A STUDY OF ALTERNATIVES TO DAIRYING AND WITHIN DAIRYING IN THE THUMB AREA OF MICHIGAN

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A B S T R A C T

A STUDY OF ALTERNATIVES TO DAIRYING AND WITHIN DAIRYING IN THE THUMB AREA OF MICHIGAN

by Charles Alexander Robertson

This thesis is concerned with the problems of choice of enterprise and resource utilization on farms in the Thumb area of Michigan. The aim was to formulate profit-maximizing patterns of production for certain classes of farms in the area.

Two types of farms were considered, a dairying type and a cash cropping type. A "representative" farm structure was developed for each type, based on the characteristics of such farms as revealed by survey. The representative farm data was then subjected to a profit maximization process using linear programming. The programming model embodied the assumption, through the medium of the input-output coefficients, that farm operations were carried out at a high level of technical efficiency.

The individual courses of action open to each representative farmer included such alternatives as labour hire or salvage, purchase or sale of land, use of credit facilities or investment of farm capital in non-farming activities. Possible livestock enterprises included dairying and hog, beef and egg production. Various alternative methods of livestock production were incorporated

within each broad group of activities. Among the crops which could be grown were corn, wheat, barley, oats, beans and alfalfa. Various outlets for disposal of these crops were included in the model.

Milk was price mapped over the range $30 per 1000 lb. to $50 per 1000 lb. All other prices were held constant.

The results suggest that dairy farmers whose farms fall within the range 80 - 149 tillable acres should move out of milk production, unless the price of milk rises beyond the level of $40 - $45 per 1000 lb., all other prices remaining constant. They should concentrate on growing wheat and hay as cash crops and corn for feeding on the farm to hogs. This optimum pattern of production also applies to cash cropping farms over the whole milk price range under consideration.

Above $40 - $45 per 1000 lb. milk dairy farmers should make full use of their existing dairying facilities in conjunction with wheat growing and the production of corn for feeding to dairy cows and hogs.

An increase in the present tillable acreage through land purchase and a net movement of labour off the farm were common factors to all optimum plans.

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I N T R O D U C T I O N

General Background

The broad lines along which this study was developed were laid down by the conditions underlying the approach to, and the methodology involved in, a wider inquiry currently being conducted into the dairying industry in the Great Lakes region, to which study this paper is a contribution. The parent investigation has as its main objective the determination of: "changes that can be made in the organization of dairy farms and in the allocation of resources to dairying in the Great Lakes region that will provide greater factor earnings and be consistent with a balance in the aggregate relationship between the supply of and the demand for dairy products."[1]

The main study is being conducted on a regional basis because of economic and technological variations among regions within the area. For each region farm types will be isolated, representing the main physical and organizational features of the principal farm groups found therein. These situations will then be analysed on a normative basis, i.e. the aim will be to develop on paper the organization as it ought to be, given the objective of profit maximization.

1. Dean E. McKee and James T. Bonnen, Suggested Procedures for the Analysis of Production Adjustments in the Great Lakes Dairy Industry, (Paper for discussion only), Michigan State University Agricultural Economics Department, January 1959, p. 1.

The analysis is static and thus ignores the time element which elapses during the transition from one type of set-up to another, the investigation being concerned only with the forms of the current and the revised organizations. Not only is the time element unaccounted for here, but also any associated loss of income deriving from interruption of the production process as a result of reallocation of resources. In practice such revisions, particularly where they relate to livestock enterprises, cannot always be accomplished in such a way as to achieve instantaneous substitution of one enterprise for another on a fully operational basis, and therefore the flow of current income to the farm family is temporarily reduced.

The Approach

The problem will be set up at the micro level in the linear programming form and will include certain features which are alien to the simple type of programming model. The principal among these is that resource fixity, in the sense that the physical quantities of farm factors are held constant, is relaxed to allow for the purchase and sale of units of resources, such transactions being a direct effect of the profit maximization process. Not all resources, however, are completely variable. There is an upper and a lower limit, for example, on the area of land which can be purchased or sold respectively; the amount of farm family labour which can be sold off the farm is less

than that available for farm work; credit availability, and thus the supply of capital, is governed by the value of the farm real estate and chattels as well as by the rate of interest. Other resources, such as hired labour, can be varied freely and in general the quantity of these resources and of other resources is conditioned by the value of a unit of the resource in the production process in relation to its market cost and to its salvage value, i.e. resource use will be fixed at that level where there is no gain to be realized from applying more of that resource in the production process, or less of it. This is the level where the MVP of the resource is less than the cost of acquiring another unit of it, but greater than the revenue obtainable by selling a unit. So long as this dual condition holds the resource will be fixed for the farm business.[2]

In theory, the only elements which limit the continued expansion of the farm firm are the managerial ability of the farmer, rising factor costs, and falling product prices. To these must be added the tendency, due to the presence of risk and uncertainty, to discount future MVPs. This factor is related to the increasingly unfavourable equity position of the farmer as the size of his business expands, when such expansion involves the use

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2. G.L. Johnson and L.G. Hardin, Economics of Forage Evaluation, North Central Regional Publication No. 48, Purdue University Agricultural Experiment Station, Lafayette, Indiana, April 1955.

of credit facilities. Within the confines of this study, however, factor prices will be variable only in the sense that units of resources of the same nature, but different quality, will be charged accordingly, e.g. the interest charge on credit obtained through land mortgage is lower than that payable where chattels are offered as security. The prices of all products, except milk, will be taken as fixed.

