

There are slight changes in the optimal solution following plan 1. Plan 3 still has capital as a limiting factor with the full $18,750 borrowed for 3 months in period 2, while $22,133 are invested for 12 months, $705 for 6 months and $11,352 for 3 months. The cattle activity, SCGD2, has increased to 147 head at the expense of the activity SYGSF1 which has fallen to only 6. To accommodate these changes which require less grain and more silage and hay, the rotation CCCC2G is reduced to 32 acres and the rotation CCOMM2S is increased to 29 acres. Net income is increased at this $15,000 level to $19,919. When land interest is added to this the return on the farmer's investment becomes 10.02 percent.

In subsequent plans net income increases slightly simply because of the interest return from the extra money invested in off-the-farm activities. The activities in the optimal solution do not change and borrowed capital is no longer limiting.

<u>Model B2</u>

For plan 1 as in model A2 plan 1, there is a significant substitution of new technology for the old. For example hog housing facilities are again no longer limiting - the shadow price is reduced to zero. The shadow price of land is increased to \$61/acre and for labor 5 to \$31/hour. So these are seriously limiting resources.

The rotation CCOMM for silage stays at the high fertilizer level (CCOMM2S) and 28 acres are planted. The rest of the cropping activities have adopted new technology - the rotation CCSb3G, is planted on 327 acres and CCOMM3G on 58 acres. Cattle have adopted the more modern auger feeding system - 117 calves (SCGD3) enter the optimal program as do 40 heifers (HYG3); and 216 litters of 4L hogs adopt new technology as well (4LNT). The yearling heifers (HYGs) enter plan 1 in B2 in place of activity SYGSF1 in B1. The activity HYG3 has a reasonable profit/animal and consumes considerably less grain. Because capital is limiting and because there is just sufficient labor available 6 litters of the 1L hog system under old technology enter the program.

Now \$16,890 of surplus funds are invested off-the-farm for 6 months, and \$5094 for 3 months while all \$6250 are borrowed in period 2 for 3 months. Net income in this model, after \$44,608 are deducted for fixed costs (which includes hired labor costs), increases (from \$19,354 in plan 1 B1) to \$20,637. This represents a net return on the farmer's total investment, once \$12,604 for land interest are added, of 9.57 percent. For the 460 acre unit new technology has not been profitable as this represents a decrease of 0.28 percent over plan 1 model B1.

There is no further change until plan 3. In this plan heifers do not enter at all - instead the top quality steer calves increase to 171 head. The rotation CCOMM2S increases by 8 acres to 36 acres, the rotation

CCSb3G has fallen to 321 acres and 56 acres of CCOMM3G are planted. Land has become slightly more limiting and hog housing expansion now has a shadow price of $2/unit. There is a deficiency of grain and 2551 bushels are bought at $1.20. Net income has increased to $21,324.

Subsequent plans show no changes in the optimal solution - net income increases (because of the interest received from the extra finance 'loaned' off the farm at 5 percent per annum at these higher initial capital levels) till it reaches $22,614 in plan 6.

In plan 7 the farmer is allowed to hire as much labor at $1.50/hour in each of the 5 labor periods, as the plan's optimal solution requires - there is no limit on the amount that can be hired. However no other restraints are removed and capital remains at $40,000 as in plan 6.

The results are interesting and useful; 571, 486, 348, 53 and 647 hours of labor are hired in periods 1-5 respectively. This is a total of 2105 hours which is equivalent to 2/3 of a hired man. The optimal solution contains only activities at new technological levels. A total of 309 acres of continuous corn for grain (CCCC3G) replace the no longer profitable CCSb3G rotation. Approximately 104 acres of rotation CCOMM are planted - 70 for grain and 34 for silage. With the cattle activities the calves (SCGD3) are reduced to 77 head while 129 beef cows (BC3) enter the solution. The significant differences with beef cows (where the calf is sold) are 1) a considerably lower net return/unit, 2) a considerably higher demand for labor and 3) a very significant reduction in grain consumption - and production of grain is a costly activity. The purchase of beef cows is, incidentally, a trend on some larger units in western Iowa today. For hogs the 1L and 4LNT activities are no longer profitable - instead 360 litters of the extremely profitable, but high labor demanding 6LNT activity enter the solution.

Shadow prices have changed markedly: land is now $94/acre and hog housing expansion has jumped to $503/unit - an extra unit of 6LNT hogs would increase gross profit by $503. Labor 5 of course, is no longer a limiting resource.

Now $43,201 of surplus funds are invested for 12 months in period 1, $13,321 are borrowed in period 2, and $6207 are invested in period 3 for 6 months. This is a very astute borrowing-lending policy. The result of these changes is very significant: net income has reached the very high figure of $35,183. This income represents an excellent net return of 13.75 percent on the farmer's investment in his property. This plan shows not only how profitable the adoption of new technology might be when adequate labor is available and purchased, but it also shows that the initial labor assumptions seriously limited both models B1 and B2.

640 Acre Farm (Table 68, Appendix B)

Model C1

Borrowed capital is not limiting in plan 1; land is mildly limiting with a shadow price of $7/acre, but labor in period 3 is a very limiting resource with a shadow price of $35/hour and labor 5 is also limiting with a shadow price of $8/hour. It is interesting to note that housing facilities are not limiting at all.

There is only enough labor for 80 yearling steers at the bucket and scoop level of feeding (SYGSF1), 104 litters of 4 litter (4L) and 66 litters of 2 litter (2L(2)) hogs, 543 acres of rotation CCSb2G, 26 acres of rotation CCOMM2G and 7 acres of rotation CCOMM2S. It is not profitable to feed all the grain produced to livestock and so 20,893 bushels (bu.) are sold at $1.00 per bushel.

In period 1 $6538 are invested off the farm for 12 months, $4348 are borrowed for 3 months in period 2, $6161 are invested for 6 months in period 3, and $3282 are invested for 3 months in period 4. Net income is only $15,972 after fixed costs including hired labor and land interest are deducted. When interest on the land is added the net revenue to the farm becomes $33,508 which represents a net return of 7.97 percent on his investment in his property.

This net income and net return are below those for the 460 acre farm simply because a) hired men come in discrete units and the 640 acre farm under present circumstances only has 1 hired man, and this is an inadequate labor supply for this farm and b) this 640 acre farm still has to pay the increased fixed costs associated with the increased size although economies of scale do reduce fixed machinery costs/unit to 70 percent.

Plans 2-6 with increased levels of available operating capital have the same solution - and as in previous models net income is due to increased investment off the farm in period 1.

Model C2

New technology substitutes in all enterprises for labor except for silage making which is harvested by custom and more modern harvesting techniques were not considered. There has been a large increase in cattle numbers; the highly profitable SCGD3 calf activity has entered with 176 calves and the SYGSF3 yearlings have increased to 123. And the efficient and profitable 4 litter hogs (4LNT) has entered with 160 litters. The cropping activities have changed to allow for these adjustments and only 8889 bushels of grain are sold.

Shadow prices have changed: land is now $28/acre (considerably more limiting), labor 2 is $3/hour, labor 3 is $18/hour and labor 5 is $23/hour. Net income has risen to $18,583 and this together with interest on land gives the farmer an 8.08 percent return on his investment in the property. This is lower than that for model B2 - again because of insufficient labor and because of the increase in fixed costs. This appears to be a low return for this size of farm then compared with the previous units.

Plans 2-6 only show changes in profit due to the increased investment in outside activities in period 1.

Plan 7, however, is the optimal solution for maximizing profit, with no restriction on the amount of labor that can be hired in periods 1-5 at $1.50/hour at the maximum $40,000 capital level. Land now has a very high shadow price of $94/acre, and so does hog housing expansion (=$509/ unit), and for the first time cattle housing expansion is limiting - it has a shadow price of $2/unit.

All activities use new technology. The rotation CCSb3G is replaced by 388 acres of continuous corn for grain (CCCC3G); and the rotation CCOMM increases with 123 acres now being planted for grain and 62 acres for silage. The calves (SCGD3) increase to 203 and the yearlings (SYGSF3) are replaced by 159 beef cows (BC3 - a high labor but low grain demanding activity). Now 420 litters of the high labor demanding and highly profitable 6 litter (6 LNT) hogs replace the less profitable and lower labor demanding 4LNT system.

There is a decrease in financial investment over plan 6 but an increase in borrowed capital. The 2 significant points about this plan are 1) the large amounts of labor now hired in periods 1-5 respectively: 1167, 881, 855, 383 and 1131 hours - this is a total of 4417 hours (equivalent to 1½ men) which proves just how limiting labor was, and 2) the net income has jumped tremendously to $45,765 representing a net return of 14.16 percent on the farmer's property investment. This model is now highly profitable.

960 Acre Farm (Table 69, Appendix B)

<u>Model D1</u>

This follows a similar pattern to model C1 simply because once again insufficient labor was hired initially. It is easily seen that labor is seriously limiting in period 3 (labor 3) with a shadow price of $35/hr., and it has an $8/hr. shadow price in period 5. The same activities enter this solution as in C1 and in similar proportions in relation to the total land area. Again the only cattle enterprise is the yearling steers activity

(SYGSF) with the bucket and scoop method of feeding - this enterprise requires no labor in period 4 and only 0.2 hours in period 5 and it has a reasonable net return of $84/steer.

It is not profitable to buy additional livestock to utilize the surplus grain, 35,909 bushels of grain are sold off the farm at $1.00 per bushel. In period 2 $12,500 are borrowed; and $11,492, $2264 and $14,792 are loaned out for 12, 6 and 3 months respectively. Net income for plan 1 is $25,663 after $66,909.52 for fixed costs are deducted including $11,000 for permanent hired labor, and $26,304 for interest on land. When this land interest is added to the net income the farmer's net return on his investment in the property is 8.46 percent. This is a low return with respect to the models studied simply because of the limiting labor factor on this farm; although it is high with respect to market interest rates.

In plans 2-6 net income increases gradually due entirely to increased investment off the farm of additional owner's capital supplied to each successive plan.

Model D2

The inclusion of the activities containing the new technologies increased net income in plan 1 to $30,439 in comparison to plan 1, D1 with 1968 technology. Land becomes significantly more limiting, with a $27/acre shadow price; so has labor 2 and labor 5 while labor 3 is not so limiting. Only 16,681 bushels of grain are sold as surplus because more grain has been profitably utilized by the increased stock. Now 210 SYGSF yearlings with the auger feeding system enter, as do 233 calves (SCGD3).

And 236 of the profitable 4 litter new technology (4LNT) hog system enter. To cope with the increased requirement for pasture, hay and silage, 56 acres are planted in the rotation CCOMM2S, 146 in the rotation CCOMM3G and 681 acres in the rotation CCSb3G.

No capital is borrowed; while \$4063, \$1638, \$14,077 and \$4792 are invested in periods 1, 2, 3 and 4 for 12, 9, 6 and 3 months respectively. The net income together with the interest on the land represents a return of 8.46 percent on the farmer's property investment. Out of this, of course, must come the reward for the owner's management and labor.

Net income increases gradually in plans 2-6 due to increased investment of 'free' capital off the farm; they have the same activities in the optimal solution as plan 1.

Plan 7, with no restrictions on hired labor (which can be hired at \$1.50 per hour) and with owner operating capital at the maximum of \$50,000, provides very interesting and useful results. A total of 1538, 1020, 1013, 1389 and 1158 hours of labor are hired in periods 1-5 respectively. This represents an addition of almost 2 full men and illustrates the seriousness of the limiting labor supply because net income jumps to \$59,286 in plan 7 compared to \$32,439 in plan 6. This net income of course has to pay the operator a reward for labor and management. When the fixed cost for interest on land is added to this net income the net return becomes 13.15 percent which can be considered a high return. Continuous corn for grain (CCCC3G) is now planted on 524 acres in place of the rotation CCSb3G; rotation CCOMM3G increases to 234 acres and rotation CCOMM for silage with new technology increases to 125 acres. As in previous models it is no longer profitable to produce soybeans - the extra labor is more profitably used growing corn, oats and meadow and feeding and taking care of livestock.

The calf activity, SCGD3, increases to 542 head, and beef cows enter, as before, with 143 head. Activities SYGSF3 and 4LNT leave the optimal solution - 6 litter (6LNT) hogs with 480 litters enter. The seriously limiting resources are land ($93/acre) and hog housing ($515/unit). However cattle housing is also limiting with a shadow price of $3/unit. No corn is bought or sold.

1280 Acre Farm (Table 70, Appendix B)

Model E1

In plan 1 this model appears to have a much better balance of resources than the previous 2 models. However land with a shadow price of $46/acre and hog housing expansion with $192/unit are seriously limiting; as well borrowed capital and labor 1, 2, 3 and 5 are limiting. Now 801 acres are planted in corn-corn-soybeans at a high level of fertilization for grain (CCSb2G); 140 acres are planted in continuous corn with high fertilizer level, for grain (CCCC2G); 157 acres in corn-corn-oats-meadow-meadow for grain and 80 acres for silage, both with high fertilizer (CCOMM2G and CCOMM2S respectively). A total of 12,426 bushels of grain are sold. Of the profitable steer calves with the self-unloading wagon feeding method (SCGD2), 362 are run on the farm; also 116 of the yearling steers with the bucket and scoop feeding method (SYGSF1). The farm also has 268 litters of the 4 litter hog system (4L) and 200 litters of the 6 litter system (6L).

Borrowed capital is limiting - $12,500 are borrowed in period 2 while $921, $12,285 and $31,866 are invested in periods 1, 3 and 4 for 12, 6 and 3 months respectively. Net income is $50,064; and again this includes the return to the owner for his labor and management. It is the figure after fixed costs, including land interest of $35,072 and 4 permanent hired men costing $22,000, have been deducted from the farm's net profit. When interest is added to the net income this net revenue represents a net return of 9.97 percent on the investment in the property - this can be considered a very respectable return.

Plans 2-7 change because the extra amounts of 'free' owner operating capital available at the increased capital levels mean increased amounts can be profitably loaned off the farm at 5 percent per annum - and because of these loans net income has reached $53,369 in plan 7.

Model E2

The advantages of new technology are quite substantial and evidence of this is shown in plan 1 which has a $59,040 net income after fixed costs have been deducted. This represents a 10.45 percent return on total initial capital investment once interest on land is added, and this can be considered a very good return with respect to the previous models.

As in past models silage is made using a rotation under old technology, and 90 acres of the rotation CCOMM with high fertilizer (only) for silage (CCOMM2S) are planted. Other cropping activities are similar to past models and use new technology. The profitable calves have increased to 404 and the yearlings to 155. The profitable hog activity, 6LNT, has expanded to 348 litters at the expense of the 4 litter 4LNT hogs. Land now has a shadow price of $53/acre, labor 5 has increased to

\$24/hour and hog housing expansion has been reduced to \$69/unit. Only 1537 bushels of grain are sold as surplus - this optimal solution has better utilization of grain production than plan 1, El. Capital borrowing is again limiting; only \$33 are invested for 12 months, while \$12,653 are invested for 6 months and \$33,083 for 3 months.

As in previous models subsequent plans show little change - and increased profit is due to interest return from additional outside investment of extra owner operating capital.

Plan 8 is the optimal solution using new technology at the maximum \$75,000 owner operating capital level with no restrictions on the amount of labor the farm can hire in any period. As a result 1290, 761, 556, and 688 hours of labor are hired in periods 1, 2, 3 and 5 respectively - this is a little over 1 full man and illustrates how limiting labor has been in these periods because net income has risen to \$75,663.

As in other models continuous corn enters the solution and soybeans are no longer grown - the extra land is more profitably used growing crops that can be fed to the livestock. All activities use the new technology. A total of 692 acres are planted in the rotation CCCC3G, 314 acres in rotation CCOMM3G (a large increase over plan 7 needed to feed the extra stock) and 1721 acres in rotation CCOMM3S (again a large increase over plan 7). In the cattle activities 799 calves and 120 beef cows enter - both with new technology - and for hog activities the highly profitable 6 litter system with new technology (6LNT) enters. Neither the yearling (SYGSF3) cattle nor the 4 litter (4LNT) hogs are profitable and they do not enter the profit maximizing optimal solution. Land has a shadow price that increases to \$94/acre; labor 1, 2, 3 and 5 are \$1.5/hour (equivalent to the price of hired labor); hog housing expansion has again reached an enormous figure of \$527/unit showing how limiting this is and how profitable the 6LNT hog system is; and cattle housing expansion is just limiting with a shadow price of \$3/unit. No grain is bought or sold.

A total of \$56,475 is invested in period 1 for 12 months, \$52,763 are borrowed in period 2 for 3 months and \$37,463 in period 3 for 3 months, while surplus funds in period 4 of \$34,464 are invested for 3 months. The net income of \$75,663 is a very good return and includes the operator's reward for his labor and management. When \$35,072 are added for the fixed cost charged for interest on land investment, the total of \$110,735 represents a 12.30 percent net return on the owner's capital investment in his property. This again, when compared to market interest rates, is a very good return.

INTERPRETATION OF RESULTS

Production economics is primarily concerned with the optimal allocation of scarce resources to maximize a given (stated) objective function. If resources are not allocated in an optimum manner then inefficient resource use results. In a study such as this the initial assumptions will control the amounts of the scarce resources available, so these assumptions will have a very large influence on the optimal solutions for each model and on the ultimate results. Before interpreting these results it is important to be fully acquainted with the essential assumptions underlying the availability of resources in this study, as they are outlined in Tables 15 and 16, Appendix A.

Important Resources

Labor

For both the 1968 and new technology levels each farm has an owner-operator as manager which represents 2925 hours of labor. The 280 acre farm has 450 hours of hired labor; the 460 and 640 acre farms each have 1 full hired man; the 960 acre farm has 2 hired men and the 1280 acre farm has 4 hired men. Each hired man represents 2925 hours of labor, with a similar distribution to that of the owner-operator. The total labor hours for each farm were thought to be realistic with respect to each particular size of farm in North-central Iowa. The total labor supply (hours) is plotted in Figure 1 and it is easily seen that the 640 and 960 acre farms are seriously handicapped in comparison to the other 3 farms. This is brought out more

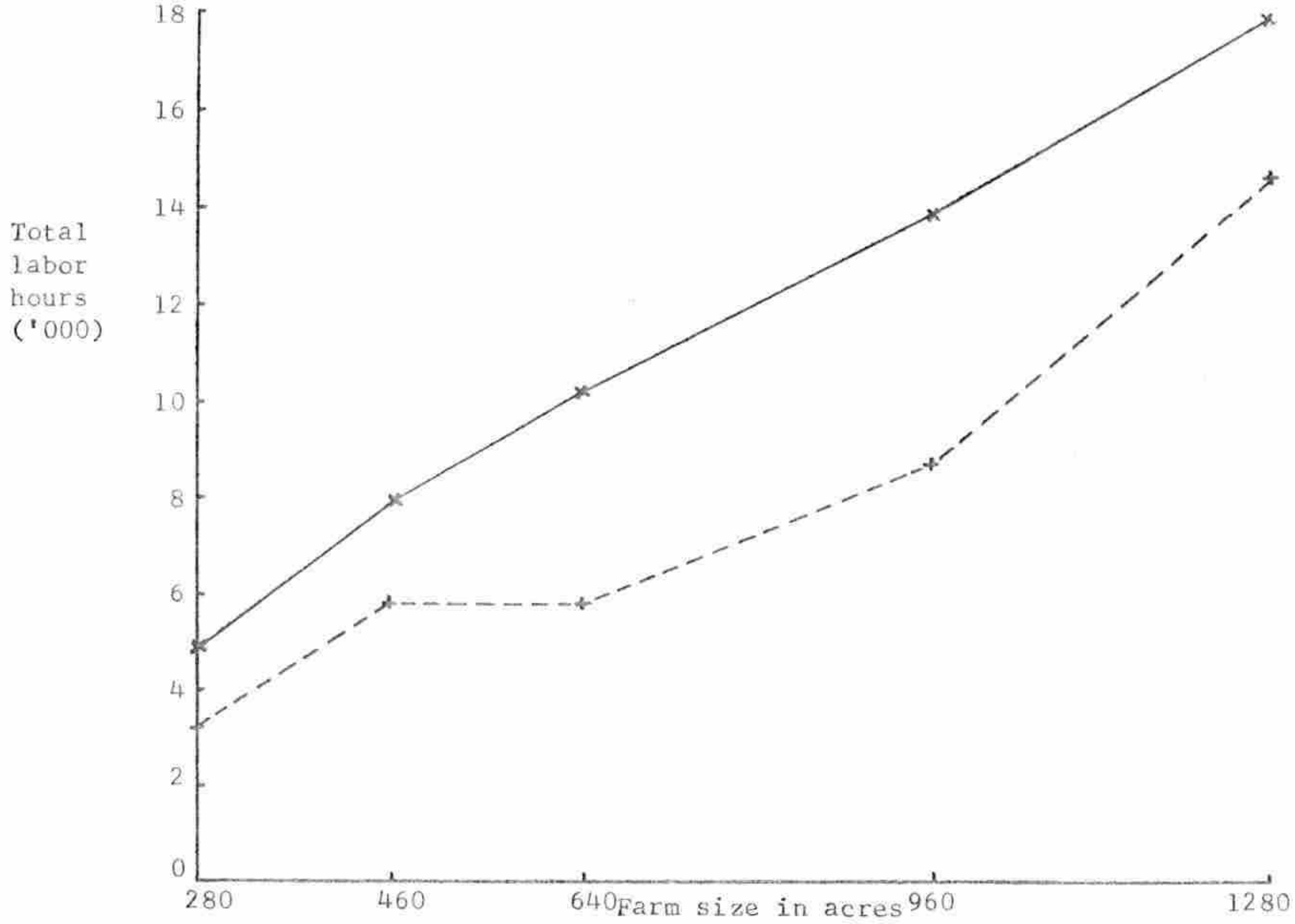


Figure 1. Total labor supply for 280, 460, 640, 960 and 1280 acre farms for:
1968 and new technology – – – – – – –;
new technology with no hired labor restraint ————.

Table 7. Total cattle and hog facilities and owned, borrowed and total maximum operating capital for the new assumptions[a,b]

Acres	Proportional increase in land over 280 acre farm	Total hog restraint	Total cattle restraint	Operating capital Own	Operating capital Borrowed	Operating capital Total
	%	units	units	$'000	$'000	$'000
280		40	200	20.00	25.00	45.00
460	1.64	65	325	32.80	41.00	73.80
640	2.28	90	455	45.60	57.00	102.60
960	3.42	135	680	68.40	85.50	153.90
1280	4.57	185	915	91.40	114.25	205.65

[a]See Tables 15 and 16 for initial assumptions which were considered realistic for each of the models concerned at the start of the study.

[b]These new assumptions allow total facilities for cattle and hog housing and for total operating capital at the maximum levels to expand with each farm in relation to the proportional increase in the land area over the 280 acre farm. This was not the case with the initial assumptions set out in Tables 15 and 16, Appendix A.

