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Effect of Capital Rationing and Time on Optimal Farm Organizations

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INTRODUCTION

Static analysis of economic problems dominates much of the research investigation in farm management. These studies, in general, are concerned with a point in the future and not necessarily with the transition to that point. Thus, the economic problems connected with time take on increased importance when the emphasis is on production timing, capital accumulation and/or acquisition, and the impact of a decision in one point in time on production alternatives in subsequent periods.

With growing commercialism and higher fixed costs in agriculture, farmers are becoming more aware of the advantages of establishing farm organizations which maximize income over a series of years. In situations involving capital rationing, the operating capital[1] expenditure and yearly flow of income of an enterprise take on extreme importance. The farm plan in any one year is highly dependent upon the amount of capital available, the income received, and the fixed costs in the preceding year or years. Hence, various production decisions at any point in time may result in a stream of income lower than maximum from the available resources.

In this study, linear programming was employed to obtain optimum farm organizations under various degrees of capital rationing where time was an explicit variable. The impact of capital accumulation on farm organizations and returns can be readily analyzed. Thus, the use of multi-period analysis may serve to further enhance "farm recommendations" set forth by static studies.

THE PROBLEM AND OBJECTIVES

The impact that time has on optimum farm organizations is an issue facing farmers and researchers alike. The problem of capital rationing and accumulation on long-range planning becomes more obvious with time as a variable. Does a

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[1]Operating capital was defined to be capital not invested in machinery, buildings, and land. Hereafter, the term "operating capital" usually will be abbreviated to capital.

high degree of capital rationing allow the farmer only exploitative cash-grain farming as a production alternative? How do yearly farm organizations change as capital accumulation takes place? Do farm plans stabilize at some future point in time? With this in mind, the general purpose of this study was to determine optimum farm plans over a period of five years with various degrees of capital rationing. More specifically the objectives of this study were:

1. To formulate a simple multi-period linear programming model.
2. To determine optimum farm organizations under capital rationing for a five year period.
3. To determine the role of capital accumulation and its impact on net returns at various initial capital levels.

In this study, optimum farm organization will be studied within the framework of the profit maximization criteria. The optimum farm organizations were obtained by the multi-period linear programming method for five years. The capital supply was varied by $1,000 units until capital use in any period did not return a net marginal value product of 4.5 percent.

MULTI-PERIOD LINEAR PROGRAMMING METHOD

The technique of multi-period (dynamic) linear programming provides a single optimum for a time span of "t" years (periods), in contrast to static linear programming, where usually a single year (period) is considered. The yearly plans in a multi-period linear program are optimum in regard to the t-year optimum.

The model involves the simultaneous determination of optimum plans for a series of time periods with decisions of each period affecting alternatives in subsequent periods.[2] Income from production in one time period becomes an input in the next year. Thus, the model becomes one of capital accumulation. The quantity to be maximized is the present value of the stream of net incomes over the planning horizon. The model used is dynamic in the Hicksian[3] sense because the inputs and outputs are dated, but risk and uncertainty are not explicitly considered. The general assumptions of additivity, linearity, divisibility, and finiteness of static linear programming are required.[4] The model used in this study was formulated to obtain a structurally simple multi-period model and to reduce transformation from computation when a static to a dynamic linear programming model is desired. The model, though different in structure, follows a similar line of thought used by Barr and Plaxico, and Loftsgard and Heady.[5]

[2]Laurel D. Loftsgard and Earl O. Heady, "Application of Dynamic Programming Models for Optimal Farm and Home Plans," *Journal of Farm Economics,* Vol. XLI, No. 1, Feb. 1959, pp. 51-62.

[3]J. R. Hicks, *Value and Capital,* (second edition), Oxford Press, 1953.

[4]Earl O. Heady and Wilfred Candler, *Linear Programming Methods* (Ames: Iowa State College Press, 1958).

[5]Alfred L. Barr and James L. Plaxico, "Optimum Cattle Systems and Range Improvement Practices for Northeastern Oklahoma: Dynamic and Static Analysis," *Miscellaneous Publication 62,* Oklahoma State University, July, 1961; and Loftsgard and Heady, *op. cit.,* pp. 51-62.

The following discussion outlines algebraically the multi-period linear programming model. The same activities in different time periods are considered as different activities. In mono-period linear programming, the a_{ij} coefficient denotes the unit requirement or output of the j^{th} activity for the i^{th} resource. Denote the year of the program by the superscript k, where $k = 1, 2, \ldots, t$; the row by the subscript i, where $i = 1, 2, \ldots, m$; and the number of activities by the subscript j, where $j = 1, 2, \ldots, n$. Let the element a^k_{ij} represent the unit requirement or output of the j^{th} activity for the i^{th} resource in the k^{th} year; and C^k_j as the net revenue of the j^{th} activity in the k^{th} year. The model can be represented by a series of inequalities as follows:

$$b^1_1 \geq a^1_{1,1}x^1_1 + \cdots + a^1_{1,j}x^1_j + a^2_{1,\hat{j}}x^2_{\hat{j}} + \cdots + a^t_{1,n-1}x^t_{n-1} + a^t_{1,n}x^t_n$$

$$b^1_2 \geq a^1_{2,1}x^1_1 + \cdots + a^1_{2,j}x^1_j + a^2_{2,\hat{j}}x^2_{\hat{j}} + \cdots + a^t_{2,n-1}x^t_{n-1} + a^t_{1,n}x^t_n$$

$$b^1_i \geq a^1_{i,1}x^1_1 + \cdots + a^1_{i,j}x^1_j + a^2_{i,\hat{j}}x^2_{\hat{j}} + \cdots + a^t_{i,n-1}x^t_{n-1} + a^t_{i,n}x^t_n$$

$$b^k_i \geq a^k_{i,1}x^k_1 + \cdots + a^k_{i,j}x^k_j + a^k_{i,\hat{j}}x^k_{\hat{j}} + \cdots + a^t_{i,n-1}x^t_{n-1} + a^t_{i,n}x^t_n$$

$$b^t_m \geq a^t_{m,1}x^t_1 + \cdots + a^t_{m,j}x^t_i + a^t_{m,\hat{j}}x^t_{\hat{j}} + \cdots + a^t_{m,n-1}x^t_{n-1} + a^t_{m,n}x^t_n$$

where $j = \hat{j}$ and $k \neq \hat{k}$.

The criteria is to maximize the objective function,

$$f(x) = C^1_1x^1_1 + C^1_2x^1_2 + C^1_3x^1_3 + \cdots + C^k_jx^k_j + \cdots + C^t_{n-1}x^t_{n-1}$$
$$+ C^t_nx^t_n \text{ subject to } x^k_j \geq O.$$

As in static linear programming, a plan which is forced to use exactly all of its resources may not be mathematically or physically possible. Production possibilities stated in terms of inequalities also present computational difficulties. To facilitate ease of solution and change the inequalities to equations, the introduction of slack activities is required. Their purpose is to allow non-use of resources. The slack activities change the number of j activities from $j = 1, 2, \ldots, n$ to $j = 1, 2, \ldots, s$ where $s = n + m$. In other words, there is one slack activity for each constraint row in the model.[6]

The objective function, $\sum_j^n\sum_k^t C^k_jX^k_j$, is changed to $\sum_j^n\sum_k^t C^1_jX^k_j$ where $\check{C}^k_j$ is the discounted net revenue of the j^{th} activity of the k^{th} year. This allows maximization of the present value of the stream of net incomes. The discounted net revenue is obtained by $\check{C}^k_j = C^k_j\,(1+r)^{-k}$ where "r" equals the interest rate.

[6] There are some rarely used exceptions to this statement. See Heady and Candler, *op. cit.*, p. 79.

TABLE 1--A SIMPLE DYNAMIC LINEAR PROGRAMMING MODEL

					Year I					Year II					Year III		
				C_i^k	C_1^1	C_2^1	C_3^1	C_4^1	C_5^1	C_6^2	C_7^2	C_8^2	C_9^2	C_{10}^2	C_{11}^3	C_{12}^3	C_{13}^3
					Continuous Corn	Hogs	Sell Corn	Corn Transfer	Capital Transfer	Continuous Corn	Hogs	Sell Corn	Corn Transfer	Capital Transfer	Continuous Corn	Hogs	Sell Corn
C_i^k			Ident	b_0	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}
C_1^1	Land	Acre	1	b_1^1	$a_{1,1}^1$	0	0	0	0	0	0	0	0	0	0	0	0
C_2^1	Capital	Dollar	2	b_2^1	$a_{2,1}^1$	$a_{2,2}^1$	0	0	0	0	0	0	0	0	0	0	0
C_3^1	Income	Dollar	3	$-b_3^1$	0	$-a_{3,2}^1$	$-a_{3,3}^1$	0	$a_{3,5}^1$	0	0	0	0	0	0	0	0
C_4^1	Corn	Bushel	4	b_4^1	$-a_{4,4}^1$	$a_{4,2}^1$	$a_{4,3}^1$	$a_{4,4}^1$	0	0	0	0	0	0	0	0	0
C_5^2	Land	Acre	5	b_5^2	0	0	0	0	0	$a_{5,6}^2$	0	0	0	0	0	0	0
C_6^2	Capital	Dollar	6	b_6^2	0	0	0	0	$-a_{6,5}^2$	$a_{6,6}^2$	$a_{6,7}^2$	0	0	0	0	0	0
C_7^2	Income	Dollar	7	$-b_7^2$	0	0	0	0	0	0	$-a_{7,7}^2$	$-a_{7,8}^2$	0	$a_{7,10}^2$	0	0	0
C_8^2	Corn	Bushel	8	b_8^2	0	0	0	$-a_{8,4}^2$	0	$-a_{8,6}^2$	$a_{8,7}^2$	$a_{8,8}^2$	$a_{8,9}^2$	0	0	0	0
C_9^3	Land	Acre	9	b_9^3	0	0	0	0	0	0	0	0	0	0	$a_{9,11}^3$	0	0
C_{10}^3	Capital	Dollar	10	b_{10}^3	0	0	0	0	0	0	0	0	0	$-a_{10,10}^3$	$a_{10,11}^3$	$a_{10,12}^3$	0
C_{11}^3	Corn	Bushel	11	b_{11}^3	0	0	0	0	0	0	0	0	$-a_{11,9}^3$	0	$-a_{11,11}^3$	$a_{11,12}^3$	$a_{11,13}^3$

The previously discussed equations allow for easy structure of multi-period linear programming matrix tableaux. The simple tableau presented in Table I is an example of a multi-period model.

The introduction of year-year resource transfer activities (corn and capital transfers in the above model) into the matrix is the feature which separates a dynamic model from a static one. Parametric programming can be used to solve a dynamic model if certain specific conditions exist and when only *one* resource is being transferred from year to year. That is, if the single resource being transferred is not influenced by production in subsequent years, then programming parametrically on that resource can be used to solve the dynamic model. Depending on the matrix formulation and the objective of the model, the resource capital may fall within the above specific conditions. For example, the generation of capital in one period may be distinct from production in subsequent periods. Thus, programming parametrically on the resource capital solving year by year can be done. A year-year resource transfer, such as corn, which is supplied in the model by one activity and used by other activities can be solved only by multi-period programming. In other words, the overproduction and subsequent transfer of surplus corn from one year to another is a resultant of production decisions in one year affecting alternatives in previous years. Hence, multi-period (dynamic) linear programming is a distinct technique from parametric programming.[7] The simple model in Table I, which is for three periods, contains five enterprise activities (continuous corn, hogs, corn selling, corn transfer, and capital transfer) and four resource restrictions (land, capital, income, and corn).

The matrix in Table I is in the usual linear programming tableau format, except for the large block of zeros in the upper-right and lower-left corners. The immediate reaction is that this model is really three static linear programming models, or the problem could be solved by pseudo-dynamics or parametric programming by solving for three solutions starting with Period I. The model maximizes income over three years, whereby a pseudo-dynamic or three static linear programming models would maximize income for each period with production in one period having no effect on subsequent periods.

A more rigorous example would contain more than the corn and capital transfer activities to supply resources to subsequent years, (i.e. capital borrowing, land buying, hay transfer, and building investment activities). For example, a land buying activity could add land to subsequent years, and thus would have the appropriate a^k_{ij} element in the land and capital resource rows in subsequent years.

The net revenues ($\bar{C}^k_j$) are equal to the income row minus the capital row. For example, the net revenue of $\bar{C}^1_2$ (hogs) is equal to the total gross income

[7]Dynamic and parametric linear programming have been considered unjustly as similar techniques in the past by some researchers. This conclusion is a direct result of not stating the specific conditions under which a dynamic model must be formulated before parametric programming can be used. Also, parametric programming can never be used if the model contains two or more year-year resource transfer activities. For a counter discussion see Wilfred Candler, "Reflections on Dynamic Programming Models," *Journal of Farm Economics,* Vol. XLII, No. 4, Nov. 1960.

of one unit of C^1_2 ($a^1_{3,2}$) minus the capital requirement of $\bar{C}^1_2$ ($a^1_{2,2}$). In such a format, all crop and buying activities are entered as costs for they require capital, but return no income. Net revenue from a crop activity is represented by a grain sell activity. For example, production of one unit of continuous corn in Period I will add to net revenue by the number of bushels of corn sold times C^{-1}_3 minus C^{-1}_1.

Activities which use a resource have positive coefficients and negative coefficients if they add to resource supply. The capital coefficients are primarily the same as the net costs typically used in static linear programming with the exception of some additional initial investment costs.

