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Linear programming analysis of potential growth of a northeast Iowa farm business

Belkis Coromoto Villa de Marquez
Iowa State University

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Linear programming analysis of potential growth of a northeast Iowa farm business

by

Belkis Coromoto Villa de Marquez

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE

Department: Economics
Major: Agricultural Economics

Signatures have been redacted for privacy

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INTRODUCTION

One of the major problems facing young farmers in agriculture today is acquiring the land and capital over time to fully employ their labor and managerial resources. Larger farms with accompanying efficiencies of scale can reduce average production cost and increase profitability of the farm business. As the farmer strives to increase his net income and equity he is forced to increase output by more intensive livestock operations or by adding additional crop acres to his farm, or both. Young farmers are faced with the need to grow in order to stay competitive. They are concerned about enlarging their individual farm operation to take advantage of new technology, economies of scale and improve their income position.

In the present study, optimum production plans will be developed for an individual farm in Jackson County, northeast Iowa. This farm's owner has as a goal to expand his business operations and in turn increase farm income and equity. Production plans are designed for two primary areas of growth potential: first, addition of cropland; second, increase of livestock program.

Penrose argues that "the expansion of firms is largely based on the opportunity to use their existing productive resources more efficiently than they are being used" (20, p. 88). She also introduces the concept of economies of

growth:

> "Economies of growth are the internal economies available to an individual firm which makes expansion profitable in particular directions. They are derived from the unique collection of productive services available to it, and create for that firm a differential advantage over other firms in putting on the market new products or increased quantities of old products" (20, p. 99).

Economies of growth are obtained from the available collection of productive resources and any unused productive service within the firm. Penrose believes there are many unused productive services available within most firms. Their availability provides an incentive for the firm to expand its operations in such a way as to use these services. Unused resources is also a condition that induces a firm's growth. The existence of unused resources besides stimulating growth may play a role in determining the production activities that normally go along with the expansion process. To Penrose economies of growth are only available to a firm that is in the process of expansion, and disappear once the firm has reached the desired or optimum size.

Bailey (2) lists five necessary conditions for a firm to grow: first, excess managerial capacity. He believes most young farmers have surplus of managerial capacity which can be used in expansion of the farm firm. The second condition is profitability of the farm business. That is, before expansion takes place, there must be enterprises or production

activities in which receipts exceed expenses. The third condition requires a minimum starting size of the firm. This size must be one that provides enough income to meet all fixed and operating expenses, family consumption expenditures and still leaves capital available for expansion purposes. This condition need not be met, if there is a source of nonfarm income to finance expenses or expansion. The fourth condition requires the existence of some unused resources; and fifth, the availability of additional resources through purchase, lease or hire. The last condition is an important one to be met since, for example, land is not always for sale or rent at the time and place it is desired for expansion.

Irwin (15) considers the principle of growth as the acquisition of control of the services of additional productive resources by paying a price less than they will earn. An increase in the number of acres farmed is an indicator of farm growth. Established and expanding farmers have become the dominant force on the demand side of the farm real estate market. Owner operators are both willing and, in most instances, eager to bid for the available supply of land. On the other hand capital investments in machinery, buildings and livestock, also contribute to growth of the farm firm.

Hopkin et al. (14, pp. 143-144) consider that conditions for growth exist when "the firm has underutilized resources, less than optimum resource allocation, or savings from

disposable income to be invested." They define growth financially as increases in the size of the farm business measured by the rate of increase of owner equity. It is this criterion which will be followed in working out the main objective of this study.

The hypothesis to be tested in the present study is that, potentials exist for farm growth through addition of land and/or livestock facilities. It is intended that the results of this analysis would provide the farmer with recommendations and suggestions which would help him in the decision making process.

Objectives of the Study

The main objective of this study is to determine the economic and financial feasibility of farm growth through modification of existing resource use or by additional labor and/or land resource, and livestock facilities.

Specifically this study will:

1. Describe and quantify the present farm organization and determine an optimum farm organization with existing resource constraints and enterprise alternatives.

2. Identify potentials for growth in the farm business and determine the economic and financial feasibilities of these alternatives.

FARM SITUATION STUDIED

The analysis was confined to the resource allocation problems of a farm in Jackson County, northeast Iowa. The average size of farms in this county is 246 acres (23). Farms in this area are diversified, producing some combination of crop and livestock enterprises. The crop enterprises produced are mainly corn for grain and silage, oats, soybeans and hay. The livestock enterprises are, in first place, dairying, from which many farms derive a relatively high proportion of income; swine enterprise, from which the two major types considered are the spring and fall litter systems, and finally the beef-cow calf enterprise.

The farm selected for this study is situated in the Fayette soil association group which also prevails in the adjoining counties of Clayton, Delaware, Jones and Clinton. The Fayette soils occur on slopes of one to thirty percent, although slopes of five to fourteen percent predominate. They were formed from thick loess under forest vegetation and are well drained. On the Fayette soils the predominant farming enterprises are livestock and dairy. About sixty percent of the land in this association is used for cultivated crops. Cropping intensity is limited by the moderate to strongly sloping topography. Erosion control practices are needed. About forty percent of the area is used for pasture and timber. Pasture improvement and timber management offer

possibilities of increasing returns on many farms in this soil association area (1).

The farm under consideration is owner operated with some rented land. The operator established the farming business five years ago. The farm's resources include land, machinery, buildings, livestock and the operator's labor and management. The area of the farm is 360 acres of which the operator owns 240 acres and rents 120 acres. The present organization of this farm is shown in Table 1.

Table 1. Present organization for a 360 acre farm and crop yields in Jackson County

Crop or land use	Acres	Yield/acre	Livestock
Corn	120	120 bu.	40 beef cows
Oats	25	60 bu.	
Hay	85	4.5 ton	30 spring litter of pigs
Timber pasture	80	3 AUM	
Temporary pasture	35	6 AUM	30 fall litter of pigs
Nonproductive	15		

The 360 acres in the farm include 345 acres of cropland, distributed as follows: 120 acres in corn (100 acres owned, and 20 acres rented on a crop share basis), 25 acres in oats,

85 acres in hay (65 acres owned and 20 acres rented on a crop share basis), 80 acres of timber pasture rented on a cash basis, 35 acres in temporary hill pasture, and 15 acres in nonproductive activities.

Enterprises and Production

Livestock enterprises

The present farm organization includes both beef and swine enterprises. The following section describes each of the livestock enterprises presently on the farm.

The hog farrowing activity includes both spring (April) and fall (September) farrowings. The farmer is presently finishing one half of feeder pigs farrowed, and selling the other half as feeder pigs. To finish feeder pigs from 40 to 240 pounds, the feed requirements per hog are, 11.4 bushels of corn and 111 pounds of protein supplement. The capacity to finish feeder pigs is 500 square feet, each pig requiring 3 square feet of space. The turn around rate is assumed to be 2.4. This rate indicates that the operator can have ready for the market 2.4 herds of hogs per year.

The base beef enterprise is 40 head of beef cows. The average calf crop is 90 percent, and 16 percent of the cows are culled each year. The feed requirements include 1.2 tons of hay, 2 acres of permanent pasture, 3.2 tons of corn stover and 80 pounds of salt and mineral per animal. The farmer

has the alternative of finishing heifers and steers, and/or selling them as feeder calves. The capacity to finish cattle is 2,000 square feet with each calf requiring 50 square feet of space. The turn around rate is assumed to be 1.2. This rate means that 1.2 herds of cows are put on sale every year. Steers are fed from 450 to 1100 pounds and the feed requirements to achieve the slaughter weight are 64 bushels of corn, 1.2 tons of hay, and 225 pounds of protein supplement per steer. Heifers are fed from 430 to 935 pounds; the feed requirements per animal include 56 bushels of corn, 1 ton of hay and 220 pounds of protein supplement.

Another beef enterprise alternative the producer has is backgrounding calves. Steers and heifers are purchased weighing 400 and 350 pounds respectively. Steers are fed to 700 pounds and are on feed 163 days. Feed requirements per steer are 13.5 bushels of corn, 0.59 tons of alfalfa brome hay and 40.5 pounds of natural supplement. Heifers are fed to 650 pounds requiring 156 days on feed. The feed requirements are 22.1 bushels of corn, 0.23 tons of alfalfa brome hay and 52.3 pounds of natural supplement per heifer.

Crop enterprise

The cropping system at present is a corn-corn-oats-meadow-meadow rotation (CCOMM). Annual variable costs per acre for corn, oats and hay are shown in Table 2. The cost

Table 2. Annual production costs per acre for selected crops in Jackson County, Iowa[a] ($/acre)

	Corn[b]	Corn[c]	Oats	Hay
Operating Costs	87.63	71.13	48.56	49.55
Capital Costs	10.81	8.96	8.38	10.07
Ownership Costs	11.64	10.66	10.72	14.17
Labor Costs	7.16	6.52	10.18	13.50
Value of Operator's Time	13.50	13.50	5.53	8.60

[a]Source: farm budgets.

[b]Corn following corn.