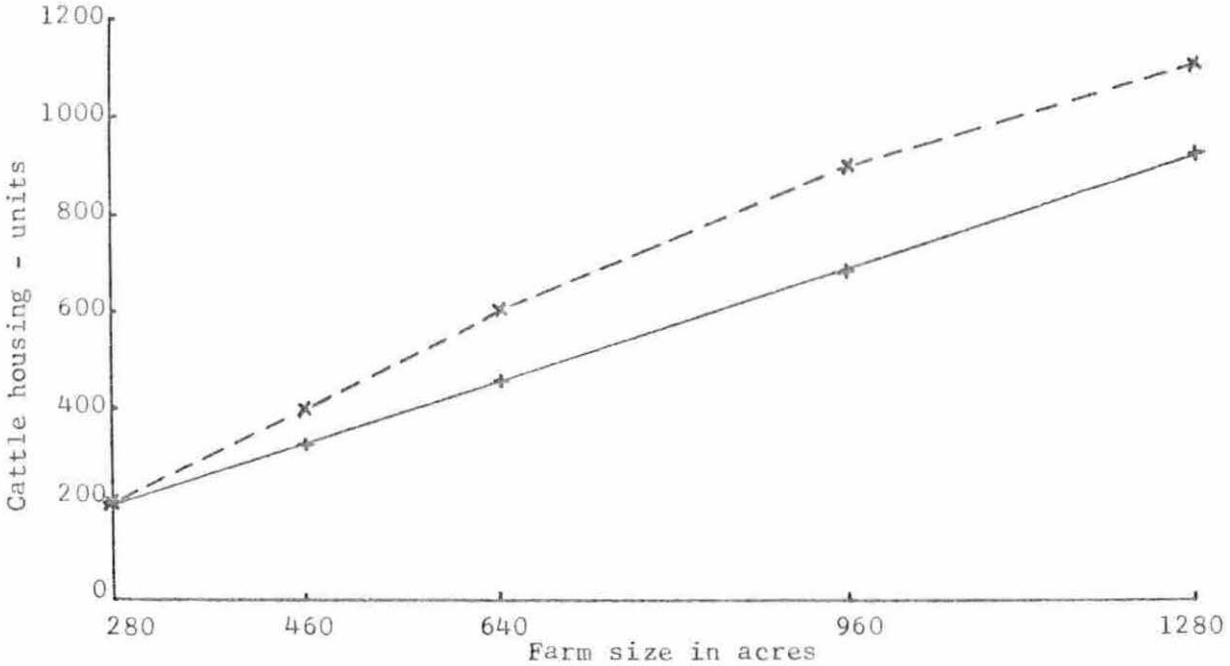


Figure 2. Total cattle housing (units) available to the 280, 460, 640, 960 and 1280 acre farms for both technology levels under:
the initial assumptions — — — — — —;
and the new assumptions ————————.

clearly when the hired labor restraint was released at maximum capital levels under new technology - the 640 and 960 acre farms hired significantly more labor when compared with the 280, 460 and 1280 acre units.

It will be seen when interpreting the results that this insufficient labor supply on the 640 and 960 acre farms had a serious limiting effect on output and on net income.

Cattle housing

In Figure 2 cattle housing units are graphed for both technologies for 2 sets of assumptions: the initial set and a new set. When interpreting the results it was realized that the initial assumptions (which were considered realistic for North Central Iowa farming) did not expand in the same proportion as farm size. This appeared to influence the results quite markedly so a new set of programs were run on the computer under a 'new' set of assumptions to check this fact. These new assumptions (which are found in Table 7) apply to cattle and hog housing and to maximum operating capital supply, and represent the same proportional increase in these resources as the increase in respective farm sizes over the 280 acre farm. It can be seen in Figure 2 that cattle housing expanded more rapidly under the initial assumptions than under the new ones, favoring all farms by about the same amount.

Hog housing

Figure 3 graphs the hog housing (in units) available to each farm for both technologies for both the initial and the new assumptions. It can be seen that hog housing expanded much faster from the 280 to the 460 acre farm and slowed down on the next three. Because of this there were large shadow

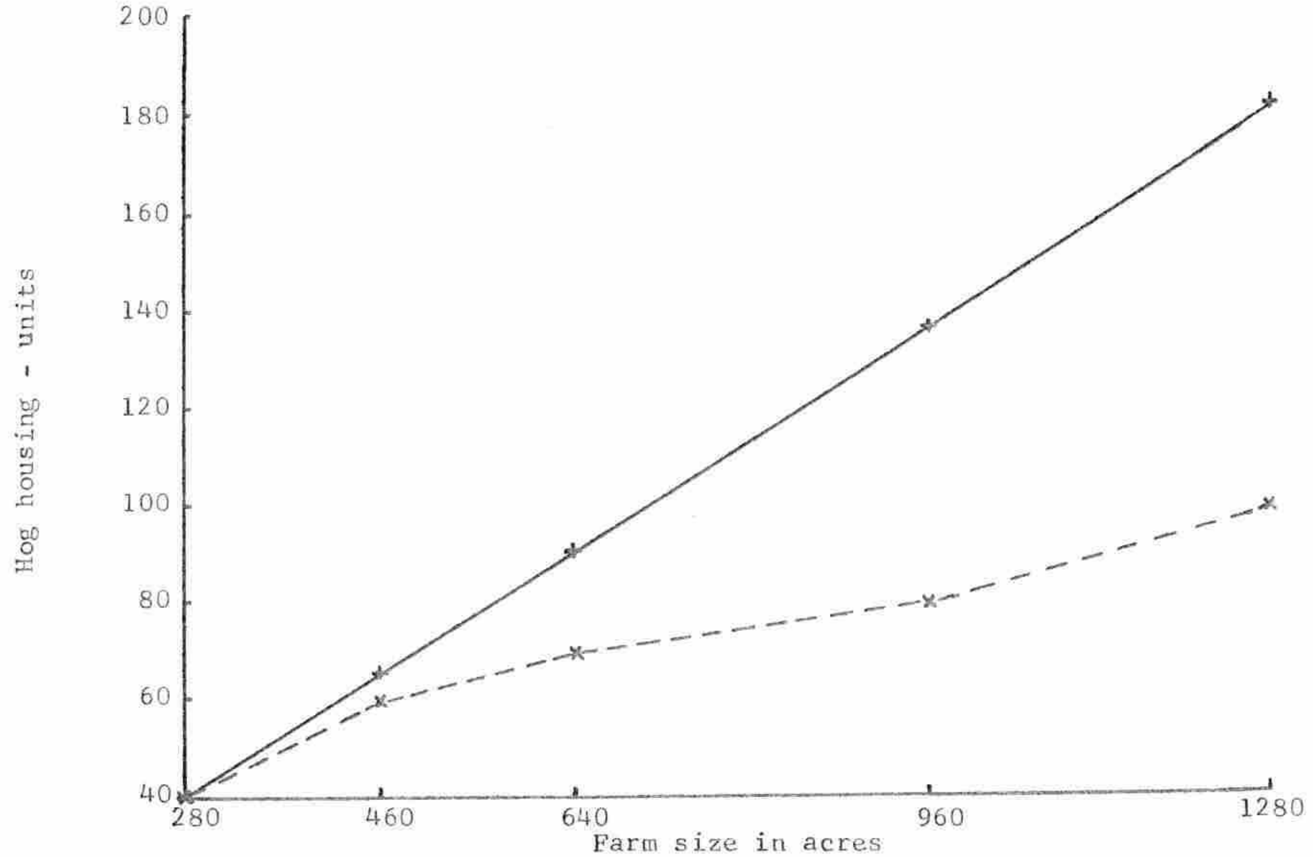


Figure 3. Total hog housing (in units) available to the 280, 460, 640, 960 and 1280 acre farms for both technology levels:
under initial assumptions — — — — — ;
under the new assumptions ————— .

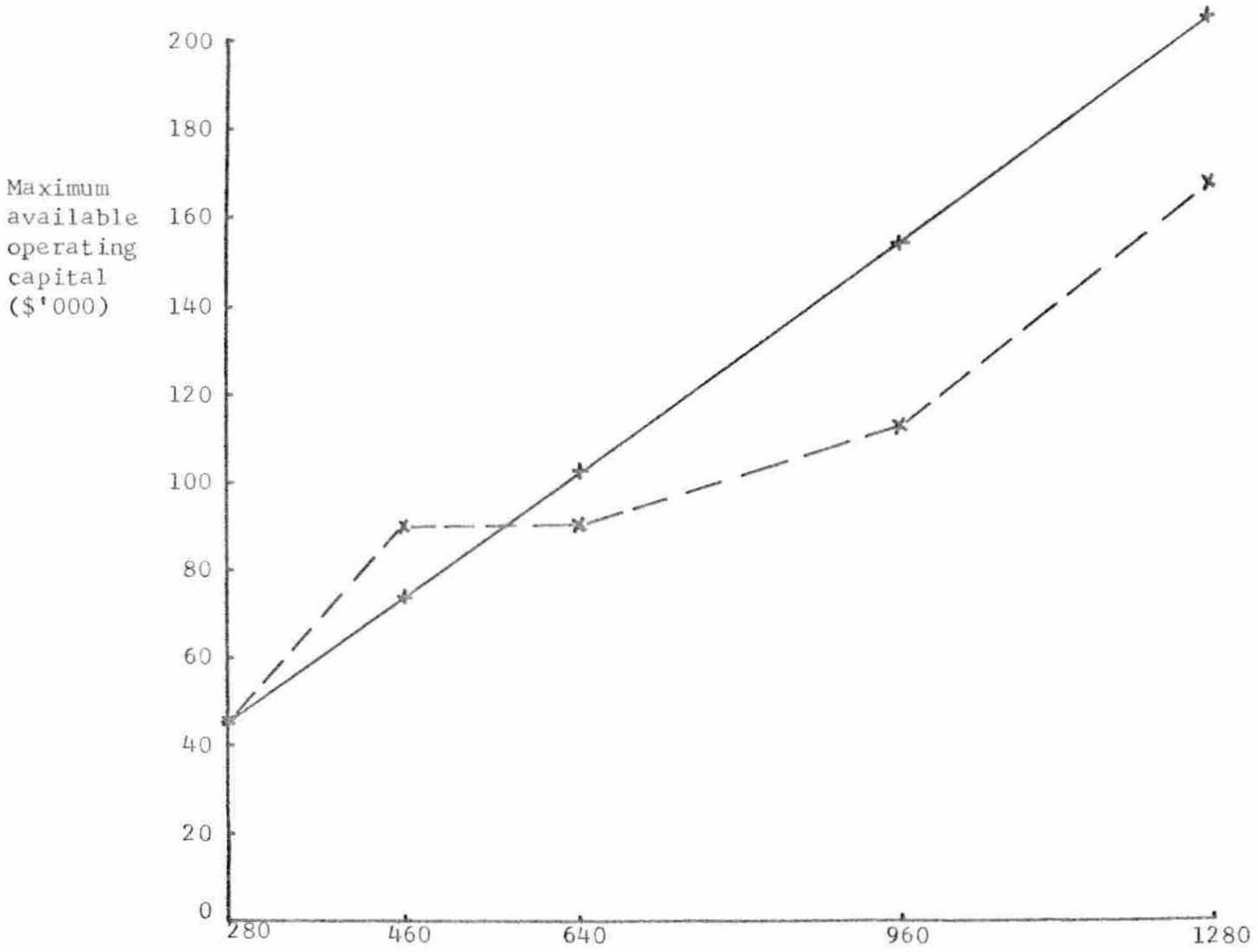


Figure 4. Maximum available operating capital for the 280, 460, 640, 960 and 1280 acre farms for: initial assumptions — — —; and new assumptions ———.

prices on hog housing under new technology at maximum capital levels and with no restraint on hired labor, so the 640, 960 and 1280 acre farms were seriously handicapped in the study by this initial hog housing assumption.

Operating capital

Figure 4 graphs the maximum available operating capital for the initial set of assumptions in Table 16, Appendix A, and for the new set of assumptions in Table 7. Again it is easily seen that the 460 acre farm had more 'than its share' of maximum capital while the 640, 960 and 1280 acre farms did not have enough, in proportion to the base 280 acre farm. Results at the maximum capital level (only) would be affected accordingly, although perhaps not to quite the same extent.

Optimum Programs

Optimum programs identify how resources are combined under 1968 and new technology to maximize profit for each individual farm, and how resource allocation should change as farm size increases. The important objective for each farm is to obtain maximum economic efficiency - i.e. to ensure that resources are combined in the most profitable manner.

Table 8 identifies these optimum programs for the 280, 460, 640, 960 and 1280 acre farms for 1968 and new technology at the $10,000 owner operating capital level. Because each farm has seriously limiting resources farm plans do not change very much as capital supply increases - therefore the $10,000 level was chosen. Table 9 identifies the optimum solutions for these farms under new technology at the maximum capital levels for each, with no hired labor restraint.

Table 8. Optimum program solutions for 280, 460, 640, 960 and 1280 acre farms at the $10,000.00 owned operating capital level for 1968 technology and for new technology[a,b]

	Units	280	460 (acres)	640	960	1280
			1968 technology			
Crops						
CCCC2G	Acres	-	37	-	-	140
CCSb2G	Acres	234	300	543	848	801
CCOMM2G	Acres	12	52	26	32	157
CCOMM2S	Acres	7	24	7	4	80
Cattle						
SYGSF1	No.	4	31	80	99	115
SCGD2	No.	33	125	-	-	362
Hogs						
2L(2)	Litters	24	27	66	76	-
4L	Litters	112	184	104	164	268
6L	Litters	-	-	-	-	200
			New technology			
Crops						
CCOMM2S	Acres	6	28	44	56	90
CCSb3G	Acres	231	327	435	681	906
CCOMM3G	Acres	16	58	94	146	182
Cattle						
SCGD3	No.	26	117	176	233	404
SYG3F3	No.	21	-	123	210	155
HYG3	No.	-	40	-	-	-
Hogs						
1L	Litters	6	6	-	-	-
4LNT	Litters	136	216	160	236	168
6LNT	Litters	-	-	-	-	348

[a]These solutions are graphed in Figure 5 for crops, Figure 6 for cattle, and Figure 7 for hogs.

[b]From Tables 66 to 70, Appendix B.

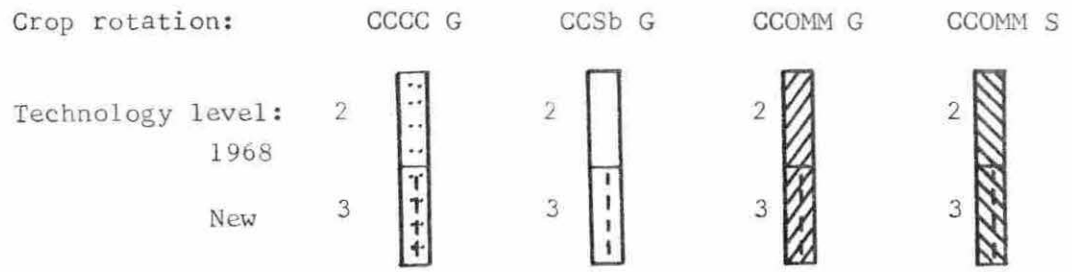
Table 9. Optimum program solutions for the 280, 460, 640, 960 and 1280 acre farms with new technology at the maximum capital levels for each farm with no hired labor restraints[a,b]

Maximum operating capital levels		Acres				
	Units	280	460	640	960	1280
Crops						
CCCC3G	Acres	204	309	388	524	692
CCSb3G	Acres	-	-	-	-	-
CCOMM3G	Acres	34	70	123	234	314
CCOMM3S	Acres	15	34	62	125	172
Cattle						
SCGD3	No.	31	77	203	542	799
SYGSF3	No.	-	-	-	-	-
HYG3	No.	-	-	-	-	-
BC3	No.	68	129	159	143	120
Hogs						
1L	Litters	-	-	-	-	-
2L(2)	Litters	-	-	-	-	-
4LNT	Litters	-	-	-	-	-
6 LNT	Litters	240	360	420	480	600

[a]These solutions are graphed in Figure 5 for crops, Figure 6 for cattle; and Figure 7 for hogs.

[b]From Tables 66 to 70, Appendix B.

Figure 5. Optimum crop rotations for 280, 460, 640, 960 and 1280 acre farms for: $10,000 owner operating capital level with 1968 technology (=2) = left bar; $10,000 owner operating capital level with new technology (=3) = center bar; and for maximum owner operating capital levels for each farm with new technology and no hired labor restraint = right bar.



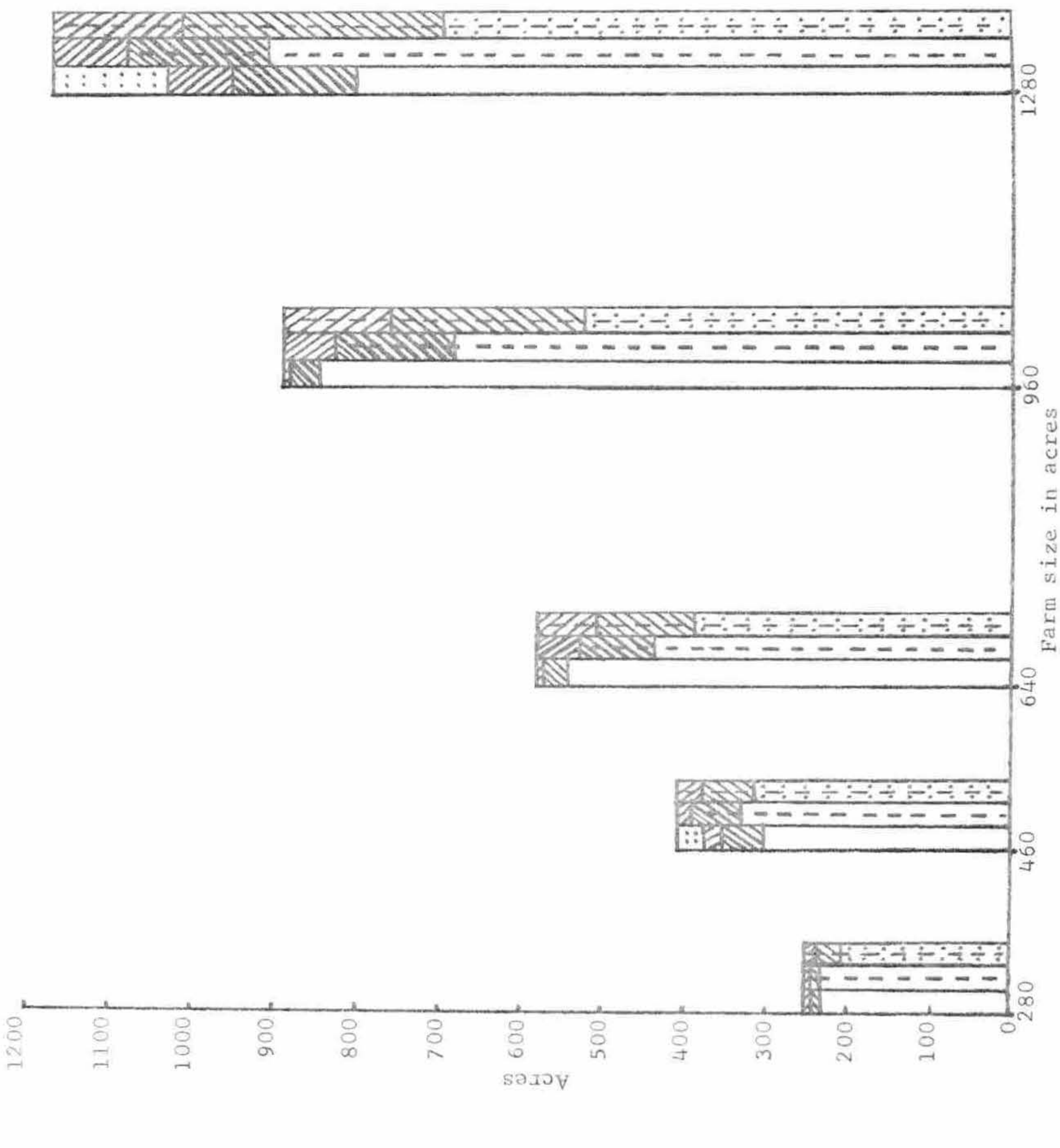
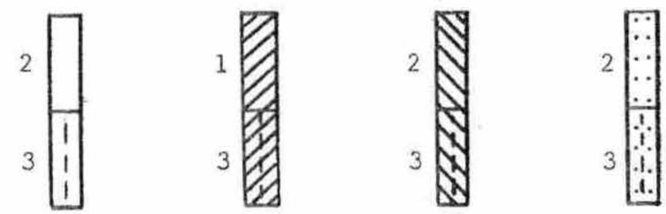

Acres
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Farm size in acres
280
460
640
960
1280

Figure 6 . Optimum cattle programs for 280, 460, 640, 960 and 1280 acre farms for: $10,000 owner operating capital with 1968 technology (=1 and 2) = left bar; $10,000 owner operating capital with new technology (=3) = center bar; and for maximum owner operating capital levels with new technology (=3) and no hired labor restraint = right bar.

Activity:	Steer calves good choice drylot fed	Steer yearlings, good choice short fed fall	Heifer yearlings good choice	Beef cows, calf sold
Abbreviation:	SCGD	SYGSF	HYG	BC

Technology level:
1968
Feeding method

New



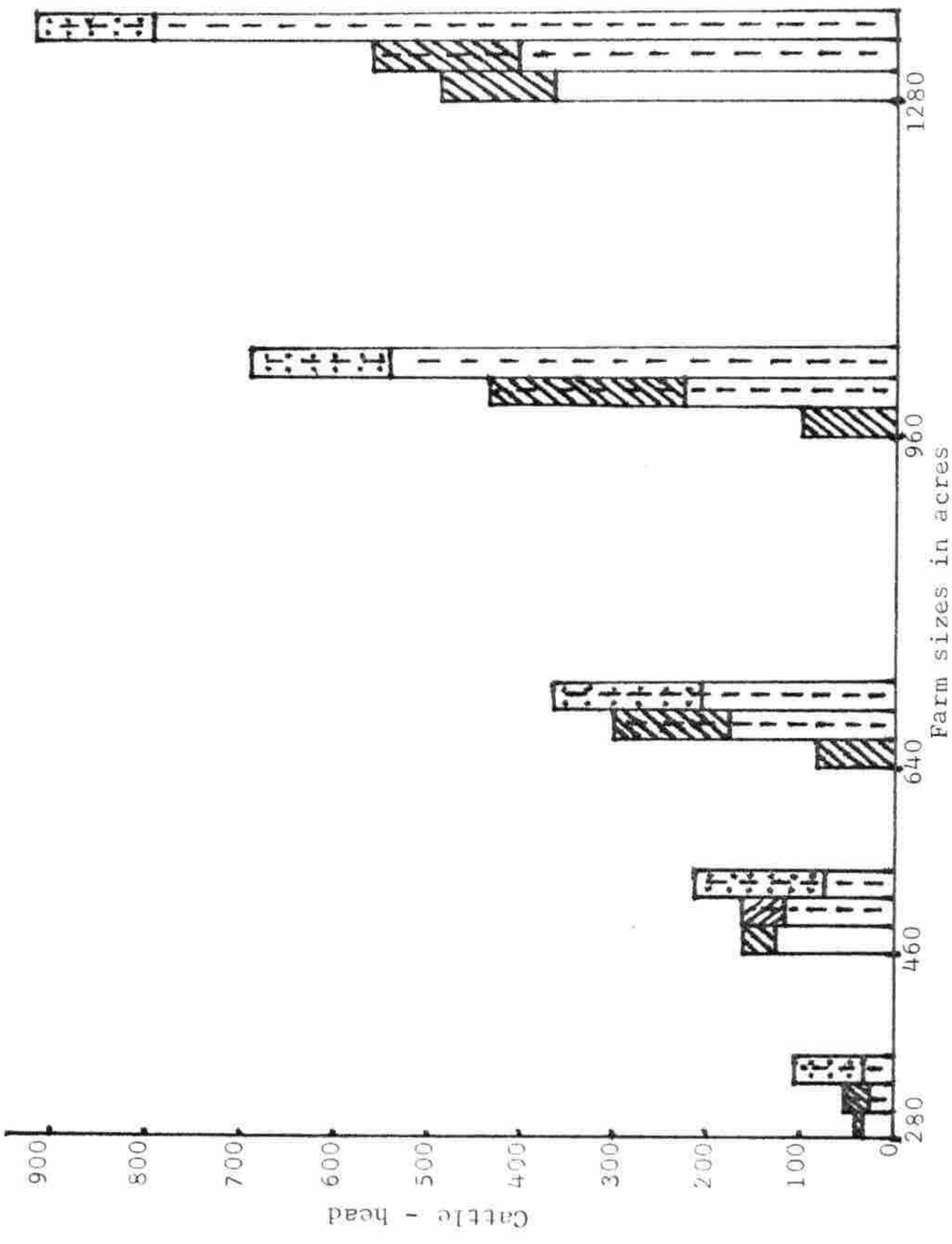
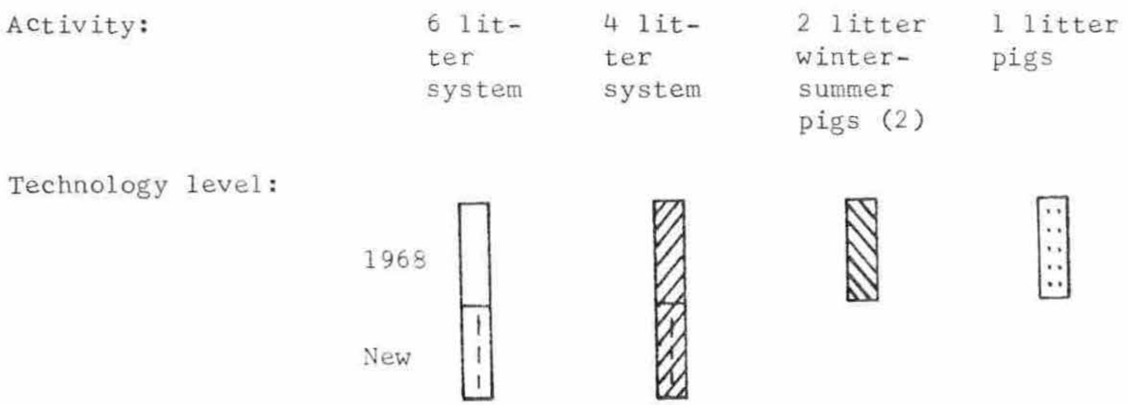

Cattle - head
900
800
700
600
500
400
300
200
100
0
280
460
640
960
1280
Farm sizes in acres

Figure 7. Optimum hog programs for 280, 460, 640, 960 and 1280 acre farms for: $10,000 owner operating capital and 1968 technology = left bar; $10,000 owner operating capital and new technology = center bar; and for maximum owner operating capital and new technology with no restriction on hired labor = right bar.