Transfer of income generated in one period to the capital row of the next period is accomplished by the use of the capital transfer activity. The livestock and sell activities generate income which adds to the income row. For example, in Period I the hog activity supplies $a^1_{3,2}$ (equal to C^1_2 plus $a^1_{2,2}$)[8] to the income row for each unit produced. Hence, the total income generated in Period I is the number of hogs times $a^1_{3,2}$ plus the number of bushels of corn sold times $a^1_{3,3}$. The allowance for family living and annual fixed costs is represented in the negative b^1_3 (undiscounted) of the income row. Thus, the capital supply available in Period II is the income generated in Period I minus b^1_3 of the income row. Capital for Period III is obtained by the same procedure. The cost of transferring capital from one period to another is zero. The capital b^k_i value, after the first period, is zero since capital for subsequent periods is generated from the previous year.

As shown in Table 1, the income row, capital transfer, and corn transfer activities have been removed in the third period. Since Period III was the last year in the example, the amount of income generated for subsequent transfer to the next period is not necessary. The C^k_j's for the third period were formulated by the same procedure as for Periods I and II.

In the above model, two important situations have to be considered. In Table 1, a portion of the allowance for family living and fixed costs ($-b^1_3$) represents income taxes and social security, which are functions of total income. For example, instead of a 1:1 ratio in the capital transfer activity, a ratio of 1:.8 may be more meaningful with the .2 reduction being a subtraction for, say, taxes and savings. The other situation is when all capital cannot be profitably used in one period. Hence, an activity must be introduced into the model which transfers unused capital from the capital row of one year to the capital row of the next year.

The number of resource restrictions and activities are limited only by the number that are relevant. Variation of resource supplies and unit requirements of outputs (e.g. labor increases, inclusion of land buying and investment activities for buildings and machinery) as the capital supply accumulates in any year can

[8]The exception to this principle is when the capital requirement contains any investment costs or non-transferable income. Then the supply of income is the net revenue plus the capital requirement minus any initial investment or non-transferable income. The coefficients in the income row are not discounted values and thus, are formed using the nondiscounted C^k_j's.

TABLE 2--ACTIVITIES AND RESOURCE RESTRICTIONS CONSIDERED

Crop Rotation:[a]

Continuous Corn
C - Sb - W (x)
C - C - O (x)
C - O - A - A - A
Sb - W - A - A - A

Livestock Enterprises:

Steer Calves -- Wintered
Yearling Steers -- Drylot
Two-Year-Old Steers -- Drylot
Plain Steers -- Wintered
Sow and Two Litters

Supplementary Activities:

Grain Selling
Grain Buying
Hay Buying
Labor Hiring
Hay Transfer
Capital Transfer
Capital Investment

Restrictions:

Land
Capital
Feed
Hay
Labor
Labor Hiring
Hog Building Space
Income
Hay Buying

[a]C = Corn
Sb = Soybeans
W = Wheat
O = Oats
A = Alfalfa
(x) = Catch Crop

be introduced into the model. For example, the increase (decrease) in fertility level of the soil over a period of years will increase (decrease) the yields of crop enterprises. A pitfall to avoid is that concerning those activities which allow for future replacements, e.g. beef cattle activities which keep a certain percentage of heifers each year. The replacements kept in one year may not (and most likely won't) match the next year's production. Thus, replacements should be purchased each year.

CAPITAL RATIONING MODEL

The multi-period linear programming model can be used to formulate a capital rationing model. Variations of beginning capital will generate different levels of capital in subsequent periods. For example, a beginning capital level of $10,000 *may* after five years accumulate $20,000 capital with intermediate levels for the other periods.

Capital rationing in this study is defined to exist when the amount of capital used is less than that which would equate the marginal value product of capital and the market rate of interest.[9]

[9]Thus, capital rationing in this study relates to external capital rationing rather than internal or risk aversion capital rationing. See Earl O. Heady, *Economics of Agricultural Production and Resource Use,* New York: Prentice-Hall Inc., 1952, Chapter 18.

In general, the studies in capital rationing have tended toward determining the amount of capital which is being borrowed at various interest rates, i.e. where the undiscounted marginal value product of capital is greater than the cost of capital. Thus, discounting of the MVP of capital by the user rations the capital and thus, is a study of internal capital rationing.

In this study, external capital rationing was forced by setting the capital levels.[10] As shown in Figure 1, if the marginal cost of capital was (r), capital in the amount of OC_1 should be used which would be at a position of equilibrium —marginal value product equal to the cost of capital. But if the capital available for production was OC_2 or OC_3, then the firm does not have enough capital to equate the cost of capital (r) and marginal value of product of capital—more capital could be used profitably.

Since in multi-period programming, only the first year (period) has a specified capital level, each level of capital will generate a marginal value product curve similar to line SS^1 in Figure 1. Those production alternatives returning a high marginal value product will enter with capital restricted to low capital levels and expand as capital accumulates. Production alternatives which return a lower marginal value product may enter also as capital accumulation occurs. Thus, the time element is an important consideration in this model.

THE CASE FARM

The case farm selected for analysis is characteristic of farms in the West Central region of Missouri. The farm selected was one developed in a recent publication of the Missouri Agricultural Experiment Station.[11] The farm was synthesized from a survey of 65 member farmers of the Extension Service Balanced Farming Program in Lafayette County, Missouri. The farm was a 200 tillable acre, owner-operator farm. The land was terraced and would support any cropping system considered. The management ability of the operator was assumed to be average with working knowledge of all current practices and technology. The farm resources, prices, and crop yields were assumed to remain constant for the five-year period.

FARM RESOURCES

Labor

The labor supply for the case farm consists solely of the operator and his family with the exception of two labor-hiring activities. The family contributes

[10]Since capital borrowing was not considered as an alternative in the model, a form of risk aversion was also forced on the model.

[11]Howard D. Utter and Fred E. Justus, Jr., "Determining Maximum Net Returns for Cropping Systems on Marshall Soil Using Linear Programming," *Research Bulletin 780,* Missouri Agricultural Experiment Station, October, 1961.

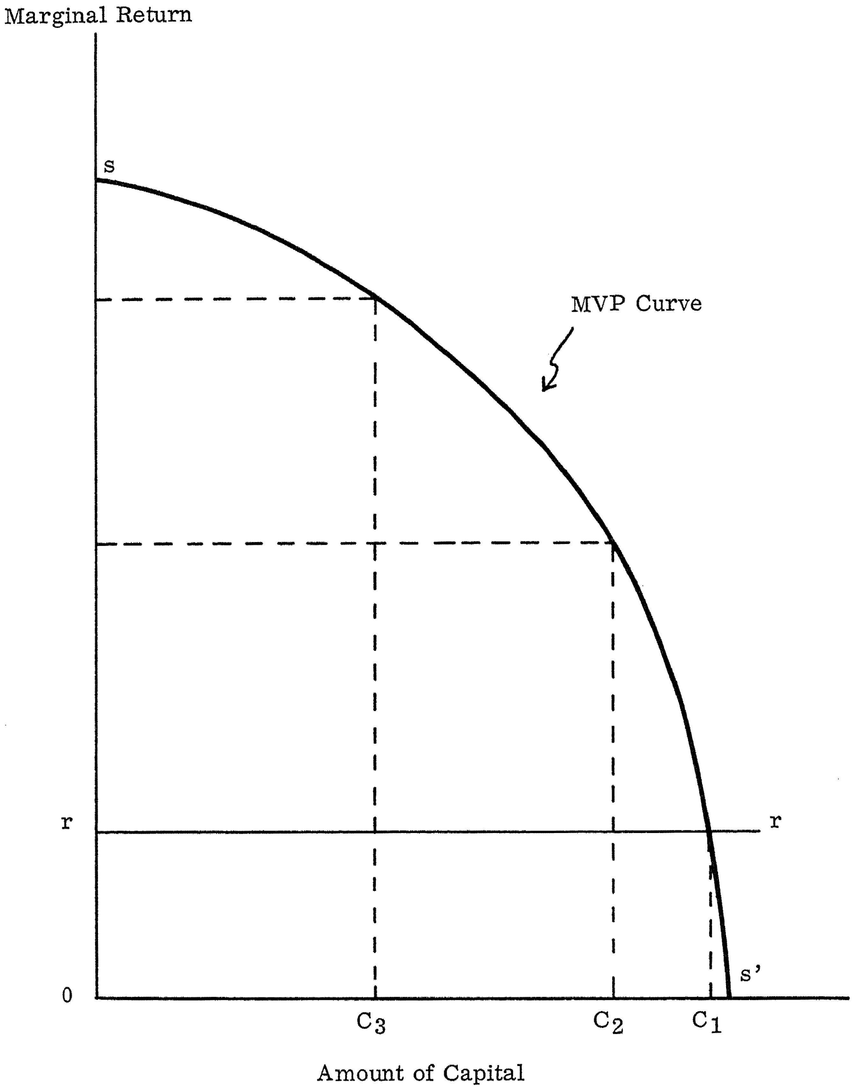

FIG. 1 -- The capital rationing model.

four months of labor equivalent. Available monthly labor hours are shown in Appendix Table 1 with sub-group periods. Labor in November and December was not considered limiting.

Operating Capital

As has been previously noted, the capital supply was stated only for the first year since the subsequent period's capital is generated from the previous year. As the model does not include a capital borrowing activity, the lowest initial capital level considered was $8,000 which allows operation of all land.[12]

Fixed Costs and Family Living Expenses

Capital income is used for production alternatives and household consumption. Although the program generates income simultaneously with the end of the period, the farm organization, in reality, generates income throughout the year. Hence, family living and fixed expenses were subtracted from the income generated. Family living and fixed cost expenditures are shown in Appendix Table 2. These expenses have no effect on the optimum organization except through the reduction in the capital supply; thus, these expenditures must be subtracted from the model's net revenue to obtain net discounted returns.[13]

Machinery and Buildings

All machinery and buildings required for any resulting farm organization were assumed available at the start of the program. Cattle facilities were unlimited; however, building space was limited to 50 litters of hogs per year. Grain and hay storage facilities were available to handle any cropping system and beginning feed inventories were zero.

The model allows annual allowaces for depreciation (see Appendix Table 2) which can be used for new and/or replacement machinery and buildings.

ACTIVITIES AND RESTRICTIONS

As previously discussed, the same activity or process in different time periods in the model is considered as a different activity. Livestock and crop rotation activities are included in every time period. Supplementary activities are used so as to allow solutions for both crops and livestock. Resource restrictions considered are those which are relevant to the area and consistent with the model. The resource restrictions and activities used in the model are presented in Table 2.

Livestock Activities[14]

As indicated in Table 2, livestock enterprises which are commonly found in the area are used, although all alternatives were not considered.

Details of the input-output data for the livestock enterprises for labor, capital, and feed requirements are given in Appendix Tables 3, 5, and 7. The livestock prices used were obtained by using the five-year average from 1959-63 and are shown in Appendix Table 4. Formulation of the C_{jk}'s for the livestock enter-

[12]If capital borrowing activities were allowed, it would interfere with formulation of the capital rationing model.

[13]Hereafter, the "net discounted returns minus family living and fixed cost expenses" will be abbreviated to net returns.

[14]Adapted from Robert M. Finley, Larry N. Langemeier, and Carrol L. Kirtley, "Effects of Varying Management Levels of Crops and Livestock on Optimum Farm Organization," *Research Bulletin 866,* Missouri Agricultural Experiment Station, July 1964.

prises and detailed information of expenses by category are shown in Appendix Tables 6 and 9.

Two-year-old steer, drylot. Two-year-old steers weighing 900 pounds are purchased in October and sold in late January or early February weighing 1,150 pounds. They are fed in drylot on a high grain ration.

Steer calf, wintered, grazed and fed. Calves are purchased in late October or early November and fed primarily on roughage during the winter, grazed and fed on pasture.[15] They are finished in drylot and sold in October weighing 1,050 pounds.

Yearling steer: high roughage—medium grain. Yearling steers weighing 650 pounds are purchased in mid-fall and fed in drylot for eight months on a high roughage—medium grain ration. Steers are sold in late June or early July weighing 1,150 pounds.

Plain steer, wintered and fed. Plain long-yearling steers weighing 700 pounds are purchased in late October or early November. They are wintered on a high roughage, low grain ration and sold in mid-summer weighing 1,000 pounds.

Sow and two litters. Sows farrow in March and September with 14 pigs raised. Replacement sows are purchased each year. Fourteen market hogs weighing 225 pounds and a 400-pound cull sow are sold.

Crop Rotation Activities[16]

Five crop rotations were considered and are shown in Table 2. The rotations considered are those common to the area and may have either high or low capital requirements. The rotations vary from a very intensive rotation, continuous corn to an extensive rotation, Sb—W—A—A—A. Since government programs are not always stable from year to year, no limitations were introduced on the cropping system due to existing programs.

All grain yields were converted to "corn equivalents" and pasture yields were calculated as "hay equivalents." (See Appendix Table 8.) Operating capital and monthly labor requirements for the crop rotations are in Appendix Tables 5 and 3. The various crop prices assumed and the C_{jk}'s formulation are shown in Appendix Tables 4 and 6.

THE RESULTS

As previously indicated optimum farm organizations[17] for the case farm were obtained for five years, at various degrees of capital rationing, by using linear programming in a multiperiod framework. Variation of beginning capital levels was started at $8,000 which was the lowest capital amount allowing operation of all

[15]Changed to hay equivalents.

[16]Adapted from Utter and Justus, *op. cit.* p. 26.

[17]Hereafter, the term "farm organization" will refer to one five-year plan and usually the term "farm plan" for a yearly plan of the farm organization.

land, and increased in $1,000 units until the net marginal value product of capital in some period of the plan was unlimited at an optimum cost of 4.5 percent (in any period of the plan). Eight optimum farm organizations were obtained; those at capital levels from $8,000 to $15,000.[18] All other resource levels, activities, and technical coefficients were the same for each case (capital level).

OPTIMUM FARM ORGANIZATIONS

The eight five-year optimum farm organizations are shown in Table 3. An analysis of each case by periods will be presented to indicate the pattern of yearly plans as capital accumulates.[19] An overall analysis will then indicate the causes of the patterns between periods and cases.