[c]Corn following meadow.

categories included in the table are as follows:

1. Operating costs:
   - Seeds
   - Fertilizer
   - Herbicide
   - Insecticide
   - Tractor and equipment fuel cost
   - Tractor and equipment repair cost
2. Capital costs:
   - Annual operating capital
   - Tractor investment
   - Equipment investment
3. Ownership costs:
   - Depreciation
   - Taxes
   - Insurance
4. Labor costs: (includes unpaid labor)
5. Value of operator's management time: it has been estimated as 5 percent of gross returns, which would be equivalent to the lower range of farm consulting service,

because of this young operator's educational background and farming experience.

Available Resources

The land resource includes 360 acres of cropland, timber pasture, and land use for roads, buildings and waste. The amount of land used for pasture and crops is shown in Table 1. The owned cropland is entirely devoted to a corn-corn-oats-meadow-meadow rotation for soil conserving reasons.

The total available labor for both crops and livestock consists of the following: the operator himself for 216 hours per month throughout the year, plus 176 additional family labor hours for May to meet peak crop labor demands.

The amount of livestock facilities is considered since this places a limitation on present livestock production. Cattle finishing space is restricted to 2,000 square feet and hog finishing space to 500 square feet. Farrowing facilities limit the size of the hog enterprise to 30 litters of spring and fall farrowings.

The initial machinery base on the farm is adequate to farm the 360 acres. The machinery description is shown in Table 3.

Table 3. Machinery investment

Machine	Size	Purchase Price ($)
Tractor	125 hp	23,040
Bin Dryer	3,000 bu	6,170
Bulk Fertilizer Sprdr.	12 ft	1,620
Chisel Plow	4-12 in.	1,233
Tandem Disk	14 ft	3,430
Planter	4-38 in.	3,240
Sprayer, Mounted	20 ft	760
Cultivator	4 R	1,350
Grain Wagon	185 bu	1,480
Large Round Baler		6,500
Mower		3,700

Financial situation

Table 4 shows the owner's estimated equity position when the farmland is valued at its original purchase price[1]. Under this situation the liquidity position is very favorable, there are $2.02 in current assets available for every dollar in current liabilities. The farmer's wife is employed off the farm so much of the family living expenses are covered by her earnings and will not be a large drain on the current asset position. The leverage ratio shows that for every dollar of

[1]Values are estimated to protect identity of the case farm.

Table 4. Farm financial position--January, 1978[a]

Assets		Liabilities	
Cash	$ 1,000	Current Liabilities	
Current Assets		Notes: on cattle loan	$ 3,000
60 Feeding Cows ($225/head)	13,500	Portion of Intermediate Due by End of Year	
20 Replacement Heifers ($275/head)	5,500	On Machinery	4,128
		On Tractor	3,818
120 Hogs for Market ($50/head)	6,000	Portion of Long Term Due by End of Year	
120 Feeder Pigs ($20/head)	2,400	On land loan	9,700
		TOTAL CURRENT LIABILITIES	20,646
5,000 bu. of Corn ($2.00/bu.)	10,000	Intermediate Liabilities	
100 tons of Hay ($34/ton)	3,400	Debt on Machinery	10,108
		Debt on Tractor	15,800
TOTAL CURRENT ASSETS	41,800	TOTAL INTERMEDIATE LIAB.	25,908
Intermediate Assets		Long Term Liabilities	
40 Beef Cows ($350/head)	14,000	Debt on Land	98,771.90
2 Bulls ($600/head)	1,200	TOTAL LONG TERM LIAB.	98,771.90
		TOTAL LIABILITIES	145,325.90

[a]Values are estimates to protect identity of the case farm.

Table 4. (continued)

Assets			Liabilities	
30	Sows ($100/head)	$ 3,000	NET WORTH	$ 87,547.10
1	Boar ($350/head)	350	TOTAL LIABILITIES AND NET WORTH	232,873.00
	Machinery	52,523		
	TOTAL INTERMEDIATE ASSETS	71,073		
Long Term Assets				
240	Acres of Farmland	120,000		
	TOTAL LONG TERM ASSETS	120,000		
	TOTAL ASSETS	232,873		

equity capital the operator is using $1.66 of debt capital. This high figure indicates a low degree of solvency within the farm. This is the major factor that has qualified the operator for Farmers Home Administration loans.

In light of the sharp increase in land values the last few years in Jackson County, the financial position of the farm changed substantially. If the value of land was adjusted to the level the owner would net out of a farm liquidation at $1,000 per acre, the net worth would increase to $207,547 and the debt to equity ratio would decrease to 0.70. This would place the farm business in a favorable solvency position for future expansion.

METHOD OF ANALYSIS

Linear programming is the analytical technique used to identify areas of growth potential in this study. The usefulness of this technique in farm decision making process has been widely demonstrated. Linear programming permits the simultaneous consideration of many possible alternative plans based on estimated input-output coefficients and prices for alternative production possibilities. It allows specification of the most profitable plan with respect to capital, labor, land, and other resource constraints of the farm. These considerations are particularly important for beginning farmers who have limited funds and multitudes of opportunities for investing them. As it is pointed out by Heady and Agrawal (10, p. 26),

> ...Linear programming is a computational method to determine the best plan or course of action, among many which are possible, when there are many alternatives for the plan, a specific or numerical objective exists for it, and the means or resources available for attaining it are limited....

This tool has particular application in agriculture because farmers are always faced with limited resources in the form of land, labor in different months of the year, funds available for operation, buildings useful for different purposes, machinery capacity, etc. On the other hand a farm always has alternative and competing ways to formulate the farm production and investment plan.

In this study linear programming is used to identify areas of growth potential. Out of the programming solution the marginal value productivities of scarce resources are obtained and used to detect those activities susceptible of expansion. Thereafter, linear programming is used to determine income possibilities and optimum farm plans for a low equity farmer, under alternative resource situations.

An understanding of the assumptions of linear programming is necessary to see its limitations in the interpretation of results. The basic assumptions are outlined below:

1. LINEARITY: The assumption of linearity means that each activity or production process is characterized by input-output ratios which are independent of the extent to which the process is used. That is, input-output coefficients do not change with the volume of output, they are constant. Also, the prices paid for resources or received for products are assumed to be constant. The linearity assumption does not seem to be unduly restrictive for some of the problems of agricultural economics, since, if necessary, the input-output coefficients can be changed so that possible economies or diseconomies of scale may be considered and the final results obtained can be more realistic.

2. ADDITIVITY: The assumption of additivity means that the total amount of the resources used by several enterprises must be equal to the sum of the resources used by each

individual enterprise (11, p. 17). The quantities of inputs and outputs are the sums which would result if several processes were used individually. The returns from one enterprise are not changed because they are being obtained simultaneously with the returns from another enterprise. No complementarity is allowed between enterprises. One way the complementary relationships of two or more different but interrelated enterprises can be treated is by setting up processes of two or more enterprises and combining them in a single process or activity.

3. DIVISIBILITY: This assumption considers continuous resources and products. It is assumed that resources are used and commodities are produced in fractional units. The divisibility assumption also implies that resources are homogeneous in quality. It is perhaps the most restrictive assumption when applied to agricultural production. Indivisibilities exist in plant, machinery, livestock and human resources. Heady and Candler (11, p. 18) believe it is not a serious limitation since a program ordinarily can be rounded to include activities produced to the nearest whole unit without causing serious decision making errors.

4. FINITENESS: There is a limit to the number of alternative activities and to the resource restrictions to be considered into the plan. This is not a serious limitation on the use of linear programming since in practice farmers are

interested in a comparatively small number of processes and enterprises.

5. SINGLE VALUE EXPECTATIONS: It is assumed that resource supplies, input output coefficients, prices of resources and activities, and so forth are known with certainty. This assumption is unrealistic for most farming situations.

In addition to determining the economic feasibility of expansion alternatives, the financial feasibility is also considered. The approach to determine financial feasibility is to do a simplified cash flow analysis of the alternatives and also consider the operator's ability to acquire necessary debt capital.

The present study uses a model consisting of 45 production, resource, selling and investment activities (see Table 5), and 32 restrictions and transfer rows. Activities can be further divided into 12 production, 15 resource, 4 financial and 13 selling activities. Restrictions consist of 9 physical restrictions on production, 4 financial restrictions and 21 transfer rows. The value of the objective function would represent return to the operator's management.

Tables 1 and 2 in Appendix A show the resource requirements per unit of output for crops and livestock respectively. Hay and grain for the livestock enterprises are provided

Table 5. List of activities or enterprises included in the study

Activity Number	Activity	Unit
P01	Crop Rotation CCOMM[a]	Acre
P02	Corn on rented land (50% crop share)	Acre
P03	Hay on rented land (50% crop share)	Acre
P04	Corn selling	Bushel
P05	Hay selling	Ton
P06	Oat selling	Bushel
P07	Straw selling	Ton
P08	Unimproved timber pasture	Acre
P09	Improved timber pasture	Acre
P10	Present cropland	Acre
P11	Rent unimproved timber pastureland	Acre
P12	Present pastureland	Acre
P13	Land purchasing	Acre
P14	Annual labor hiring	Hours
P15	May labor hiring	Hours
P16	Borrow operating capital	$
P17	Borrow intermediate capital	$
P18A	Borrow long term capital from FHA[b]	$
P18B	Borrow long term capital from FLB[c]	$
P19	Tractor	Hours
P22	Beef cow calf	Head
P23	Finish steers to slaughter weight	Head

[a] CCOMM: refers to corn-corn-oats-meadow-meadow rotation.