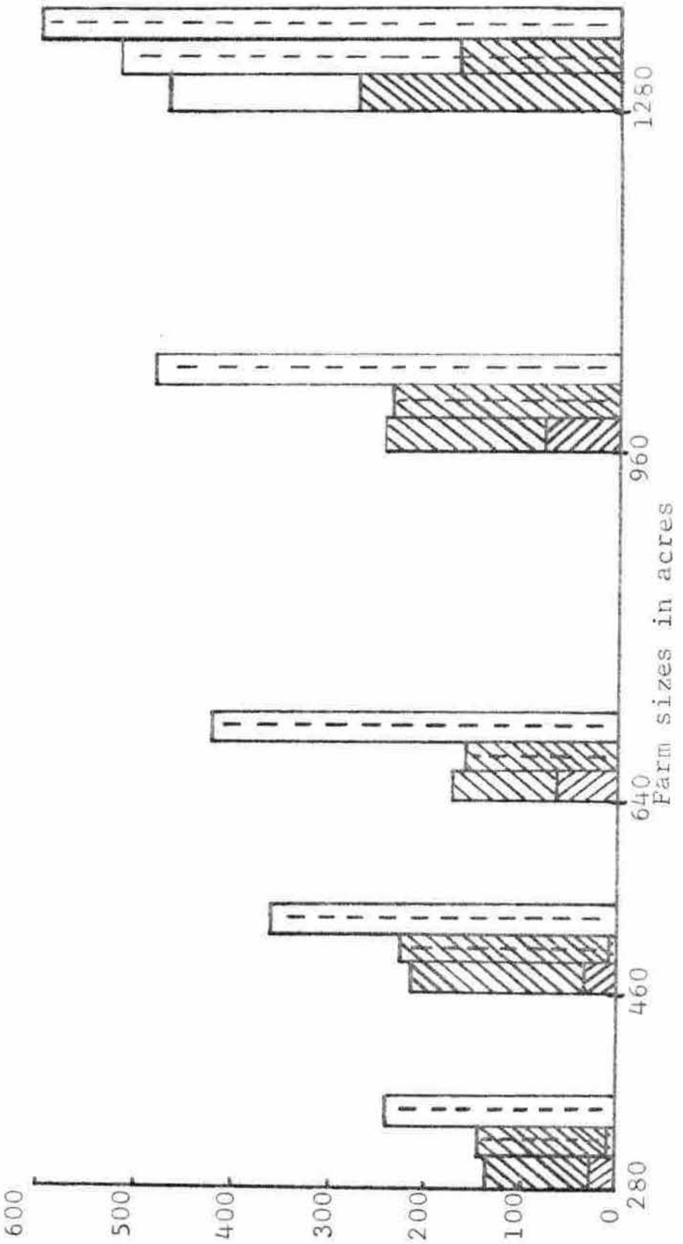

Hogs - litters
600
500
400
300
200
100
0
280
460
640
960
1280
Farm sizes in acres

Figure 5 identifies the optimal solutions for crops, Figure 6 the optimal solutions for cattle and Figure 7 the optimal solutions for hogs. The optimum combination of crop rotations and cattle and hog enterprises is reasonably consistent for the different farm sizes although the actual proportions do vary as these figures show, due to the different proportional resource constraints for each farm under the initial assumptions. The optimal solutions are interpreted under three major headings.

Optimum enterprise combinations under 1968 technology

Crops The optimum crop rotations for each farm are a combination of corn-corn-soybeans for grain, and corn-corn-oats-meadow-meadow for grain and for silage, all at high fertilizer levels (CCSb2G, CCOMM2G and CCOMM2S respectively). However, the 460 and 1280 acre farms do have the continuous corn rotation for grain at the high fertilizer level (CCCC2G) as well. These two units have a much better 'balance' of resources and this high grain producing rotation is required to produce the large amounts of grain to feed the extra livestock that are on these farms.

Cattle The optimum cattle activities for each farm are a combination of good choice, drylot fed steer calves with the self-unloading wagon feeding method, (SCGD2), and good choice yearling steers, short fed in the fall with the bucket and scoop feeding method (SYGSF1). These calves however, require 8.9 hours of labor compared to 6.01 hours for these yearling steers. As noted earlier the 640 acre and 960 acre farms have a serious labor shortage - as a result only the yearling steers enter the optimal solutions for these 2 farms. Because the 280, 460 and 1280 acre farms have a good 'balance' of resources they have a large number of cattle in the optimal solutions in comparison to the 640 and 960 acre farms.

Hogs The optimum hog activities for each farm are a combination of the 2 litter winter-summer pigs, (2L(2)), and the 4 litter system (4L). However the 1280 acre farm with its adequate labor supply has a combination of the 4L activity and the 6 litter hog system (6L) - a high labor and grain demanding (602 bushels compared with 395 bushels for the 4L activity) activity with a high profit margin of $1148 per unit.

Optimum enterprise combinations under new technology

Crops The optimum crop rotations still have the rotation CCOMM2S to produce silage because although the new technology on the farm has meant slightly higher yields, greater efficiency in silage harvesting techniques with new machinery was not included, because custom harvesting of silage is assumed to be done at a constant cost of 1968 prices. However new technology has been adopted by the other rotations: CCSb3G and CCOMM3G. In effect the higher yielding new technology rotations for grain were adopted instead of the lower yielding 1968 technological methods - a direct substitution of new for 1968 technology. It must be noted that the rotation CCCC for grain does not enter the optimal solutions now in either the 460 or the 1280 acre units. This is because the rotations CCOMM3G and CCSb3G can now supply the extra grain required at a more reasonable cost than either CCCC3G or CCCC2G.

Cattle The optimum cattle activities are still SCGD calves and SYGSF yearlings - however they are now both at the new technological level - again a direct substitution of the new technology for 1968 technology. The calves have now become more efficient under the new technology - their labor requirement has become low enough for them to compete favorably for other resources on all farms and so they enter the optimal solutions on the 640 and 960 acre farms. This represents a substitution of technology for labor.

The 460 acre farm does not have any surplus grain and because of this good choice yearling heifers with new technology (HYG3) enter the optimal plan. The HYG3 activity only requires 28 bushels of grain while the SCGD3 activity requires 52 bushels and the SYGSF3 activity requires 51 bushels. Beef cows are the only activity with a grain requirement lower than the heifers. These cows only consume 3 bushels; however labor in period 5 on the 460 acre farm has a shadow price of \$31/hour - the heifers only require 0.36 hours while the cows require 1.27 hours in this period. Therefore the heifers were selected.

Hogs The optimum hog activities include the 4 litter system on all farms and the 6 litter system on the 1280 acre farm as well - both at new technology levels (4LNT and 6LNT respectively). So again there has been a direct substitution on all farms of new for 1968 technology. However there was just sufficient surplus labor and hog housing on the 280 and 460 acre farms to allow 6 units of the very low labor demanding 1 litter pig system to enter at 1968 technology levels.

Optimum enterprise combinations with new technology, maximum capital levels and no hired labor restraint

Crops The most significant feature about the optimal programs for each farm is the departure of the corn-corn-soybean rotation and the entry of continuous corn for grain with new technology (CCCC3G). The extra hired labor supply available to each farm means that it is more profitable to purchase this labor at $1.50 per hour and use it to produce extra corn for grain, and feed this grain to the extra livestock, than to produce soybeans that are sold at $2.50 per bushel, and purchase less labor and sell fewer livestock. The optimum rotations are now CCCC3G, CCOMM3G and CCOMM3S.

Cattle The significant feature about these solutions is the absence of the yearling steer activity (SYGSF3) and the entry of beef cows with new technology, (BC3), on each farm. Beef cows use a little more than twice the labor that the yearlings do; however they only consume 3 bushels of grain compared with 59 bushels for the yearlings. The only other activity in the optimal solution is the steer calves with new technology (SCGD3).

Hogs The significant feature in the optimal solutions for each farm is that only the 6 litter hog system using new technology (6LNT) enters. This is a very profitable activity with high grain consumption, and high labor utilization (85 hours compared to 57 hours for the 4LNT activity). Now that hired labor is unrestrained no other hog activity is able to compete favorably with this very profitable 6LNT enterprise.

This section illustrates the significant impact of the serious labor restraints on each farm. In both the cattle and hog activities a substantial increase in livestock numbers with their respective increases in output, resulted over the plans when hired labor was a restricted resource. These results indicate that it would be important for farms using either of the technology levels discussed in this study, to adopt the same particular cropping activities and cattle and hog enterprises as these optimum programs, if farmers wish to maximize profit and utilize their resources in an optimal manner. Furthermore it is important that they hire labor up to the point where it is no longer a restricting resource, to ensure better utilization of other resources still not fully used. This gives an even more efficient utilization of all resources. However, since farmers have different quantities of resources, the program which is optimum for one farm need not be optimum for another.

Shadow Prices

The shadow price of a resource is the increment in the objective function obtained by the acquisition of one more unit of that resource, i.e. it represents the marginal contribution or marginal product to income of the last unit of the resource. Shadow prices offer useful estimates of additional returns accruing to the firm which acquires another unit of any resource limiting the optimum solution (4). As long as the cost or market price of any one of the limiting resources is less than its shadow price, net income may be raised by employing additional quantities of the limiting resources. Any addition in the amounts of limiting resources beyond the firm's initial supply, also makes possible a more extensive use of the unemployed or non-limiting factors of production. The changes in price values of these scarce firm resources are associated with changes in the combinations in the programs in which they are used. The productivity of one resource depends on the amount and kind of other resources with which it is combined.

A zero shadow price indicates that a resource is not limiting. For the varying capital levels within each farm size there was very little change in the shadow prices. Therefore shadow prices for both 1968 and new technology are interpreted at the $10,000 level for various important resources.

<u>1968 Technology with $10,000 owner operating capital (Table 10)</u>

Because the owner's capital is always all used and because surplus finance can be loaned out at 5 percent per annum the shadow price for owner's capital is $0.05/dollar of extra capital. When borrowed capital (which can be borrowed at 7 percent per annum interest rate) is not limiting the shadow price in period 1 is very low implying that an additional dollar of borrowed capital would only have a very small contribution to net income.

Land is a seriously limiting resource with a high shadow price of $43/acre, $54/acre and $46/acre for the 280, 460 and 1280 acre farms, respectively. These farms have an adequate supply of labor. However for the 640 and 960 acre farms the shadow price is much lower - $7 and $8 per acre respectively. This is because labor is the main limiting factor on these two farms.

Labor in period 3 is a very limiting factor on the 640 and 960 acre farms, with a shadow price of $35/hour each. An additional hour of labor in this period would add $35 in gross profit to the farm. If labor is hired at $1.50 per hour then net income would increase by $33.50. The 1280 acre farm also has small shadow prices of $2, $2 and $12 per hour on periods 1, 2 and 3 respectively. Period 5 has shadow prices of $20, $23, $8, $8 and $6 per hour on the 280, 460, 640, 960 and 1280 acre farms respectively, implying that an additional hour of labor on these farms would bring in additional gross profit equivalent to each farm's shadow price for labor 5.

Grain can be sold at $1.00 per bushel and its shadow price is therefore $1.00. Hay has a shadow price of $30/ton for the 280 acre farm, $32/ton

Table 15. Shadow prices ($/unit) for limited resources for 280, 460, 640, 960 and 1280 acre farms at $10,000.00 operating capital level with 1968 technology and with new technology [a]

Resources	Unit	1968 technology					New technology (acres)				
		280	460	640	960	1280	280	460	640	960	1280
Own capital	$1	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Borrowed cap. 1	$1	.0075	.005	-	.0013	.0075	.0008	.0075	-	-	.0075
Land	1 acre	43	54	7	8	46	45	61	28	27	53
Labor 1	1 hour	5	2	-	-	2	6	-	-	-	7
Labor 2	1 hour	-	-	-	-	2	-	-	3	2	1
Labor 3	1 hour	-	-	35	35	12	-	-	18	20	-
Labor 4	1 hour	-	-	-	-	-	-	-	-	-	-
Labor 5	1 hour	-	23	8	8	6	-	31	23	22	24
Hired labor 5	1 hour	20	-	-	-	-	27	-	-	-	-
Grain	1 bu	1	1	1	1	1	1	1	1	1	1
Hay	1 ton	30	32	32	32	33	35	38	37	37	36
Pasture	1 ton	25	27	3	3	22	28	32	15	17	30
Soybeans	1 bu	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Hog hous. exp.	1 unit	45	45	-	2	192	-	-	-	-	69
Cattle hous.exp.	1 unit	-	-	-	-	-	-	-	-	-	-

[a] From Tables 66 - 70, Appendix B.

for the next 3 farms, and $33/ton for the 1280 acre farm. If hay can be bought for $16/ton approximately, then probably the program should have included a hay buying activity to help increase net income.

When land is very limiting the shadow price on pasture is $25, $27 and $22 per ton for the 280, 460 and 1280 acre farms respectively. On the 640 and 960 acre farms where land is not so limiting the shadow price is much lower on pasture = $3/acre. The premium on an additional ton of pasture on these 2 farms is not as high as it is on the 280,460 and 1280 acre farms.

Soybeans are sold at $2.50/bushel and this is their shadow price on each farm. Hog housing is seriously limiting on the farms where land is a seriously limiting factor of production. It is $45/unit on both the 280 and 460 acre farms; on the 1280 acre farm where labor 1, 2, 3 and 5 are also limiting the shadow price on hog housing jumps to $192/unit. The effect of the limiting hog facilities in Figure 3 can be seen in this result. Cattle housing is not limiting under 1968 technology at all. So it appears that under these conditions owner-operators should investigate the possibility of purchasing additional hog housing facilities. In particular this would apply to the 1280 acre farm.

<u>New technology with $10,000 owner operating capital (Table 11)</u>

The important contributions by new technology appear to be: 1) a significant substitution for labor in period 3 on the 640, 960 and 1280 acre farms by the new technology when compared with 1968 technology, because of the reduction in the shadow price of labor 3 for these farms under new technology, and 2) a significant substitution of new technology for hog housing facilities on all farms, again because of the reduction of the shadow price.

However hog housing still has a $69/unit shadow price on the 1280 acre farm so the manager on this farm should still investigate the possibilities of additional hog buildings. Shadow prices on land have increased and land is now a significant limiting resource on the 640 acre and 960 acre farms. The shadow price for labor 2 indicates this labor is now limiting on these two farms. The shadow price on labor 5 has increased on all farms though the largest increase is on the 640 acre and 960 acre farms - but the shadow price for labor 5 on these 2 farms is still below that of the other 3 farms. And the shadow price on pasture for all farms has increased - on the 640 acre and 960 acre farms it has now reached $18/ton and $17/ton respectively. So the managers on all farms should investigate possibilities of obtaining additional acres of pasture to feed stock.

New technology, maximum capital levels and no hired labor restraint

When each farm was able to hire as much labor at $1.50/hour as it required the shadow price of course for labor in all periods became $1.5/hour - except for period 4 for the 1280 acre farm when labor was not limiting. Land now has a large shadow price for each farm of $94/acre. Hay is $46/acre on all farms, and pasture is $42/ton. If hay can be bought for about $16/ton, it would be profitable for the farmer to buy it until its marginal cost/ton was equal to the marginal product/ton, i.e. its shadow price.

The most significant change has been in hog housing where the shadow price is $503, $503, $509, $515 and $527 per unit for the 280, 460, 640, 960 and 1280 acre farms respectively. This is a large increase over the previous $10,000 level models with a hired labor restriction, and it indicates how important it would be for each farm manager to try and expand his

Table 11. Shadow prices ($/unit) for limited resources for 280, 460, 640, 960 and 1280 acre farms with new technology, at the maximum capital levels for each and with no restraint on hired labor; and for each farm with new technology and no hired labor restraint, and with new hog and cattle housing and the new maximum capital levels (= new assumptions)[a]

Resources	Unit	New technology, maximum capital, no hired labor restraint					New technology, no hired labor restraint and new assumptions + max. capital				
		280	460	640	960	1280	280	460	640	960	1280
		(acres)					(acres)				
Own capital	$1	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Borrowed cap.	$1	-	-	-	-	-	-	-	-	-	-
Land	1 acre	94	94	94	94	94	94	94	94	94	94
Labor 1	1 hr	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Labor 2	1 hr	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Labor 3	1 hr	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Labor 4	1 hr	1.5	1.5	1.5	1.5	-	1.5	1.5	1.5	1.5	1.5
Labor 5	1 hr	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Grain	1 bu	1	1	1	1	1	1	1	1	1	1
Hay	1 ton	46	46	46	45	44	46	46	46	46	46
Pasture	1 ton	42	42	42	42	42	42	42	42	42	42
Soybeans	1 bu	2.5	2.5	2.5	2.5	2.5	2.5	2.9	2.9	2.9	2.9
Hog hous.exp.	1 unit	503	503	509	515	527	503	503	503	503	503
Cattle hous. exp.	1 unit	2	2	2	3	3	2	2	2	2	2

[a]From Tables 66 - 70, Appendix B.

hog housing facilities. Of significant interest is the gradual rise in the shadow price on hog housing from $503 on the 280 and 460 acre farms to $527 on the 1280 acre farm. In Table 15 it can be seen that under the initial assumptions the 640, 960 and 1280 acre farms did not have anywhere near the same proportional increase in hog facilities over the 280 acre farm, as did the 460 acre farm. And the shadow prices for the 640, 960 and 1280 acre farms reflect this. Cattle housing is now also limiting - however the shadow price is small and expansion of facilities would not increase the net income.

When the new assumptions are included in the program with new technology, maximum capital levels and no hired labor restraint, the shadow prices become the same for all farms. Hog housing now becomes a constant $503/unit and cattle housing becomes $2/unit. So again the farm managers should investigate the possibilities of additional hog housing on all farms.

Net Income

In this study net income is defined as the total profit from the farming activities for the year once the various fixed costs for land taxes, interest on land, and machinery and building depreciation and insurance for example, have been deducted from the farm's gross profit. It includes the return to the owner-operator for his management and labor. An activity or a group of activities can only be considered profitable when they increase the net income from the total organization or farm firm, assuming that the objective is to maximize profit. If a change in farm planning and organization by the management does not add to the net income, and they are trying to maximize this income, then the change should not be made.

This study is interested in the effect of various resource constraints on the net income; and Table 12 summarizes this net income for the different plans.

Capital

Table 12 shows that additional amounts of operating capital only had a small positive effect on net income in all of the farm models under both technologies - this was because each farm had resources that were very limiting even at low capital levels, and so the programs optimized without large sums of capital. In effect large sums of capital are not needed until restraints on seriously limiting resources are released.

Farm size

Figure 8 , with net income at the $10,000 owner operating capital level at 1968 and new technology levels, graphed against size of farm, shows an increase in net income with each larger farm except for the 640 acre farm. The decrease in net income from the 460 acre to the 640 acre farm is mainly due to the limiting labor supply, which was discussed earlier.

Labor supply

The 640 acre farm has only 2 labor units (the same as the 460 acre farm), and as the shadow prices show, this is a serious handicap. Similarly the 960 acre farm's net income was restricted because of an insufficient labor supply. Figure 9 illustrates this more clearly. Net income is plotted at the maximum capital levels for each farm, and similar results are obtained for both technology levels to the results in the previous figure.

However when the hired labor restraint is removed at the new technology

Table 12. Net income for different capital levels for 280, 460, 640, 960 and 1280 acre farms for 1968 and for new technology; and for new technology at maximum capital with no hired labor restraint; and for new technology with new maximum capital levels, no hired labor restraint and new hog and cattle expansion facilities

Own operating capital	280 acres	460 acres	640 acres	960 acres	1280 acres
	Net income - dollars				
		1968 technology			
5,000	$10,305	$19,354	$15,972	$	
10,000	10,585	19,640	16,222	25,663	$50,064
15,000	10,835	19,919	16,472	25,914	50,361
20,000	11,084	20,173	16,722	26,164	50,619
30,000		20,673	17,222	26,664	51,119
40,000		21,173	17,722	27,164	51,619
50,000				27,664	52,119
75,000					53,369
		New technology			
5,000	9,790	20,637	18,583		
10,000	10,087	21,027	18,833	30,439	59,040
15,000	10,337	21,324	19,083	30,689	59,329
20,000	10,587	21,604	19,333	30,939	59,603
30,000		22,115	19,833	31,439	60,103
40,000		22,614	20,333	31,939	60,603
50,000				32,439	61,103
75,000					62,353
No hired labor restraint with max. capital	19,786	35,183	45,765	59,286	75,663
No hired labor restraint, new max. capital levels, and new hog and cattle expansion facilities[a]	19,786	37,051	55,834	87,753	119,585

[a]See footnote (b), Table 7 .