Case A

Period I. In Year One, the available capital was $8,000, which just allowed production on all land. Hence, the farm plan was almost wholly a cash-grain plan with only enough capital available after production of the cropping system for 13.5 litters of hogs. Corn was the dominant crop at 198.4 acres. Thus, as a result of the large corn acreage and low livestock production, a surplus of 12,299.6 bushels of grain was sold. Land and capital were the only limiting resources in Period I. The net return was $895. The amount of capital generated for Period II was $8,945.

Period II. In Year Two, the amount of available capital was only $945 more than that used in Period I, thus, the farm plan is very similar to that in Period I.[20] Hog production increased to 24.4 litters with grain selling declining a bit to 11,102.6 bushels. Since more forage was required by hogs, corn acreage declined slightly to 197.1 acres. The net return was $1,683, an 88.0 percent increase from Period I. Hogs gave the highest return to capital; thus, the slightly larger capital amount available in Period II was used to increase hog production.

Period III. In Year Three, the amount of capital available was $10,800. Since hogs gave the highest return to capital, this enterprise increased to 45.5 litters. With forage production limited to that required by hogs, corn continued to be the dominant crop. Although grain selling declined from Period I to Period III,

[18]The different farm organizations at the various capital levels will be called "cases" with Case A being the organization at the $8,000 level. As explained previously, capital level is stated only for the first year with subsequent years capital levels being generated from the previous year. For example, the $8,000 capital level of Case A is for the first year.

[19]Hereafter, the terms "year" and "period" will be used interchangeably to denote the year of the farm plans.

[20]The net return of a farm plan and the increase (from previous year) in capital generated for the next period are not identical. For example the return of $895 for Period I was due to the discounted C^k_j value of $7,733 minus the *discounted* allowance for family living and fixed cost of $6,838. The capital available for a period is a result of the total income generated by the previous period minus the allowance for family living and fixed costs. The gross income generated is formulated from undiscounted coefficients as is the family living and fixed costs allowance. Thus, the $8,945 of capital for Period II, an increase of $945 from the $8,000 level of Period I, was equal to 12,299.55 bushels of corn sold times $1.00 plus 13.548 litters of hogs times $282.35 (one-half of income from two litters) minus $7,180.

a surplus of 8,764.8 bushels was still sold in this period. The capital supply of $10,800 was not large enough to allow a greater production of livestock numbers to consume the surplus grain. Labor in the April-May period was hired—7.9 hours. The net return for Period III was $3,130, with $14,422 of capital being generated for Period IV.

Period IV. In Year Four, the steer calf enterprise entered the organization for the first time at 22.9 head. Since the production of hogs was at the maximum of 50.0 litters allowed by building space, the larger capital supply of $14,422 was used in production of the enterprise with the second highest returns to capital—steer calves. With the greater concentration of livestock in the plan, the requirement for hay increased from 11.4 tons to 49.1 tons. Hence, the Sb—W—A—A—A rotation increased from 5.4 acres in Period III to 23.4 acres in Period IV. Since operation of all land was required, the cropping system became more extensive when the larger capital supply allowed greater livestock production. Although grain consumption had increased and production had decreased, as shown in Table 3, the number of bushels of grain sold was still high at 6,391.0 bushels. The net return for Period IV was $4,070.

Period V. In Year Five, the amount of capital available for production alternatives was $19,367. The number of steer calves increased to 57.5 head while hogs remained at the 50.0 litter limit. Since grain was in surplus in all periods, the cropping system changed only enough to fulfill the increased hay requirement. Alfalfa acreage increased 15.9 acres to 29.9 acres and corn acreage declined to 150.1 acres. A total of 97.1 hours of labor in Period V was hired in the April-May and September-October periods. Net returns for Period V were $4,957.

The farm organization (five-year plan) for Case A showed a definite pattern. Hogs had the highest return to capital and thus increased until limited by building space. Capital accumulation caused the following enterprise movement from Period I to Period V: grain selling declined, steer calves increased, and the cropping system became more extensive—13,722.1 bushels produced in Period I as compared to 11,391.7 bushels in Period V. The total net return for the five-year period was $14,735 with a capital accumulation of $11,367 from the $8,000 beginning level.

Case B

Period I. In Year One, the amount of capital available for production alternatives was $9,000. As shown in Table 3, the farm plan of this period and Period II of Case A were similar since the capital available only differed by $55. The farm plan was a high cash-grain plan with 11,032.6 bushels of grain sold. Corn acreage was 197.0 acres with only 1.8 acres of alfalfa produced which fulfills the hay requirements of the 25.0 litters of hogs. Although the requirement for hay by the hog numbers was low (6.3 tons) production of hay was more economical than purchasing hay and producing all corn. The net return in Period I was $1,812, with $10,908 of capital generated for Period II.

Period II. In Year Two, the farm plan remained a high cash-grain plan with 8,633.5 bushels of grain sold. Hog production increased to 46.7 litters and corn

TABLE 3--FIVE-YEAR OPTIMUM FARM ORGANIZATIONS FOR THE EIGHT CASES

Activity and Time Period	Unit	Cases A	B	C	D	E	F	G	H
Period I									
Corn	Acre	198.4	197.0	195.7	194.3	189.8	184.4	178.9	173.5
Oats	Acre	0	0	0	0	0	0	0	0
Alfalfa	Acre	1.0	1.8	2.6	3.4	6.1	9.4	12.7	15.9
Soybeans and Wheat[a]	Acre	.6	1.2	1.7	2.3	4.1	6.2	8.4	10.6
Grain Sell or Buy[b]	Bushel	12,299.6	11,032.6	9,765.3	8,522.3	7,804.3	7,220.8	6,637.2	6,053.6
Grain Produced	Bushel	13,722.1	13,656.3	13,590.5	13,526.0	13,306.4	13,043.9	12,781.3	12,518.8
Buy Hay	Ton	0	0	0	0	0	0	0	0
Hay Transfer	Ton	0	0	0	0	0	0	0	0
Steer Calf	Head	0	0	0	0	5.6	12.7	19.9	27.0
Yearling Steers	Head	0	0	0	0	0	0	0	0
Hogs	Litter	13.5	25.0	36.4	47.7	50.0	50.0	50.0	50.0
Total Labor Hired	Hour	0	0	0	15.3	25.7	28.9	32.2	35.4
Capital Available	Dollar	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000
Net Discounted Returns[c]	Dollar	895	1,812	2,730	3,613	4,016	4,301	4,587	4,872
Period II									
Corn	Acre	197.1	194.5	185.0	174.6	166.8	159.8	152.9	137.1
Oats	Acre	0	0	0	0	0	0	0	0
Alfalfa	Acre	1.7	3.3	9.0	15.2	19.9	24.1	28.2	37.7
Soybeans and Wheat[a]	Acre	1.2	2.2	6.0	10.2	13.3	16.1	18.8	25.2
Grain Sell or Buy[b]	Bushel	11,102.6	8,633.5	7,295.7	6,171.8	5,341.5	4,583.2	3,848.5	2,656.4
Grain Produced	Bushel	13,660.0	13,531.7	13,077.6	12,571.9	12,198.4	11,857.3	11,526.7	10,760.6
Buy Hay	Ton	0	0	0	0	0	0	0	0
Hay Transfer	Ton	0	0	0	0	0	0	0	0
Steer Calf	Head	0	0	11.8	25.6	35.7	45.0	54.0	63.4
Yearling Steers	Head	0	0	0	0	0	0	0	0
Hogs	Litter	24.4	46.7	50.0	50.0	50.0	50.0	50.0	50.0
Total Labor Hired	Hour	0	11.9	28.5	34.8	39.4	43.6	80.0	123.8
Capital Available	Dollar	8,945	10,908	12,871	14,797	16,220	17,520	18,819	20,119
Net Discounted Returns[c]	Dollar	1,683	3,372	4,605	4,588	4,975	5,328	5,633	5,639

TABLE 3 (Continued)

Activity and Time Period	Unit	Cases A	B	C	D	E	F	G	H
Period III									
Corn	Acre	194.6	175.5	160.7	140.7	116.0	103.9	123.6	138.2
Oats	Acre	0	0	0	0	0	0	9.1	15.5
Alfalfa	Acre	3.2	14.7	14.6	35.6	50.4	57.6	51.3	46.4
Soybeans and Wheat[a]	Acre	2.2	9.8	15.7	23.7	33.6	38.4	16.1	0
Grain Sell or Buy[b]	Bushel	8,764.8	6,272.3	4,680.6	2,918.6	1,112.6	0	0	0
Grain Produced	Bushel	13,538.6	12,617.1	11,901.1	10,935.5	9,741.2	9,159.3	9,622.5	9,982.6
Buy Hay	Ton	0	0	0	0	0	0	0	0
Hay Transfer	Ton	0	0	0	0	0	0	0	18.2
Steer Calf	Head	0	24.3	43.8	61.5	75.1	86.9	97.2	104.2
Yearling Steers	Head	0	0	0	0	0	0	0	..9
Hogs	Litter	45.5	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Total Labor Hired	Hour	7.9	34.2	43.0	114.9	177.6	233.1	279.1	313.0
Capital Available	Dollar	10,800	14,625	17,353	19,855	21,704	23,392	25,028	26,335
Net Discounted Returns[c]	Dollar	3,130	4,326	5,031	5,381	5,324	5,592	6,526	7,244
Period IV									
Corn	Acre	176.6	144.3	102.7	136.9	144.0	150.1	155.6	154.7
Oats	Acre	0	0	0	15.4	14.0	12.5	11.1	4.4
Alfalfa	Acre	14.0	33.4	58.4	47.1	42.0	37.4	33.3	29.8
Soybeans and Wheat[a]	Acre	9.4	22.2	38.9	.6	0	0	0	11.1
Grain Sell or Buy[b]	Bushel	6,391.0	3,168.0	0	0	0	0	0	0
Grain Produced	Bushel	12,670.6	11,109.2	9,098.6	9,921.8	10,342.5	10,717.1	11,058.7	11,376.5
Buy Hay	Ton	0	0	0	0	0	20.3	83.4	114.9
Hay Transfer	Ton	0	0	0	13.7	43.8	50.3	11.5	0
Steer Calf	Head	22.9	59.8	85.5	103.8	105.3	106.4	107.5	104.3
Yearling Steers	Head	0	0	0	0	7.9	15.0	21.6	31.8
Hogs	Litter	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Total Labor Hired	Hour	33.5	107.2	226.4	308.5	337.2	362.4	385.3	400.0
Capital Available	Dollar	14,422	19,631	23,176	26,084	27,867	29,867	32,583	34,720
Net Discounted Returns[c]	Dollar	4,070	5,149	5,211	6,789	7,525	7,845	7,402	7,401

TABLE 3 (Continued)

Activity and Time Period	Unit	Cases A	B	C	D	E	F	G	H
Period V									
Corn	Acre	150.1	134.1	149.3	157.2	132.5	107.3	85.7	85.7
Oats	Acre	0	14.0	12.7	7.7	0	0	0	0
Alfalfa	Acre	29.9	47.9	38.0	30.3	40.5	55.6	68.6	68.6
Soybeans and Wheat[a]	Acre	20.0	4.0	0	4.7	27.0	37.1	45.7	45.7
Grain Sell or Buy[b]	Bushel	3,546.3	0	0	0	-1,185.1	-2,767.1	-4,123.0	-4,123.0
Grain Produced	Bushel	11,391.7	9,865.1	10,671.3	11,319.4	10,540.5	9,323.8	8,281.0	8,281.0
Buy Hay	Ton	0	0	12.2	112.4	84.2	38.9	0	0
Hay Transfer	Ton	0	8.8	55.1	0	0	0	0	0
Steer Calf	Head	57.5	102.4	106.3	106.5	95.9	88.4	82.1	82.1
Yearling Steers	Head	0	0	14.1	28.3	48.0	63.6	76.9	76.9
Hogs	Litter	50	50	50	50	50	50	50	50
Total Labor Hired	Hour	97.1	302.7	359.3	400	400	400	400	400
Capital Available	Dollar	19,367	25,890	29,510	34,339	37,016	39,404	41,582	43,718
Net Discounted Returns[c]	Dollar	4,957	6,351	7,515	7,010	7,193	7,326	7,445	7,451
Off-Farm Investment	Dollar	0	0	0	0	0	0	131	2,267
Total Five-Year Net Discounted Returns	Dollar	14,735	21,010	24,552	27,381	29,033	30,392	31,593	32,697

[a]One-half of acreage in column is acreage for each crop.

[b]Grain buying will be represented by a negative sign (-) before amount purchased.

[c]After family living and fixed costs have been subtracted.

acreage declined to 194.5 acres. Since the hog enterprise required seven hours of labor per unit in the April-May period, the increase in this activity required a total of about 12 hours of labor to be hired in this period. Land and capital were the only limiting resources. The net return for Period II was $3,372.

Period III. In Year Three, the enterprise steer calves entered the farm plan as hog production was at the 50.0 litter limit allowed by building space. Grain selling declined 2,361.2 bushels, although grain production was still high at 12,617.1 bushels. The increase in hog production coupled with the entrance of the cattle enterprise caused hay consumption to increase to 51.4 tons, an increase of 39.7 tons. Thus, corn acreage declined to 175.5 acres with the Sb—W—A—A—A rotation increasing. The net return was $4,326, with $19,631 of capital generated for Period IV.