[b] FHA refers to Farmers Home Administration loans.

[c] FLB refers to Federal Land Bank loans.

Table 5. (continued)

Activity Number	Activity	Unit
P24	Finish heifers to slaughter weight	Head
P25	Feeder steer selling	cwt
P26	Feeder heifer selling	cwt
P27	Finished steer selling	cwt
P28	Finished heifer selling	cwt
P29	Cull cows selling	cwt
P30	Purchase steer calves	cwt
P31	Purchase heifer calves	cwt
P32	Raise background steers	Head
P33	Raise background heifer	Head
P34	Background steer selling	cwt
P35	Background heifer selling	cwt
P36	Hog farrowing	One litter
P37	Finish feeder pigs	Head
P38	Finished hogs selling	cwt
P39	Feeder pigs selling	Head
P40	Cull sows selling	cwt
P41	New facility for hogs	Sq. feet
P42	New facility for cattle	Sq. feet
P43	New farrowing facility	One litter
P44	Present annual labor	Hours
P45	Present May labor	Hours
P46	Corn buying	Bushels

entirely by the crop activities. Other feeds such as protein and mineral supplements, are to be purchased and, thus included in the annual operating expenses or capital coefficients.

Product prices used in the analysis are summarized in Table 6. These prices represent the average prices received by Iowa farm products in 1977.

Table 6. Prices used in the study[a]

Item	Unit	Purchase Price ($)	Selling Price ($)
Crops			
Corn	bu	2.10	2.00
Hay	ton		34.00
Oats	bu		1.10
Straw	ton		25.00
Livestock and livestock products			
Feeder steer (450 lb)	cwt		45.00
Feeder heifer (430 lb)	cwt		40.00
Finished steer (1100 lb)	cwt		44.00
Finished heifer (935 lb)	cwt		43.00
Cull cows (1000 lb)	cwt		28.00
Backgrounded steer (700 lb)	cwt	46.00	42.00
Backgrounded heifer (650 lb)	cwt	41.00	38.00
Feeder pigs (40 lb)	head		38.50
Finished hogs (240 lb)	head		38.00
Cull sows (400 lb)	cwt		33.00

[a]Average Iowa farm product prices for 1977.

PRESENTATION AND ANALYSIS OF SITUATIONS STUDIED

The present study analyzes the following farm situations:

Situation 1: existing farm resource structure and enterprise alternatives.

Situation 2: feasibility of land addition under initial resource levels and the possibility of hiring hourly May labor.

Situation 3: addition of new hog farrowing facilities.

Situation 4: addition of new hog farrowing and finishing facilities.

Situation 1

In this section an optimum farm plan is developed under the actual resource structure and enterprise alternatives. Activities and resources in the optimum plan are shown in Tables 7 and 8. This plan yields a net farm income of $18,348.27. The existence of unused resources is noted in Table 8. There are 1123.5 hours of unused labor annually, 22 hours of unused May labor and 47.4 hours of tractor and 213.24 square feet of hog finishing space idle on the farm.

In Table 9, actual and optimum plans are compared. There is a close similarity between the two plans. This is an indicator that the operator is working close to the optimal

Table 7. Situation 1--activities in the optimum plan

Activity Number	Activity	Level	Marginal Value Productivity
P01	CCOMM rotation	185 acres	--
P02	Corn on rented land (50% crop share)	20 acres	+ 90.86
P03	Hay on rented land (50% crop share)	20 acres	+ 60.18
P04	Corn selling	3,828 bu	--
P05	Hay selling	253.26 ton	--
P06	Oat selling	2,220 bu	--
P07	Straw selling	46.25 ton	--
P08	Unimproved timber pasture	46.25 acres	--
P12	Rented unimproved timber pasture	46.25 acres	--
P16	Borrow operating capital	$14,952.77	--
P17	Borrow intermediate capital	$61,419.25	--
P18A	Borrow long term capital (FHA)	$83,250.00	--
P22	Beef cows	46 head	--
P23	Steer finished	20 head	--
P26	Feeder heifer selling	13 head	--
P27	Finished steer selling	20 head	--
P29	Cull cow selling	6 head	--

Table 7. (continued)

Activity Number	Activity	Level	Marginal Value Productivity
P30	Purchase steer calves	74 head	--
P32	Background steer raising	74 head	--
P34	Sell background steer	74 head	--
P36	Hog farrowing	30.00 litters	--
P37	Hog finished	229 head	--
P38	Sell hogs	229 head	--
P40	Sell cull sows	21 head	--

Table 8. Situation 1--resource use in the optimum plan

Resources	Used	Unused	Marginal value productivity
Cropland (acre)	185	--	112.03
Annual labor (man hours)	1,476.5	1,123.5	--
May labor (man hours)	154	22	--
Tractor (hours)	111	47.4	--
Cattle finishing space (sq ft)	2,000	--	0.86
Hog finishing space (sq ft)	286.76	213.24	--
Farrowing facility (litter)	30.00	--	204.35
Operating capital ($)	14,952.77	--	--
Intermediate capital ($)	61,419.25	--	--
Long term capital ($) from FHA[a]	83,250.00	--	--

[a]FHA refers to loans from the Farmers Home Administration.

Table 9. Actual plan and optimum plan for the case farm

Actual Plan		Optimum Plan	
Enterprise	Level	Enterprise	Level
CCOMM	185 acres	CCOMM	185 acres
Corn on rented land	20 acres	Corn on rented land	20 acres
Hay on rented land	20 acres	Hay on rented land	20 acres
Beef cows	40 head	Beef cows	46 head
Background calves	20 head	Background calves	74 head
Pigs farrowed	30 litters	Pigs farrowed	30 litters
Hogs finished	240 head	Hogs finished	229 head

situation. The major difference between the two plans is the number of background calves produced which increases to 74 head in the optimum plan. This result deviates from the present farm organization because of the capital limitations of the operator for this enterprise, and the risk involved in feeding cattle especially after several years of severe losses by cattle feeders.

The existence of unused resources within the farm illustrates a condition for farm growth. The amount of idle resources might be used for future expansion. Thus, potential areas for growth must be identified before a decision is made as to which area will lead to the most profitable and greatest economic growth. The linear programming analysis identifies potential areas for profitable expansion through the shadow prices or the value added to the objective function of the last unit of the resource used in production.

Programming results show that income was increased by $112.03 for the last unit of land resource used in production. The range analysis indicates that this value would remain the same up to 33 acres given that all prices and constraints remain constant. This can be interpreted as meaning if an additional acre of land could be acquired at a cost of less than $112.03 it would increase net farm income. Also, the marginal value productivities for the land using activities PO2 and PO3 (see Table 7) indicate that an additional acre of

cropland used in these activities would raise net farm income by the amount reflected in their shadow prices. Thus, addition of cropland to the farm will be considered as a potential area of business expansion.

Additional hog farrowing facilities are identified as another area of farm growth. Results show that the last unit of farrowing capacity added $204.35 to farm income. The range analysis indicates that this value is relevant (ceteris paribus) up to 52 litters of farrowing facilities. This would suggest that if new farrowing facilities are built at a cost of less than $204.35 per additional litter space, net farm income would be positively affected.

In the sections below it is intended to analyze the conditions under which farm business growth would be profitable. The conditions refer mainly to those that arise from the acquisition of highly limiting resources of production, like land and hog farrowing facilities.

Situation 2

In this section an optimum plan is derived for an increased farm size. To consider the possibility of acquiring additional land, a land purchasing activity was placed into the model (P13). A long term capital borrowing activity was included to provide the supply of capital necessary to undertake such an investment if economically feasible (P18B).

Since the amount of available May labor is the most limiting factor in this situation a May hired labor activity was added to the model (P14).

Programming results are shown in Tables 10 and 11. They reflect the economic feasibility of adding 79 more acres of cropland. The marginal value productivity of long term capital indicates that the last dollar employed in the program yielded a return of 10 percent. Since the interest rate on borrowing capital for land purchase purposes is 9 percent, the return on capital would be greater than the interest charge.

The optimum combination of enterprises after the 79 acres of land are added, is diversified among CCOMM rotation, cattle and swine activities. Swine production remains unchanged at 30 litters a year. The beef cow calf raising herd increases from 40 to 66 head. The background calf herd increases from 20 to 49 head. The added acreage provides the needed corn and hay, leaving 1,386 bushels of corn and 375 tons of hay for sale. Thirty hours of additional May labor are hired to meet peak crop requirements with the added land.

Table 11 shows the marginal value productivities of scarce resources. These values indicate how net farm income would increase if one additional unit of resource were available for production.