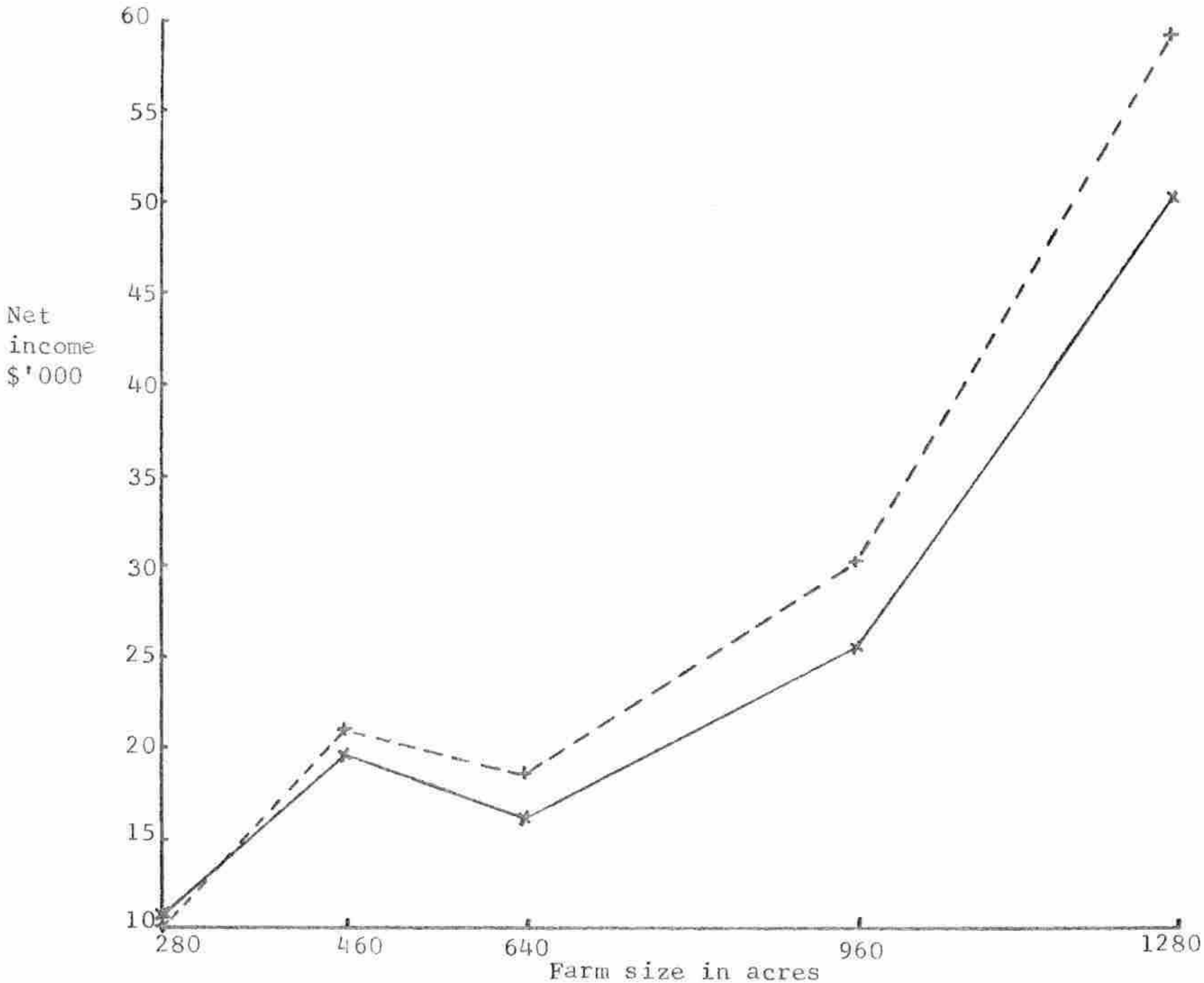


Figure 8. Net income for 280, 460, 640, 960 and 1280 acre farms at $10,000.00 owner operating capital level and:
1968 technology ————;
new technology – – – – – –.

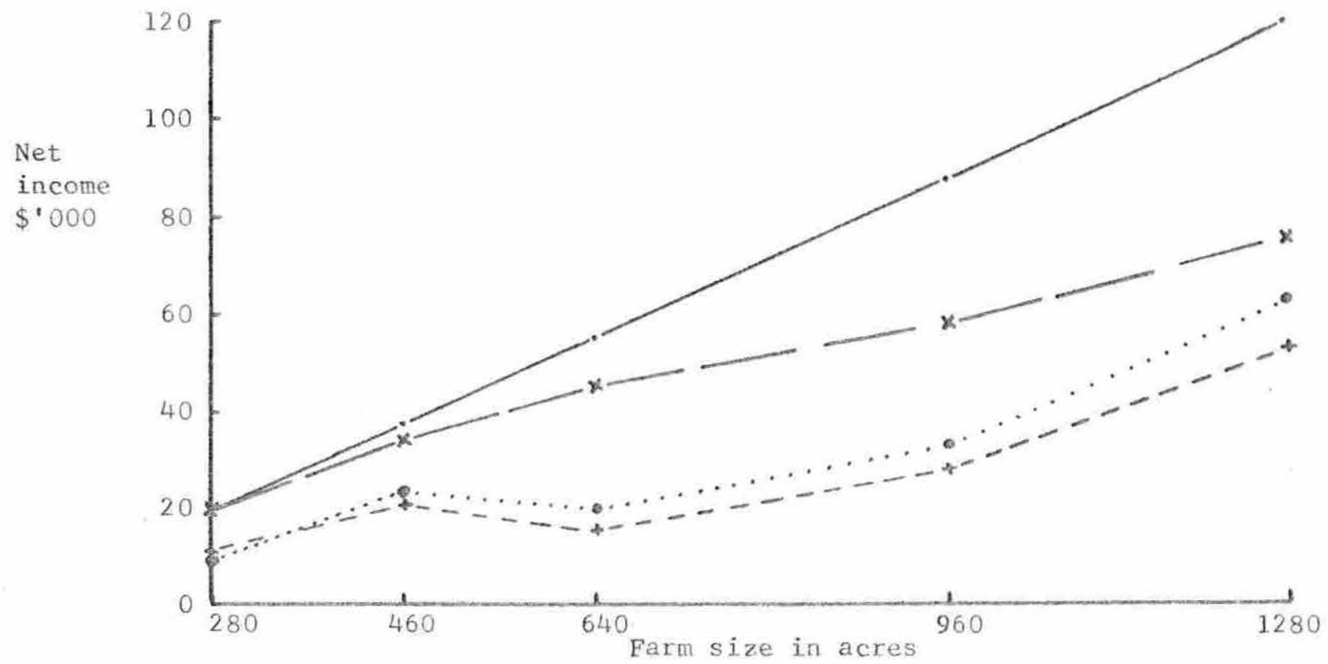


Figure 9. Net income for 280, 460, 640, 960 and 1280 acre farms at the maximum capital levels for each with:
1968 technology — — — — — — — ;
new technology . . . . ;
new technology with no hired labor restraint x—— ——x;
and new technology with no hired labor restraint and the new assumptions for maximum capital levels and hog and cattle facilities ——————.——————.

level there is a significant jump in net income for all farms, although it is greater for the 640 acre and 960 acre farms. Labor is a seriously limiting resource on all farms in this study, and farmers farming with labor restrained as it was under the initial assumptions in this study for each farm, would increase their net income by hiring labor at $1.50 per hour until it is no longer limiting.

Technology level

Both Figure 8 and Figure 9 show that the new technologies, as they are defined in this study, are profitable at different capital levels on all farms except for the 280 acre farm. This is simply because this farm did not make enough gross profit when new technology was included in the program to pay for the extra fixed costs of the new technology. The implication of this in agriculture in North Central Iowa is simply that net income would increase on 460, 640, 960 and 1280 acre farms if the new technologies defined in this study were adopted instead of the 1968 technologies.

New assumptions (Table 7)

The limiting effect of the initial assumptions regarding total cattle and hog facilities and maximum capital levels is clearly seen in Figure 9. When the restraints on these resources are increased for each farm in the same proportion as the increase in the size of each farm over the 280 acre farm, and there is no restraint on hired labor, the net income, when plotted against the size of farm, (see Figure 9), increases in a straight line. This is what one would expect since linearity (which represents constant returns to scale) is a basic assumption underlying linear programming. However, the implication of this is very important because the initial (original) assumptions allow resources to expand as North Central Iowa farmers are presently allowing them to expand with increased farm size. However net income on all farms except the 'base' 280 acre farm is greater for the new assumptions than for the old assumptions. Therefore farmers should expand their resources accordingly, providing they recognize the nature of the assumptions involved.

Net Return

The true measure of the profitable allocation of scarce resources is the economic efficiency of the total business firm, and comparisons between different techniques or methods, or between different levels of operating capital or between different sizes of firms can only be made, in the final analysis, on the basis of the financial return calculated as a percentage of the total capital investment. Optimum allocation of resources comes hand in hand with valuation of the total enterprise. In this study net return is equal to the net income plus the fixed cost of interest on land; percent return is equal to the net return divided by the total initial capital investment expressed as a percentage. This study is finally interested in the effect of various resources on the percent net return and Tables 13 and 14 have this calculated for 100 percent and for 50 percent and 25 percent equity values.

Capital

With increased levels of operating capital on each farm for both technology levels, percent return increases. The use of this extra capital is therefore profitable. However the use of additional operating capital is most significant when resource restraints on hired labor and on hog and cattle facilities are released as they are under the new assumptions. So farmers

Table 13. Percent net return[a] on initial investment[b] for the different levels of owned and borrowed operating capital for 1968 and for new technology; and for new technology with maximum operating capital with no hired labor restraint; and for new technology with maximum capital, no hired labor restraint and the new expansion[c] restraints on hog and cattle housing for the 280, 460, 640, 960 and 1280 acre farms each with 100% equity

	Operating capital ($'000)			Percent return on initial investment for 100% equity				
	Own	Borrowed	Total	280 acres	460 acres	640 acres	960 acres	1280 acres
				1968 technology				
	$ 5.00	$ 6.25	$11.25	8.88	9.85	7.97	-	-
	10.00	12.50	22.50	9.02	9.93	8.03	8.46	9.97
	15.00	18.75	33.75	9.14	10.02	8.09	8.50	10.00
	20.00	25.00	45.00	9.26	10.10	8.15	8.54	10.03
	30.00	37.50	67.50	-	10.25	8.27	8.62	10.10
	40.00	50.00	90.00	-	10.41	8.38	8.70	10.15
	50.00	62.50	112.50	-	-	-	8.78	10.21
	75.00	93.75	168.75	-	-	-	-	10.36
				New technology				
	5.00	6.25	11.25	7.89	9.57	8.08	-	-
	10.00	12.50	22.50	8.02	9.68	8.14	8.72	10.45
	15.00	18.75	33.75	8.13	9.76	8.19	8.76	10.48
	20.00	25.00	45.00	8.25	9.84	8.25	8.82	10.51
	30.00	37.50	67.50	-	10.00	8.36	8.87	10.57
	40.00	50.00	90.00	-	10.13	8.47	8.95	10.62
	50.00	62.50	112.50	-	-	-	9.02	10.68
	75.00	93.75	168.75	-	-	-	-	10.82
No hired labor restraint+	75.00	93.75	168.75	12.40	13.75	14.16	13.15	12.30
No hired labor restraint+ new expansion restraints for hog + cattle facilities+	75.00	93.75	168.75	12.40	14.29	16.41	17.52	17.20

[a]Net return = net income + the fixed cost which was deducted for interest on land investment (Table 17).

[b]Initial investment is the total capital in Tables 2 and 3 .

[c]Cattle and hog expansion restraints and maximum operating capital are now in the same proportion on all farms as they are on the 280 acre farm.

should try to expand their facilities and hire additional labor in order to employ extra operating capital more efficiently and maximize their percent return on their investment.

Farm size

Figure 10 at the $10,000 operating capital level and Figure 11 at the $20,000 operating capital level both show increased percent return from the 280 to the 460 acre farms with 100 percent equity for both technology levels. This is to be expected because of the balanced resource supply on these 2 farms. Because of the unbalanced nature of the resource supply on the next 3 farms, and especially because of the seriously limiting labor supply for the 640 acre and the 960 acre farms in particular, percent return for the 640, 960 and 1280 acre farms is below that for the 460 acre farm for both technology levels, except for the new technology level on the 1280 acre farms.

So again it is seen that an adequately balanced supply of resources is required on all farms. It is interesting to note that some of the increased percent return from the 280 to the 460 acre farm would be due to the cost economies of scale for farm machinery. This was taken as 80 percent of the machinery cost/acre (of the 280 acre farm), for the 460 acre farm. And 70 percent of this cost/acre was taken as the reduction in machinery cost, for the 640, 960 and 1280 acre farms. This would help stop the percent return for these 3 farms falling as low as they would if cost economies were not incorporated in each farm. It is important to note that the percent return increases from the 640 acre to the 960 acre to the 1280 acre farms.

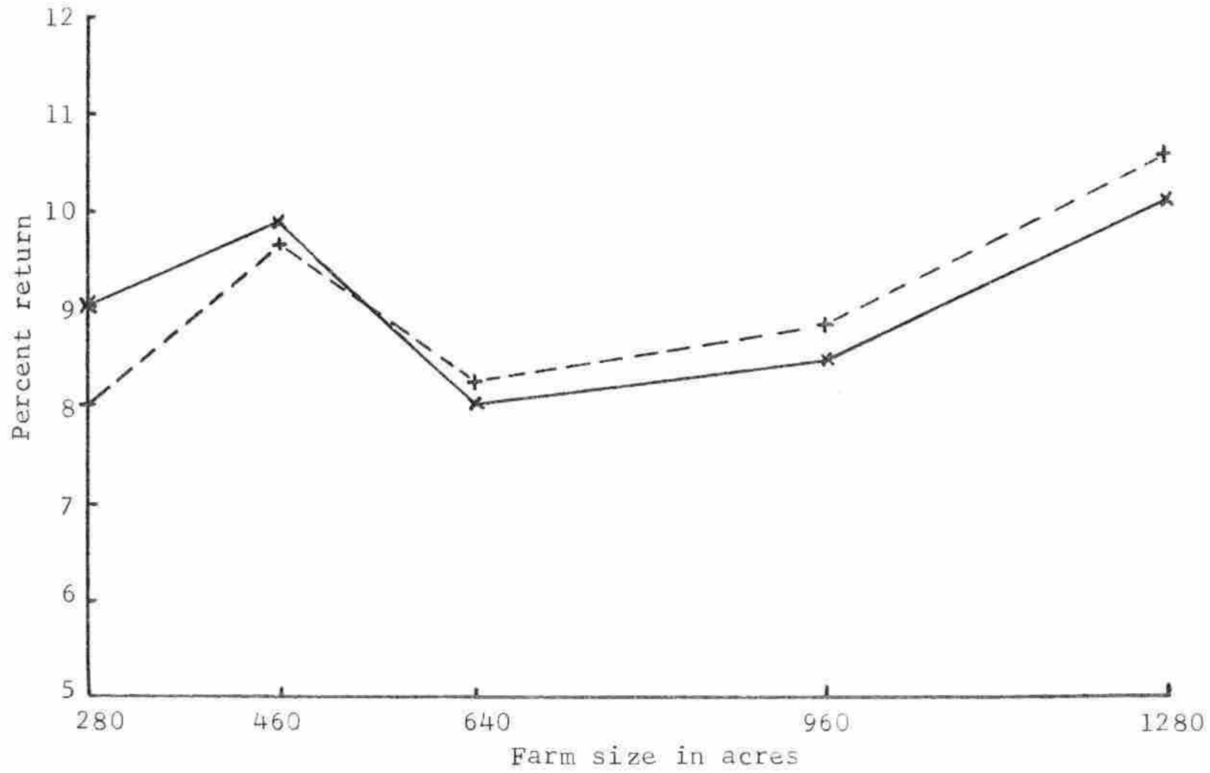


Figure 10. Percent net return on initial investment with 100% equity for 280, 460, 640, 960 and 1280 acre farms with $10,000 owner operator capital and:
1968 technology ————;
new technology — — — — —.

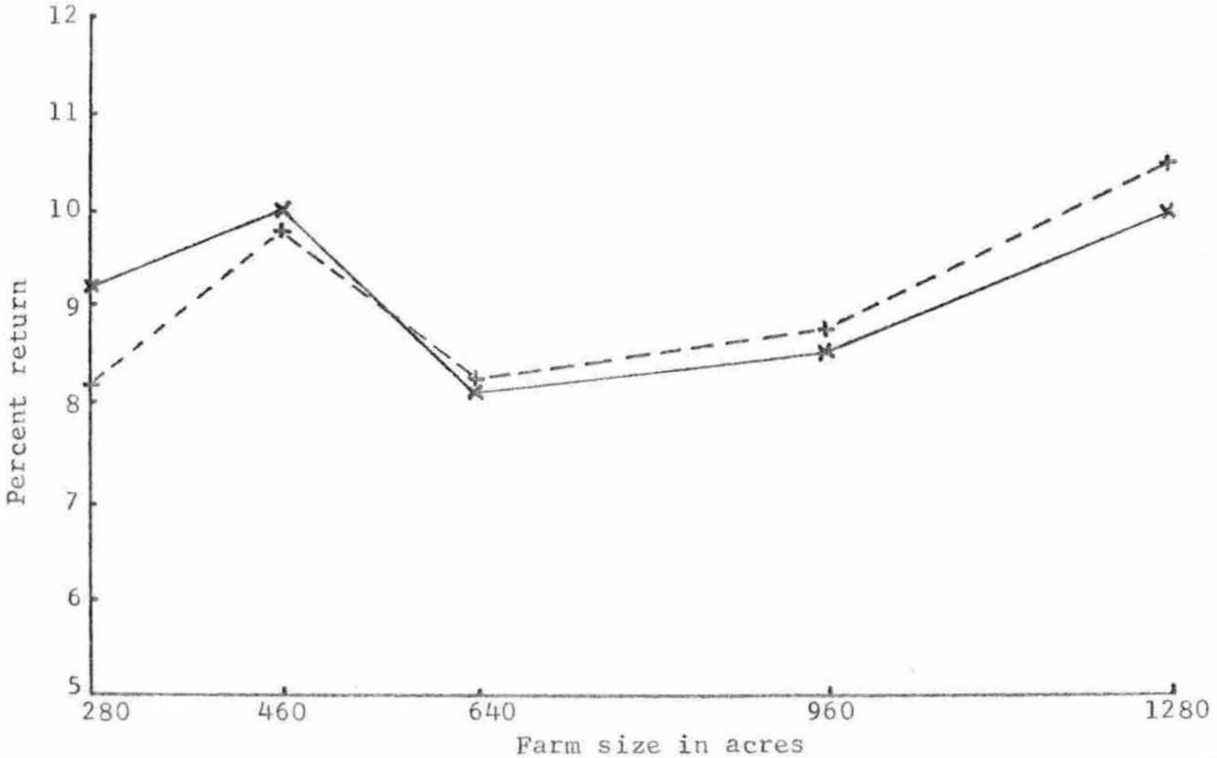


Figure 11. Percent net return on initial investment with 100% equity for 280, 460, 640, 960 and 1280 acre farms with $20,000.00 owner operating capital and:
1968 technology ———— ;
new technology — — — — .

Technology

With owner operating capital at $10,000, $20,000 or at the maximum level it is easily seen in Figures 10, 11 and 12 that new technology had a lower percent return than 1968 technology on the 280 acre and 460 acre farms than on the other 3 farms because these two farms could not cover the extra fixed costs involved. New technology, as it is defined in this study, was not profitable on these 2 small farms. However on the 640, 960 and 1280 acre farms new technology is a more profitable venture. Assuming linearity between the 460 and 640 acre farms there is a point at about the 550 acre mark, where the farmer will be equally as well off using either 1968 or new technology.

Implications from this are that farmers on 280 and 460 acre farms in North Central Iowa would be wise to use 1968 technology in order to maximize percent net return, while farmers with 640, 960 and 1280 acre farms can afford the increased fixed costs involved in the extra machines, and in the larger and more efficient machines, equipment and buildings, because this new technology increases percent net return on these 3 farms.

Labor

In Figure 12 the percent return on the initial capital investment with 100 percent equity is plotted at the maximum operating capital levels for the 280, 460, 640, 960 and 1280 acre farms. At this stage the important feature to be considered is the effect on the percent return for each farm when the

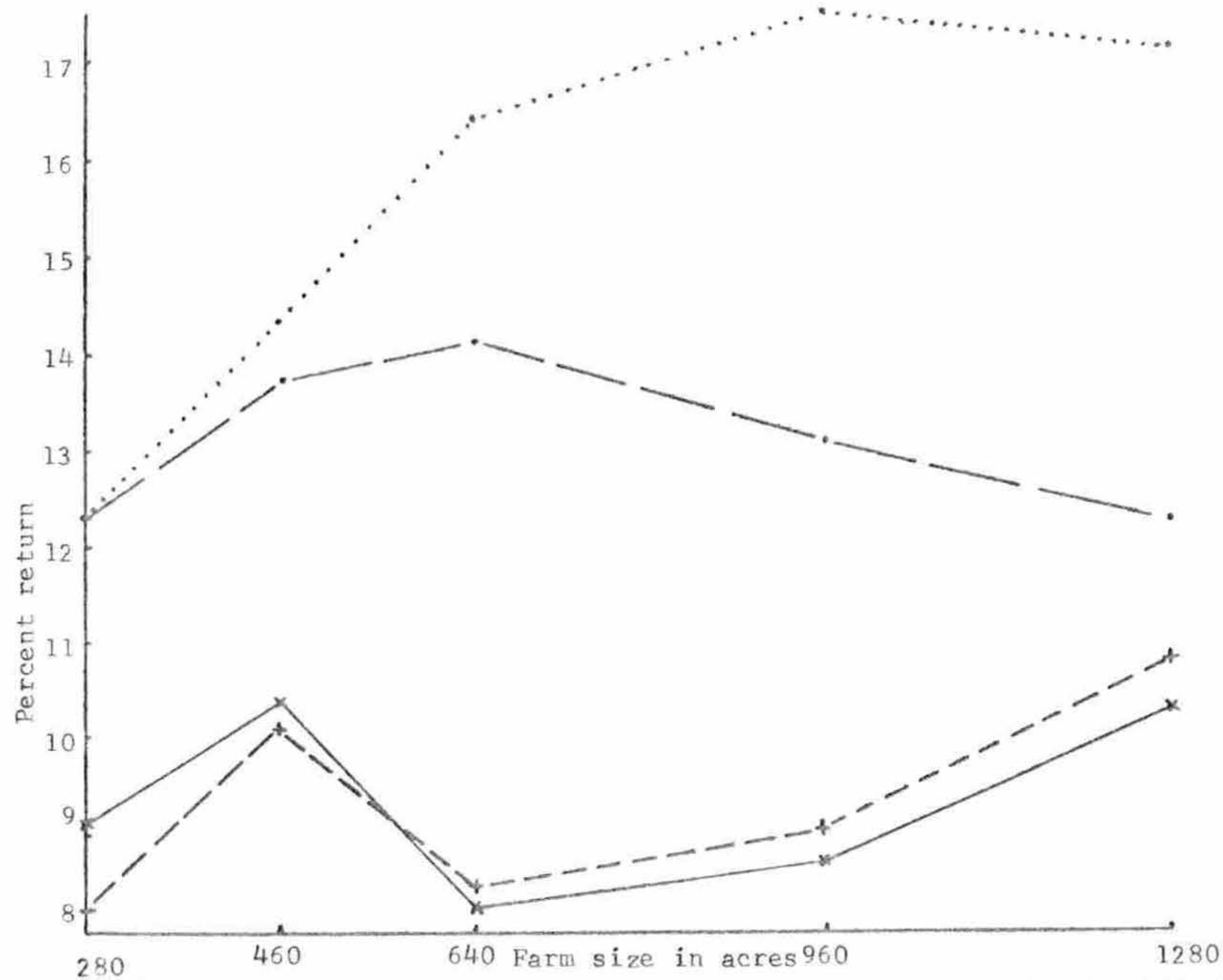


Figure 12. Percent net return on initial investment with 100% equity for 280, 460, 640, 960 and 1280 acre farms with maximum levels of owner operating capital and: 1968 technology ———— ; new technology — — — — — —; and new technology and no hired labor restraint ——— ——— ; and for each farm with no hired labor restraint and the new assumptions for maximum capital levels and hog and cattle facilities ············ .

hired labor restriction is released. When comparing the line for new technology with the line for new technology with no hired labor restraint, it can be seen that the hired labor restraint has been a very limiting influence on each farm. The percent return increase on the 280 acre farm is 4.15 percent, on the 460 acre farm it is 3.62 percent, on the 640 acre farm it is 5.69 percent, on the 960 acre farm it is 4.13 percent, and on the 1280 acre farm it is 1.48 percent. These are all very significant increases due entirely to the extra labor that each farm can hire at $1.50/hour.