Period IV. In Year Four, the corn acreage declined to 144.3 acres as the number of steer calves increased 146.1 percent to 59.8 head, thus increasing the requirement for hay. An important feature of Period IV was that only 108.2 tons of the 117.0 tons of hay produced were consumed. Hence, five-year net returns were maximized if 8.8 tons were transferred to Period V. Capital restriction limited a further increase in livestock, thus 3,168.0 bushels of grain were in surplus and sold. The profitability of hay transfer is due to two factors. First, the transfer of hay to Period V reduced the amount of hay required to be produced in that period. thus the cropping system was allowed to fulfill the increased grain requirement. Second, at this point in time selling rather than feeding grain gave higher returns to capital. The net return for Period IV was $5,149.

Period V. In Year Five, the amount of capital available for production was $25,890. In this period two important features significantly influenced the farm plan. First, the transfer of 8.8 tons of hay from Period IV allowed the cropping system to fulfill the grain requirement, since no grain was sold. If hay had not been transferred, either hay or grain would have had to be purchased. As a result, steer calves increased to 102.4 head as compared to 59.8 head in Period IV. Hog production remained at the 50.0 litter limit. Second, the rotation C—O—A—A—A entered the farm organization for the first time in partial replacement of the Sb—W—A—A—A rotation. The former rotation required .5 hours less labor per rotation acre in the critical September-October period. The difference between the two rotations was slight, with 1.1 bushel difference in grain production and hay production the same per rotation acre. The limiting resources were land, capital, hog building space, and September-October labor. The net return for Period V was $6,351.

The total five-year net return for the farm organization was $21,010, with a capital accumulation of $16,890. The farm organization for Case B followed the pattern of Case A except for the greater number of steer calves and consequently hay production, and a greater decline in grain selling. In Case B, 8.8 tons of hay were transferred from Period IV to Period V and the rotation C—O—A—A—A replaced Sb—W—A—A—A in the fifth period.

Case C

Period I. In Year One, the amount of capital available for production alternatives was $10,000. As previously indicated, the highest return to capital was from hogs, thus the extra capital in this plan in Period I was used to increase hog production to 36.4 litters. The amount of grain sold was 9,765.3 bushels; however, grain sold and produced had declined from Case A and B of Period I, as shown in Table 3. The net return was $2,730 for Period I.

Period II. In Year Two, the amount of capital transferred from Period I was $12,871. Hog production reached the maximum limit of 50.0 litters, consequently the steer calf enterprise entered the plan with 11.8 head. Grain production was 13,077.6 bushels with the surplus of 7,295.7 bushels sold. A total of 28.5 hours of labor in the April-May period was hired. In Period II, the net return was $4,065.

Period III. In Year Three, the farm plan was similar to Period II. The major change was in the cropping system where corn acreage declined 24.3 acres and hay acreage increased 5.6 acres. The number of steer calves increased to 43.8 head as hog production remained constant. Net returns for Period III were $5,031.

Period IV. This period could be called the transition phase in the farm organization as the net return increased $180 from Period III to $5,211, although the amount of capital used was $23,176. Corn acreage declined to 102.7 acres as the rotation Sb—W—A—A—A increased to 97.3 acres. Although 204.4 tons of hay were produced, livestock consumed only 149.3 tons and 55.1 tons were transferred to Period V. Grain selling was dropped from the farm organization as grain production decreased 2,802.5 bushels to 9,098.6 bushels. Steer calves were in the plan at 85.5 head. Thus, the five-year farm organization was more profitable if hay was over produced in this period and the surplus transferred to Period V.

Period V. In Year Five, the capital available for production alternatives was $29,510. The enterprise, yearling steers, entered the farm organizations for the first time at 14.1 head. The number of steer calves increased to 106.3 head and hog production remained at 50.0 litters. The larger concentration of livestock numbers demanded an increase in both grain and hay by the cropping system, an impossible situation with land constant at 200 acres. However, since 55.1 tons of hay were transferred from Period IV and 12.2 tons were purchased, the cropping system was able to revert to a more intensive rotation with grain production increasing to 10,671.3 bushels. Corn acreage increased to 149.3 acres. Thus, instead of purchasing grain, returns were sacrificed in Period IV by transferring hay to Period V in order to maximize five-year returns by allowing greater grain production in this period. As the labor hiring in the September-October period reached the maximum limit, the rotation C—O—A—A—A was substituted for the Sb—W—A—A—A rotation. The net return for Period V was $7,515, an increase of $2,304 over Period IV. The total five-year net return for Case C was $24,552, as compared to $14,735 for Case A. Capital accumulation was $19,510, over $10,000 more than that accumulated in Case A.

Case D

Period I. In Year One, the capital available for production alternatives was $11,000. As shown in Table 3, the farm plan was almost identical to those of Period II, Case B, and Period III, Case A, where the capital available was $10,908 and $10,800, respectively. Grain production was only 196.1 bushels less than in Period I of Case A, yet grain selling was 3,777.3 bushels less. Hog production was 47.7 litters with 15.3 hours of labor being hired in the April-May period. Net returns were $3,613 for Period I.

Period II. The capital available for production in Period II was $14,797. Hypothesizing from the discussion for Period I, the farm plan of this period should be similar to Period III of Case B. While this was generally true, certain dissimilarities appear since the rate of capital accumulation was faster in Case D. As hog production reached the 50.0 litter maximum, steer calves became more profitable and entered the plan at 25.6 head. The cropping system was still a very intensive system with 174.6 acres of corn. Net returns were $4,588 with $19,855 of capital being generated for Period III.

Period III. In Year Three, the farm plan was similar to Period II, although steer calf numbers were higher and grain selling lower. The cropping system was less intensive as grain production was 10,935.5 bushels and hay production was at 124.5 tons. Note that 13.7 tons of hay were transferred to Period IV, whereby the transfer of hay in Cases B and C was from Period IV to Period V. Thus, as the capital level becomes higher in earlier periods, the increased requirement for both grain and hay shifted from Period V of earlier cases to Period IV of Case D. For the April-May and September-October periods 114.9 hours of labor were hired.

Period IV. In Year Four, the capital available for the farm plan was $26,084, an increase of $6,229 from that in Period III; net returns increased from $5,381 to $6,789. The large increase in net returns was due basically to the transfer of 13.7 tons of hay from Period III; thus grain production was allowed to remain fairly constant, with no grain selling. The number of steer calves increased 68.8 percent to 103.8 head and hog production remained constant at 50.0 litters. As labor hiring in the September-October period reached the 200 hour limit, the rotation C—O—A—A—A was substituted for the Sb—W—A—A—A rotation again.

Period V. In Year Five, the capital available for production alternatives was $34,339. Steer calf numbers increased slightly to 106.5 head with yearling steers entering at 28.3 head. Hog production remained constant at 50.0 litters. This high concentration of livestock numbers increased the need for both grain and hay. Thus, the most profitable plan was one of buying hay, 112.4 tons, and reverting the cropping system to a more intensive rotation (grain production increased from 9,921.8 bushels in Period IV to 11,319.4 bushels in Period V.) Hay production declined from 164.9 tons in Period IV to 106.0 tons in Period V. As labor in both the April-May and September-October periods reached their maximum hiring limits, acres of the C—O—A—A—A rotation declined while the Sb—W—A—A—A rotation increased. The net return in Period V was $7,010.

The capital accumulation for the five-year period of Case D was $23,339 and the five-year total net returns were $27,381. The major difference between the farm organizations of Case C and Case D was that the shortage of hay and grain became acute in the Period IV in Case D, not Period V. Thus, a large tonnage of hay was purchased in Period V allowing the cropping system to become more intensive.

Case E

Period I. In Year One, the capital available for production alternatives was $12,000 which was enough to allow steer calf enterprise to enter the plan at 5.6 head and hog production to attain the 50.0 litter maximum. The cropping system was still very intensive as 13,306.4 bushels of grain were produced with 7,804.3 bushels being in surplus. Labor in the April-May period was supplemented by hiring 25.7 hours. The net return for Period I was $4,016.

Though the question relating to feeding of the surplus grain may have been mentioned earlier, it becomes more apparent in this period. First, grain selling has high returns to capital; thus it is a profitable enterprise. Second, for steer calves to increase, the cropping system would have had to be more extensive, but the capital requirement of the rotations continuous corn and Sb—W—A—A—A differ by less than $10. Hence the capital level was too restrictive to allow a larger steer calf production.

Period II. In Year Two, the amount of capital available for the farm plan was $16,220. Besides an increase in steer calf numbers to 35.7 head and a decline in grain selling to 5,341.5 bushels, the farm plan differs little from that of Period I. Net returns for Period II were $4,975.

Period III. In Year Three, the capital available for production was $21,704. The farm plan was similar to the plan of Period III of Case D with surplus hay being transferred to Period IV. The steer calf enterprise increased to 75.1 head as hog production remained constant. Corn acreage declined from 166.8 acres to 116.0 acres with grain selling declining to 1,112.6 bushels. The net return for Period III was $5,324 as compared to $5,381 for Period III of Case D.

Period IV. In Year Four, the net returns were $7,525, an increase of $2,201 from Period III. The yearling steers entered the plan at 7.9 head with the number of steer calves at 105.3 head and hogs constant at 50.0 litters. Since 43.8 tons of hay were transferred from Period III, the cropping system was able to revert to a more intensive rotation and hence, grain production increased from 9,741.2 bushels to 10,342.5 bushels. Since hay had become a limiting factor, the presence of yearling steers in the plan was due to the lower hay requirement of 1.25 tons per head as compared to 1.6 tons per head for steer calves. Labor hiring in the September-October period was at the maximum limit of 200 hours and as a direct result, the rotation C—O—A—A—A replaced the rotation Sb—W—A—A—A.

Period V. In Year Five, the net returns decreased from $7,525 of Period IV to $7,193. As the farm organizations are optimum in regard to the five years, the program was not degenerating.[21] The requirements for both hay and grain had increased to such a magnitude that either one or both had to be purchased. Grain was purchased, 1,185.1 bushels, also 84.2 tons of hay was purchased. Although hay consumption increased by 7.5 tons from Case D to Case E in Period V, hay purchased declined 28.2 tons. Hence, the alternative of purchasing grain and reverting the cropping system to a more extensive rotation was more profitable. Since yearling steers require .35 tons less hay per head than steer calves, the shortage of hay and grain caused steer calf numbers to decline to 95.9 head while yearling steer numbers increased to 48.0 head. Thus, the profitability of the yearling steer enterprise was advanced when hay became limiting. Hog production remained at 50.0 litters with the Sb—W—A—A—A rotation replacing the C—O—A—A—A rotation as labor in both hiring periods had reached their 200 hour maximum limit.

In the optimum five-year farm organization for Case E the shortage of both hay and grain caused purchasing of grain in Period V. This same problem enhanced the profitableness of the yearling steer enterprise in last period. The five-year total net return was $29,033 with an accumulation of capital of $25,016.

Case F

Period I. In Year One, the amount of capital available for production alternatives was $13,000. The farm organization was similar in the pattern of activity movement to that of Case E. Hog production was at the 50.0 litter limit, thus allowing 12.7 head of steer calves in the plan. Grain surplus was still high with 7,220.8 bushels sold. Labor in the April-May period was already limiting with 28.9 hours being hired. Net returns for Period I were $4,301.

Period II. In Year Two, the amount of capital available for production was $17,520. The number of steer calves increased to 45.0 head. Corn acreage declined to 159.8 acres, but 4,583.2 bushels of grain were still in surplus and sold. Net returns were $5,328 with $23,392 of capital generated for Period III.

Period III. In Year Three, the steer calves increased to 86.9 head with hog production constant at 50.0 litters. With the large concentration of livestock numbers in the plan, a greater amount of hay and grain was required. Since grain was in surplus in Period II, the cropping system became more extensive in this period by eliminating grain selling from the farm plan. Hence, hay acreage increased to 57.6 acres and corn acreage declined to 103.9 acres. A total of 233.1 hours of labor was hired in the September-October and April-May periods. Net returns for Period III were $5,592.

Period IV. In Year Four, the net return was $7,845, an increase of $2,253 over Period III and the highest yearly net return of any plan. The high return was due primarily to the transfer of 50.3 tons of hay from Period III which allowed the cropping system to become more intensive in this period as grain pro-

[21]Technically, net returns could decline from Period I to Period V, if this were optimum with regard to the five-year horizon. Degeneration of the model exists only when the amount of income generated in one period was less than the annual allowance for family living and fixed costs. Thus, if the capital level of the initial period were high, capital could, without degeneration of the program, decrease from Period I to Period 5.

duction increased to 10,717.1 bushels. Of the 201.6 tons of hay required, the cropping system produced only 131.0 tons. The purchasing of hay became profitable in this period as well as in Period V. Numbers of steer calves increased to 106.4 head, but the relative profitability of yearling steers was enhanced by the shortage of hay and were in the plan at 15.0 head. The rotation C—O—A—A—A entered the farm plan as labor hiring had reached the 200 hour maximum limit in the September-October period.

Period V. In Year Five, the capital available for production was $39,404 and net returns declined to $7,326. The cropping system, which became more intensive in Period IV, reverted to a more extensive rotation in this period with corn acreage declining to 107.3 acres and the Sb—W—A—A—A rotation increasing to 92.7 acres. Although 38.9 tons of hay were purchased, it is interesting to note that this was a decline of 45.3 tons from Period V of Case E. With the cropping system producing only 9,323.8 bushels of grain, 2,767.1 bushels of grain were purchased. Numbers of yearling steers increased to 63.6 head as steer calves declined to 88.4 head.

The total five-year net return was $30,392, with a five-year capital accumulation of $26,404.

Case G

Period I. In Year One, the capital used for production alternatives was $14,000. Steer calves were in the plan at 19.9 head and hog production was at the 50.0 litters allowed by building space. Since hay production was only 44.3 tons, the cropping system was quite intensive with 178.9 acres of corn. Although grain selling was high at 6,637.2 bushels, this was a decline of 5,662.4 bushels from Period I of Case A. Net returns were $4,587 and $18,819 of capital was transferred to Period II.