The marginal value productivity on the corn production activity (PO2) indicates that if one additional acre of land

Table 10. Activities in the optimum plan with added cropland

Activity Number	Activity	Level	Marginal Value Productivity
P01	CCOMM rotation	264 acres	--
P02	Corn on rented land (50% crop share)	20 acres	+ 83.49
P03	Hay on rented land (50% crop share)	20 acres	+ 46.31
P04	Corn selling	7,386.64	--
P05	Hay selling	375.79 ton	--
P06	Oat selling	3,168.00 bu	--
P07	Straw selling	66 ton	--
P08	Unimproved timber pasture	66 acres	--
P12	Rented unimproved timber pasture	66 acres	--
P13	Land purchase	79 acres	--
P15	May labor hire	30 hours	--
P16	Borrow operating capital	$15,378.71	--
P17	Borrow intermediate capital	$69,813.00	--
P18A	Borrow long term capital from FHA	$83,250.00	--
P18B	Borrow long term capital from FLB	$82,950.00	--
P22	Beef cows	66 head	--

Table 10. (continued)

Activity Number	Activity	Level	Marginal Value Productivity
P23	Finish steers to slaughter weight	29 head	--
P26	Sell feeder heifers	19 head	--
P27	Sell finished steers	29 head	--
P29	Sell cull cows	9 head	--
P30	Purchase steer calves	49 head	--
P32	Finish background steers	49 head	--
P34	Sell background steers	49 head	--
P36	Hog farrowing	30 litters	--
P37	Finish hogs	229 head	--
P38	Sell hogs	229 head	--
P40	Sell cull sows	21 head	--

Table 11. Resource use in the optimum plan with added cropland

Resources	Used	Unused	Marginal value productivity
Cropland (acre)	264	--	74.20
Annual labor (man hours)	1,723.6	876.4	--
May labor (man hours)	206	--	4.83
Tractor (hours)	158.4	--	62.68
Cattle finishing space (sq ft)	2,000	--	0.863
Hog finishing space (sq ft)	286.76	213.24	--
Hog farrowing facilities (litter)	30	--	204.35
Operating capital ($)	15,387.71	--	--
Intermediate capital ($)	69,813.00	--	--
Long term capital from FHA ($)	83,250.00	--	--
Long term capital from FLB ($)	82,950.00	--	0.10

were rented and dedicated to this activity, net farm income would be increased by $83.49. This same interpretation is valid for the marginal value productivity on the hay production activity (PO3).

Linear programming results demonstrated the economic feasibility of the land purchase. In addition to this, the financial feasibility is considered in the section below.

Cash flow analysis of the land purchase

The analysis of prospective investments cannot occur in isolation from their means of financing. Self financing of farm expansion is seldom feasible. The inability of owner savings to provide the funds needed for investment in land, and the traditional seasonality of cash flows in many types of farming place great emphasis on borrowing and efficient credit use (3). Then the cash flow consequences of a land purchase should be carefully evaluated before a decision is made.

This section will concentrate on the financial analysis of purchasing an 80 acre add-on unit. The asking price for the land is $1,500.00 per acre. The total investment amounts to $120,000. The sources of financing are assumed to be a 70 percent loan from the Federal Land Bank and a 30 percent down payment from the owner's equity. The interest rate in the loan is a nominal rate of 9 percent. The total amount of

the loan is $84,000 to be amortized in 30 years. Given these conditions, the cash flow requirements to cover principal and interest annually are $102.20 per added acre.

The cash outflows considered are those cash costs of production to be incurred in operating the add-on unit. They are operating costs, real estate taxes and interest on operating capital. For purposes of simplicity no income tax considerations were made[1].

In estimating the cash inflows it was assumed that the operator will not use the cash generated from the unit he is managing presently to make the principal and interest payments on the new acquisition, but will rely solely on the proceeds generated by the new unit to defray the annual debt service. In deriving the gross returns from the crop enterprise, it was necessary to consider expected yields and commodity prices. The following considerations were made:

1. The yields the farmer has on present land can be sustained on the added land. Yields per acre were estimated to be 120 bushels for corn, 60 bushels for oats, 1.25 tons

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[1]The importance of income taxes in making projections of future cash flows is recognized eventhough they are not taken into account. Considerations should be made about which components of cash flows are tax deductible and which are not. Adjustments for income taxes are important, since at high levels of income, before-tax and after-tax incomes may differ substantially.

for straw, and 4.5 tons for hay.

2. Due to a great deal of price uncertainty for future years, and in recognition that prices are low presently relative to cost of production, three price levels for commodities were used to determine gross returns to land (Table 12). In doing this, a historical series of relative prices were estimated taking the price of corn as the base for the period 1969-1976 (see Table 13). This historical trend shows that the price of oats has been on the average 0.55 times the price of corn, and the price of hay per ton has averaged 17 times the price of corn per bushel. By these means three gross return per acre figures were derived.

Table 12. Level of prices used in the study ($)

	Low	Medium	High
Corn (bu)	2.00	2.25	2.50
Hay (ton)	34.00	38.25	42.50
Oats (bu)	1.10	1.24	1.40
Straw (ton)	25.50	28.70	31.88

The net cash flows generated by each acre under three commodity price assumptions are shown in Table 14. The net cash flows reflect the cash amount per acre that would be available to cover principal and interest payments.

Table 13. Historical relative prices, northeast Iowa

Years	Corn[a] (bu)	Oats/Corn	Hay/Corn
1969	1.14	0.56	18.05
1970	1.22	0.52	16.6
1971	1.26	0.55	16.4
1972	1.16	0.66	18.6
1973	1.86	0.52	13.9
1974	2.92	0.49	13.7
1975	2.71	0.56	18.9
1976	2.48	0.60	22.9

[a]Iowa average price received plus 5¢/bu for corn in northwest Iowa.

Table 14. Net cash flow per acre under three commodity price assumptions

	High Commodity Prices ($/acre)	Medium Commodity Prices ($/acre)	Low Commodity Prices ($/acre)
1. Cash inflows	223.27	198.90	176.76
2. Cash outflows	70.45	70.45	70.45
Operating Costs	61.25	61.25	61.25
Real Estate Tax	7.00	7.00	7.00
Interest on operating Capital	2.45	2.45	2.45
3. Net Cash Flow (1-2)	152.82	128.45	106.33

After comparing the cash available under three levels of commodity prices to the cash requirements for principal and interest payments ($102.20 per acre), the conclusion is that the land at the present price will "pay its own way." The net cash flow available would be more than sufficient to cover the annual debt service for the levels of commodity prices considered. According to his cash flow situation the maximum price the farmer could pay for an acre of land is $2,293.56 under high commodity prices, $1,927.81 under medium commodity prices, and $1,595.75 under low commodity prices. Under these conditions it would be financially feasible to undertake the land investment.

Total farm financial feasibility of land purchase

The purpose of this analysis is to determine the financial feasibility of the land purchase given the actual debt structure of the farm. The 30 year projected cash flow (see Table 15) shows whether other debts may interfere with payments on the new land and whether financial progress is being made.

To incorporate the 80 acre purchase within the financial structure of the farm it is necessary to refinance the present land loan together with the new land loan. The remaining principal on the present land loan is $98,772. The new land purchase requires a $120,000 investment. This total

Table 15. Per acre projected net cash flows ($/acre)

		Years					
		1	2	3	4	5	6
1.	Cash inflows	176.76	176.76	176.76	176.76	176.76	176.76
2.	Cash outflows	156.13	156.13	156.13	145.60	145.60	145.60
2.1	Operating costs	61.25	61.25	61.25	61.25	61.25	61.25
2.2	Real estate tax	7.00	7.00	7.00	7.00	7.00	7.00
2.3	Interest on operating capital	2.45	2.45	2.45	2.45	2.45	2.45
2.4	Periodic payment on machinery	10.53	10.53	10.53	0	0	0
2.5	Periodic payment on tractor loan	8.23	8.23	8.23	8.23	8.23	8.23
2.6	Periodic payment on land loan	66.92	66.92	66.92	66.92	66.92	66.92
NET CASH FLOW		20.63	20.63	20.63	31.16	31.16	31.16

Table 15. (continued)

		Years					
		7	8	9	10	11	12
1.	Cash inflows	176.76	176.76	176.76	176.76	176.76	176.76
2.	Cash outflows	137.37	137.37	137.37	137.37	137.37	137.37
2.1	Operating costs	61.25	61.25	61.25	61.25	61.25	61.25
2.2	Real estate tax	7.00	7.00	7.00	7.00	7.00	7.00
2.3	Interest on operating capital	2.45	2.45	2.45	2.45	2.45	2.45
2.4	Periodic payment on machinery	0	0	0	0	0	0
2.5	Periodic payment on tractor loan	0	0	0	0	0	0
2.6	Periodic payment on land loan	66.92	66.92	66.92	66.92	66.92	66.92
NET CASH FLOW		39.39	39.39	39.39	39.39	39.39	39.39

Table 15. (continued)

		Years					
		13	14	15	16	17	18
1.	Cash inflows	176.76	176.76	176.76	176.76	176.76	176.76
2.	Cash outflows	137.37	137.37	137.37	137.37	137.37	137.37
2.1	Operating costs	61.25	61.25	61.25	61.25	61.25	61.25
2.2	Real estate tax	7.00	7.00	7.00	7.00	7.00	7.00
2.3	Interest on operating capital	2.45	2.45	2.45	2.45	2.45	2.45
2.4	Periodic payment on machinery	0	0	0	0	0	0
2.5	Periodic payment on tractor loan	0	0	0	0	0	0
2.6	Periodic payment on land loan	66.92	66.92	66.92	66.92	66.92	66.92
NET CASH FLOW		39.39	39.39	39.39	39.39	39.39	39.39