Managerial efficiency is assumed to be unaffected by changes in the size of the farm business.

The Problem under Consideration

The paper now being developed will be concerned specifically with the resource allocation problem within the farm firm in the Thumb area[a] of Michigan. Among the main agricultural features of the area in question are the preponderance of dairying enterprises and the importance of cash cropping. Sanilac and Huron are two of Michigan's leading dairying counties in terms of cow numbers,[3] while certain sections of the area (e.g. Denmark Township, Tuscola County) are noted for their high natural level of soil fertility and related capacity for producing large tonnages of cash crops per acre.

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a. The area under consideration comprises the following five counties: Huron, Lapeer, Sanilac, St. Clair, Tuscola.

3. Michigan Department of Agriculture, Michigan Agricultural Statistics, July 1958.

Related Studies

Two studies having a bearing on the present problem will be described in brief.

Hildebrand[4] programmed the production pattern of a typical central Michigan dairy farm and the method by which he deals with the resource supply problem is basically the same as that which will be followed in this paper. By inserting acquisition and salvage activities for all relevant resources he develops a model within which resources are fixed at levels endogenously determined. Within this setting and under the assumed technological conditions the solution indicates that cropping is more profitable than dairying. The technical coefficients used, however, probably tend to encourage a result of this nature since they infer that management of the cropping enterprises is on a higher plane than in dairying.

An Iowa State College study[5] deals with the competition among various dairy enterprises and between dairying and other farm enterprises using continuous capital and variable price programming. Among the several conclusions reached are that the milk price at which

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4. Hildebrand, Peter E., Farm Organization and Resource Fixity: Modification of the Linear Programming Model, unpublished thesis for the degree of Ph.D., Michigan State University, 1959.

5. Ladd, George W. and Easley, Eddie V., An Application of Linear Programming to the Study of Supply Responses in Dairying, Department of Economics and Sociology, Agricultural and Home Economics Experiment Station, Iowa State College, Research Bulletin 467, May 1959.

dairying is forced out of the optimum plan is related inversely to the size of the operator's capital supply, and that where hog housing is unlimited there is an inverse relationship between milk output and hog prices. Spring labour is the most limiting factor in dairy production.

THE APPROACH TO BE USED IN THIS STUDY

Scope

It is proposed to consider the problem in its broader aspects rather than to probe deeply into a narrower field. For example, out of the infinite number of possible crop sequences only four are represented here. Similarly, with the exception of the dairy activities, the level of feeding in the livestock enterprises is restricted to one for each, although several feed input-output relationships might have been considered. The chief danger of too broad a study lies in the relative superficiality inherent therein, compared to the more thorough if less comprehensive nature of the narrower approach in which fewer enterprises might be examined, but each would be subjected to more detailed scrutiny. The logical sequence, however, would seem to be, first, the establishment of favourable lines for more specific investigations, followed by detailed consideration of alternatives along these lines. Thus, the question posed is: "In the area under scrutiny, what alternatives compare favourably on a profit basis with dairying, and how can dairy farmers adjust their organizations to secure higher financial gains?"

Although the approach is broad this does not entirely preclude considerations of alternative systems within particular enterprises, e.g. rearing beef feeders or

purchasing them. Within each enterprise group or set, various systems of management compete with one another. Since the fate of the dairy enterprise is the main issue this enterprise is considered in more specific terms than the others.

Approach at the Micro-Level.

In the interests of realism the study will aim, not at deriving the optimum organization for an "average" farm in the Thumb area, but at developing the end result of an adjustment path for two selected farm types in the area, on the basis of their resource supplies and the associated technological and physical factors which currently attend the operation of the farm business. From this it should be possible to indicate how groups of farmers with differing equity ratios, farm sizes, types of resources, etc., can best adjust to benefit their own commercial interests by attaining organizational patterns which, though different from those of their neighbours, are suited to their own specific circumstances. As far as dairy farms are concerned, any adjustment which is required will be definable in terms of a change of emphasis between milk production and production of other livestock products, crop products, or between systems of dairying.

General Form of Micro-Model.

In order to lend itself to linear programming a problem must satisfy three criteria. It must have:

(1) An objective.