Period II. In Year Two, 80 hours of labor were hired in the April-May and September-October periods. Grain selling was at 3,848.5 bushels, although grain production declined to 11,526.7 bushels from the 12,781.3 bushels in prior period. Numbers of steer calves increased 171.4 percent to 54.0 head as hog production remained at 50.0 litters. Net returns for Period II were $5,633.

Period III. In Year Three, the capital used for production was $25,028 with net returns increasing $893 from Period II to $6,526. As steer calf numbers increased to 97.2 head and hogs remained at 50.0 litters, the requirement for both hay and grain increased. Hence, the cropping system became more extensive as hay acreage increased to 51.3 acres as compared to only 28.2 acres in Period II. Grain production increased 463.2 bushels over Period III of Case F, thus, hay being transferred to Period IV was only 11.5 tons as compared to 50.3 tons transferred in Case F.. As livestock concentration was large, labor hiring in the September-October period was at the maximum limit of 200 hours.

Period IV. In Year Four, the capital available for production was $32,583. Number of steer calves were at the highest level of any previous plan (107.5 head). Thus, the large steer calf enterprise coupled with 21.6 head of yearling steers and

50.0 litters of hogs caused the requirement for hay and grain to increase from Period III. Since 83.4 tons of hay were purchased in this period and 11.5 tons were transferred from Period III, the cropping system was allowed to become more intensive with 11,058.7 bushels of grain produced as compared to only 9,622.5 bushels in Period III. Corn acreage increased 32.0 acres to 155.6 acres. The rotation C—O—A—A—A completely replaced the Sb—W—A—A—A rotation in this period. Net returns were $7,402 which compares with $7,525 and $7,845 of Period IV of Cases E and F, respectively.

Period V. In Year Five, $131 of the $41,582 of capital available for production was invested in off-farm sources since it could not return 4.5 percent in the farm plan. The yearling steer enterprise increased 256.0 percent to 76.9 head as steer calves declined to 82.1 head. Hog production remained at the 50.0 litters allowed by building space. With the large number of livestock in the plan, the cropping system reverted to a more extensive rotation as 4,123.0 bushels of grain were purchased. The Sb—W—A—A—A rotation was the dominant rotation at 114.3 acres as all of the 240.5 tons of hay required was produced. The 8,281.0 bushels of grain produced in this period compares with 9,622.5 bushels and 11,058.7 bushels of Periods III and IV respectively. The maximum amount of labor available, 400 hours, was hired. The net return of $7,445 was similar to the $7,326 of Period V of Case F, but the returns of Case F declined $519 from Period IV to Period V whereas in Case G the returns increased slightly. The total five-year net return for Case G was $31,593.

Case H

The farm plans of Cases G and H of Period V were identical except that off-farm investment was $2,267 in Case H as compared to only $131 in Case G. Hence, net returns in Period V increased $96 from Case G to Case H. As shown in Table 3, the farm plans of the other periods were not the same; however, the pattern of activity movement remained. Thus, as long as the capital levels of the other four periods return at least 4.5 percent, the farm plans will continue to change. The five-year net return for Case H was $32,697, an increase of $1,104 from that of Case G. Capital accumulation increased to $28,718.

General Patterns

In all cases the farm organizations showed certain definite patterns among the activities and contained almost the same activities—continuous corn and Sb—W—A—A—A, hogs, steer calves, yearling steers, and grain selling. As would be expected, the farm plans of different cases were similar when the capital available for production was almost identical, although the period of production would differ. Since the operation of land was required, livestock numbers were those allowed by the capital supply available after the production of the cropping system. Thus, livestock numbers were low until the capital supply available for production alternatives increased. Under the pricing system used, hogs gave highest returns to capital. Consequently, hogs were the only livestock enterprise in the farm plan until the limit of 50.0 litters allowed by building space was reached. Since the hog enterprise required only .25 tons of hay per litter, the cropping system could be very intensive until hogs reached the 50 litter maximum. Hence, grain surplus was sold. Feeding of the extra grain would have required greated production of forage-consuming livestock and consequently forage; an impossible system when the capital supply was very restrictive. Steer calves, which gave the second highest returns to capital, entered the farm plan when a further increase in hog production was restricted. The steer calf enterprise first entered the farm organization in the fourth period of Case A, although as more rapid capital accumulation took place they entered in the first period of Case E. Although steer calves and hogs were the principal livestock enterprises in the farm organizations, the yearling steer enterprise entered the plan when hay became limiting. The presence of yearling steers was due to two factors. First, the yearling steer enterprise required .35 tons less hay per head than steer calves, thus the profitability of yearling steers was enhanced when hay became limiting. Second, labor in the September-October period was limiting and the yearling steer enterprise required no labor in this critical period.

The cropping system was basically composed of two rotations in all of the cases—continuous corn and Sb—W—A—A—A. The rotation C—O—A—A—A replaced the Sb—W—A—A—A rotation when labor in the September-October period reached the maximum hiring limit since the labor requirement of the former was .5 hours less per rotation acre in this period. The pattern was reversed when labor hiring was limited in the April-May period also. For example, the rotation C—O—A—A—A was in the yearly plan of Period IV of Case E, but the Sb—W—A—A—A rotation replaced it in Period V. Grain production declined from Period I to Period V and from Case A to Case H as long as grain was in surplus. The cropping system changed in these periods only enough to supply the increased hay requirement; thus, the problem of more hay and grain required by livestock was solved simply by selling less grain and producing more hay. But the problem became acute when grain selling ceased and livestock concentration increased. This problem was resolved in two ways. First, surplus hay in one period was transferred to the next period and/or was purchased; thus, the cropping system was able to increase grain production. Second, grain was purchased when it became more profitable to revert the cropping system to a more extensive rotation. For example, grain production increased to 10,717.1 bushels in Period IV of Case F and 50.3 tons of hay were transferred from Period III and 20.3 tons were purchased. In Period V of the same case, hay production increased from 131.0 tons in Period IV to 194.6 tons in Period V while grain production declined 1,393.3 bushels in the same interval. Intensifying the cropping system was profitable as long as hay could be transferred from a previous period. The farm organization had higher five-year returns when grain was purchased only when hay purchasing became unprofitable.

The trend of activities from Period I to Period V, as well as the differences between farm organizations as the beginning capital level became larger, is shown by Figures 2 and 3 for Cases A and F, respectively, These examples show the pattern of activity movement presented in Table 3, as well as the contrast between the cash grain organization of Case A and the farm organization involving more livestock in Case F. For Case A (Figure 2), hogs were the only livestock enterprise in the farm organization until period IV when steer calves first entered. The cropping system was dominately corn until Period IV when hay production increased from 11.4 tons in Period I to 49.1 tons in Period V. Grain selling, as well as grain production, declined steadily from Period I to Period V. Although corn acreage declined rapidly from Period III to Period V, grain production remained high since the Sb—W—A—A—A rotation in the cropping system supplied 20.7 bushels of grain per acre.

In Figure 3, the general pattern of activity movement shown in Figure 2 remains, but production of livestock was greater since the initial capital available was larger—$13,000 as compared to $8,000. Hog production was at the 50.0 litters allowed by building space in Period I and steer calves were in all yearly plans. The grain selling activity dropped from the farm organization in Period III as grain production declined from Period I to Period III and then stayed fairly constant. In Period IV, the transfer from Period III of 50.3 tons and the purchase of 20.3 tons of hay allowed grain production to increase with the corn acreage increasing from 103.9 to 150.1 acres. Although both hay and grain consumption continued to increase in Period V, purchasing of 2,767.1 bushels of grain allowed hay production to increase to 194.6 tons as corn acreage declined. This change had an impact on the cattle enterprises. Steer calves first increased at an increasing rate from Period I to Period III, then at a decreasing rate from Period III to Period IV. They declined 18.0 head in Period V as yearling steers first entered the organization in Period IV at 15.0 and increased to 63.6 head in Period V.

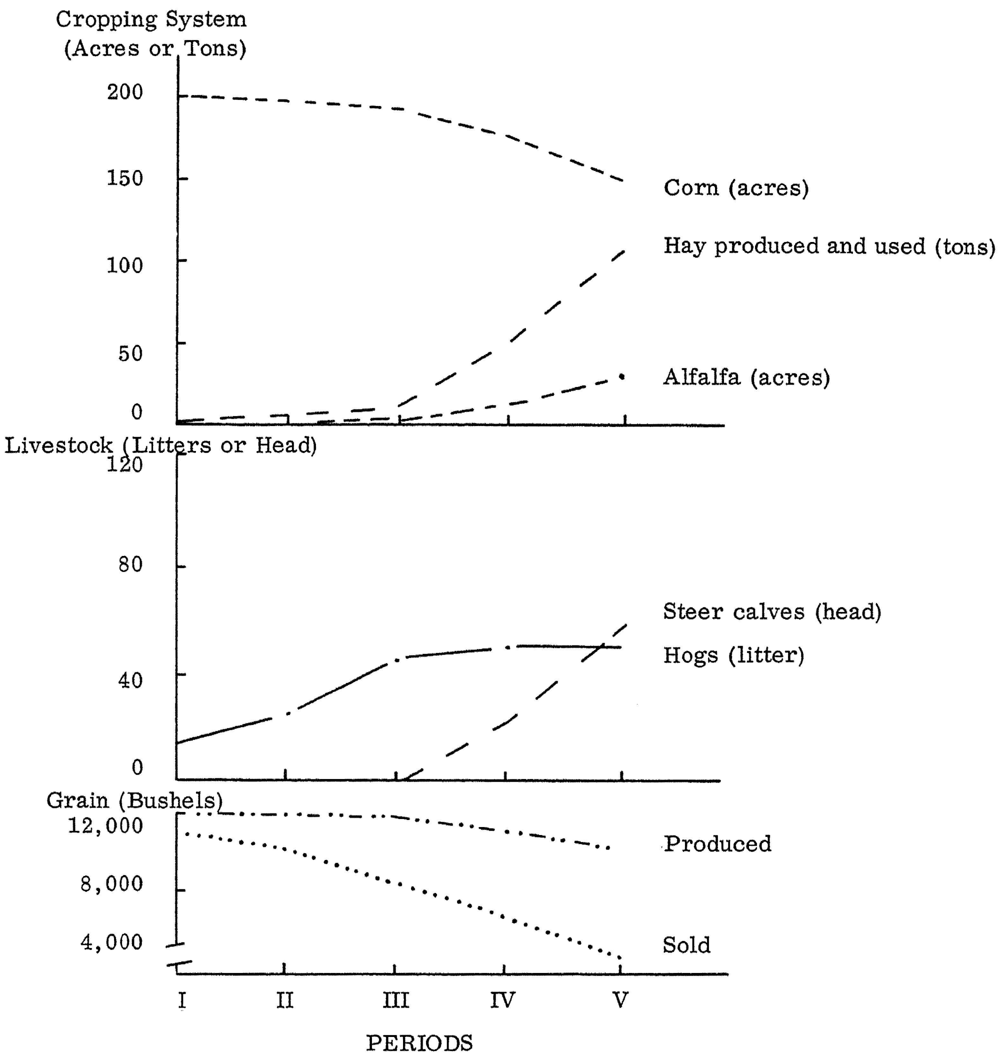

FIG. 2 -- The changing of the cropping system, livestock production, and grain production from Period I to Period V for the farm organization of Case A.

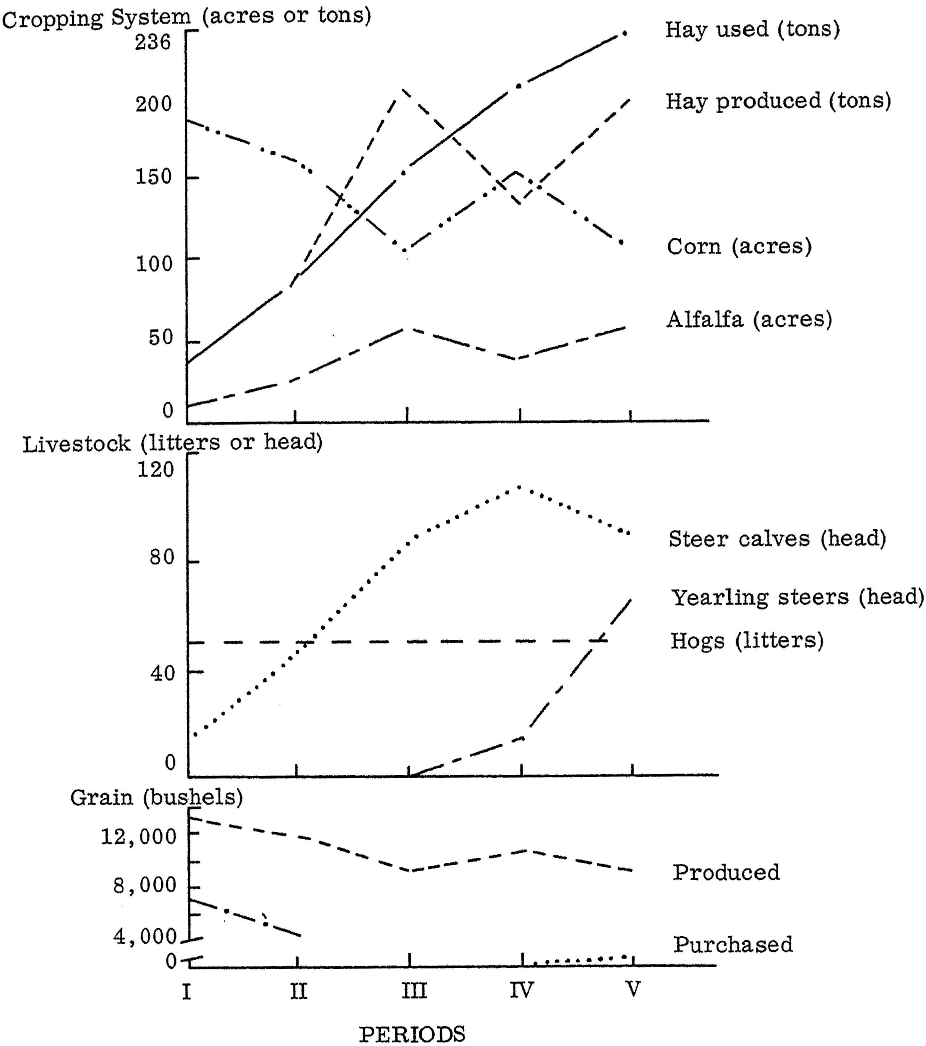

FIG. 3 -- The changing of the cropping system, livestock production, and grain production from Period I to Period V for farm organization of Case F.