Table 15. (continued)

		Years					
		19	20	21	22	23	24
1.	Cash inflows	176.76	176.76	176.76	176.76	176.76	176.76
2.	Cash outflows	137.37	137.37	137.37	137.37	137.37	137.37
2.1	Operating costs	61.25	61.25	61.25	61.25	61.25	61.25
2.2	Real estate tax	7.00	7.00	7.00	7.00	7.00	7.00
2.3	Interest on operating capital	2.45	2.45	2.45	2.45	2.45	2.45
2.4	Periodic payment on machinery	0	0	0	0	0	0
2.5	Periodic payment on tractor loan	0	0	0	0	0	0
2.6	Periodic payment on land loan	66.92	66.92	66.92	66.92	66.92	66.92
NET CASH FLOW		39.39	39.39	39.39	39.39	39.39	39.39

Table 15. (continued)

		Years					
		25	26	27	28	29	30
1.	Cash inflows	176.76	176.76	176.76	176.76	176.76	176.76
2.	Cash outflows	137.37	137.37	137.37	137.37	137.37	137.37
2.1	Operating costs	61.25	61.25	61.25	61.25	61.25	61.25
2.2	Real estate tax	7.00	7.00	7.00	7.00	7.00	7.00
2.3	Interest on operating capital	2.45	2.45	2.45	2.45	2.45	2.45
2.4	Periodic payment on machinery	0	0	0	0	0	0
2.5	Periodic payment on tractor loan	0	0	0	0	0	0
2.6	Periodic payment on land loan	66.92	66.92	66.92	66.92	66.92	66.92
NET CASH FLOW		39.39	39.39	39.39	39.39	39.39	39.39

is rounded to $220,000 of land debt. Present equity and inflated land value would be used to meet the down payment requirement of $66,000.

Since land values have been increasing very rapidly during the last few years, it is possible to inflate the existing land value to support the $220,000 loan. The present 240 acre tract value is adjusted to its estimated current market value of $240,000 ($1,000 per acre). The new 80 acre unit has a market value of $120,000. Then the total land tract is valued at $360,000, an amount which can favorably support the loan in question.

The Federal Land Bank conditions for the $220,000 loan are assumed to be a nominal interest rate of 9 percent and a 30 year amortization period. The required annual payment amounts to $21,414. The annual cash flow requirements to cover principal and interest are $66.92 per acre.

The total farm cash flow analysis (Table 15) is based on the assumptions that low commodity prices prevail, gross returns from the land will continue indefinitely and that family consumption expenditures are covered by the operator's wife nonfarm income. Thus, neither the wife's income is considered as an inflow nor consumption expenses as an outflow. For purposes of simplicity no income tax considerations were introduced (see footnote 1 on page 35). The 30 year projected net cash flows indicate that enough cash will be

available to defray principal and interest payments till the debt is completely amortized in year 30. Thus, it demonstrates the total farm financial feasibility of the land purchase.

This study considers equity as that portion of the value of a resource not pledged as security for a loan. As one might expect, investments on real estate assets would increase owner equity and annual income. Thus, the farm financial progress after the land purchase, will be studied by analyzing the average annual rate of equity growth.

Programming results showed that net farm income was increased by $2978.64 after the land purchase, this represents an increment of 16 percent in net farm income due to the increased volume of production. Taking into account the current market value of the land, the initial equity is estimated to be $140,000. Assuming that land values would remain unchanged in the future, changes in land equity position are derived for 7 different projection periods (see Table 16). The average annual rate of land equity growth reflect the progressive increase in equity as time passes. During the first five years of the period land equity grew at 2 percent annually while for the last five years this rate went up to 5 percent annually. This is a good indicator of financial progress within the farm. Both net income and equity have been positively affected by the new land investment.

Table 16. Changes in land equity for seven different projection periods

Year	Outstanding Principal ($)	Land Equity ($)	Average Annual Rate of Land Equity Growth (%)
1	220,000	140,000	--
5	210,341	149,659	2
10	195,479	164,521	2
15	172,612	187,388	3
20	137,427	222,573	4
25	83,293	276,707	5
30	--	360,000	5

In view of the sharp increase in Iowa land values through the years a new series of changes in land equity were derived assuming a 6 percent annual rate of appreciation in land values[1] (see Tables 17 and 18). In this case two factors are inducing land equity growth, first, the 6 percent gain in value and second, the progressive decrease in land debt. By comparing the average annual rates of land equity growth before and after gains in land values are taken into account, it is found that due to the inflation in land values, equity grows at a higher rate for each one of the periods considered. It

[1] "1976 Iowa land value survey" (18b).

Table 17. Projected land values assuming a 6 percent rate of appreciation

Year	Land Value ($)
1	360,000
5	468,000
10	608,400
15	790,920
20	1,028,196
25	1,336,654
30	1,737,650

Table 18. Changes in land equity position considering land value appreciation

Year	Outstanding Principal ($)	Land Equity ($)	Average annual rate of land equity growth (%)
1	220,000	140,000	--
5	210,341	257,659	16.8
10	195,479	412,921	12.01
15	172,612	618,308	9.9
20	137,427	890,769	8.8
25	83,293	1,253,361	8.14
30	--	1,737,650	7.7

is important to note that after inflating land values, rates of land equity growth are decreasing along the period in study. The reason for this is the high level of financial leverage during the first years of the period, which tends to accelerate the rate of equity growth. It seems to be a positive correlation between the level of financial leverage and the rate of equity growth. As land appreciates in value, the leverage ratio decreases and consequently smaller growth rates are observed.

Situation 3

This section will analyze the addition of hog farrowing facilities as a source of farm growth. The number of litters farrowed at present is physically restricted at 30 per year. It was found in "Situation 1" that relaxing this constraint would increase net farm income. A hog housing construction activity was included in the programming model, to allow farrowing facilities to be built if economically feasible. Assuming fixed costs as 7 percent depreciation, 2 percent insurance and tax, and 3 percent for repairs, a $36 annual ownership cost per unit added of farrowing space was considered. The size of the building was restricted to less than or equal to 60 annual litter capacity.

Activities and resources in the optimum plan are shown in Tables 19 and 20.

Table 19. Activities in the optimum plan after adding new hog farrowing facilities

Activity Number	Activity	Level	Marginal Value Productivity
P01	CCOMM rotation	185 acres	--
P02	Corn on rented land	20 acres	+ 136.03
P03	Hay on rented land	20 acres	+ 46.68
P05	Hay selling	243 ton	--
P07	Straw selling	46.25 ton	--
P08	Unimproved timber pasture	46.25 acres	--
P12	Rented unimproved timber pasture	46.25 acres	--
P16	Borrowing operating capital	$22,065.58	--
P17	Borrowing intermediate capital	$102,129.25	--
P18A	Borrowing long term capital (FHA)	$83,250.00	--
P22	Beef cow-calf herd	46 head	--
P25	Feeder steer selling	20 head	--
P26	Feeder heifer selling	13 head	--
P29	Sell cull sows	6 head	--
P30	Purchase steer calves	133 head	--
P32	Raise background steers	133 head	--

Table 19. (continued)

Activity Number	Activity	Level	Marginal Value Productivity
P34	Sell background steers	133 head	--
P36	Hog farrowing	90 litters	--
P37	Finish hogs	386 head	--
P38	Sell hogs	386 head	--
P39	Sell feeder pigs	307 head	--
P40	Sell cull sows	63 head	--
P43	New hog farrowing facilities	60 litters	+ 43.48

Table 20. Resource level in optimum plan after new farrowing facilities are added

Resources	Used	Unused	Marginal value productivity
Cropland (acres)	185.0	--	151.81
Annual labor (man hours)	2,262.7	337.3	--
May labor (man hours)	154.0	22.0	--
Cattle finishing space (sq ft)	2,000.0	--	0.077
Hog finishing space (sq ft)	483.5	16.5	--
Tractor (hours)	111.0	47.4	--
Hog farrowing capacity (litter)	90.0	--	90.73
Operating capital ($)	22,065.58	--	--
Intermediate capital ($)	102,129.25	--	--
Long term capital from FHA ($)	83,250.00	--	--

Programming results indicate that it is economically feasible to construct a hog housing with capacity for farrowing 60 litters of pigs. In this situation the number of pigs farrowed increased to 90 litters a year. The number of hogs produced increased to 386 head of market hogs and 307 head of feeder pigs. There was little or no variation in the level of the other activities in the plan. Under this situation the most limiting resource is land, its marginal value productivity reflects that the last acre used in production added $151.81 to farm income. Another feature of this situation is the high marginal value productivity of farrowing facility resource, which means that relaxing the restriction imposed to the number of litters farrowed would increase net farm income. The $43.48 marginal value productivity in tne hog housing construction activity indicates that one additional litter capacity would increase net farm income by that amount. The range analysis shows that this value stays the same up to 103 litter capacity. Although the construction of a bigger hog house seems to be profitable this alternative was not considered in the model due to the capital limitations of this operator.