The implication is that the initial labor assumptions which represent realistic conditions on farming in North Central Iowa, are not the optimum labor restrictions for these different sized farms. Farmers using new technology, and having sufficient operating capital available, should hire additional labor to ensure better utilization of all resources and to increase their percentage return on their investment.

New assumptions (Table 7)

Another important feature of Figure 12 is the declining slope (second derivative) of the line for new technology at maximum capital levels with no restraint on hired labor, from the 640 acre farm to the 960 acre farm to the 1280 acre farm. The main reason for this was thought to be the unbalanced or inconsistent resource restraints for the different farm sizes (as noted earlier) for hog and cattle building facilities and for the maximum capital levels. When these restraints were released under the new assumptions the percent return increased on all farms except of course, the base 280 acre farm. On the 460 acre farm this increase is 0.54 percent; on the 640 acre farm it is 2.25 percent; on the 960 acre farm it is 4.37 percent; and on the 1280 acre farm it is 4.90 percent.

So implicit in this result is the interpretation that the initial restraints on cattle and hog housing and on the maximum capital levels (which were assumed to be realistic for farms in North Central Iowa), have a very limiting effect on the percent return for these farms. As farmers expand their farms they would be wise to expand the hired labor restraint and the cattle and hog facilities and the maximum capital levels in the same manner as the new assumptions in this study.

100 Percent, 50 percent and 25 percent equity

Results so far have been based on the farmer having 100 percent equity in his estate. However farmers very rarely have such a high equity value, and so the percent return was calculated in Table 14 for 50 percent and 25 percent equity for 1968 technology and for new technology. Interest was charged at 7 percent per annum on 50 percent and 75 percent respectively of the total initial capital value. Naturally the trend is the same as that for 100 percent equity. In Figure 13 the percent return is plotted for each farm size, at the $10,000 owner operator capital level with 1968 technology, for 100 percent, 50 percent and 25 percent equity. It can be seen that the trend with the increased farm sizes follows the same pattern for each equity level.

A farmer with only 50 percent equity makes approximately 2.70 percent less return than a farmer with 100 percent equity; while a farmer with 25 percent equity value makes approximately 1.35 percent less return than does the farmer with 50 percent equity value in his estate.

Table 14. Percent net return[a] on initial investment[b] for the different levels of owned and borrowed operating capital for 1968 and for new technology; and for new technology with maximum operating capital with no hired labor restraint; and for new technology with maximum capital, no hired labor restraint and the new expansion[c] restraints on hog and cattle housing for the 280, 460, 640, 960 and 1280 acre farms each with 50% and 25% equity[d]

	Operating capital ($'000)			Percent return on initial investment									
	Own	Borrowed	Total	280 acres		460 acres		640 acres		960 acres		1280 acres	
				50%	25%	50%	25%	50%	25%	50%	25%	50%	25%
				1968 technology									
	$ 5.00	$ 6.25	$11.25	6.23	4.90	7.13	5.77	5.05	3.59	-	-	-	-
	10.00	12.50	22.50	6.37	5.04	7.22	5.86	6.11	3.65	5.46	3.96	7.09	5.66
	15.00	18.75	33.75	6.49	5.16	7.30	5.94	5.17	3.71	5.50	4.00	7.13	5.69
	20.00	25.00	45.00	6.61	5.29	7.38	6.02	5.23	3.77	5.54	4.04	7.16	5.72
	30.00	37.50	67.50	-	-	7.53	6.18	5.35	3.89	5.62	4.12	7.22	5.78
	40.00	50.00	90.00	-	-	7.69	6.33	5.47	4.01	5.70	4.21	7.28	5.84
	50.00	62.50	112.50	-	-	-	-	-	-	5.78	4.29	7.34	5.90
	75.00	93.75	168.75	-	-	-	-	-	-	-	-	7.48	6.04
				New technology									
	5.00	6.25	11.25	5.46	4.25	7.04	5.77	5.33	3.96	-	-	-	-
	10.00	12.50	22.50	5.60	4.38	7.14	5.87	5.39	4.02	5.89	4.47	7.72	6.36
	15.00	18.75	33.75	5.71	4.50	7.23	5.96	5.45	4.07	5.93	4.51	7.75	6.39
	20.00	25.00	45.00	5.82	4.61	7.31	6.04	5.50	4.13	5.96	4.55	7.78	6.42
	30.00	37.50	67.50	-	-	7.46	6.18	5.61	4.24	6.04	4.63	7.84	6.48
	40.00	50.00	90.00	-	-	7.60	6.33	5.73	4.35	6.12	4.70	7.89	6.53
	50.00	62.50	112.50	-	-	-	-	-	-	6.19	4.78	7.95	6.59
	75.00	93.75	168.75	-	-	-	-	-	-	-	-	8.09	6.73
No hired labor restraint+	75.00	93.75	168.75	9.98	8.76	11.21	9.94	11.41	10.04	10.32	8.90	9.57	8.20
No hired labor restraint + new expansion restraints on hog and cattle facil.+	75.00	93.75	168.75	9.98	8.76	11.75	10.48	13.67	12.29	14.69	13.28	14.44	13.08

[a,b,c]See footnotes, Table 13.

[d]Interest is charged at 7 percent per annum on 50% and 75% respectively, of the total initial capital value.

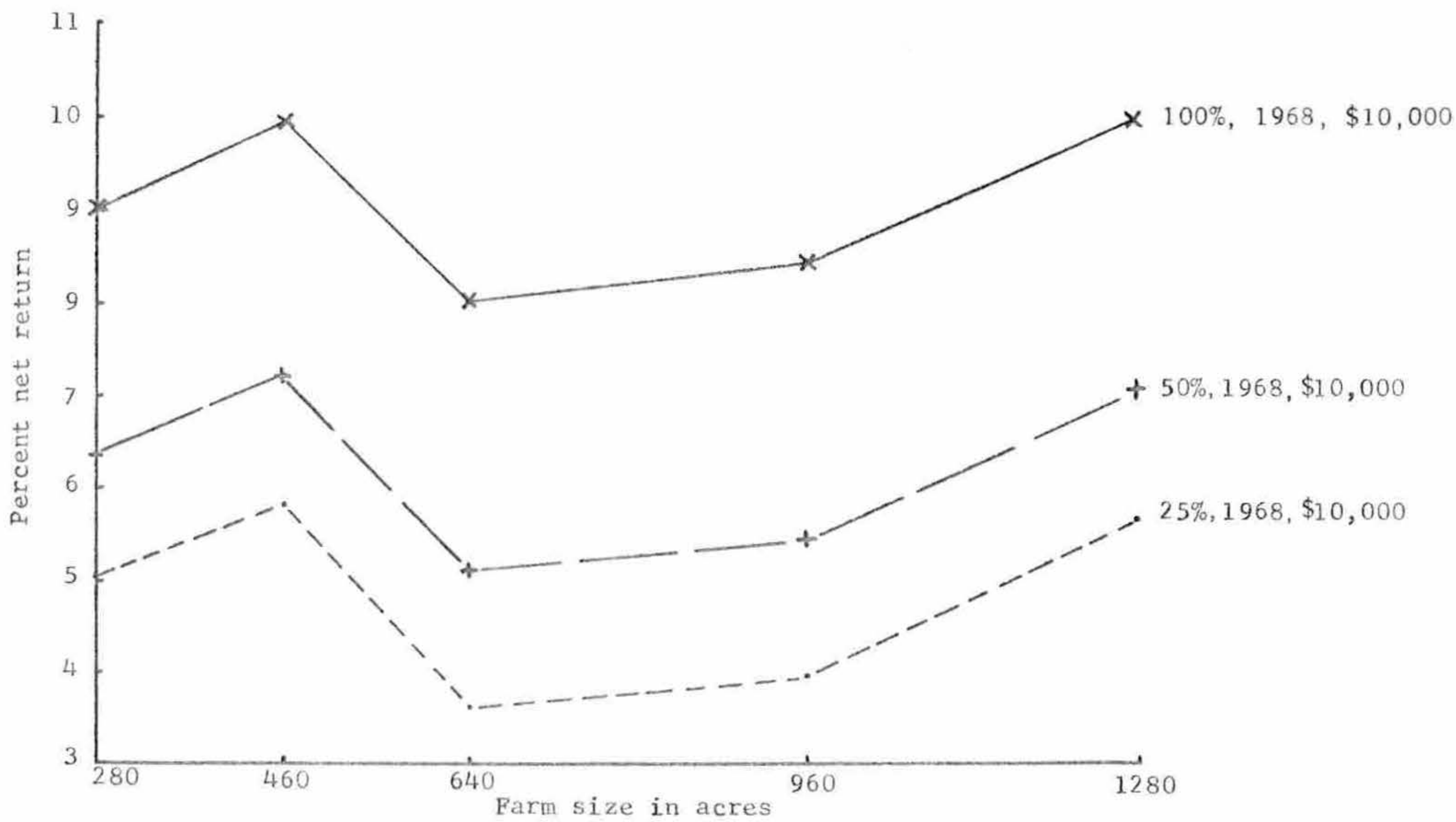


Figure 13. Percent net return on 100%, 50% and 25% equity value of the initial capital investment in each farm at the $10,000 owner operating capital level with 1968 technology:
100% equity ———— ;
50% equity —— —— ;
25% equity — — — — .

SUMMARY AND IMPLICATIONS FOR NORTH CENTRAL IOWA FARMERS

General

This study is an attempt to answer various questions concerning the farm plans for the optimal allocation of resources under North Central Iowa agricultural conditions. With this basic concept in mind the study has several important aims:

1) To examine the effects of certain types of technology on the plans, organization and profit of a typical 280 acre farm in the North Central area of Iowa, and on a 460 acre, a 640 acre, a 960 acre and a 1280 acre farm under the same conditions. This study examines the effects of certain 1968 technologies on farm planning and organization, and then it compares these results with certain new technologies which farms are beginning to adopt (or might soon adopt) in North Central Iowa.

2) To examine the effects of increased amounts of owner operating capital, and borrowed operating capital, on farm planning and organization.

3) To examine the effect on farm planning and organization when each farm model is able to hire as much labor as the program needs to maximize net income (i.e. no restraint is placed on hired labor) at maximum capital levels.

4) To examine and compare the profitability for the different sized farms: 280 acres, 460 acres, 640 acres, 960 acres and 1280 acres. In the United States approximately 40 percent of the farms are run on a small scale and these farms produce less than 10 percent of the total output. These small farms are a major source of inefficient resource use, and a

large reason for the unemployment of resources. However at the other end of the scale some farms are becoming very large and specialized e.g. the large beef fattening units with the 'push-button' feeding equipment and the feedlot feeding system. Both resource efficiency and production are much higher proportionately on these large units than on the very small ones.

Profitability is examined and compared for the 280 acre, 460 acre, 640 acre, 960 acre and 1280 acre farms for both net income and net return on the total initial investment for each farm. Net return is examined at 100 percent, 50 percent and 25 percent equity, since farmers rarely have complete ownership of their whole enterprise, although the basic farm models in this analysis were made on the assumption that farmers have 100 percent equity. Given that farmers wish to maximize net income, the efficient allocation of scarce resources can only be judged by the profitability of the total enterprise. And the profitability of different farm plans either within a given farm, or between different farms can only be judged as a net return on the asset value of each enterprize, given 100 percent equity; or on the asset - the liability value for enterprises with less than 100 percent equity.

So this study attempts to show how technology, capital, labor and size affect farm planning and how profitability changes with different sets of conditions for certain basic assumptions, and what the implications of these results on farm planning, organization and management will be.

Basic assumptions concerning labor, hog and cattle housing and capital restrictions for the different farm sizes under both 1968 and new technology are outlined in Tables 15 and 16, Appendix A. Minor assumptions which will also have an effect on the final results in this study are:

1) The stock on hand at the beginning of the year are taken as those selected in the first plan for each farm by the computer.

2) Constant returns to scale (i.e. linearity) are assumed in all calculations except a) machinery cost/acre which is assumed to be 80 percent of the value for the 280 acre farm, and the 460 acre farm, and 70 percent for each of the 640 acre, 960 acre and 1280 acre farms, and b) the waste land, buildings and roads etc. are assumed to take up 10 percent of the land area for the 280 acre, 460 acre and 640 acre farms, and only 8 percent for the 960 acre and 1280 acre farms. It must be remembered that while results in this study will provide valuable information for farm managers, each farm has varying kinds and amounts of resources. Therefore the optimal plan for one farm with 1 set of conditions need not be the optimal plan for another farm with a slightly different set of conditions.

Technology, Hired Labor and Optimum Programs

Crops

Optimum programs for each farm size indicate how each farm should be organized to obtain maximum economic efficiency by combining the resources available in an optimal manner to maximize net income. At low and medium capital levels and using 1968 technology (as defined in this study) North Central Iowa farmers should plant rotations corn-corn-soybeans for grain, corn-corn-oats-meadow-meadow for grain and corn-corn-oats-meadow-meadow for silage, all at high fertilizer levels. Because of the better balance of resources on the 460 acre and 1280 acre farms continuous corn for grain at a high fertilizer level should also be planted to provide the extra grain required by the extra livestock on these two farms. When new technology (as defined in this study) is available the only changes will be corn-corn-soybeans for grain and corn-corn-oats-meadow-meadow for grain, both now at the new technological levels. The extra production from these crops provides the increased grain required by the extra livestock on the 460 acre and 1280 acre farms - continuous corn should no longer be planted on these 2 farms.

When the hired labor restraint is removed at the maximum capital level for each farm all the cropping activities should be planted at the new technological levels. The continuous corn rotation, which is a very expensive though highly productive cropping activity with a reasonably high labor demand, will be the main grain producing crop. The soybean rotation should no longer be produced - it is more profitable for farmers to hire more labor and feed the extra grain to additional livestock. Hay and silage should be produced from the corn-corn-oats-meadow-meadow rotations.

Cattle

With 1968 technology (as it is defined in this study) North Central Iowa Farmers should run good choice yearling steers short fed in the fall with the bucket and scoop method of feeding on all farms. And on the farms with adequate labor supply (i.e. the 280 acre, 460 acre and 1280 acre farms) good choice steer calves with the self-unloading feeding method should also be run. Under new technology each farm should adopt the new auger-feeding method for both the calf and yearling activities. However the 460 acre farms should adopt good choice yearling heifers in place of the yearlings simply because there is no surplus grain available in the profit-maximizing plan for these farms.

When the hired labor restriction is removed at maximum capital levels the optimal solutions indicate that all farms should run beef cows in place of the heifers and yearlings, along with the calves. Beef cows have a reasonable net return/unit - but more important is the fact that they only have very low grain consumption. Grain has a shadow price of $1.00 and this value puts beef cows (now that labor is not restricting) in a very favorable light.

Hogs

The 2 litter (2) and the 4 litter hog systems using 1968 technology should be in all plans for all farms except for those of the 1280 acre farm which should have the 4 litter and 6 litter systems using 1968 technology. The 6 litter system is very profitable and it is a high labor demanding and grain consuming activity - and the 1280 acre farm has an adequate supply of both. Under new technology all farms should run the 4 litter pigs using this new technology. The 280 acre and 460 acre farms have some surplus labor and hog housing, and so they should also run 6 units of the 1 litter activity. And the 1280 acre farm should run a large number of the 6 litter, new technology, activity. When the labor restraint is removed at the maximum capital levels on each farm, only the 6 litter activity with new technology should enter the optimum programs for all farms.

It is evident from these results that a definite pattern of cropping and livestock activities enter the optimal solutions for each farm size. Farmers should attempt to follow the plans as they are summarized in this chapter; they should attempt to follow the acreages planted for each crop rotation and the livestock numbers run for each livestock activity in Tables 8 and 9 for each size of farm; and they should make minor adjustments in their interpretation of these results depending on their own resource base, their own management ability and their own goals.

Investment in additional resources

For North Central Iowa farmers who contemplate expanding their operations the shadow prices provide valuable information concerning the profitability of additional units of the different scarce resources. Under 1968 technological conditions farmers with 280 and 460 acre farms should investigate the possibilities of obtaining additional hours of labor in September-October-November, while those with 640, 960 and 1280 acre farms should try to obtain more in May-June. All farms should investigate the possibility of obtaining additional tons of hay; and the 280, 460 and 1280 acre farms should investigate the chances of obtaining additional acres of pasture and additional units of hog housing.

These trends are similar when new technology is added to each farm. However all farms should try to obtain more units of hired labor in September-October-November, and additional hog housing should now only be considered on the 1280 acre farm. When each farm is at the maximum capital levels and the hired labor restraint is released all farms should contemplate obtaining additional land, hay, pasture and hog housing to increase net income. The shadow prices indicate that of these various alternatives, hog housing is by far the most important.

Technology and Profitability

The objective function in this study is concerned with maximizing net income as a return to the farm, and to the manager for his labor and management, once fixed costs have been deducted. The fixed costs of course will vary for each farm for each technological level. To determine whether one particular set of technologies is better than another on any farm, simply involves deducting the appropriate fixed costs from each and comparing the respective net incomes.

On this basis Figures 8 and 9 both indicate that for 280 acre farms 1968 technology is the most profitable - i.e. investment in new machinery and methods etc. do not pay. At about the 370 acre mark it appears that a farmer would not be unduly concerned about which level of technology he uses. However for the 460, 640, 960 and 1280 acre farms the use of the new technology is definitely a payable proposition. This result is very interesting and very important. It indicates that the smaller farms in North Central Iowa should not be concerned with the 'new' methods and machinery, while the larger farms should definitely use them.

However the true measure of the profitability of the allocation of scarce resources to maximize net income is not strictly a measurement of this net income per se, but of the net return on the total capital investment. In this study net return is equal to the net income, plus the fixed cost that has been deducted within the program for interest on land. On this basis Figures 10, 11 and 12 indicate that 1968 technology is more profitable on the 280 and 460 acre farms while the new technology is more profitable on the 640, 960 and 1280 acre farms. The increased investment for new technology on the 280 and 460 acre farms does not result in a sufficient increase in net income (through reduced costs and increased output) to offset the extra fixed costs involved.

Hence this study shows that North Central Iowa farmers should only use 'new technology' on 640, 960 and 1280 acre farms - and on the 280 and 460 acre farms they should only use '1968 technology'.

Operating Capital and Profitability

Tables 12 and 13 both indicate that for all farms both net income and net return increase as additional operating capital is made available to successive farm plans. Within each farm, solutions optimized at low operating capital levels simply because various significant limiting resources prevented further expansion. However a very interesting concept developed in this study. Each plan for each farm model had a given amount of owner operating capital available (see Table 16), and a given restraint on the amount of operating capital that could be borrowed at 7 percent per annum for any of the 4 three month capital periods. As well, each plan could invest any surplus finance that could not return 5 percent per annum on the farm, in an outside investment activity for 12, 9, 6 or 3 months (depending on how many months remained until the end of the year).

Careful examination of Tables 66-70 in Appendix B reveals the unique way the computer chose to use these facilities to maximize net income for the year. For example, plan 1 in Table 66: $6998 are invested for 12 months at 5 percent per annum in the first period, the full $6250 are borrowed at 7 percent per annum in the second period for 3 months to help cover the sudden short influx of cropping costs, and in the third period $6271 are invested at 5 percent per annum for 6 months. This represents a very astute borrowing-lending policy and it makes full use of all financial borrowing and lending facilities.

So the results of this study show that additional amounts of operating capital had very little effect on optimum farm plans and on net income, simply because various resources became significantly limiting factors at low levels of operating capital. The study does show however, that farmers in North Central Iowa could make much better use of their borrowing and lending facilities to maximize their net income at any given capital level.

Hired Labor, Farm Size and Profitability

The serious restraint that hired labor has had on net income is demonstrated in 2 ways in Figures 9 and 12. First, at both technology levels net income and net return fell for the 640 and 960 acre farms because these 2 farms had an insufficient supply of hired labor (see Figure 1) in comparison to the other 3 farms. Second, Figure 1 illustrates how much extra labor each farm added when the hired labor restraint was released on all farms at the maximum capital levels under new technology, while Figures 9 and 12 illustrate the increase in net income (i.e. the payoff) and net return respectively for each farm.

Table 71 in Appendix B summarizes the extra labor hired and the extra net income that resulted for each farm - the 640 and 960 acre farms were clearly jeopardized the most by the hired labor restraint.

However on all farms the increase in net income is considerable and it indicates how limiting labor, under the initial assumptions in Table 15 of Appendix A (which were thought to be realistic for farming conditions in North Central Iowa) really are. Figure 12 also shows that if the extra labor is available the optimum farm size is 640 acres, and when the new assumptions are included then the optimum farm size increases to 960 acres.

These results show that it is important that farms in the area hire these extra hours of labor to maximize the return on their investment by more efficient utilization of all resources, and they should plan around an optimum farm size of 640 acres. If farmers expand their facilities under the new assumptions they should plan around an optimum farm size of 960 acres.

Livestock Housing and Profitability

Figures 2 and 3 show that under the initial assumptions for this study (Table 15 of Appendix A), cattle housing was allowed to expand faster, and hog housing slower than the proportional increase in farm size. However the line (Figure 12) for the 'no hired labor restraint' declines from the 640 acre farm out to the 1280 acre farm. Because of this and because of the high shadow price associated with hog housing, new assumptions were made (Table 7) where total hog and cattle housing and maximum operating capital levels were increased in relation to the proportional increase in each farm size over the 280 acre farm.

The results of these new assumptions appear to be very significant. Figure 9 shows a considerable increase in net income for all farms (except the base 280 acre farm) and Figure 12 shows a considerable increase in net return for all farms. Net return does decrease from the 960 to the 1280 acre farm - partly due to the large numbers of stock initially run on this larger farm and partly because this decline is to be expected at some point due to diminishing returns.

From the results of these new assumptions North Central Iowa farmers should expand facilities in similar proportions as farm size increases, to that of the 280 acre farm and become more specialized towards hog than towards cattle production given the other assumptions, conditions and prices in this study.

Suggestions for Further Research

However at present it does not appear to be realistic for farmers to expand resources in the manner just suggested. For this reason, as well as others, it is important that this study be developed into a dynamic linear programming growth model which develops the optimum plans for a farm to follow while it grows - both intensively and extensively. It is not realistic to allow the computer to decide what stock are on the farm when the program starts - rather the stock that are 'now' on the typical farm should be included in the basic program and the computer should work from there. As well it is not entirely realistic to let the program hire 'as much' labor as it requires to optimize the solution. Labor can only come in discrete units. Either a full man is employed for 12 months or he is not employed at all. One cannot expect him to be available at 10 hours per day for example, for 8 months of the year, and then let him find work somewhere else for the remaining 3 months. However, this study does indicate what the optimal solutions would like to have - future studies might move towards an integer programming model where only discrete units would be considered. And this would also apply to the purchase of additional machinery and the expansion of livestock building facilities.

This study barely touched on the advantages and disadvantages of size or the economies and diseconomies of scale. This is an important topic and needs to be given full consideration in future studies.