INITIAL CAPITAL LAND AND CAPITAL ACCUMULATION

In this example of multi-period linear programming a basic problem was one of capital accumulation since the capital output of one year is the capital input of the next year. The amount of capital available for production alternatives in the initial period had a large impact on the farm organization and similarly on the rate of capital accumulation.

In Figure 4, an analysis of capital accumulation of the eight cases is shown. The accumulation curves for each case were increasing functions, although the rates of increase were not identical. Figure 5 shows the percentage of total capital accumulation for each case from Period I to Period V. For example, the total capital accumulation for Case B was $16,890, an increase of 187.6 percent from the $9,000 level of the first year. The rate of capital accumulation increased to 212.2 percent for Case D and then declined steadily to 191.5 percent for Case H. Whereas the increase in capital was high for all cases, the presence of a low rate of 142.1 percent for Case A should be noted. Table 4 shows the percent increase in capital from one period to the next for each case. Although there are exceptions, the rate of increase from period to period was generally increasing for Cases A and B, but decreasing for Cases C to H. The low percentage increase between Periods IV and V for Cases G and H was due to capital being invested in off-farm sources where opportunity costs were greater than the returns which could be obtained with additional on-farm investments. As will be shown in a later section, these rates had a large impact on the capital rationing curves.

The capital accumulation curves become closer together as one proceeds from Case A to Case H, (see Figure 4). This trend is shown in Table 5, which was derived by taking the difference in the capital levels between subsequent cases for each period. The capital variation of Period I between each case was set at $1,000, thus, the capital difference for this period was constant. Note that the capital accumulation levels were increasing at a decreasing rate for each period from Case A to Case H, with a few exceptions.

As shown in Figures 4 and 5 and Tables 4 and 5, capital accumulation increased at an increasing rate from Period I to Period V only for Case A with Cases B and C having both increasing and decreasing rates. With a few exceptions, capital accumulation increased at a decreasing rate from Period I to Period V for Cases D through H.

The causes of variation in capital accumulation are to be found in initial capital levels and attendant farm organizations. In Case A, the $8,000 capital level restricted the farm organization to a cash-grain and hog farm. Since hogs and steer calves generate large capital returns, the presence of these activities at their maximum in all yearly plans causes the highest rates of capital accumulation. Case D had this type of organization. Although Cases E through H had larger numbers of livestock, the cropping system limited capital accumulation by requiring the organization to purchase hay and/or grain, and thus reduced the rate of capital accumulation.

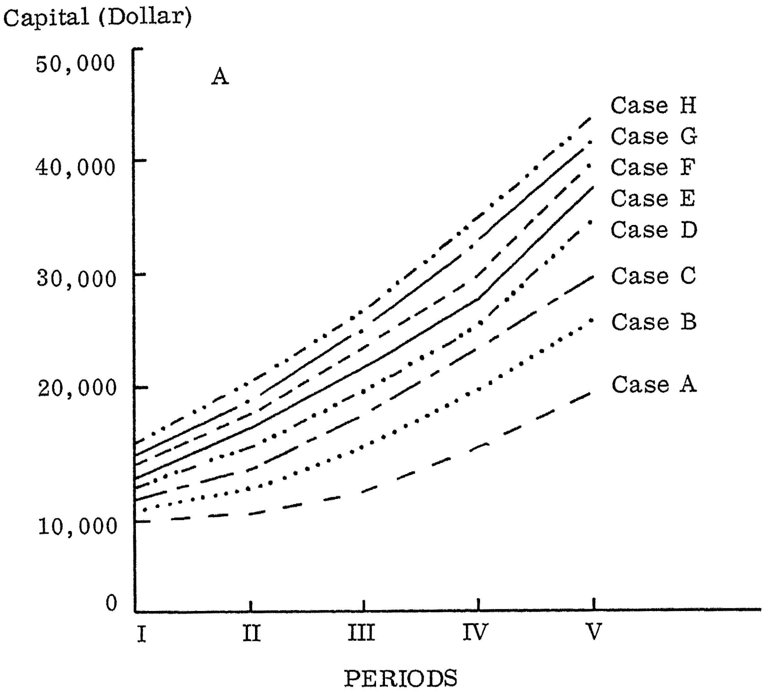

FIG. 4 -- Capital accumulation for Period I to Period V for the eight cases.

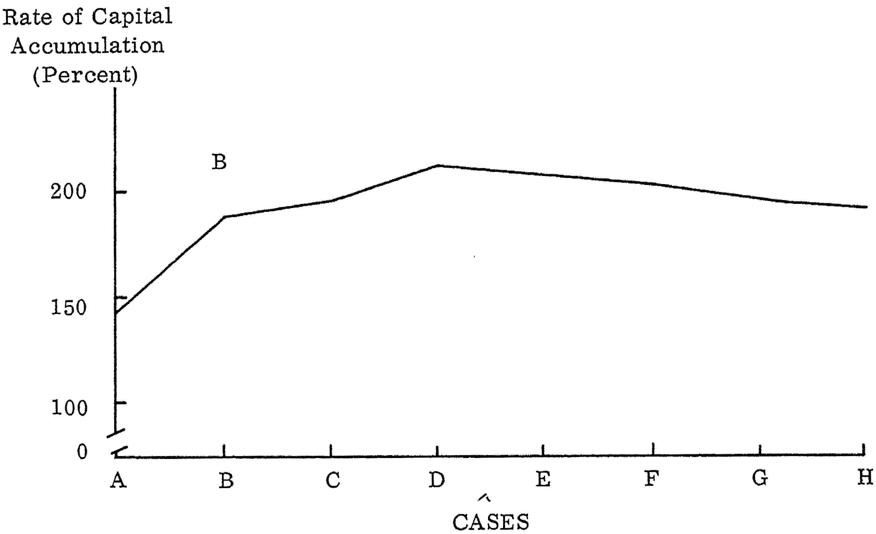

FIG. 5 -- The rate of total capital accumulation from Period I to Period V for the eight cases.

TABLE 4--PERCENT INCREASE IN CAPITAL BETWEEN SUBSEQUENT PERIODS FOR THE EIGHT CASES

Periods	Cases A	B	C	D	E	F	G	H
	Percentage Increase							
I-II	11.8	21.2	28.7	34.5	35.2	34.8	34.4	34.1
II-III	20.7	34.1	34.8	34.2	33.8	33.5	33.0	30.9
III-IV	33.5	34.2	33.6	31.4	28.4	27.7	30.2	31.9
IV-V	34.3	31.9	27.3	31.6	32.8	31.9	27.6	25.9

TABLE 5--ABSOLUTE CHANGES IN CAPITAL LEVELS BETWEEN SUBSEQUENT CASES FOR THE FIVE PERIODS

Cases	Periods I	II	III	IV	V
A-B	$1,000	$1,963	$3,825	$5,209	$6,523
B-C	1,000	1,963	2,728	3,545	3,620
C-D	1,000	1,926	2,503	2,908	4,829
D-E	1,000	1,423	1,849	1,783	2,677
E-F	1,000	1,300	1,688	2,000	2,388
F-G	1,000	1,300	1,636	2,716	2,178
G-H	1,000	1,300	1,307	2,137	2,136

CAPITAL ACCUMULATION AND NET RETURNS

Since the capital level was in a direct relationship with net returns, the variation in capital accumulation had an impact on the magnitude of net returns. Although net returns have been discussed with the farm organizations, a separate analysis will show more completely the magnitude of net returns among the cases and certain inherent relationships. The surface in Figure 6 was constructed with the horizontal axes representing the eight cases and five periods, and net returns being the vertical coordinate. The surface, in general, increased from left to right as larger amounts of capital were available—$15,000 for Case H as compared to $8,000 for Case A in Period I.

A ridge, zyxwvu, runs through the surface whereby the net returns increase and then decrease. To more completely show the cause of this ridge as well as the magnitude of total net returns, the iso-net returns from Figure 6 are shown in Figure 7 for each period for the eight cases. The total five-year net returns increase from Case A to Case H, but at a decreasing rate. In general, the yearly net

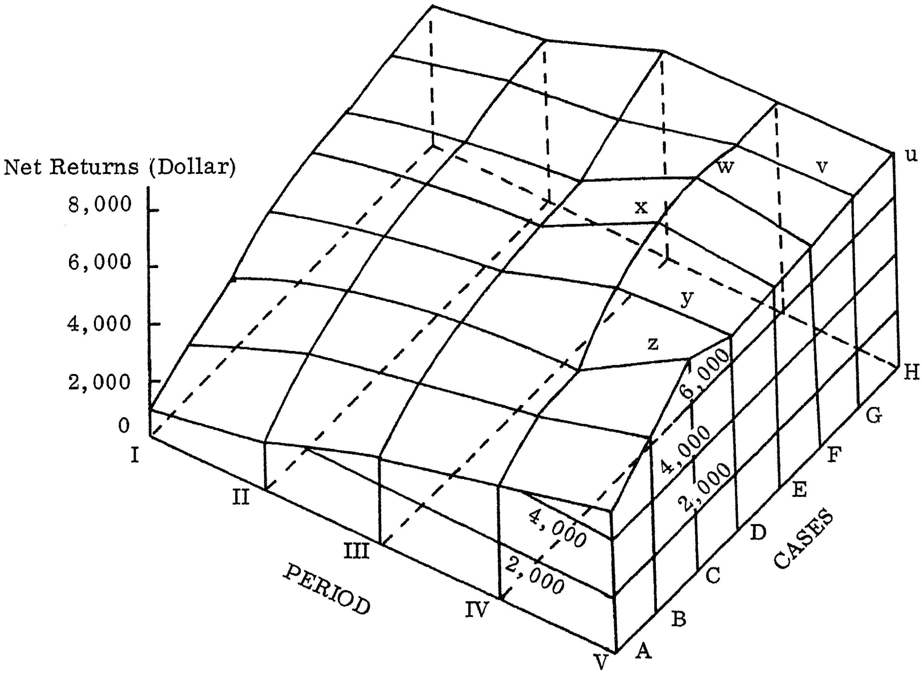

FIG. 6 -- The relationship of net returns to capital accumulation for the eight cases and five periods.

returns increase in magnitude from Period I to Period V for each case, although the ridge, zyxwvu, interrupted this trend. Net returns increased sharply in Period V of Case C; Period IV of Cases D, E, and F, and Period III of Case H; but then declined in Period V of Cases E and F and increased only slightly in Cases G and H of the same period. The direct cause of the above was the cropping system which became a limiting factor in the farm organizations as capital accumulation increased the concentration of livestock numbers, thus increasing the demand for larger requirements of both grain and hay. The cropping system became restrictive and thus, to relieve this situation, some hay was transferred allowing the cropping system to revert to a more intensive rotation in the later period. Until the start of the restrictive cropping system, yearly net returns had increased steadily for each period from case to case as the amount of capital available for production increased.

The cropping system first became restrictive in Period V of Case C, thus 55.1 tons of hay were transferred to this period from Period IV which allowed grain production to increase 1,572.7 bushels, as shown in Table 3. Consequently, the net return in Period V increased sharply. As capital available for production was larger in Case D, the transfer of hay in this case was to Period IV, with net returns increasing sharply in that period. As shown in Table 3, a comparison of

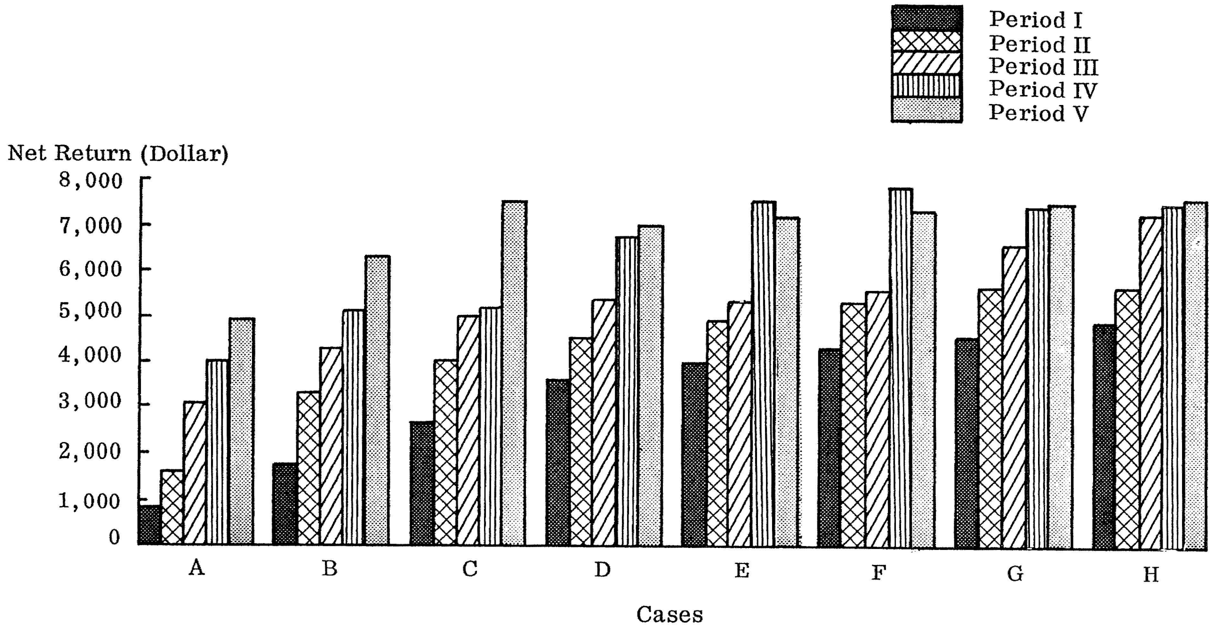

FIG. 7 -- Net returns from Period I to Period V for the eight cases.