In demonstrating the financial feasibility of adding a 60 litter capacity farrowing facility, it is necessary to analyze the ability of this investment to generate sufficient income to meet annual principal payments. The hog house

construction calls for an $18,000 investment. This amount would be financed with a Farmers Home Administration loan. The requirements on this loan are, a 10 percent down payment, a nominal interest rate of 7-1/2 percent and 7 year amortization period. The cash flow requirements to amortize annual principal amounts to $2,314.29. The interest payments are accounted for in the model. The down payment would come from present equity without interfering with payments on other debts.

After the hog house addition, net farm income increased by $6,036.83. This represents an increment of 33 percent from its original level before the hog enterprise expansion. The expected increase in net farm income is sufficient to repay the loan within its maturity period. This capacity of repayment and the self-liquidating nature of the livestock investments lead to the conclusion that it is financially feasible to construct a 60 litter capacity hog house.

The estimated life of this hog facility is 15 years. Since the loan term is shorter than the depreciable life of the building, the income generated in excess of the debt payment could be either invested or saved. Thus, the investment in question would increase owner equity and consequently make an important contribution to farm growth.

Situation 4

The purpose of this section is to analyze the feasibility of expanding the swine enterprise through the addition of both a farrowing house and a hog finishing facility. Using the preceding situation, the model was modified by including an activity which allows for constructing a hog finishing facility if economically advisable. The activities and resource level in the optimum plan are illustrated in Tables 21 and 22. Programming results indicate that it is economically feasible to build a hog farrowing house with capacity for farrowing 60 litters of pigs, and a hog finishing facility with capacity for finishing 288 hogs.

In this situation the optimum plan is dominated by swine enterprise with a production of 688 market hogs. Because corn production is not sufficient to meet needs of the hog activities 3,982 additional bushels of corn are bought at the price of $2.10 per bushel. The crop and cattle enterprise levels remained unchanged.

Net farm income is increased by $7573.30. This amount represents an increment of 41 percent in net income due to the larger volume of hog production.

The new farrowing and finishing facilities require a $23,250 investment. The means of financing would be an intermediate term loan from the Farmers Home Administration. The conditions for the loan are a $2,325 down payment, a

Table 21. Activities in the optimum plan after hog farrowing and finishing facilities are added

Activity Number	Activity	Level	Marginal Value Productivity
P01	CCOMM rotation	185 acres	--
P02	Corn on rented land (50% crop share)	20 acres	+ 99.11
P03	Hay on rented land (50% crop share)	20 acres	+ 46.68
P05	Hay selling	253 ton	--
P06	Oat selling	2,220 bushels	--
P07	Straw selling	46.25 ton	--
P08	Unimproved timber pasture	46.25 acres	--
P12	Rented unimproved timber pasture	46.25 acres	--
P16	Borrow operating capital	$27,632.52	--
P17	Borrow intermediate capital	$104,756.39	--
P18A	Borrow long term capital from FHA	$83,250.00	--
P22	Beef cow-calf herd	46 head	--
P23	Finish steers	20 head	--
P26	Feeder heifer selling	13 head	--
P27	Finished steer selling	20 head	--
P29	Cull cows selling	6 head	--
P30	Purchase steer calves	74 head	--

Table 21. (continued)

Activity Number	Activity	Level	Marginal Value Productivity
P32	Finish background steers	74 head	--
P34	Sell background steers	74 head	--
P36	Hog farrowing	90 litters	--
P37	Finish hogs	688 head	--
P38	Sell hogs	688 head	--
P40	Sell cull sows	63 head	--
P41	New hog finishing facility capacity	288 head	--
P43	New farrowing facility	60 litters	+101.62
P46	Corn buying	3,982 bushels	

Table 22. Resource use in the optimum plan after new hog farrowing and finishing facilities are added

Resources	Used	Unused	Marginal value Productivity
Cropland (acres)	185.0	--	123.63
Annual labor (man hours)	2,351.0	249.0	--
May labor (man hours)	154.0	22.0	--
Tractor (hours)	111.0	47.4	--
Cattle finishing space (sq ft)	2,000.0	--	0.63
Hog finishing space (sq ft)	500.0	--	2.29
Operating capital ($)	27,632.52	--	--
Intermediate capital ($)	104,756.39	--	--
Long term capital ($)	83,250.00	--	--
Hog farrowing facilities (litter)	90	--	148.87

nominal interest rate of 7-1/2 percent, and a 7 year amortization term. The cash flow requirements to amortize annual principal are $2,989.29. It is expected that the increased annual net income would be sufficient to cover annual principal payments. The $2,325 down payment would be paid from present owner equity without affecting the solvency position of the farm. Given the operator's capacity for financing a down payment and the self-liquidating nature of the expanding hog facilities, the investment is financially feasible. Given that the loan maturity is shorter than the depreciation period of such facilities, an increased income flow would be available for investment or saving purposes. Owner equity would be substantially increased, favoring farm growth.

SUMMARY AND CONCLUSIONS

The major objective of this study was to determine the economic and financial feasibility of farm growth through expansion of existing resources with additional labor, land or livestock facilities.

The farm selected for this study is owner operated with some rented land. The total area of the farm is 360 acres, of which the operator owns 240 acres and rents 120 acres. Forty acres are rented on a 50 percent crop share basis and eighty acres on a cash basis. The farm business was started five years ago. It is in the Fayette soil association. The present organization of the farm includes a corn-corn-oats-meadow-meadow rotation on owned land, and corn and hay productions on the rented land. The livestock enterprises include a beef cow calf herd, a background calf herd and swine production (spring and fall farrowings). The farm resources include land, machinery, buildings and the operator's labor and management.

This farm's owner has as a goal to expand his business operations and in turn increase farm income and equity. In examining the possible ways of achieving his objective, the financial criterion of farm growth was followed. It considers the rate of increase of owner equity as the adequate measure of farm business growth.

The linear programming technique was used to identify

possible areas of farm expansion and to determine optimum production plans under alternative resource situations. The model used in the study consists of 45 production, resource, selling and investment activities, and 32 restrictions and transfer rows.

Four farm situations were analyzed in the development of the study.

In "Situation 1" an optimum farm plan was developed under the actual resource structure and enterprise alternatives. Optimal and actual plans were compared. A close similarity between the two plans was found, indicating that the operator is working close to the optimal situation. The existence of unused resources showed that conditions for farm growth exist. The idle resources could be used in the process of farm expansion. The linear programming results identified potential areas for profitable expansion, through evaluation of the shadow prices or the value added to the objective function of the last unit of the resource used in production. Two areas of growth potential were identified: addition of cropland and addition of farrowing facilities. The results of this situation led to acceptance of the hypothesis that potentials exist for farm growth through the addition of land and/or livestock facilities.

"Situation 2" considered the economic and financial feasibility of acquiring additional land. Programming

results indicated the economic feasibility of adding 79 more acres of cropland. An optimum production plan was developed for the increased farm size. This plan was diversified among CCOMM rotation, cattle and swine activities. In this situation the amount of May labor was the most limiting factor, thus, thirty hours of additional May labor were hired to meet peak crop requirements with the added land. The financial feasibility of the land addition was studied by developing a simplified cash flow analysis and considering the operator's ability to acquire necessary debt capital. The land purchase requires an investment of $120,000. The cash flow projections are on a before-tax basis and based on the assumptions that gross returns from the land will continue indefinitely, and that family consumption expenditures are covered by the operator's wife off farm income. Two cash flow analyses were developed. The first one considered only the cash generated and costs incurred on managing the new unit. The second one took into account the actual debt structure of the farm. The cash flows attributable to both present and new unit were considered. The second analysis was done to detect the possible interference of other debts with payments on the new land and to study the farm financial progress along the years. The resulting net cash flows showed that under the assumptions stated above the land purchase is financially feasible. Enough cash will be available to cover principal and interest

payments on the new acquisition. The land purchase generated a 16 percent increment in net farm income and rising rates of equity growth. Also, the expected appreciation in land values contributed to obtain higher rates of equity growth. The absence of income tax considerations in projecting future cash flows limit the scope of this analysis. Adjustments for income taxes are important, since at high levels of income, before-tax and after-tax incomes may differ substantially. In further research it would be advisable to consider income taxes in estimating net cash flows.

In "Situation 3" the economic and financial feasibilities of adding hog farrowing facilities were analyzed. The programming results showed that it is economically feasible to construct a hog house with capacity for farrowing 60 litters of pigs. An optimum plan with the new facility was developed. This plan is dominated by swine production, the number of hogs produced increased substantially. The level of other production activities was not affected by the new acquisition. The hog house construction calls for an $18,000 investment. Net farm income was increased by 33 percent after adding the new facility, then it was assumed that this investment would generate sufficient income to meet annual principal payments. This capacity of repayment and the self-liquidating nature of the livestock investments led to the conclusion that the investment is financially feasible.