Finally a study such as this can be developed (once additional relevant activities such as the aerial sowing of dwarf corn and aerial spraying of crops, and the growing of grain sorghum for example, are included) into a variable pricing program or parametric program. In parametric programming different prices and costs, or different objective functions or different right hand sides can be considered and the results compared to find the 'best' plan of action. For example the present program is able to consider the many different enterprise possibilities in the present matrix, for the 1280 acre farm, for the 2 different levels of technology. Each technology level has 7 different levels of operating capital, as well as the maximum capital level at new technology with no hired labor restraint. These are all considered in just a few minutes of computer time at a total cost of approximately $10-12: an incredible amount of information is obtained in an incredibly short time and at a remarkably low cost.

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APPENDIX A

Table 15. Characteristics of the short-run growth models including restraints for land, labor and livestock expansion, with the appropriate cost economies for machinery

Models		Land acres	Machinery[a] cost per unit %	Operator labor hours	Labor hours hired	Expansion[b] units	
						Hogs	Cattle
A1[c]	A2[c]	280	100	2925	450[d]	20	100
B1	B2	460	80	"	2925[e]	40	300
C1	C2	640	70	"	"	50	500
D1	D2	960	70	"	5850[f]	60	800
E1	E2	1280	70	"	11,700[g]	80	1000

[a]Source: (23); machinery cost/unit is reduced by 80% for the 460 acre farm and 70% for the 640, 960 and 1280 acre farms respectively due to economies of scale with increasing farm size.

[b]All models already have facilities for housing 20 units of hogs and 100 units of cattle on the farm.

[c]1 = 1968 Technology.
2 = 1968 Technology + New Technology.

[d]This is evenly divided between periods 2, 3 and 5.

[e]This represents 1 hired man at a total cost of $5500.

[f]This represents 2 hired men at a total cost of $5500/man.

[g]This represents 4 hired men at a total cost of $5500/man.

Table 16. Levels of owner's capital, borrowed capital and total capital available and the way they are varied in models A, B, C, D, and E[a]

Owner's capital $	Borrowed capital[b] $	Total capital available $	Capital variation in the respective models A	B,C	D	E
5,000	6,250	11,250	▲	▲		
10,000	12,500	22,500	|	|	▲	▲
15,000	18,750	33,750	|	|	|	|
20,000	25,000	45,000	▼	|	|	|
30,000	37,500	67,500		|	|	|
40,000	50,000	90,000		▼	|	|
50,000	62,500	112,500			▼	|
75,000	93,750	168,750				▼

[a]This capital is operating capital only - it does not include fixed capital.

[b]Capital can be borrowed at the rate of $1.25 for $1.00 equity, at an interest rate of 7 percent per annum.

Table 17. Annual fixed costs[a] for 1967 and new technology for the 280, 460, 640, 960 and 1280 acre farms respectively

Item	Source	Acres 280	460	640	960	1280
1967 technology						
Taxes - property		2,287.90[b]	3,758.66	5,229.44	7,844.16	10,458.88
Living expenses		5,260.24[c]	5,260.24	5,260.24	5,260.24	5,260.24
Machinery: cropping	Table 19	4,950.33	6,506.24	7,920.64	11,881.00	15,841.28
Cattle: equipment	Table 56	613.14	613.14	613.14	613.14	613.14
buildings	Table 53	346.18	346.18	346.18	346.18	346.18
Hogs: buildings	Table 62	2,118.08	2,118.08	2,118.08	2,118.08	2,118.08
Land: interest[d]		7,672.00	12,604.00	17,536.00	26,304.00	35,072.00
Corn cribs	(20)	150.00				
Machinery housing	(20)	300.00	739.22	1,024.48	1,542.72	2,056.96
Labor: hired			5,500.00	5,500.00	11,000.00	22,000.00
Total fixed costs		$23,697.87	$37,445.76	$45,552.20	$66,909.52	$93,766.76

[a]These fixed costs are deducted from net profit to give net income.

[b]Calculated as follows: 280 acres x $548/acre (15) x .1491 (millage rate (20)). Taxes are paid in periods 2 and 4 only.

[c]$5146 (Table 18 x index 332/315 (37) = $5,260.24.

[d]Calculated as follows: 280 acres x $548/acre (15) x 5% interest per year.

Table 17. (Continued)

Item	Source	Acres 280	460	640	960	1280
New technology						
Taxes - property		2,287.90	3,758.66	5,229.44	7,844.16	10,458.88
Living expenses		5,260.24	5,260.24	5,260.24	5,260.24	5,260.24
Cropping machinery	Table 38	9,762.47	12,828.48	15,617.28	23,425.92	31,234.56
Cattle: equipment	Table 57	580.51	580.51	580.51	580.51	580.51
buildings	Table 53	346.18	346.18	346.18	346.18	346.18
Hogs: buildings	Table 62	2,990.99	2,990.99	2,990.99	2,990.99	2,990.99
Land: interest		7,672.00	12,604.00	17,536.00	26,304.00	35,072.00
Corn cribs		150.00	739.22	1,024.48	1,542.72	2,056.96
Machinery buildings		300.00				
Labor: hired			5,500.00	5,500.00	11,000.00	22,000.00
Total fixed costs		$29,350.29	$44,608.28	$54,089.12	$79,294.72	$110,000.00

Table 18. Total family living expenses (33)

Item	Family living costs - dollars	
Cash expenses for living:		
Food purchased	$1,039	
Clothing and personals	617	
Household operations	497	
Repairs	157	
Health	362	
Recreation	220	
Education	139	
Giving	379	
Auto-operative	278	
Total		$3,688
New housing, furniture, auto, and equipment		746
Life insurance		473
Total cash living expenses		$4,907
Farm produce used		239
Total income used for living		$5,146

Table 19. Capital requirement and fixed costs for crop machinery with 40" rows and 1967 technology

Machine	New value[a] 1967	90% new[b] value
4 bottom diesel tractor 45-65 hp	$ 6,775	$ 6,097
4 - 14/16" semi mount plows	962	866
12' tandem disc harrow	967	870
20' spring tooth harrow	450	405
4 row planter (trail type)	1,150	1,035
4 row cultivator	925	832
14' rotary hoe mounted and adjustable	500	450
2 row mounted corn picker-sheller	3,500	3,150
48' grain elevator	1,175	1,057
2 4 wheel 200 bu trailers with grain boxes and hayracks	1,000	900
8 row sprayer and attachments	900	810
9' P.T.O. combine (3 row)	2,840	2,556
7' mower	612	551
Side delivery rake	675	607
Endgate seeder	150	135
P.T.O. baler	1,850	1,665
Total	24,431	
Average value[c]	$13,437.05	

[a]Source: (6, 20, 19).

[b]For depreciation purposes a 10% salvage value is deducted from the new value (5, 23).

[c]For the purpose of calculating machinery investment on the farm it is assumed that the typical farmer does not have all new machinery; instead an average value of 55% of the purchase price is used (11).

	Estimated life[d] years	Annual depreciation
	8	$ 762,12
	12	72.17
	10	87.00
	8	50.63
	10	103.50
	8	10.40
	8	56.25
	7	450.00
	8	132.12
	10	90.00
	10	81.00
	6	426.00
	6	91.83
	7	86.71
	6	22.50
	7	237.85
		$2,760.08
Interest[e]		846.54
Taxes and insurance		610.78
Repairs		732.93
		$4,950.33

[d]Source: (4, 23).

[e]See "Costs".

Table 20. Labor requirement and tractor hours for CCCC rotation with 1967 technology

Operation	Rate of work acres/hr[a]	Total labor hrs[b] M	Total labor hrs[b] H	Tractor hrs[b] M	Tractor hrs[b] H
Spreading fertilizer	4.1	.98			
Discing	3.3	1.20			
Plowing	1.7	2.35			
Discing	4.0	1.00			
Harrowing	8.0	.50			
Planting	3.35	1.20			
Spraying	7.8	.51			
Rotary hoeing	7.0	.57			
Cultivating	4.7	.85			
Corn picking	1.7	2.35			
		11.51	11.51	11.51	11.51
Hauling and storing corn at .0094 hr/bu					
M[b] 380 bu		3.56		2.12	
H[b] 452 bu			4.24		2.54
Totals		15.07	15.75	13.63	14.05

[a]Source: (16, 3, 14).

[b]M = medium fertilizer;
H = high fertilizer.

Table 21. Labor requirement and tractor hours for CCSb rotation with 1967 technology

Operation	Source	Rate of work acres/hr	Total labor hrs M	Total labor hrs H	Total tractor hrs M	Total tractor hrs H
Corn[a]	Table 20		7.53	7.87	6.81	7.02
Soybeans						
Spraying		7.8	.12			
Cropping		5.0	.20			
Discing		4.0	.25			
Plowing		1.7	.59			
Harrowing		8.0	.13			
Planting		3.35	.30			
Rotary hoeing		7.0	.14			
Cultivation		4.7	.21			
Combining		1.9	.52			
Hauling and storing	at .0062 hr/bu					
			2.46	2.46	2.46	2.46
	M		.19		.13	
	M 35 bu			.22		.15
			2.65	2.68	2.59	2.61
		Totals	10.18	10.55	9.40	9.63

[a]This is half the value of the 4 acres of CCCC in Table 20.

Table 22. Labor requirement and tractor hours for a CO rotation with 1967 technology

Operation	Source	Rate of work acres/hr	Total labor hrs		Total tractor hrs	
			M	H	M	H
Corn[a]	Table 21		3.77	3.94	3.41	3.51
Oats						
Spreading fertilizer		4.1	.26			
Discing		4.0	.25			
Seeding oats		6.8	.16			
Discing		3.3	.31			
Seeding seed		6.8	.16			
Harrowing		8.0	.13			
Combining oats		1.6	.64			
			1.91	1.91	1.91	1.91
Hauling and storing at .0062 hr/bu						
	M 60 bu		.37		.27	
	H 70 bu			.43		.32
			2.28	2.34	2.18	2.23
		Totals	6.05	6.28	5.59	5.75

[a]This is one half the value for 2 acres of CC in Table 21.

Table 23. Labor requirement and tractor hours for a CSbCOM rotation with 1967 technology

Operation	Source	Rate of work acres/hr	Total labor hrs		Total tractor hrs	
			M	H	M	H
Corn	Table 21		7.53	7.87	6.81	7.02
Oats	Table 22		2.28	2.34	2.18	2.23
Hay						
Mowing		2.95	.54			
Conditioning		2.90	.46			
Side delivery		3.70	.27			
Baling			1.27	1.27	1.27	1.27
	M 3.4 ton/hr		0.94		0.94	
	H			1.03		1.03
Hauling and storing	M 1.15 hr/ton		3.68		1.47	
	H			4.03		1.61
	Totals		5.89	6.33	3.68	3.91
Soybeans	Table 21		2.65	2.68	2.59	2.61
	Totals		18.35	19.22	15.26	15.77

Table 24. Labor requirement and tractor hours for CCOMM rotation with 1967 technology

Operation	Source	Total labor hours		Total tractor hours	
		M	H	M	H
Corn	Table 21	7.53	7.87	6.81	7.02
Oats	Table 22	2.28	2.34	2.18	2.23
Hay[a]	Table 23	11.78	12.66	7.36	7.82
	Total	21.59	22.87	16.35	17.07

[a]This is double the value for the 1 acre of hay in Table 23.

Table 25. Summary of seasonal labor requirements for crop rotations for grain with 1967 technology

Period	CCCC	CCSb	CO	CSbCOM	CCOMM
			Medium fertilizer		
D-J-F	.15	.10	.09	.26	.35
M-A	1.45	.75	.89	1.86	2.47
M-J	6.43	4.67	1.98	7.07	7.44
J-A	.71	.84	1.00	4.59	6.24
S-O-N	6.33	3.82	2.09	4.55	5.09
Total	15.07	10.18	6.05	18.35	21.59
			High fertilizer		
D-J-F	.16	.11	.09	.27	.37
M-A	1.51	.76	.93	1.95	2.62
M-J	6.70	4.83	2.07	7.40	7.89
J-A	.74	.88	1.06	4.42	6.60
S-O-N	6.64	3.97	2.13	5.18	5.39
Total	15.75	10.55	6.28	19.22	22.87

Table 26. Derivation of haymaking costs[a] using 1967 technology

Item	Medium fertilizer	High fertilizer
Operating costs[b]	$2.79	$2.96
Twine[c]	2.46	2.46
Totals	5.25	5.42

[a]From Table 23.

[b]Operating costs derivation:

Med.	3.68 hrs at 4.5 gals. fuel/hr at 16.5 cents/gal	=	$2.73	
High	3.91 hrs " " "	=		$2.90
	3.68 hrs at 0.01 gals oil/hr at $1.60/gal	=	.06	
	3.91 " " "	=		.06
			2.79	2.96

[c]From Table 33.

Table 27. Distribution of labor used for haymaking for two levels of fertilization (hours)

Period	Fertilizer	
	Medium	High
March - April	.26	.33
May - June	2.43	2.60
July-- August	2.73	2.90
Sept. - Oct. - Nov.	.47	.50
Totals	5.89 hrs	6.33 hrs

Table 28. Derivation of silage production coefficients for both levels of technology

Item		Custom cost $/acre[a,b]		
		Medium fertilizer	High fertilizer	New technique
Yield[c]		15 T/acre[d]	18.5 T/acre	20.0 T/acre
Forage harvester	$6.25			
Blower and tractor	2.00	8.25	8.25	8.25
Self-unloading wagon and haulage at $.50/T		7.50	9.25	10.00
Total		15.75	17.50	18.25

[a]Source: (14).

[b]The hours for labor, and the cash expenses (see Table 31) required for grain harvesting and storage were subtracted from the crop rotation figures for grain. The cost of custom harvesting was then added to the remaining cash expenses.

[c]Source: (34).

[d] T = ton.

Table 29. Estimated crop yields and fertilizer applications for the crop rotations (per rotation acre)[a] with 1967 technology[b]

Crops in each rotation	Medium fertilizer (lbs/A) N	P_2O_5	K_2O	Yield	High fertilizer (lbs/A) N	P_2O_5	K_2O	Yield
C	133	60	53	95 bu	193	100	70	113 bu
C	80	30	30	95 bu	104	33	36	113 bu
C	80	30	30	95 bu	104	33	36	113 bu
C	80	30	30	95 bu	104	33	36	113 bu
Rotation total lbs	373	150	143	95 bu	505	199	181	113 bu
C	133	60	53	95 bu	193	100	73	113 bu
C	80	30	30	95 bu	104	33	36	113 bu
Sb		40	13	31 bu		50	27	35 bu
Rotation total lbs	213	130	96		297	183	136	
C	133	60	53	95 bu	193	100	73	113 bu
O	40	30	3	60 bu	60	40	17	70 bu
Rotation total lbs	173	90	56		253	140	90	
C	133	60	53	95 bu	193	100	73	113 bu
Sb		40	13	31 bu		50	27	35 bu
C	113	60	53	95 bu	173	100	73	113 bu
O	40	30	3	60 bu	60	40	17	70 bu
M		10	70	3.2 T		27	100	3.5 T
Rotation total lbs	286	200	192		426	317	290	
C	133	60	53	95 bu	193	100	73	113 bu
C	80	30	30	95 bu	104	33	36	113 bu
O	40	30	3	60 bu	60	40	17	70 bu
M		10	70	3.2 T		27	100	3.5 T
M		30	70	3.2 T		50	100	3.5 T
Rotation total lbs	253	160	226		357	250	326	

[a]Source: (3, 28, 30, 42).

[b]Grain conversion - 2 bu oats = 1 bu corn.

Table 30. Operating costs for the crop rotations using 1967 technology

	$CCCC_1$	$CCSb_1$	CO_1	$CSbCOM_1$	$CCOMM_1$	$CCCC_2$	$CCSb_2$	CO_2	$CSbCOM_2$	$CCOMM_2$
Tractor hours[a]	13.63	9.40	5.59	15.26	16.35	14.05	9.63	5.75	15.77	17.07
Gals fuel used/hr = 4.1 at 16.5 cents/gal	$10.18	7.02	4.17	11.33	12.14	10.50	7.19	4.30	11.70	12.67
Gals oil used/hr = .01 at $1.6/gal	$ .22	.15	.09	.24	.26	.23	.15	.09	.25	.26
Total operating cost	$10.40	7.17	4.26	11.57	12.40	10.73	7.34	4.39	11.95	12.93

[a] From Tables 20 - 24.

Table 31. Grain harvesting and storing hours and costs used to derive silage operating costs using 1967 technology

Item	Source	$CCCC_1$	$CCSb_1$	CO_1	$CSbCOM_1$	$CCOMM_1$	$CCCC_2$	$CCSb_2$	CO_2	$CSbCOM_2$	$CCOMM_2$
Grain harvesting and storing	Tables 20 - 24	hrs 4.47	2.24	2.03	3.80	3.15	4.89	2.45	2.19	4.08	3.41
Costs:											
Fuel[a]	Table 30	$3.32	1.66	1.51	2.82	2.34	3.63	1.82	1.63	3.03	2.53
Oil[a]		.07	.04	.03	.06	.05	.08	.04	.04	.06	.05
Total cost		$3.39	1.70	1.54	2.88	2.39	3.71	1.86	1.67	3.09	2.58
Silage operating cost[b]		$7.01	5.47	2.72	8.69	10.01	7.02	5.48	2.72	8.86	10.35

[a]Derived as in Table 30.

[b]Total cost (Table 30) - Total cost (Table 31).

Table 32. Annual cost of seed per rotation acre for the various cropping rotations[a]

Rotation	Unit	$ cost/acre[b]	Total $
C	1 acre	3.01	
C	1 acre	3.01	
C	1 acre	3.01	
C	1 acre	3.01	12.04
C	1 acre	3.01	
C	1 acre	3.01	
Sb	1 acre	3.08	9.10
C	1 acre	3.01	
O	1 acre	4.50	7.51
C	1 acre	3.01	
C	1 acre	3.01	
O	1 acre	4.50	
M	1 acre	5.43	
M	1 acre	5.43	21.38
C	1 acre	3.01	
Sb	1 acre	3.08	
C	1 acre	3.01	
O	1 acre	4.50	
M	1 acre	5.43	19.03

[a]Source: (19).

[b]From Table 4 .

Table 33. Baling twine cost for given crop rotations

Rotation	Tons of hay	Cost/ton[a]	Total cost
	Medium fertilizer		
CSbCOM	3.2	.77	2.46
CCOMM	6.4	.77	4.93
	High fertilizer		
CSbCOM	3.5	.77	2.70
CCOMM	7.0	.77	5.40

[a]Source: independent investigation.

Table 34. Spraying costs (materials only) for crop rotations using 1967 technology

Rotation	Crop sprayed	Spray[a,b]	Rate/acre/yr	Cost[b]	Cost/acre/year[b]	Cost total
CCCC	C	Atrazine	2 lbs	$2.20/lb Band.	$4.40	
		Oil	1 gal	.75/gal	.75	
		Bux 10	1½ lbs	3.50/lb Band.	5.25	41.60
CCSb	C 1st yr	Atrazine			4.40	
	C 2nd yr	24-D ester			1.25	
	Sb	Treflan			6.00	
	C	Bux 10			5.25	
	C	Bux 10			5.25	22.15
CO	C	Ramrod			4.40	
	C	Bux 10			5.25	9.65

[a]Source: (35, 7).

[b]Agronomy Dept.

Table 34. (Continued)

Rotation	Crop sprayed	Spray[a,b]	Rate/acre/yr	Cost[b]	Cost/acre/year[b]	Cost total
CSbCOM	C 1st yr	Atrazine		$	$4.40	$
	Sb	Treflan			6.00	
	C	24-D			1.25	
	C	Aldrin	2 lbs (B.C.)	2.70/lb	5.40	
	C	Bux 10			5.25	22.30
CCOMM	C 1st yr	24-D			1.25	
	C 2nd yr	24-D			1.25	
	C 1st yr	Aldrin	3 lbs	2.70	8.10	
	C 2nd yr	Bux 10			5.25	15.85

Table 35. Cost of fertilizer for each rotation[a] at both medium and high levels of application using 1967 technology

Rotation	Element	Price[b] ¢/lb.	Fertilizer level Medium Lbs required[c]		Total cost	High Lbs required[c]		Total cost
CCCC	N	6.00	373	22.38	$	505	30.30	$
	P_2O_5	9.00	150	13.50		199	17.91	
	K_2O	4.50	143	6.44	42.32	181	8.15	56.36
CCSb	N	6.00	213	12.78		297	17.82	
	P_2O_5	9.00	130	11.70		183	16.47	
	K_2O	4.50	96	4.32	28.80	136	6.12	40.41
CO	N	6.00	173	10.38		253	15.18	
	P_2O_5	9.00	90	8.10		140	12.60	
	K_2O	4.50	56	2.52	21.00	90	4.05	31.83
CSbCOM	N	6.00	286	17.16		426	25.56	
	P_2O_5	9.00	200	18.00		317	28.53	
	K_2O	4.50	192	8.64	44.40	290	13.05	67.74
CCOMM	N	6.00	253	15.18		357	21.42	
	P_2O_5	9.00	160	14.40		250	22.50	
	K_2O	4.50	226	10.17	40.95	326	14.67	59.79

[a] 60¢ per acre added for cost of custom topdressing meadow in CSbCOM and CCOMM (Source: independent investigation).

[b] From Table 4.

[c] From Table 29.

Table 36. Total annual variable costs ($) for crop rotations for grain and silage with 1967 technological levels

	Source (Table)	$CCCC_1$[a]	$CCSb_1$	CO_1	$CSbCOM_1$	$CCOMM_1$	$CCCC_2$	$CCSb_2$	CO_2	$CSbCOM_2$	$CCOMM_2$
						Grain					
Operating costs	30	10.40	7.17	4.26	11.57	12.40	10.73	7.34	4.39	11.95	12.93
Seed	32	12.04	9.10	7.51	21.38	19.03	12.04	9.10	7.51	21.38	19.03
Fertilizer	35	42.32	28.80	21.00	44.40	40.95	56.36	40.41	31.83	67.74	59.79
Spray	34	41.60	22.15	9.65	22.30	15.85	41.60	22.15	9.65	22.30	15.85
Twine	33				2.46	4.93				2.70	5.40
Lime	-[b]	3.24	2.43	1.62	4.05	4.05	3.24	2.43	1.62	4.05	4.05
Drying	-	14.25	7.12	3.56	7.12	7.12	16.95	8.47	4.23	8.47	8.47
Total cost	$	123.85	76.77	47.60	113.28	104.33	140.92	89.90	59.23	138.59	125.52
						Silage					
Operating costs	31	7.01	5.47	2.72	8.69	10.01	7.02	5.48	2.72	8.86	10.35
Seed	32	12.04	9.10	7.51	21.38	19.03	12.04	9.10	7.51	21.38	19.03
Fertilizer	35	42.32	28.80	21.00	44.40	40.95	56.36	40.41	31.83	67.74	59.79
Spray	34	41.60	22.15	9.65	22.30	15.85	41.60	22.15	9.65	22.30	15.85
Twine	33				2.46	4.93				2.30	5.40
Lime	-[b]	3.24	2.43	1.62	4.05	4.05	3.24	2.43	1.62	4.05	4.05
Custom (at 15 T/acre)	32	63.00	31.5	23.62	39.37	39.37					
At 18.5 T/acre)							70.00	35.00	26.25	43.75	43.75
Total cost	$	169.21	99.45	66.12	142.65	134.19	190.26	114.57	79.58	170.78	158.22

[a] Subscript 1 = medium fertilizer; subscript 2 = high fertilizer.