Cases D, E and F shows that grain production and hay buying steadily decreased in Period V, but grain production and hay transfer steadily increased in Period IV. Hay transfer reached a maximum tonnage of 50.3 tons in Period IV in Case F with hay buying being at 20.3 tons. Hence, net returns in Period IV increased rapidly in all three cases. In the cases E and F, net returns in Period V decreased from the level in Period IV. In Case G, the cropping system was partially restrictive in both Periods III and IV. Hence, the ridge was in a transitional phase between Periods IV and V. As greater capital accumulation occurred, hay transfer became profitable in Period III of Case H as net returns in this period increased rapidly, although the profitability of grain buying in Period V caused net returns to increase from Period I to Period V.

These changes in the cropping system are shown in Figure 8, which has the same horizontal axes as Figure 7, but the height represents grain production. Grain production declined from Period I to Period III, then generally increased in Period IV and declined in Period V. The surface slopes downward from left to right whereas the reverse was true of Figure 7.

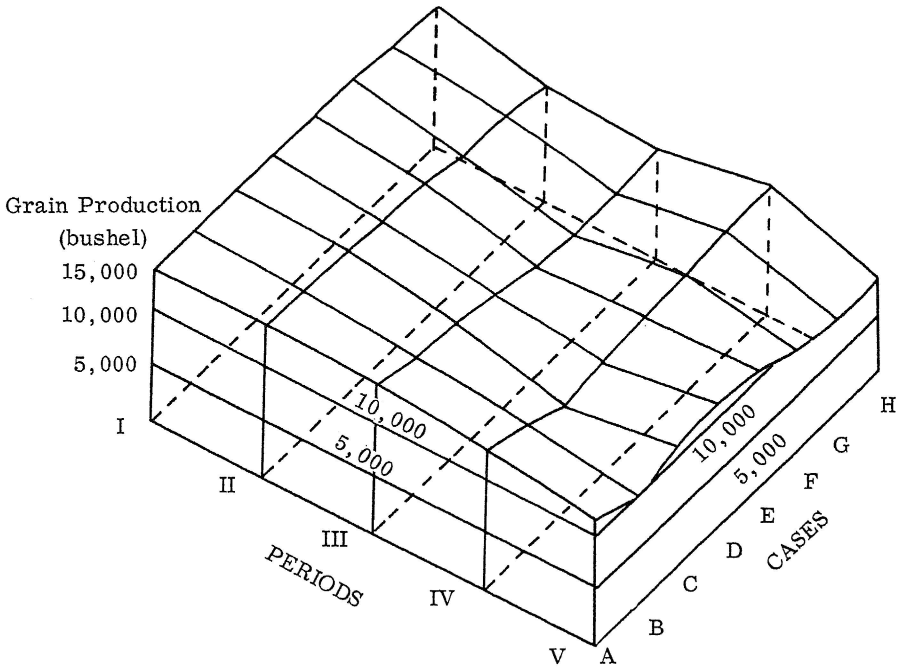

FIG. 8 -- The relationship of grain production to capital accumulation for eight cases and five periods

AVERAGE AND MARGINAL RETURNS

Capital was a variable input in the model with the variation accounted for in the initial period of the eight cases or by capital accumulation for the subsequent periods for each case. By using the level of capital available for each period as the variable input and net return as the output of each case, the marginal and average returns (to capital) can be computed. The marginal, average, and yearly net returns for all eight cases are shown in Table 6. Comparison of average and marginal returns should be made primarily between periods. Comparisons between cases must be made with care since only in the first period was the difference in the capital levels identical. For example, the net return for Case B for Period I was $1,812 with a capital supply of $9,000, thus, an average return of $.20. Net returns increased $1,560 and the capital supply increased $1,908 from Period I to Period II for Case B, thus, a marginal return of $.82.[22] Although the variable input was capital, it is important to remember that Table 6 was based on five years and the capital level and the rate of capital accumulation were different for each case. Since variation in beginning capital levels resulted in different degrees of impact on farm organizations and net returns the value of capital, in terms of marginal value product, was affected.

CAPITAL RATIONING

Capital rationing existed whenever the amount of capital used was less than that which would equate the marginal value product of capital and the interest rate. Since the level of capital in the first period was varied at $1,000 units, capital rationing was forced upon the farm organization rather than being determined by the amount of capital that can be borrowed at various interest rates.

In Figure 9, the rationing curves of Cases A, B, C, F, and H are shown.[23] The presence of five distinct curves suggests inherent relationships. The value of capital (the marginal value product) for all five periods increased from Case A to Case H as the capital supply in Period I increased from $8,000 to $15,000. In other words, capital borrowing would be in direct relationship with the capital supply at the beginning of the economic horizon. For example, the capital borrowed at a marginal value product of $.20 or a 20 percent interest rate would be $19,250, $23,300, $26,200, $28,200, and $30,000 for Cases A, B, C, F, and H respectively.

[22]Due to this method of calculating marginal returns, the marginal return in Period V of Cases G and H did not equal the off-farm investment rate of $.045, although these cases had off-farm investment as an activity in Period V. If calculation of marginal returns had been between cases for each period, then the marginal return in Period V between Cases G and H would have been equal to the investment rate. In other words, the difference in net returns between Cases G and H in Period V was $96 and the difference in capital supply was $2,136, thus, a marginal return of $.045.

[23]The marginal value products of Cases D, E, and G were not obtained.

TABLE 6--THE AVERAGE, MARGINAL AND YEARLY NET RETURNS FOR THE FIVE PERIODS AND EIGHT CASES

Period	Cases[a] A	B	C	D	E	F	G	H
				Average Returns				
I	$ .11	$ .20	$ .27	$ .33	$ .33	$ .33	$ .33	$ .32
II	.19	.31	.32	.31	.31	.30	.30	.28
III	.29	.30	.29	.27	.25	.22	.22	.21
IV	.28	.26	.24	.23	.23	.22	.22	.21
V	.26	.25	.24	.23	.23	.22	.22	.21
				Marginal Returns				
I-II	.83	.82	.46	.26	.23	.23	.22	.15
II-III	.78	.26	.22	.16	.11	.09	.08	.08
III-IV	.26	.18	.20	.11	.11	.09	.08	.08
IV-V	.18	.18	.20	.11	.11	.09	.08	.08
				Net Returns				
I	895.00	1,812.00	2,730.00	3,613.00	4,016.00	4,301.00	4,587.00	4,872.00
II	1,683.00	3,372.00	4,065.00	4,588.00	4,975.00	5,328.00	5,633.00	5,639.00
III	3,130.00	4,326.00	5,031.00	5,381.00	5,324.00	5,592.00	6,526.00	7,244.00
IV	4,070.00	5,149.00	5,211.00	6,789.00	7,525.00	7,845.00	7,402.00	7,401.00
V	4,957.00	6,351.00	7,515.00	7,010.00	7,193.00	7,326.00	7,445.00	7,541.00
				Five-Year Average Returns				
	2,947.00	4,202.00	4,910.00	5,476.00	5,807.00	6,078.00	6,319.00	6,539.00

[a] Average and marginal returns are rounded to the nearest hundredth.

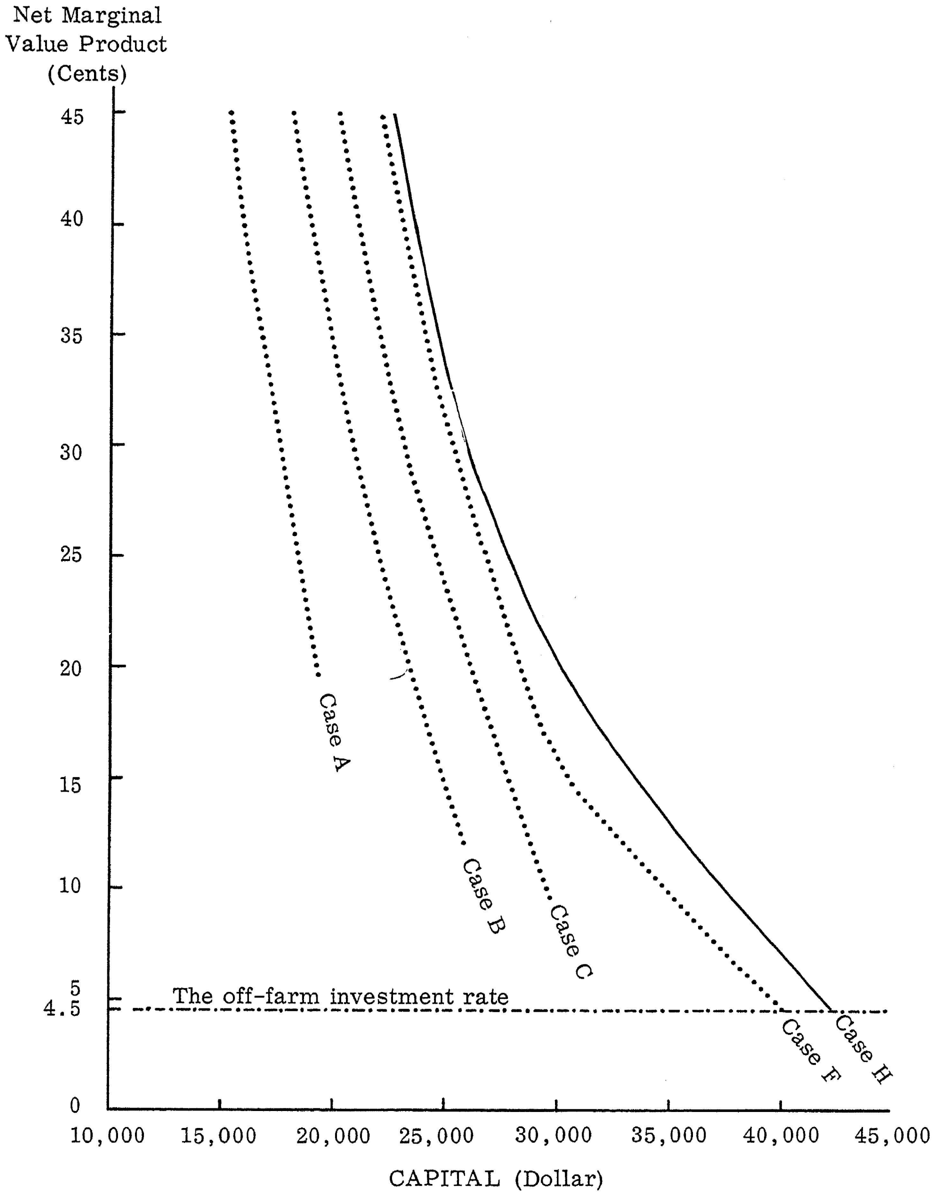

FIG. 9 -- The marginal value product curves for Cases A, B, C, F, and H.

These rationing curves actually suggest two factors; that of relevancy and that of cause. If the only limitation on borrowing was the rate of interest, the relevant curve was that of Case H since this curve was on a higher surface than the others. The causes of distinct curves were due to two related factors. Remembering that net returns were discounted, the capital accumulation of the cases differed not only in total, but in the same period. For example, the capital level of Case C was $23,176 in Period IV whereas the capital level of Case F was $23,392 in Period III. Although the capital supplies were similar, the marginal value product for this capital was $.39 for Case F and $.30 for Case C. Thus, the value of capital depended on the period it was available. This conforms not only with the time principle, but with Bohm-Bawerk's third cause of interest in that productive goods available at the present are on technical grounds superior to future goods; thus, they have a higher value.[24]

Although the distinct rationing curves are important, the shape of the curves should be noted. The curves point out that capital accumulation, with all other factors constant, caused a reduction in the marginal value product of capital. The rationing curves are all convex to the origin, although the change in slope becomes greater as one moves from Case A to Case H. This convexity of the rationing curves, especially of Case F and Case H, is due to the difference in the rate of capital accumulation between periods. For example, the difference in capital amounts between Cases H and F at the $.25 rate was $900 whereas at the $.15 rate the difference increased to $2,950, as shown. This large increase was due to the difference in the rate of capital accumulation from Periods III to IV which was 31.9 percent for Case H, but only 27.7 percent for Case F.

SUMMARY AND CONCLUSIONS

The general purpose of this study was to determine optimum farm organizations over a five-year period under various levels of capital rationing. The case farm selected for analysis was developed from a survey of 65 member farmers of the Balanced Farming Program in Lafayette County, Missouri.

The farm organizations were obtained by use of a multi-period linear programming technique. Variation of beginning capital levels was started at $8,000 (the lowest capital level which would allow all land to be operated) and increased in $1,000 units until the net marginal value product of capital was equal to or lower than 4.5 percent in any year. Thus, eight optimum farm organizations were obtained at initial capital levels of $8,000 to $15,000.

A definite trend of activity movement was apparent as the initial capital level varied from $8,000 to $15,000 (Table 3). The yearly plans of the different cases were similar when the capital available for production was almost identical, although the period of production might be different. In other words, in situations with low initial capital levels, the plans of the later periods were similar to those for the earlier periods of the situations with higher levels of initial capital.