"Situation 4" studied the possibility of expanding the swine enterprise through the addition of both a farrowing house and a hog finishing facility. Programming results demonstrated the economic feasibility of building a hog farrowing house with capacity for farrowing 60 litters of pigs, and a hog finishing facility with capacity for finishing 288 hogs. The volume of hog production in the optimum plan increased to 688 market hogs after including the new facilities. It was necessary to buy additional corn to meet needs of the hog activities. These new facilities require a $23,250 investment. The cash flow requirements to amortize annual principal payments are expected to be provided by the increased annual net income. The increment in net farm income produced by the new investment is 41 percent. The financial feasibility of this investment was assumed after evaluating the repayment capacity and the self-liquidating nature of the expanding hog facilities. The income generated by these facilities in excess of the debt payment requirements is assumed to be allocated either to savings or new investments which add to net worth. Thus, these new facilities would contribute substantially to farm growth.

Given the capital limitations of this young operator, in the short run it seems to be advisable to add the livestock facilities which require a smaller capital investment and generate a higher increment in net farm income than the land

purchase. The net returns from the livestock investment could be allocated to the land purchase once the livestock debt is completely amortized. In making the decision on investment priority the farmer must also consider the availability of land for an add on unit. Timing of land availability makes this investment less flexible than the livestock expansion that could take place almost at any time.

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APPENDIX A: INPUT-OUTPUT COEFFICIENTS USED IN THE STUDY

Table A-1. Per acre input-output coefficients for crop-pasture enterprises[a]

Enterprise	Land (acres)	Capital[b] ($)	Annual Labor (man hrs)	May Labor (man hrs)	Tractor (hrs)
CCOMM	1	27.2	2.3	0.66	0.60
Corn on rented land[c]	1	20.5	1.1	0.50	--
Hay on rented land[d]	1	6.9	1.9	1.1	--
Unimproved timber pasture	1	--	--	--	--
Improved timber pasture	1	17.0	--	--	--

[a]Source: ISU Cooperative Extension Service.

[b]Includes only annual operating expenses.

[c,d]The coefficients for corn and hay on rented land represent a 50 percent of the input requirements (crop share).

Table A-2. Input-output coefficients for livestock enterprises[a]

Enterprises	Unit	Capital[b] ($)	Pasture AUM	Corn (bu)	Corn Stover (ton)	Hay (ton)	Building Space (sq ft)	Annual Labor (man hrs)
Beef cows	head	8.5	6.0	--	3.2	1.2	--	5.3
Steer calves	head	16.0	--	64	--	1.2	42	4.0
Heifer calves	head	15.65	--	56	--	1.0	42	4.0
Background steer	head	6.60	--	13.5	--	0.59	15	3.0
Background heifer	head	6.60	--	22.1	--	0.15	15	3.0
Hog farrowing	litter	23.0	--	43.0	--	--	--	10.0
Hog finishing	head	6.4	--	11.4	--	--	1.25	0.60

[a]Source: ISU Cooperative Extension Service.

[b]Includes only annual operating expenses.

APPENDIX B: COMPUTER OUTPUT REPORTS FOR THE FOUR SITUATIONS STUDIED

Situation 1

Section 1 - Rows

No.	Row	AT	Activity	Slack Activity	Lower Limit	Upper Limit	Dual Activity
1	C	BS	18343.27439	18348.27439-	None	None	1.00000
2	R01	UL			None		4.50000-
3	R02	UL			None		4.50000-
4	R03	UL			None		112.03353-
5	R04	UL			None		5.00000-
6	R05	UL			None		.07500-
7	R06	UL			None		.07500-
8	R07A	UL			None		.05000-
9	R07B	BS			None		
10	R08	BS	47.40000-	47.40000	None		
11	R09	UL	2000.00000		None	2000.00000	.86300-
12	R10	BS	286.76471	213.23529	None	500.00000	
13	R11	UL			None		2.00000-
14	R12	UL			None		14.92941-
15	R13	UL			None		34.00000-
16	R14	UL			None		1.10000-
17	R15	UL			None		25.00000-
18	R16	UL			None		1.66667-
19	R17	UL			None		40.00000-
20	R18	UL			None		49.16089-
21	R19	UL			None		28.00000-
22	R20	UL			None		44.00000-
23	R21	UL			None		43.00000-
24	R22	BS			None		
25	R23	UL			None		47.50000-
26	R24	UL			None		39.44000-
27	R25	UL			None		42.00000-
28	R26	UL			None		38.00000-
29	R27	UL			None		48.25490-
30	R28	UL			None		33.00000-
31	R29	UL			None		38.00000-
32	R30	UL	30.00000		None	30.00000	204.35574-
33	R31	BS		1.00000	None	1.00000	

Situation 1

Section 2 - Columns

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
34	P01	BS	185.00000	61.20000-		None	
35	P02	UL	20.00000	27.60000-		20.00000	83.66250
36	P03	UL	20.00000	15.80000-		20.00000	46.68250
37	P04	BS	3828.07199	2.00000		None	
38	P05	BS	253.26381	34.00000		None	
39	P06	BS	2220.00000	1.10000		None	
40	P07	BS	46.25000	25.00000		None	
41	P08	BS	46.25000			None	
42	P09	LL		40.00000-		None	35.44167-
43	P10	UL	185.00000	7.00000-		185.00000	82.53353
44	P11	LL		7.00000-		35.00000	2.00000-
45	P12	BS	46.25000	10.00000-		80.00000	
46	P16	BS	14952.77341	.07500-		None	
47	P17	BS	61419.25000	.07500-		None	
48	P18A	BS	83250.00000	.05000-		None	
49	P19	EQ	1.00000	5440.90000-	1.00000	1.00000	7384.00000-
50	P22	BS	46.25000	34.06000-		None	
51	P23	BS	20.86389	38.53000-		None	
52	P24	LL		37.57000-		None	8.93975-
53	P25	LL		45.00000		None	4.16089-
54	P26	BS	57.81250	40.00000		None	
55	P27	BS	229.50278	44.00000		None	
56	P28	BS		43.00000		None	
57	P29	BS	64.75000	23.00000		None	
58	P30	BS	299.65778	46.00000-		None	
59	P31	LL		41.00000-		None	2.83500-
60	P32	BS	74.91444	30.00000-		None	
61	P33	BS		30.00000-		None	
62	P34	BS	524.40111	42.00000		None	
63	P35	BS		38.00000		None	
64	P36	BS	30.00000	92.07000-		None	
65	P37	BS	229.41176	16.00000-		None	

Situation 1

Section 2 - Columns (continued)

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
66	P38	BS	550.58824	38.00000		None	
67	P40	BS	84.00000	33.00000		None	
68	P44	BS	1476.47095	4.50000-		2600.00000	
69	P45	BS	154.10000	4.50000-		176.00000	

Situation 2

Section 1 - Rows

No.	Row	AT	Activity	Slack Activity	Lower Limit	Upper Limit	Dual Activity
1	C	BS	21326.91695	21326.91695-	None	None	1.00000
2	R01	UL			None		4.50000-
3	R02	UL			None		4.83750-
4	R03	UL			None		74.20000-
5	R04	UL			None		5.00000-
6	R05	UL			None		.07500-
7	R06	UL			None		.07500-
8	R07A	UL			None		.05000-
9	R07B	UL			None		.06400-
10	R08	UL			None		62.68463-
11	R09	UL	2000.00000		None	2000.00000	.86300-
12	R10	BS	286.76471	213.23529	None	500.00000	
13	R11	UL			None		2.00000-
14	R12	UL			None		14.92941-
15	R13	UL			None		34.00000-
16	R14	UL			None		1.10000-
17	R15	UL			None		25.00000-
18	R16	UL			None		1.66667-
19	R17	UL			None		40.00000-
20	R18	UL			None		49.16089-
21	R19	UL			None		28.00000-
22	R20	UL			None		44.00000-
23	R21	UL			None		43.00000-
24	R22	BS			None		
25	R23	UL			None		47.50000-
26	R24	UL			None		39.44000-
27	R25	UL			None		42.00000-
28	R26	UL			None		38.00000-
29	R27	UL			None		48.25490-
30	R28	UL			None		33.00000-
31	R29	UL			None		38.00000-
32	R30	UL	30.00000		None	30.00000	204.35574-
33	R31	BS		1.00000	None	1.00000	

Situation 2

Section 2 - Columns

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
34	P01	BS	264.00000	61.20000-		None	
35	P02	UL	20.00000	27.60000-		20.00000	83.49375
36	P03	UL	20.00000	15.80000-		20.00000	46.31125
37	P04	BS	7386.64455	2.00000		None	
38	P05	BS	375.79088	34.00000		None	
39	P06	BS	3168.00000	1.10000		None	
40	P07	BS	66.00000	25.00000		None	
41	P08	BS	66.00000			None	
42	P09	LL		40.00000-		None	35.44167-
43	P10	UL	185.00000	7.00000-		185.00000	44.70000
44	P11	LL		7.00000-		35.00000	2.00000-
45	P12	BS	66.00000	10.00000-		80.00000	
46	P13	BS	79.00000	7.00000-		None	
47	P15	BS	30.24000	4.50000-		None	
48	P16	BS	15387.71743	.07500-		None	
49	P17	BS	69813.00000	.07500-		None	
50	P18A	BS	83250.00000	.05000-		None	
51	P18B	BS	82950.00000	.06400-		None	
52	P19	EQ	1.00000	5440.90000-	1.00000	1.00000	2545.24489
53	P22	BS	66.00000	34.00000-		None	
54	P23	BS	29.77333	38.53000		None	
55	P24	LL		37.57000-		None	8.93975-
56	P25	LL		45.00000		None	4.16089-
57	P26	BS	82.50000	40.00000		None	
58	P27	BS	327.50667	44.00000		None	
59	P28	BS		43.00000		None	
60	P29	BS	92.40000	28.00000		None	
61	P30	BS	199.87200	46.00000-		None	
62	P31	LL		41.00000-		None	2.83500-
63	P32	BS	49.96800	30.00000-		None	
64	P33	BS		30.00000-		None	