[b] 1 ton applied every 4 years at cost of $3.25/ton = $0.81/acre/year.

Table 37. Fertilizer applications and costs and crop yields, with new technology

Crops in each rotation	N lbs.	P_2O_5 lbs.	K_2O lbs.	Yield	Total cost $
C	223	120	93	128.8 bu	
C	123	35	40	128.8 bu	
C	123	35	40	128.8 bu	
C	123	35	40	128.8 bu	
Rotation total lbs	592	225	213		
Cost[a]	$35.50	20.25	9.59		65.34
C	223	120	93	128.8 bu	
C	123	35	40	128.8 bu	
Sb		50	27	41.2 bu	
Rotation total lbs	346	205	160		
Cost[a]	$20.76	18.45	7.20		46.41
C	223	120	93	128.8 bu	
O	60	40	17	70.0 bu	
Rotation total lbs	283	160	110		
Cost[a]	$16.98	14.40	4.95		36.33
C	223	120	93	128.8 bu	
Sb		50	27	41.2 bu	
C	203	120	93	128.8 bu	
O	60	40	17	70.0 bu	
M		27	100	3.5 T	
Rotation total lbs	486	357	330		
Cost[a]	$29.16	32.13	14.85		76.74[b]
C	223	120	93	128.8 bu	
C	123	35	40	128.8 bu	
O	60	40	17	70.0 bu	
M		27	100	3.5 T	
M		27	100	3.5 T	
Rotation total lbs	406	249	350		
Cost[a]	$24.36	22.41	15.75		63.72[b]

[a] N at 6¢ per lb.; P_2O_5 at 9¢ per lb.; K_2O at 4.5¢ per lb.

[b] 60¢ per acre added for custom topdressing meadow.

Table 38. Capital requirements and fixed costs for cropping activities with new technology[a]

Machinery	New value 1967	90% new value	Estimated life yrs.	Annual depreciation
4 bottom diesel tractor (45-65 hp)	$ 6,775	$ 6,097	8	$ 762.12
4 - 14/16" plows - semi mount	962	866	12	72.17
12' tandem disc harrow	967	870	10	87.00
20' spring tooth harrow	450	405	8	50.63
6 row planter (30" rows)	2,000	1,980	10	198.00
6 row cultivator (30" rows)	1,165	1,048	8	131.00
14' rotary hoe - mounted, adjustable	500	450	8	56.25
4 row corn picker-sheller (mounted)	5,400	4,860	7	694.29
Grain elevator (48')	1,175	1,057	8	132.12
2 - 300 bu trailers	2,600	2,340	10	234.00
10 row sprayer with attachments	950	855	10	85.50
15' combine (6 - 30" rows)	13,000	12,870	8	1,608.75
7' mower	612	551	6	91.83
7' side delivery rake	675	607	7	86.71
P.T.O. baler	1,850	1,665	7	237.85
Endgate seeder	150	135	6	22.50
1 drier (200 bu/hr)	8,000	7,920	8	977.50
Total	47,231			5,528.22
Av. value = $	25,977.05		Interest[b]	1,636.55
			Taxes and ins.	1,180.77
			Repairs	1,416.93
				$9,762.47

[a]See footnotes, Table 19.

[b]See "costs".

Table 39. Labor requirement and tractor hours for CCCC with new technology

Operation	Acres/hr	Total hours Labor	Tractor
Spreading fertilizer		.98	
Discing		1.20	
Plowing		2.35	
Discing		1.00	
Harrowing		.50	
Planting	3.75	1.07	
Spraying		.51	
Rotary hoeing		.57	
Cultivating	5.25	.76	
Corn picking	2.3	1.70	
		10.68	10.68
Hauling and storing	516.2 bu at .0063 hr/bu	3.25	1.95
Drying[a]	516.2 bu at .1 hr/100 bu	.52	
		14.45	12.63

[a]Source: (3).

Table 40. Labor requirement and tractor hours for CCSb with new technology

Operation	Source	Acres/hr	Labor hrs	Tractor hrs
		Corn		
	Table 39[a]		7.23	6.32
		Soybeans		
Spraying			.12	
Chopping			.20	
Discing			.25	
Plowing			.59	
Harrowing			.13	
Planting		3.75	.27	
Rotary hoeing			.14	
Cultivating		5.25	.19	
Combining		3.00	.34	
			2.23	2.23
Hauling and storing	41.2 bu at .0041 hr/bu		0.17	0.12
			2.40	2.35
		Total	9.63	8.67

[a]This is half the value for CCCC in Table 39.

Table 41. Labor requirement and tractor hours for CO with new technology

Operation	Source		Labor hrs.	Tractor hrs
			1 acre	
		Corn		
	Table 40[a]		3.61	3.16
		Oats		
	Table 22		1.91	1.91
Hauling and storage	70 bu at .0041 hr/bu		.29	.22
			2.20	2.13
		Total	5.81	5.29

[a]This is half the value for CC in Table 40.

Table 42. Labor requirement and tractor hours for CSbCOM with new technology

Operation	Source		Labor hrs	Tractor hrs.
Corn	Table 40		7.23	6.32
Oats	Table 22		2.20	2.13
Hay	Table 23		6.33	3.91
Sb	Table 40		2.40	2.35
		Total	18.16	14.71

Table 43. Labor requirement and tractor hours for CCOMM with new technology

Operation	Source		Labor hrs	Tractor hrs
Corn	Table 40		7.23	6.32
Oats	Table 22		2.20	2.13
Hay	Table 24		12.66	7.82
		Total	22.09	16.27

Table 44. Summary of labor coefficients and their distribution for crop rotations using new technology

Period	CCCC	CCSb	CO	CSbCOM	CCOMM
Distribution:					
D.J.F.	.14	.10	.09	.25	.35
M.A.	1.35	.66	.85	1.82	2.50
M.J.	5.93	4.29	1.76	6.89	7.53
J.A.	.66	.79	1.41	4.11	6.30
S.O.N.	6.37	3.79	1.70	5.09	5.41
Total	14.45	9.63	5.81	18.16	22.09

Table 45. Seed costs for crop rotations with new technology

	CCCC	CCSb	CO	CSbCOM	CCOMM
Corn[a]	$43.80	$21.90	$10.95	$21.90	$21.90
Sb[b]	-	5.00	-	5.00	-
Oats	-	-	4.50	4.50	4.50
Meadow	-	-	-	5.43	10.86
Total cost	43.80	26.90	15.45	36.83	37.26

[a]Corn: 4 way cross seed at 17 lbs/acre = $3.65
So 17 lbs of single cross seed = $10.95/acre.

[b]Soybeans: 60 lbs/acre of top seed = $5.00/acre.

Table 46. Spray costs for crop rotations with new technology

Rotation	Crop sprayed	Spray	Cost/acre/yr	Total cost
CCCC	C	Atrazine	$ 5.87	
		Oil	.75	
	C	Bux 10	7.00	$54.48
CCSb	C	Atrazine	5.87	
	C	24-D	1.25	
	Sb	Treflan	6.00	
	C	Bux 10	7.00	
	C	Bux 10	7.00	27.12
CO	C	Ramrod	4.40	
	C	Bux 10	7.00	11.40
CSbCOM	C	Atrazine	5.87	
	Sb	treflan	6.00	
	C	24-D	1.25	
	C	Aldrin	5.40	
	C	Bux 10	7.00	25.52
CCOMM	C	24-D	1.25	
	C	24-D	1.25	
	C	Aldrin	8.10	
	C	Bux 10	7.00	17.60

Table 47. Derivation of operating costs for crop rotations using new technology

Item		CCCC	CCSb	CO	CSbCOM	CCOMM
Tractor hours[a]	hrs	12.63	8.67	5.29	14.71	16.27
Gals fuel used/hr=4.5 at 16.5¢/gal	fuel	$ 9.38	6.44	3.93	10.92	12.08
Gals. oil used/hr=0.1 at $1.6/gal	oil	$ .20	.14	.08	.24	.26
Total operating cost		$ 9.58	6.58	4.01	11.16	12.34

[a]From Tables 39-53.

Table 48. Grain harvesting and storing hours and costs for crop rotations and the derivation of silage operating costs using new technology

Item		Source		CCCC	CCSb	CO	CSbCOM	CCOMM
Grain harvesting and storing		Tables 39-53	Hrs	3.69	2.31	1.78	3.17	2.71
Costs:	Fuel[a]	Table 47	$	2.74	1.71	1.32	2.36	2.14
	Oil[a]	Table 47	$	.05	.04	.03	.05	.04
Total cost			$	2.79	1.75	1.35	2.41	2.18
Silage operating cost[b]			$	6.79	4.83	2.66	8.75	10.16

[a]Derived as in Table 47.

[b]= total cost (Table 47) - Total cost (Table 48).

Table 49. Summary of costs for crop rotations for grain and silage with new technology

Item	Source	CCCC	CCSb	CO	CSbCOM	CCOMM
		Grain				
Operating costs	Table 47	$ 9.58	6.58	4.01	11.16	12.34
Seed	45	43.80	26.90	15.45	36.83	37.26
Fertilizer	37	65.34	46.41	36.33	76.74	63.72
Spray	46	54.48	27.12	11.40	25.52	17.60
Twine	33	-	-	-	2.70	5.40
Lime	36	3.24	2.43	1.62	4.05	4.05
Total annual variable costs		$176.44	109.44	68.81	157.00	140.37
		Silage				
Operating costs	48	$ 6.79	4.83	2.66	8.75	10.16
Seed	45	43.80	26.90	15.45	36.83	37.26
Fertilizer	37	65.34	46.41	36.33	76.74	63.72
Spray	46	54.48	27.12	11.40	25.52	17.60
Twine	33	-	-	-	2.70	5.40
Lime	36	3.24	2.43	1.62	4.05	4.05
Custom (at 20 ton/A)	28	73.00	36.50	27.37	45.62	45.62
Total annual variable costs		$246.65	144.19	94.83	200.21	183.81

Table 50. Cattle enterprises with input-output coefficients, feed fed and labor hours for feeding method A[a] (bucket and scoop system)

Item	Calves 1	2	3	Yearling steers 4	5
			good	choice	
	steers dry lot	steers pasture	heifers	steers long fed	short fed--fall
Unit	1 steer	1 steer	1 heifer	1 steer	1 steer
Basic data:					
Purchase date	Oct-Nov	Sept-Oct	Nov	Oct	Oct
Marketing "	Sept	Oct	June	Aug	May
Days on farm	340	330	240	300	215
Initl. wt.lbs	450.00	450.00	420.00	630.00	630.00
Markt. wt.lbs	1100.00	1010.00	850.00	1150.00	1100.00
Net gain "	650.00	560.00	430.00	520.00	470.00
Gain/day "	1.91	1.70	1.79	1.77	2.18
Death loss %	2.50	2.50	2.50	1.00	1.00
Meat sold lbs	1088.75	998.75	839.50	1143.70	1093.70
Feed fed[b]:					
Corn equiv.bu.	51.69	37.86	30.02	60.00	59.41
Supplement lbs	275	220	175	250	200
Hay tons	.6015	.3535	.4030	.8500	.3635
Silage tons	1.932	2.07	1.1495	.4500	.3000
Pasture tons (hay equiv.)	.147	.541	.175	.2	.15
Labor[c]					
Hrs. Dec Jan Feb	4.08	4.08	3.34	1.82	2.50
Mar Apr	1.69	1.69	2.06	2.81	2.81
May June	1.33	1.53	1.80	2.66	.5
July Aug	1.00	1.10	-	1.34	-
Sept Oct Nov	.80	.70	0.30	0.37	.2
Total hrs	8.90	9.10	7.50	9.00	6.01

[a]Source: (5, 18, 19, 32, 43).

[b]Source: (1).

[c]Source: (5).

Yearling steers				
6	7	8	9	10
good choice steers short fed--Spring	medium steers Drylot fin.	good yearling heifers	good choice 2 year steers short fed	beef cows calf sold
1 steer	1 steer	1 heifer	1 steer	1 cow+calf+repl.
Feb	Sept	Oct-Nov	Oct-Nov	-
June	May	May	March	Nov
150	250	210	160	230
700.00	600.00	570.00	800.00	-
1050.00	1050.00	1000.00	1150.00	482.60
350.00	450.00	430.00	350.00	482.60
2.33	1.80	2.04	2.18	2.09
1.00	1.00	1.00	1.00	1.30
1043.00	1044.00	994.30	1142.00	476.40
				140.00 cull cow
50.60	34.15	28.14	48.22	2.79
150	250	182	200	43.99
.3375	.7320	.4095	.3800	.3500
.3000	.2	.7700	.4	1.5
.1	.7235	.392	.1	.332
.81	3.05	3.21	2.00	4.26
2.72	2.09	2.03	.2	3.28
2.47	1.00	1.14	-	1.95
-	-	-	-	1.58
-	.36	.62	2.3	2.20
6.00	6.50	7.00	4.50	13.27

Table 51. Variable costs and net revenue for cattle enterprises using feeding method A (bucket and scoop system)

Item Cattle enterprises	1		2		3		4	
<u>Annual variable cash exps.</u> $[a]								
Supplement at 5¢/lb	13.55		11.00		8.75		12.50	
Power and machinery	4.63		3.85		2.62		3.07	
Taxes on L.S.	.97	24.93[b]	.97	22.57	.97	20.36	.97	23.03
Vet. and death	5.85		5.85		5.85		4.45	
Transporting	12.18		10.73		9.86		13.34	
Feeder stock	120.02		124.47		104.54		168.02	
Interest on L.S.	6.00		6.22		3.45		8.40	
Repairs	1.56		1.56		1.56		1.94	
Total variable costs	166.06		165.82		138.66		213.89	
Gross receipts	$282.42		261.87		202.99		302.74	
Net revenue	$116.36		96.05		64.33		88.85	

[a]Adopted from (5).

[b]Inflated value from 1963-1967; source: (37).

5	6	7	8	9	10
10.00	7.55	12.50	8.65	10.00	2.20
2.20	13.5	2.20	2.20	1.35	2.42
.97	.97	.97	.97	.97	.97
4.45	3.25	4.45	4.45	3.25	3.60
12.76	13.00	12.80	12.80	13.00	11.00
} 21.49	} 19.59		} 21.54	} 19.59	} 22.26
168.02	167.09	138.00	135.43	204.80	49.05
5.54	4.20	5.20	4.47	4.05	2.74
1.94	1.94	1.94	1.94	2.32	3.89
206.99	200.37	179.18	172.03	241.76	80.14
291.69	263.77	244.71	241.42	304.57	147.57
84.70	63.40	65.53	69.39	63.81	67.43

Table 52. Input-output coefficients, feed fed, labor, variable costs and net returns for cattle enterprises using feeding methods B (self-unloading wagon system) and C (auger system)

Item Cattle enterprises		1	2	3	4	5	6	7	8	9	10
Unit		1 st.	1 st.	1 h.	1 st.	1 st.	1 st.	1 st.	1 h.	1 st.	1 cow+repl
Feed fed											
Corn equiv.bu	B	51.69	37.86	30.02	60.00	59.41	50.6	34.15	28.14	48.22	2.79
	C	"	"	"	"	"	"	"	"	"	"
Suppl. lbs	B	275	220	175	250	200	150	250	182	200	43.99
	C	"	"	"	"	"	"	"	"	"	"
Hay tons	B	.6485	.7945	.478	.85	.3635	.3375	.932	.5095	.38	.55
	C	"	"	"	"	"	"	"	"	"	"
Silage tons	B	1.932	2.07	1.1495	.45	.3	.3	.972	.77	.4	1.5
	C	"	"	"	"	"	"	"	"	"	"
Past.(hay eq.)	B	.1	.1	.1	.2	.15	.1	.2	.292	.1	.132
	C	"	"	"	"	"	"	"	"	"	"
Labor hours											
Ax.7120[a] DJF	B	2.90	2.90	2.38	1.30	1.78	.58	2.17	2.28	1.42	3.03
Ax.5785[a]	C	2.36	2.36	1.93	1.05	1.45	.47	1.76	1.85	1.16	2.46
MA	B	1.20	1.20	1.47	2.00	2.00	1.94	1.49	1.45	.14	2.34
	C	.98	.98	1.19	1.63	1.63	1.57	1.21	1.17	.12	1.90
MJ	B	.95	1.09	1.28	1.89	.36	1.76	.71	.81	-	1.39
	C	.77	.88	1.04	1.54	.29	1.43	.58	.66	-	1.13
JA	B	.71	.78	-	.95	-	-	-	-	-	1.12
	C	.58	.64	-	.76	-	-	-	-	-	.92
SON	B	.57	.50	.21	.26	.14	-	.26	.44	1.64	1.57
	C	.46	.40	.17	.21	.12	-	.21	.36	1.33	1.27

[a] Source: (5).

Table 52. (Continued)

Item Cattle enterprises		1	2	3	4	5	6	7	8	9	10
Annual variable costs $											
Ax1.0316[a]	B	171.31	171.05	143.04	220.65	213.53	206.70	184.84	177.47	248.05	82.67
Ax1.0039[a]	C	166.70	166.47	139.20	214.72	207.80	201.15	179.88	172.70	236.66	80.45
Gross receipts $		282.42	261.87	202.99	302.74	291.69	263.77	244.71	241.42	304.57	147.57
Net returns $	B	111.11	90.82	59.95	82.09	78.16	57.07	59.87	63.95	56.52	64.90
	C	115.72	95.40	63.79	88.02	83.89	62.62	60.83	68.72	62.91	67.12

Table 53. The cost of an open-front building (2000 sq. ft.) for cattle[a,b]

Item		Total cost	
Site preparation			
Grading	400 cu yds at 25¢	$ 100.00	
Fill sand		50.00	150.00
Shell			
Concrete foundation		425.00	
Walls and doors		525.00	
Roof	2000 sq.ft. at 30¢	600.00	
Concrete floor	" " " 65¢	1300.00	
" " outside	" " " 80¢	1600.00	4450.00
Utilities			
Water piping		175.00	
No sewage system assumed			175.00
	Total cost		$4775.00
	Av. value at 55%		$2626.00

[a]Source: (36).

[b]Stock restrictions	Area required/animal	No. accommodated	Building cost/head
Calves	20 sq.ft.	100 head	$26.26
Yearlings	25 sq.ft.	80 head	32.90
2 yr olds	30 sq.ft.	67 head	39.25
cows	50 sq.ft.	40 head	65.60

Table 54. Annual fixed costs[a] for cattle building

Item	Cost	
Depreciation at 5% of av. value	$131.30	
Interest at 3% of new cost	143.25	
Taxes and insurance 1½% of new cost	71.63	
	$346.18	
Repairs at 1½% of new cost	71.63	= .72/calf = .89/yrlg. = 1.07/2yr = 1.79/cow
Total fixed costs	$417.81	

[a]See "costs".

Table 55. Capital investment and fixed costs for equipment with feeding method A (Technology A) for cattle enterprises

Item	New cost[a] 1967	1963	Av. value[b] 1963	Av. value[c] 1967	Depre-ciation	Ins., taxes, interest	Annual Fixed costs	Repairs
Silo 16'x40' (180 T cap.)	$2250.00			1237.50	81.67	90.00	171.67	33.75
Silo unloader	1300.00			715.00	71.50	52.00	123.50	19.50
Feed bank	2038.00	80.00	44.00	46.41	74.01	81.52	155.53	30.57
Concrete		1200.00	660.00	696.23				
Grinder		227.00	125.00	131.86				
Fence		292.00	161.00	169.84				
Water		40.00	22.00	23.21				
Hay feeder		84.00	46.00	48.53				
Forks, baskets, etc.		9.00	5.00	5.27				
Totals				$3073.85		$450.70	$450.70	$83.82
						Total fixed costs		534.52

Note: in the printed table, braces group the Feed bank through Forks rows; the single values 2038.00 (New cost 1967), 74.01, 81.52, 155.53 and 30.57 apply to the whole group.

Av. value = $30.74/calf Repairs = .84/calf
= 38.42/yrlg = 1.05/yrlg
= 45.88/2yr = 1.25/2yr old
= 76.85/cow = 2.10/cow

[a] Source: (34).

[b] Source: (5).

[c] Inflated by Production Price Index (37).

Table 56. Capital investment and fixed costs for feeding equipment for cattle enterprises with technology B

Item	New cost[a] 1967	New cost[a] 1963	Av. value[a] 1963	Av. value[a] 1967	Depn.[b]	Ins. taxes int.[b]	Annual fixed costs	Repairs[b]
Silo 16'x40' 180 Ton capacity	$2250.00			$1237.50	$81.67	$ 90.00	$ 171.67	$ 33.75
Self unloading wagon	1181.49	$1120.00	$616.00	649.81	64.98	47.26	112.24	17.72
Mechanical silo unloader	1300.00			715.00	71.50	52.00	123.50	19.50
Feed bunk		703.63	387.00					
Concrete		1200.00	660.00					
Grinder		227.00	125.00					
Fence	2695.93	292.00	161.00	1483.19	97.89	107.84	205.73	40.44
Water		40.00	22.00					
Hay feeder		84.00	46.00					
Forks, baskets, etc.		9.00	5.00					
Totals				$4085.50			$613.14	$111.41
					Total fixed costs			$724.55

Av. value = $40.85/calf
= 51.20/yrlg
= 60.98/2 yr
=102.20/cow

Repairs = $1.11/calf
= 1.39/yrlg
= 1.66/2yr old
= 2.78/cow

[a] See Table 55.

[b] See "Costs".

Table 57. Capital investment and fixed costs for cattle enterprises with advanced feeding equipment (C) i.e. new technology

Item	New cost[a] 1967	New cost[a] 1963	Av. value[a] 1963	Av. value[a] 1967	Depn.[b]	Ins. taxes int.[b]	Annual fixed costs	Repairs[b]
Silo 16'x40' 180 Ton capacity	$2250.00	$	$	$1237.50	81.67	90.00	171.67	33.75
Feed bunk		407.00	224.00	236.30	15.60	16.28	31.88	
Mechanical feed system	1563.00	575.00	316.00	333.35	33.34	23.00	56.34	23.45 (Feed bunk, Mechanical feed system, Auger)
Auger		500.00	275.00	290.10	29.01	20.00	49.01	
Mechanical silo unloader	1300.00			715.00	71.50	52.00	123.50	19.50
Concrete		1200.00	660.00	696.23				
Grinder		227.00	125.00	131.86				
Fence	1954.00 (Concrete through Forks)	293.00	161.00	169.84	70.95 (Concrete through Forks)	78.16	149.11	29.31
Water		40.00	22.00	23.21				
Hay feeder		84.00	46.00	48.53				
Forks, baskets, etc.		8.00	5.00	5.27				
Totals				$ 3887.19			$580.51	$106.01
Total fixed costs								$ 686.52

Av. value = $38.88/calf
= 48.59/yrlg
= 58.02/2yr
= 97.18/cow

Repairs = $1.06/calf
= 1.33/yrlg
= 1.58/2yr old
= 2.66/cow

[a]See Table 55.

[b]See "costs".

Table 58. Cost of expansion of cattle facilities for each feeding method

Item		Calves	1 yr	2 yr	Cows
		Method A[a]			
Equipment		$30.74	$38.42	$45.88	$76.85
Building[b]		26.26	32.90	39.25	65.60
		57.00	71.32	85.13	142.45
Annual amortization charge (15 yr life)		3.8	4.76	5.68	9.50
Ann. fixed costs:					
Equip. total	534.52[a]				
Build. total[b]	417.81				
	952.33				
		9.52	11.88	14.20	23.76
Total amortization charge		$13.32	16.74	19.88	33.26
		Method B			
Equipment		40.85	51.20	60.98	102.20
Building[b]		26.26	32.90	39.25	65.60
		67.11	84.10	100.23	167.80
Annual amortization charge (15 yr life)		4.47	5.61	6.68	11.19
Ann. fixed costs:					
Equip. total	724.55[c]				
Build. total[b]	417.81				
	1142.36				
		11.42	14.28	17.05	28.56
Total amortization charge		$15.89	19.89	23.73	39.75

[a]Source: Table 55.