[24]Eugene Von Bohm-Bawerk, *The Positive Theory of Capital,* (The Smart Translation) (London: Macmillan and Co., 1891). p. 260.

Capital available in the first period was influential in determining the scale of operations of the farm organization. The restrictive capital supply of Periods I and II of Case A ($8,000) and Period I of Case B ($9,000) limited the yearly plans to cash-grain farms, although capital accumulation in the remaining periods allowed for greater livestock production. Since operation of all land was required, livestock numbers were those allowed by the capital supply available after utilizing all land in the cropping system. Hence, production of livestock remained low until the capital supply increased.

Basically, as the initial periods' capital supply increased from Case A to Case H and as capital accumulated from Period I to Period V, the pattern of enterprise movement was as follows:

1. The hog enterprise was the only livestock enterprise in the organizations until they reached the 50.0 litter limit allowed by building space.
2. Steer calves entered when hog numbers were limited by building space and increased sharply thereafter.
3. Yearling steers became profitable when the restrictive hay supply reduced the profitableness of steer calves (yearling steers, however, contributed over 25 percent of the gross income in only three plans).
4. The cropping system steadily became more extensive as livestock concentration increased, thus resulting in steady decreases in grain selling and production.

Both grain and hay requirements increased as livestock production expanded was required. When grain was in surplus, this problem was solved simply by decreasing grain selling and producing more hay. But the problem became more acute when grain selling was eliminated from the farm organization. This problem was resolved in two ways. First surplus hay produced in one period was transferred to the next period and/or was purchased, thus allowing the cropping system to increase grain production. Second, grain was purchased when it became more profitable to revert the cropping system to a more extensive rotation. This transitional phase or pattern is shown by Cases D, E, F, G, and H.

The pattern of enterprise movement previously discussed was a result of capital accumulation. Since the hog and steer calf enterprises generate high levels of income plus high returns, the presence of these enterprises in the farm organization would influence the rate of capital accumulation. Thus, the cash grain farm organizations of Cases A and B have low rates of capital accumulation. The rate of capital accumulation of Case A from Period I to Period II was only 35 percent —a direct effect of the restrictive capital supply which limited the farm plans of those periods to cash-grain production. The capital accumulation curves were all increasing functions. The rate of total capital accumulation from Period I to Period V increased from a rate of 142.7 percent for Case A to a rate of 212.2 percent for Case D, and then declined steadily to 191.5 percent for Case H. The effect on capital accumulation was primarily caused by the livestock feed limits. The lowest rate of capital accumulation between periods was where hay was transferred from one period to the next and/or purchased allowing the cropping system to revert to a more intensive rotation in the next period.[25] If the capital used for overproduction of hay had been funneled into livestock production, then the rate of capital accumulation would have been greater although net returns would not have been maximized.

Since the rate of capital accumulation for Case A was low, the presence of capital amounts lower than $8,000 would indicate serious problems. A beginning capital level of, say, $6,000 would have been too low to allow operation of the plan for Period I and thus for the five-year organization. Hence, for the case farm, farm organizations below the $8,000 beginning capital level would have had to have been formulated without allowances for fixed costs such as depreciation.

The capital level and accumulation determined the farm organizations and affected net returns. As would be expected, total five-year net returns increased from Case A to Case H as the amount of capital available in the initial period increased. (Figure 6.)

A closer analysis of net returns was shown in Table 6. Cases A, B, and C had a stage of increasing average returns which paralleled the increasing rate of capital accumulation between periods. Marginal returns decreased throughout the five periods for all eight cases. The impact of capital on the magnitude of returns was shown by the high marginal return between Periods I and II of $.83 for Case A and only $.15 for Case H.

Capital rationing was imposed upon the farm organizations and the level of capital amounts in the first period was increased by $1,000 units in the model. Thus, the rationing curves shown in Figure 9 were obtained from the model. Since the capital supply of each case in Period I was different, the marginal value product curves for each case were different. In other words, capital borrowing in intermediate years would be in direct relationship with the capital supply at the beginning of the economic horizon. If the only limitation on borrowing was the interest rate, then the relevant curve would be the one with the highest initial capital level—Case H in this study. The cause of distinct rationing curves was due to the rate of capital accumulation and the discounting of net returns. The value of capital depended on the period the capital was available for production. For example, the capital levels of Case F (Period III) and Case C (Period IV) were similar, but the net marginal value of capital was $.39 for Case F and only $.30 for Case C. This was due to the higher rate of capital accumulation of Case F and the lower discount rate in Period III than in Period IV.

[25]The exception to this was for Cases A and B and between Periods IV and V in Cases G and H.

APPENDIX TABLE 1--AVAILABLE OPERATOR AND FAMILY LABOR HOURS BY MONTHS AND SUB-PERIODS[a]

Month	Operator	Family	Total
January	240	50	
February	240	50	
March	240	50	
January - March			870
April	260	50	
May	260	75	
April - May			645
June	260	150	
July	260	150	
August	260	150	
June - August			1,230
September	260	75	
October	240	50	
September - October			625

[a]Adapted in part from Utter and Justus, op. cit. p. 15.

APPENDIX TABLE 2--ALLOWANCE FOR FIXED COSTS AND FAMILY LIVING EXPENSES[a]

Item	Annual Amount
Household Consumption	$3,600
Land, Income, and Social Security Taxes	1,500
Depreciation[b]	1,080
Replacement and New Investment	1,000
Total	$7,180

[a]The method used to obtain taxes and depreciation allowances was by use of average values of similiar one-year plans.

[b]Some depreciation was allowed for in the crop and livestock capital coefficients.

APPENDIX TABLE 3--LABOR REQUIREMENTS FOR LIVESTOCK ENTERPRISES AND CROP ROTATIONS IN THE FOUR SUB-PERIODS

Activity	Unit	Periods January-March	April-May	June-August	September-October
Crop Rotations[a]		Hours			
Continuous Corn	Acre	0.20	2.50	1.80	1.35
C - Sb - W (x)	Acre	0.07	1.33	2.73	1.88
C - C - O (x)	Acre	0.47	2.00	2.40	1.03
C - O - A - A - A	Acre	0.24	1.75	5.22	1.87
Sb - W - A - A - A	Acre	0	1.35	5.42	2.38
Livestock Enterprises[a]					
Steer Calves	Head	3.00	1.33	1.66	3.50
Yearling Steer	Head	3.00	2.50	2.00	0
Two-year-old Steer	Head	2.00	0	0	1.60
Plain Steer	Head	3.00	3.00	0	0
Hogs	Sow and 2 Litters	10.00	7.00	6.00	6.00

[a]Sources: Utter and Justus; op. cit., p. 16; Bernard Bowlen and Earl O. Heady, "Optimum Combinations of Competitive Crops," Research Bulletin 426, Iowa Agriculture Experiment Station, 1955.

[b]Sources: "Farm Business Planning Guide," and "Planning the Farm Business," Agricultural Extension Service and Department of Agriculture Economics, College of Agriculture, University of Nebraska; "Farm Business Planning Guide," B. F. 6103, University of Missouri, College of Agriculture and USDA Cooperating, January, 1961; R. G. Johnson and T. R. Nodland, "Labor Used in Cattle Feeding," Station Bulletin 451, University of Minnesota, Agricultural Experiment Station, Minneapolis, Minnesota, March 1960.

APPENDIX TABLE 4--PRICES ASSESSED FOR THE VARIOUS CROPS, LIVESTOCK AND LABOR HIRING ACTIVITIES

Commodity	Unit	Price: Purchase	Price: Selling
Crops[a]			
Corn	Bushel	$1.10	$1.00
Soybeans	Bushel	---	2.00
Wheat	Bushel	---	1.73
Oats	Bushel	---	.60
Alfalfa	Ton	20.00	---
Livestock[b]			
Steer Calves	Pound	27.55	25.65
Yearling Steer	Pound	24.95	25.65
Two-year-old Steer	Pound	23.30	25.74
Plain Steer	Pound	16.00	18.00
225 lb. Market Hog	Pound	---	16.20
Cull Sow	Pound	---	13.60
Other			
Labor	Hour	1.25	---

[a]Sources: Utter and Justus, *op. cit.* p. 17; and "Farm Business Planning Guide," Missouri, *op. cit.*

[b]Sources: USDA, "Livestock and Meat Statistics, 1962" *Statistical Bulletin No. 333*, July 1963; and University of Missouri Extension Service.

APPENDIX TABLE 5--CAPITAL REQUIREMENTS FOR THE CROP ROTATIONS AND LIVESTOCK ENTERPRISES[a]

Activity	Unit	Capital
Rotations		
Continuous Corn	Acre	$34.08
C - Sb - W (x)	Acre	32.40
C - C - O (x)	Acre	32.58
C - O - A - A - A	Acre	24.72
Sb - W - A - A - A	Acre	25.21
Livestock		
Steer Calves	Head	146.36
Yearling Calves	Head	184.37
Two-year-old Steers	Head	222.14
Plain Steers	Head	124.65
Hogs	Sow and 2 Litters	176.91

[a]Sources: Utter and Justus, op. cit. p. 18; and "Farm Business Planning Guide."

APPENDIX TABLE 6--C_{jk}'S FOR THE VARIOUS CROP ROTATION, LIVESTOCK, AND SUPPLEMENTARY ACTIVITIES BEFORE DISCOUNTING

Activity	Unit	Capital Requirement	Gross Income	C_{jk}
Crop Rotations				
Continuous Corn	Acre	$ 34.08	$ 0.0	$-34.08
C - Sb - W (x)	Acre	32.40	0.0	-32.40
C - C - O (x)	Acre	32.58	0.0	-32.58
C - O - A - A - A	Acre	24.72	0.0	-24.72
Sb - W - A - A - A	Acre	25.21	0.0	-25.21
Livestock				
Steer Calves	Head	$146.36	$263.94	$117.58
Plain Steers	Head	124.65	180.00	55.35
Yearling Steers	Head	184.37	290.56	106.19
Two-year-old Steers	Head	222.14	291.57	69.43
Hogs	Sow and two litters	176.91	564.70	387.79
Supplementary				
Grain Buying	Bushel	$ 1.10	$ 0.0	$ -1.10
Grain Selling	Bushel	0.0	1.00	1.00
Hay Buying	Ton	20.00	0.0	-20.00
Hay Transfer	Ton	0.0	0.0	0.0
Capital Transfer	Dollar	0.0	0.0	0.0
Capital Investment	Dollar	1.00	1.045	0.045
Labor Hiring	Hour	1.25	0.0	-1.25

APPENDIX TABLE 7--LIVESTOCK FEED REQUIREMENTS[a]

Activity	Unit	Feed Required: Corn Equivalents (bu)	Feed Required: Hay (ton)
Steer Calves	Head	45	1.6
Yearling Steers	Head	45	1.25
Two-year-old Steers	Head	40	.5
Plain Steers	Head	15	1.5
Hogs	Sow and 2 Litters	210	.5

[a]Source: "Farm Business Planning Guide."

APPENDIX TABLE 8--EXPECTED YIELDS FOR CROPS, AND HAY AND CORN EQUIVALENT PRODUCTION BY CROP ROTATION[a]

Enterprise	Unit	Yield	Production: Corn Equivalent (bu)	Production: Hay (ton)
Crops				
Corn	Bushel	69.0	---	---
Soybeans	Bushel	25.2	---	---
Wheat	Bushel	31.1	---	---
Oats	Bushel	48.5	---	---
Alfalfa	Ton	3.5	---	---
Red Clover	Ton	2.0	---	---
Rotation				
Continuous Corn	Acre	---	69.0	0
C - Sb - W (x)	Acre	---	57.5	.17
C - C - O (x)	Acre	---	55.6	.17
C - O - A - A - A	Acre	---	19.6	2.1
Sb - W - A - A - A	Acre	---	20.7	2.1

[a]Source: Utter and Justus, op. cit., p. 12.

APPENDIX TABLE 9--RETURNS AND ITEM COSTS FOR THE LIVESTOCK ENTERPRISES

Enterprise	Steer Calves		Yearling Steer		Two-Year-Old Steer	
	1050# @ 25.65 =	$269.33	1150# @ 25.65 =	$294.98	1150# @ 25.74 =	$296.01
	Less 2% death loss	5.39	Less 1.5% death loss	4.42	Less 1.5% death loss	4.44
Gross Receipts		263.94		290.56		291.57
Purchase Cost	450# @ 27.55	123.94	650# @ 24.95	162.18	900# @ 23.30	209.70
Protein, Salt and Mineral		14.00		15.00		6.00
Veterinary and Drugs		2.00		1.00		1.00
Taxes and Insurance 1.5% of Livestock Equipment and Investment		2.83		1.83		1.08
Depreciation on Livestock Equipment		.45		.45		.45
Breeding Charge		.00		.00		.00
Miscellaneous Charges		3.55		3.91		3.91
Enterprise Costs		146.36		184.37		222.14
Returns to Feed, Capital and Labor		117.58		106.19		69.43

APPENDIX TABLE 9 (Continued)

Enterprise	Plain Steer		Sow and Two Litters	
	1000# @ 18.00 = $130.00		14 Market Hogs x 225# @ 16.20	$510.30
			1 cull sow x 400# @ 13.60	54.40
Gross Receipts		180.00		564.70
Purchase Costs	700# @ 16.00	112.00		50.00
Protein, Salt and Mineral		8.00		84.00
Veterinary and Drugs		.30		16.00
Taxes and Insurance 1.5% of Livestock Equipment and Investment		1.35		4.05
Depreciation on Livestock Equipment		.45		4.50
Breeding Charge		.00		4.00
Miscellaneous Charges		2.55		14.36
Enterprise Costs		124.65		176.91
Returns to Feed Capital and Labor		55.35		387.79

Source: "Farm Business Planning Guide" B. F. 6103, University of Missouri, College of Agriculture and USDA Cooperating, January 1961.