Situation 2

Section 2 - Columns (continued)

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
65	P34	BS	349.77600	42.00000		None	
66	P35	BS		38.00000		None	
67	P36	BS	30.00000	92.07000-		None	
68	P37	BS	229.41176	16.00000-		None	
69	P38	BS	550.58824	38.00000-		None	
70	P39	LL		38.50000		None	9.75490
71	P40	BS	84.00000	33.00000		None	
72	P44	BS	1723.64439	4.50000-		2600.00000	
73	P45	UL	176.00000	4.50000-		176.00000	.33750

Situation 3

Section 1 - Rows

No.	Row	AT	Activity	Slack Activity	Lower Limit	Upper Limit	Dual Activity
1	C	BS	24385.10082	24385.10082-	None	None	1.00000
2	R01	UL			None		4.50000-
3	R02	UL			None		4.50000-
4	R03	UL			None		151.81661-
5	R04	UL			None		5.00000-
6	R05	UL			None		.07500-
7	R06	UL			None		.07500-
8	R07A	UL			None		.05000-
9	R07B	BS			None		
10	R08	BS	47.40000-	47.40000-	None		
11	R09	UL	2000.00000		None	2000.00000	.07747-
12	R10	BS	483.55263	16.44737	None	500.00000	
13	R11	UL			None		2.87281-
14	R12	UL			None		12.28984-
15	R13	UL			None		34.00000-
16	R14	UL			None		1.10000-
17	R15	UL			None		25.00000-
18	R16	UL			None		1.66667-
19	R17	UL			None		40.00000-
20	R18	UL			None		45.00000-
21	R19	UL			None		28.00000-
22	R20	UL			None		44.00000-
23	R21	UL			None		43.00000-
24	R22	BS			None		
25	R23	UL			None		47.50000-
26	R24	UL			None		37.29539-
27	R25	UL			None		42.00000-
28	R26	UL			None		38.00000-
29	R27	UL			None		38.50000-
30	R28	UL			None		33.00000-
31	R29	UL			None		38.00000-
32	R30	UL	30.00000		None	30.00000	90.73680-
33	R31	BS		1.00000	None	1.00000	

Situation 3

Section 2 - Columns

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
34	P01	BS	185.00000	61.20000-		None	
35	P02	UL	20.00000	27.60000-		20.00000	136.03092
36	P03	UL	20.00000	15.80000-		20.00000	46.68250
37	P04	LL		2.00000		None	.87281-
38	P05	BS	243.83333	34.00000		None	
39	P06	BS	2220.00000	1.10000		None	
40	P07	BS	45.25000	25.00000		None	
41	P08	BS	46.25000			None	
42	P09	LL		40.00000-		None	35.44167-
43	P10	UL	185.00000	7.00000-		185.00000	122.31661
44	P11	LL		7.00000-		35.00000	2.00000-
45	P12	BS	46.25000	10.00000-		80.00000	
46	P16	BS	22065.58114	.07500-		None	
47	P17	BS	102129.25000	.07500-		None	
48	P18A	BS	83250.00000	.05000-		None	
49	P18B	LL		.06400-		None	.06400-
50	P19	EQ	1.00000	5440.90000-	1.00000	1.00000	7384.00000-
51	P22	BS	46.25000	34.06000-		None	
52	P23	LL		38.53000-		None	4.14354-
53	P24	LL		37.57000-		None	24.82484-
54	P25	BS	93.88750	45.00000		None	
55	P26	BS	57.81250	40.00000		None	
56	P27	BS		44.00000		None	
57	P28	BS		43.00000		None	
58	P29	BS	64.75000	28.00000		None	
59	P30	BS	533.33333	46.00000-		None	
60	P31	LL		41.00000-		None	4.97961-
61	P32	BS	133.33333	30.00000-		None	
62	P33	BS		30.00000-		None	
63	P34	BS	933.33333	42.00000		None	
64	P35	BS		38.00000		None	

Situation 3

Section 2 - Columns (continued)

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
65	P36	BS	90.00000	92.07000-		None	
66	P37	BS	386.84211	16.00000-		None	
67	P38	BS	923.42105	38.00000		None	
68	P39	BS	307.42105	38.50000		None	
69	P40	BS	252.00000	33.00000		None	
70	P43	UL	60.00000	36.00000-		60.00000	43.48680
71	P44	BS	2262.73026	4.50000-		2600.00000	
72	P45	BS	154.10000	4.50000-		176.00000	

Situation 4

Section 1 - Rows

No.	Row	AT	Activity	Slack Activity	Lower Limit	Upper Limit	Dual Activity
1	C	BS	25921.57002	25921.57002-	None	None	1.00000
2	R01	UL			None		4.50000-
3	R02	UL			None		4.50000-
4	R03	UL			None		123.63267-
5	R04	UL			None		5.00000-
6	R05	UL			None		.07500-
7	R06	UL			None		.07500-
8	R07A	UL			None		.05000-
9	R07B	BS			None		
10	R08	BS	47.40000-	47.40000	None		
11	R09	UL	2000.00000		None	2000.00000	.63125-
12	R10	UL	500.00000		None	500.00000	2.29687-
13	R11	UL			None		2.25750-
14	R12	UL			None		13.97834-
15	R13	UL			None		34.00000-
16	R14	UL			None		1.10000-
17	R15	UL			None		25.00000-
18	R16	UL			None		1.66667-
19	R17	UL			None		40.00000-
20	R18	UL			None		47.66167-
21	R19	UL			None		28.00000-
22	R20	UL			None		44.00000-
23	R21	UL			None		44.45735-
24	R22	BS			None		
25	R23	UL			None		47.50000-
26	R24	UL			None		38.80729-
27	R25	UL			None		42.00000-
28	R26	UL			None		38.00000-
29	R27	UL			None		42.56216-
30	R28	UL			None		33.00000-
31	R29	UL			None		38.00000-
32	R30	UL	30.00000		None	30.00000	148.87987-
33	R31	BS	.15012		None	1.00000	

Situation 4

Section 2 - Columns

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
34	P01	BS	185.00000	61.20000-		None	
35	P02	UL	20.00000	27.60000-		20.00000	99.11250
36	P03	UL	20.00000	15.80000-		20.00000	46.68250
37	P04	LL		2.00000		None	.25750-
38	P05	BS	253.26381	34.00000		None	
39	P06	BS	2220.00000	1.10000		None	
40	P07	BS	46.25000	25.00000		None	
41	P08	BS	46.25000			None	
42	P09	LL		40.00000-		None	35.44167-
43	P10	UL	185.00000	7.00000-		185.00000	94.18267
44	P11	LL		7.00000-		35.00000	2.00000-
45	P12	BS	46.25000	10.00000-		80.00000	
46	P14	LL		4.50000-		None	.33750-
47	P16	BS	27632.52810	.07500-		None	
48	P17	BS	104756.89461	.07500-		None	
49	P18A	BS	83250.00000	.05000-		None	
50	P18B	LL		.06400-		None	.06400-
51	P19	EQ	1.00000	5440.90000-	1.00000	1.00000	7384.00000-
52	P22	BS	46.06000-	34.06000-		None	
53	P23	BS	20.86389	38.53000-		None	
54	P24	BS		37.57000-		None	
55	P25	LL		45.00000		None	2.66167-
56	P26	BS	57.81250	40.00000		None	
57	P27	BS	229.50278	44.00000		None	
58	P28	LL		43.00000		None	1.45735-
59	P29	BS	64.75000	28.00000		None	
60	P30	BS	299.65778	46.00000-		None	
61	P31	LL		41.00000-		None	3.46771-
62	P32	BS	74.91444	30.00000-		None	
63	P33	BS		30.00000-		None	
64	P34	BS	524.40111	42.00000		None	

Section 2 - Columns (continued)

No.	Col.	AT	Activity	Input Cost	Lower Limit	Upper Limit	Reduced Cost
65	P35	BS		38.00000		None	
66	P36	BS	90.00000	92.07000-		None	
67	P37	BS	688.23529	16.00000-		None	
68	P38	BS	1651.76471	38.00000		None	
69	P40	BS	252.00000	33.00000		None	
70	P41	BS	.15012	4200.00000-		None	
71	P42	LL		4200.00000-		None	1725.00000-
72	P43	UL	60.00000	36.00000-		60.00000	101.62987
73	P44	BS	2351.76507	4.50000-		2600.00000	
74	P45	BS	154.10000	4.50000-		176.00000	
75	P46	BS	3982.51624	2.10000-		None	