[b]Source: Table 53.

[c]Source: Table 56.

Table 58. (Continued)

Item	Calves	1 yr	2 yr	Cows
	Method C (New technology)			
Equipment	38.88	48.59	58.02	97.18
Building[b]	26.26	32.90	39.25	65.60
	65.14	81.49	97.27	162.78
Annual amortization charge(15 yr life)	4.34	5.43	6.48	10.85
Ann. fixed costs: Equip. total 686.52[d]				
Build. total 417.81				
1104.33	11.04	13.80	16.48	27.60
Total amortization charge $	14.38	19.23	22.96	38.45

[d]Source: Table 57.

Table 59. Input-output coefficients, feed fed, cash expenses and net revenue for hog enterprises with 1967 technology[a]

Item	1 Spring pigs	2 Spring + fall pigs	3 Winter-summer pigs1	4 Winter-summer pigs2	5 4 litter system	6 6 litter system
Unit	1 sow+1 lit.	1 sow+2 lit.	1 sow+2 lit.	1 sow+2 lit.	2 sows+4 lit.	3 sow+6 lit.
Basic data						
Farrowing date	April	Feb+Aug[a]	Jun-Jul+Dec-Jan*	Jun-Jul+Dec-Jan*	Feb+Aug; Jun+Dec**	Jan-Mar-May-Jul-Sep-Nov***
Selling months	Sep	Aug+Feb	Dec+Jun	Dec+Jun	Aug-Feb;Dec-Jun	Jun-Aug-Oct-Dec-Feb-Apr
Repl. gilts kept	1.00	1.00	1.00	1.00	2.0	3.0
No. pigs weaned/ unit no.	7.5	14.9	14.9	14.9	29.8	44.6
No. pigs sold/unit no.	6.28	13.45	13.45	13.45	26.90	40.3
Death loss after/ weaning %	3.00	3.00	3.00	3.00	3.00	3.00
Selling month-sows	Aug	June	April	April	Apr-Aug	Apr-Jun,Oct
Market hog sales/ unit lbs	1444.40	3093.50	3093.50	3093.50	6187.00	9269.00
Sell. wt of pigs lbs	230.00	230.00	230.00	230.00	230.00	230.00
Sow sales/unit lbs	300.00	400.00	400.00	400.00	600.00	600.00

[a]Source: (36, 18, 10, 41).

*Replacement gilts kept out of winter litters.

**Replacement gilts kept out of June and August litters.

***Replacement gilts kept out of May, July and September litters.

Table 59. (Continued)

Item	1 Spring pigs	2 Spring + fall pigs	3 Winter-summer pigs 1	4 Winter-summer pigs 2	5 4 litter system	6 6 litter system
Av. sale price						
Pigs $/cwt	18.10	19.23-17.66	19.05-17.18	19.05-17.18	19.14-17.42	18.40-17.41
Sows "	16.32	15.01	15.30	15.30	15.34	15.35
Gross receipts/ unit $	310.40	632.35	623.85	623.85	1226.59	1755.13
Feed fed[b]						
Corn equiv. bu.	95.11	193.23	193.23	197.33	394.65	601.74
Supplement tons	.4850	.9950	.9550	1.0259	2.0519	3.1302
Hay	-	-	-	-	-	-
Pasture tons	.1894	.1894	.1894	-	-	-
Annual cash exps/unit[c] $						
Supplements	64.58	134.31	134.31	140.25	280.50	419.94
Boar charge	5.00	5.00	5.00	5.00	7.50	7.50
Power and machinery	2.16	4.32	4.32	4.00	9.00	12.00
Bedding	2.71	5.56	5.56	5.56	0.00	0.00
Misc.(inc. grinding)	2.85	5.70	5.70	5.70	12.40	17.10
Vet. and med.	7.50	14.90	14.90	14.90	29.80	45.60
Mktg exp.	9.40	19.17	19.17	19.17	38.30	58.40
Taxes (livest.+feed)	4.00	4.00	4.00	4.00	8.00	12.00
Interest on l.s.	2.35	3.01	2.95	2.95	4.43	6.64
Repairs	7.78	13.74	15.91	14.08	21.91	28.09
Total	108.33	209.81	211.92	215.61	409.46	607.27
Net revenue $	202.07	422.54	411.93	408.24	817.13	1147.86

[b] Source: (19).

[c] Source: (40).

Table 60. Capital investment in equipment and buildings for hog enterprises[a] with 1967 technology

Item	Total cost, 1967
Central farrowing unit (1300 sq.ft)	
Site preparation	$ 75.00
Building shell	4025.00
Utilities	2375.00
Storage - feed only	300.00
Building equipment	3425.00
Zonal air conditioning	450.00
Total	$10,650.00
Enclosed partially controlled growing-finishing building (3600 sq.ft.)	
Site preparation	225.00
Building shell	9590.00
Utilities	550.00
Equipment	6700.00
	$17,065.00
+ Modifications	
Manure disposal equipment	1500.00
	$18,565.00
Total	$29,215.00
	Av. value = $16,068.25

[a]Source: (36).

Table 61. Capital investment in equipment and buildings for hog systems with advanced technology[a]

Item	Total cost, 1967	
Central farrowing unit (1300 sq. ft.)		
Site preparation		$ 75.00
Building shell (with concrete floor)		4025.00
Storage - feed only		300.00
Utilities (liquid manure handling)	$2575.00	
+ floor heat	800.00	
+ zonal air conditioning	450.00	3825.00
Building equipment		
Steel farrowing stalls and waterers	2400.00	
Cramp feeders and waterers	125.00	
In stall feeders	400.00	
Ventilation system	325.00	3250.00
		$11,475.00
Nursery (1500 sq. ft.)		
Site preparation		75.00
Building		4020.00
Utilities	450.00	
+space heater	325.00	
+zonal air conditioning	520.00	1295.00
Equipment		3050.00
Manure handling		
Hydraulic flush and storage		350.00
Oxidation pond		460.00
		$9,250.00
Growing and finishing unit (3600 sq. ft.)		
Site preparation		225.00
Building shell		9590.00
Utilities	550.00	
+ space heater	720.00	
+ air conditioning	1245.00	2515.00
Equipment		6700.00
Manure disposal equipment		
Hydraulic flush + oxidation pond	1100.00	
" " recycle system	400.00	1500.00
		$20,530.00
Total		$41,255.00

[a]Source: (36).

Table 62. Total fixed costs for hog enterprises for both technology levels

Item		Old technology	New technology
Depreciation on buildings at	5% of av. value	$803.40	$1134.52
Interest " "	3% of new value	876.45	1237.65
Taxes + insurance	1% " "	438.23	618.82
		$2118.08	$2990.99

Table 63. Cost of expansion of hog facilities for both technology levels

Item	Source	Old technology	New technology
Bldg. and equip.	Tables 60 and 61	$29,215.00	$41,255.00
Annual fixed costs	Table 62	2,118.08	2,990.99
	Total cost	$31,333.08	$44,245.99
	Total cost/unit	1,566.65	2,212.29
Annual per unit amortization cost (15 yrs)		$ 104.44	$ 147.49

Table 64. Labor requirements and distribution for hog activities for both technological levels (hours)

	Activity					
Period	1	2	3	4	5	6
Dec-Jan-Feb	2.82	8.88	9.38	6.96	15.06	21.70
Mar-April	5.23	5.66	5.60	4.82	8.66	14.92
May-June	3.77	4.98	4.90	4.82	9.30	14.98
July-Aug	3.42	5.80	6.40	5.50	9.62	12.80
Sept-Oct-Nov	2.43	8.44	7.48	6.02	14.10	19.96
Total hours	17.67	33.76	33.76	28.12	56.74	84.36

Table 65. Input-output coefficients, feed fed, cash expenses and net revenue for 4 and 6 litter hog systems with advanced technology

Item	4 litter system	6 litter system
Unit	2 sows + 4 litters	3 sows + 6 litters
Basic data		
Farrowing date	Feb-Aug;Jun-Dec**	Jan-Mar-May-Jul-Sep-Nov***
Selling months	Aug-Feb;Dec-Jan	Jun-Aug-Oct-Dec-Feb-Apr
Repl. gilts kept	2.0	3.0
No. pigs weaned/unit No.	34.0	51.0
No. pigs sold/unit No.	31.15	46.7
Death loss after weaning %	2.5	2.5
Selling month - sows	Apr-Aug	Apr-June-Oct
Market hog sales/unit lbs	7164.5	10741.00
Selling weight of pigs lbs	230.00	230.00
Sow sales/unit	600.00	600.00
Av. sale price	J.A. D.F.	A.J.A. O.D.F.
Pigs $/cwt.	19.14 - 17.42	18.40 - 17.41
Sow	15.34	15.35
Gross Receipts/unit $	1405.68	2018.69
Feed fed		
Corn equiv. bu	440.22	660.33
Supplement tons	2.2965	3.4448
Hay		-
Pasture (hay equiv)		-
Annual cash exps. $		
Supplements	314.44	471.66
Boar charge	7.50	7.50
Power and machinery	11.00	15.00
Bedding	0.00	0.00
Miscellaneous	14.00	19.00
Vet and med.	33.00	50.00
Marketing exps.	45.00	66.80
Taxes on L.S. and feed	8.50	12.00
Interest " " "	4.50	6.64
Repairs	30.94	30.94
Total variable costs	468.88	679.50
Net revenue $	936.80	1339.15

**Replacement gilts kept out of June and August litters.

***Replacement gilts kept out of May, July and September litters.

APPENDIX B

Table 66. Optimum farm plans for the 280 acre farm (models A1 and A2 in Table 15) at 1968 and new technological levels, with the different quantities of capital available

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
Model A1 1968 technology								
1.	$5,000	$6,250	2	$10,305	CCSb2G	234		
					CCOMM2G	12		
					CCOMM2S	7		
					$SYGSF_1$			13
					$SCGD_2$			25
					2L(2)		24	
					4L		112	
Changes only[c]								
2.	10,000	12,389	2	10,585	$SYGSF_1$			4
					$SCGD_2$			33
3.[c]	15,000			10,835				
4.[c]	20,000			11,084				
Model A2 New technology								
	5,000	6,250	2	9,790	CCOMM2S	6		
					CCSb3G	231		
					CCOMM3G	16		
					SCGD3			26
					SYGSF3			21
					IL		6	
					4LNT		136	
Changes only[c]								
2.	10,000	12,500	2	10,087				
3.[c]	15,000	13,205	2	10,337	SCGD3			28
					SYGSF3			18
4.[c]	20,000			10,587				

[a] Capital is operating capital only - it does not include fixed capital.

[b] Fixed costs of $23,697.87 are subtracted from net revenue to obtain net income in Model A1; and of $29,350.29 subtracted from net revenue to obtain net income in Model A2.

[c] Plans following plan 1 in each model give only the changes from this initial plan, and the preceding plan. Plan 3, for example, will equal the results in plan 1 after the changes (if any) in plans 2 and 3 have been added.

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Capital invested Months inv.	Hired labor Hours	Hired labor Period
	$	bushels				
Land	-43	+2770	6998	12	78	3
Labor 1	- 5		6271	6	150	5
Hired labor 5	-20					
Hog expansion	-45					
		+2813	15,652	12	81	3
			2,694	3		
			0	6		
			20,652	12		
			25,652	12		
Land	-45	+2816	4,389	12	44	3
Labor 1	- 6		7,569	6	150	5
Hired labor 5	-27					
			15,602	12		
			1,315	6		
			41	3		
		+2866	20,460	12		
			518	6		
			977	3		
Hog expansion	-1		25,460	12		
			0	6		
			0	3		

Table 66. (Continued)

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
5.[c,d]		$8,752	2	$19,786	CCSb3G	0		
		9,560	4		CCCC3G	204		
					CCOMM3G	34		
					CCOMM3S	15		
					SCGD3			31
					BC3			68
					SYGSF3			0
					6LNT		240	
					4LNT		0	

[d]This is the optimum solution with no restrictions on hired labor in periods 1-5.

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Capital invested Months inv.	Hired labor Hours	Hired labor Period
		bushels				
Land	-94	0	24,341	12	494	1
Labor 1	- 1.5		3,938	6	406	2
Hired labor 5	- 1.5				391	3
Hog expansion	-503				158	4
Cattle expansion	- 2				599	5

Table 67. Optimum farm plans for the 460 acre farm (models B1 and B2 in Table 15) at 1968 and new technological levels, with the different quantities of capital available

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
Model B1 1968 Technology								
1.	$ 5,000	$ 6,250	2	$19,354	CCCC2G	37		
					CCSb2G	300		
					CCOMM2G	52		
					CCOMM2S	24		
					SCGD2			111
					SYGSF1			46
					4L		184	
					2L(2)		27	
Change only[c]								
2.	10,000	12,500	2	19,640	SCGD2			125
					SYGSF1			31
3.[c]	15,000	18,750	2	19,919	CCCC2G	32		
					CCOMM2S	29		
					SCGD2			147
					SYGSF1			6
4.[c]	20,000	19,424	2	20,173				
5.[c]				20,673				
6.[c]	40,000			21,173				
Model B2 New technology								
1.	5,000	6,250	2	20,637	CCOMM2S	28		
					CCSb3G	327		
					CCOMM3G	58		
					SCGD3			117
					HYG3			40
					IL		6	
					4LNT		216	

[a,b,c]See footnotes for Table 66. Fixed costs for B1 are $37,445.76 and for B2 are $44,608.28 (both include $5,500 for hired labor).

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Months inv.	Hired labor Hours	Period
		bushels				
Land	-54		$10,062	12		
Labor 1	- 2		13,677	6		
Labor 5	-23					
Hog housing exp.	-45					
			17,186	12		
			7,240	6		
			4,491	3		
			22,133	12		
			705	6		
			11,352	3		
			27,127	12		
			12,092	3		
			37,126	12		
			0	3		
			47,127	12		
Land	-61		16,890	6		
Labor 5	-31		5,094	3		

Table 67. (Continued)

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
Changes only[c]								
2.	$10,000	$12,500	2	$21,027				
3.[c]	15,000	18,750	2	21,324	CCOMM2S	36		
					CCSb3G	321		
					CCOMM3G	56		
					SCGD3			171
					HYG3			0
4.[c]	20,000	23,990	2	21,604				
		1,010	3					
5.[c]	30,000	27,731	2	22,115				
		5,288	3					
6.[c]	40,000			22,614				
7.[c,d]		13,321	2	35,183	CCSb3G	0		
		0	3		CCCC3G	309		
					CCOMM3G	70		
					CCOMM3S	34		
					BC3			129
					SCGD3			77
					6LNT		360	
					1L		0	
					4LNT		0	

[d]See footnote for Table 66.

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Months inv.	Hired labor Hours	Period
		bushels				
			$ 1,884	12		
			9,943	6		
			15,770	3		
Land	-63	-2251	13,134	12		
Hog housing exp.	- 2		3,693	6		
			15,770	3		
			24,399	12		
			13,703	3		
			0	6		
			37,115	12		
			10,483	3		
			47,115	12		
Land	-94	0	43,201	12	571	1
Labor 5	- 1.5		6,207	6	486	2
Hog housing exp.	-503				348	3
Cattle hous.exp.	- 2				53	4
					647	5

Table 68. Optimum farm plans for the 640 acre farm (models C1 and C2 in Table 15) at 1968 and new technological levels, with the different quantities of capital available

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
Model C1 1968 technology								
1.	$ 5,000	$ 4,348	2	$15,972	CCSb2G	543		
					CCOMM2G	26		
					CCOMM2S	7		
					SYGSF1			
					4L		104	80
					2L(2)		66	
Changes only[c]								
2.	10,000			16,222				
3.[c]	15,000			16,472				
4.[c]				16,722				
5.[c]				17,222				
6.[c]				17,722				
Model C2 New technology								
1.	5,000	3,345	2	18,583	CCOMM2S	44		
					CCSb3G	435		
					CCOMM3G	94		
					SYGSF3		123	
					SCGD3		176	
					4LNT	160		
Changes only[c]								
2.	10,000			18,833				
3.[c]	15,000			19,083				
4.[c]	20,000			19,333				
5.[c]	30,000			19,833				
6.[c]	40,000			20,333				

[a,b,c] See footnotes, Table 66. Fixed costs for C1 = $45,552.20 and for C2 = $54,089.12 (both include $5500 for hired labor).

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Months inv.	Hired labor Hours	Period
		bushels				
Land	- 7	+20,893	6,538	12		
Labor 3	-35		6,161	6		
Labor 5	- 8		3,282	3		
			11,538	12		
			16,538	12		
			21,538	12		
			31,538	12		
			41,538	12		
Land	-28	+ 8,889	2,582	12		
Labor 2	- 3		6,413	6		
Labor 3	-18		5,742	3		
Labor 5	-23					
			7,582	12		
			12,582	12		
			17,582	12		
			27,582	12		
			37,582	12		

Table 68. (Continued)

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
7.[c,d]		$19,500	2	$45,765	CCCC3G	388		
		4,951	4		CCOMM3G	123		
					CCOMM3S	62		
					BC3			159
					SCGD3			203
					6LNT		420	
					SYGSF3			0
					4LNT		0	

[d]See footnote, Table 66.

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Capital invested Months inv.	Hired labor Hours	Hired labor Period
		bushels				
Land	- 94	0	36,248	12	1167	1
Hog housing exp.	-509				881	2
Cattle hous.exp.	- 2				855	3
Labor 2	- 1.5				383	4
Labor 3	- 1.5				1131	5
Labor 5	- 1.5					

Table 69. Optimum farm plans for the 960 acre farm (models D1 and D2 in Table 15) at 1968 and new technological levels, with the different quantities of capital available

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
Model D1 1968 technology								
1.	$10,000	$12,500	2	$25,663	CCSb2G	848		
					CCOMM2G	32		
					CCOMM2S	4		
					SYGSF1			99
					2L(2)		76	
					4L		164	
Changes only[c]								
2.	15,000	13,240	2	25,914				
3.[c]	20,000			26,164				
4.[c]	30,000			26,664				
5.[c]	40,000			27,164				
6.[c]	50,000			27,664				
Model D2 New technology								
1.	10,000			30,439	CCOMM2S	56		
					CCSb3G	681		
					CCOMM3G	146		
					SCGD3			233
					SYGSF3			210
					4LNT		236	
Changes only[c]								
2.	15,000			30,689				
3.[c]	20,000			30,939				
4.[c]	30,000			31,439				
5.[c]	40,000			31,939				
6.[c]	50,000			32,439				

[a,b,c] See footnotes for Table 66. In model D1 fixed costs of $66,909.52 are deducted to give the net income. In model D2 fixed costs of $79,294.72 are deducted to give the net income (both include $11,000.00 for hired labor).

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Capital invested Months inv.	Hired labor Hours	Hired labor Period
		bushels				
Land	- 8	+35,909	$11,492	12		
Labor 3	-35		2,264	6		
Labor 5	- 8		14,792	3		
Hog housing exp.	- 2					
			16,517	12		
			1,550	6		
			15,481	3		
			21,517	12		
			31,517	12		
			41,517	12		
			51,517	12		
Land	-27	+16,681	4,063	12		
Labor 2	- 2		1,638	9		
Labor 3	-20		14,077	6		
Labor 5	-22		4,792	3		
			9,063	12		
			14,063	12		
			24,063	12		
			34,063	12		
			44,063	12		

Table 69. (Continued)

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
7.[c,d]		$38,589	2	$59,286	CCCC3G	524		
			3		CCOMM3G	234		
		23,808			CCOMM3S	125		
					SCGD3			542
					BC3			143
					6LNT		480	
					SYGSF3			0
					4LNT		0	

[d]See footnote for Table 66.

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Months inv.	Hired labor Hours	Period
Land	-93	0	$38,311	12	1538	1
Labor 1-5	- 1.5		14,026	3	1020	2
Hog housing exp.	-515		0	9	1013	3
Cattle housing exp.	- 3		0	6	389	4
					1158	5

Table 70. Optimum farm plans for the 1280 acre farm (models E1 and E2 in Table 15) at 1968 and new technological levels, with the different quantities of capital available

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
Model E1 1968 technology								
1.	$10,000	$12,500	2	$50,064	CCCC2G	140		
					CCSb2G	801		
					CCOMM2G	157		
					CCOMM2S	80		
					SCGD2			362
					SYGSF1			116
					4L		268	
					6L		200	
Changes only[c]								
2.	15,000	18,750		50,361				
3.[c]	20,000	19,897		50,619				
4.[c]	30,000			51,119				
5.[c]	40,000			51,619				
6.[c]	50,000			52,119				
7.[c]	75,000			53,369				
Model E2 New technology								
1.	10,000	12,500	2	59,040	CCOMM2S	90		
					CCSb3G	906		
					CCOMM3G	182		
					SCGD3			404
					SYGSF3			155
					4LNT		168	
					6LNT		348	
Changes only[c]								
	15,000	18,750		59,329	SCGD3			425
					SYGSF3			125

[a,b,c] See footnotes for Table 66. In model E1 fixed costs of $93,766.76 are deducted to give net income and in model E2 fixed costs of $110,000.32 are deducted to give net income (both include $22,000 for hired labor).

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Capital invested Months inv.	Hired labor Hours	Hired labor Period
		bushels				
Land	-46	+12,426	$ 921	12		
Labor 1	- 2		12,285	6		
Labor 2	- 2		31,866	3		
Labor 3	-12					
Labor 5	- 6					
Hog housing exp.	-192					
			12,171	12		
			6,035	6		
Labor 1	- 3		18,318	12		
Labor 2	- 1		4,888	6		
Labor 5	- 7					
Hog house exp.	-189					
			28,318	12		
			38,318	12		
			48,318	12		
			73,318	12		
Land	-53	+ 1,537	33	12		
Labor 1	- 7		12,653	6		
Labor 2	- 1		33,083	3		
Hog housing exp.	-69					
Labor 5	-24					
Labor 2	0	+ 2,262	9,173	12		
			0	6		
			42,194	3		

Table 70. (Continued)

Plan	Own capital[a]	Borrowed capital	Period borrowed	Net income[b]	Enterprises in plan	Acres	Litters	No.
Changes only[c]								
3.[c]	$20,000	$25,000		$59.603				
4.[c]	30,000	25,034		60,103				
5.[c]	40,000			60,603				
6.[c]	50,000			61,103				
7.[c]	75,000			62,353				
8.[c,d]		52,763	2	75,663	CCCC3G	692		
		37,463	3		CCOMM3G	314		
					CCOMM3S	172		
					SCGD3			799
					BC3			120
					6LNT		600	
					SYGSF3			0
					4LNT		0	

[d]See footnote for Table 66.

Limiting resources	Shadow price	Grain Sale(+) Purchased(-)	Capital invested $	Months inv.	Hired labor Hours	Period
			$14,442	12		
			24,442	12		
			34,442			
			44,442			
			69,442			
Land	- 94	0	56,475	12	1290	1
Labor 1,2,3,5	- 1.5		34,464	3	761	2
Hog housing exp.	-527				556	3
Cattle hous,exp,	- 3				688	5

Table 71. Additional net income resulting from the additional labor (hours) that each farm hired when the restraint on hired labor was removed[a]

Farm size (acres)	Additional hired labor (hours)	Additional net income ($)
280	+ 2048	+ 9199
460	+ 2105	+12,569
640	+ 4417	+25,432
960	+ 6118	+26,847
1280	+ 3295	+13,310

[a] From Tables 66 - 70.