(2) A series of alternative ways of achieving the objective.

(3) A set of resources or other quantifiable restraints.

Since the problem under review fulfills all three conditions it is adapted to solution by linear programming, and also subject to the disadvantages which are associated with this technique.

Assumptions

It seems appropriate at this stage to mention three of the assumptions which apply to the working of the model, the first two are simplifying measures, the third is technological in nature.

(1) The approach followed is that of conditional normativism i.e. given a certain end, in this case profit maximization, the model will illustrate the organizational features which are concomitants of its attainment. There is no attempt made to specify what the end should be.

(2) Absence of risk and uncertainty. It is assumed that what is will be; that current prices, costs[b]

[b] Basically "current" prices and costs are averages of those ruling over the five years, 1954-58.

and technical coefficients maintain their present relationships, with the exception of the product (milk), which is being price mapped. Viewed in the strict sense the model will merely solve the question of how farms ought to be organized in time period t_o, which in itself is not of great practical value unless the assumption of the constancy of the interrelationship among the critical factors does in fact apply, or unless a measure is required of the extent of current maladjustment in relation to the present demand situation.

(3) A high degree of managerial ability at the technological level. The requisite qualities of the good manager are easy to specify, but difficult to express in quantitative terms. In the sense in which it is used here, however, managerial aptitude refers to the ability to farm efficiently. This implies achieving a given rate of output with a minimum of input, or, conversely, using given quantities of inputs in such a way as to maximize output. Since the study is normative in nature this third assumption would appear to be a realistic one i.e. farmers ought to be technologically efficient. As improved practices become adopted and advisory facilities more widely used, the gap between the positive and the normative position can be expected to narrow.

THE DATA.

The Sample

Total population of area sample segments in the Thumb area	= 5,205
Number of sample segments taken in sample	= 56
Total number of schedules obtained in survey	= 81
Number of Economic Class I-V farms in the Thumb Area (1954 census)	= 13,013

The sampling technique used was based on the Master Sample of Agriculture. Farms falling outside the Class I to Class V range - this covers farms with a gross income of $1200 or more - were excluded from the sample, as were specialty farms, i.e. fruit, vegetable, truck crop, and poultry farms. A minimum sample size of 80 farms was aimed at. The sample size of 81 farms represents 1.08% of the relevant population.

The numbers of sample segments drawn from each county were in the same proportion as the numbers of Class I-V farms in the county to the total of such farms for the whole area. The total number of sample segments needed in the area to provide the minimum size of sample was estimated on the 1954 census count of eligible farmers. In order to allow for the decline in farm numbers which has occurred since the 1954 census and to provide replacements for refusals, a secondary sample one third as large as the

original sample was also drawn. In the Thumb area, half of the replacement or secondary sample segments were used to maintain the minimum sample size.

In each segment drawn all farmers were interviewed provided that their farms fell within Economic Classes I-V.

Collection of the Data

A field survey was undertaken in the months of May and June, 1959, when the sample farms were visited and data recorded through question and answer interviews with the co-operating farmers. Practically all of the quantitative data collected refers to 1958.

Classification of the Data

This was carried out in three stages from the first of which three classes of farms were isolated on a tillage acreage basis:

Class	Description	Tillable Area (Acres)
A	Small	0 to 79
B	Medium	80 to 149
C	Large	150 to 320

Each class was then further sub-classified into categories determined by the availability of dairy and hog facilities in the form of buildings and equipment. Farms having dairy facilities only were designated as Dairy farms; Hog farms were defined on a similar basis. Dairy-Hog farms were those having facilities of both types, while Other

farms included operations with no capacity for either type of livestock. The Dairy and Dairy-Hog groups were then further reduced to grade A and grade B milk producers.

Since the circumstances attending the rigorous interpretation of the above method would have led, in certain cases, to somewhat unrealistic groupings, certain refinements were applied. No dairy farm with capacity for less than ten cows was included in the Dairy or Dairy-Hog groups. Similarly, if hog facilities were such that fewer than three sows could be carried, the particular farm was excluded from the Hog and Dairy-Hog sub-classes. Possession of hog or dairy capacity has been interpreted as controlling specific dairy or hog facilities. Farms having loose-housing of a general-use type suitable for dairying, but with no other dairy facilities, were not included in the Dairy and Dairy-Hog sub-classes. The presence on a farm, however, of a dairy stanchion barn was taken to be indicative of the possession of other dairy facilities even though the present operations did not include a dairy enterprise. Such producers were classified under the relevant grade B heading. Similar arguments apply to the hog enterprises; for example the possibility of substituting hogs for poultry in the use of chicken coops was not accepted as being evidence of hog facilities and classification was in accordance with general rules of this sort.

Analysis of the sample into type groups resulted in the development of strata of the type and numerical constitution shown in Table III-I.

Table III-I Farm Type-Group Analysis.

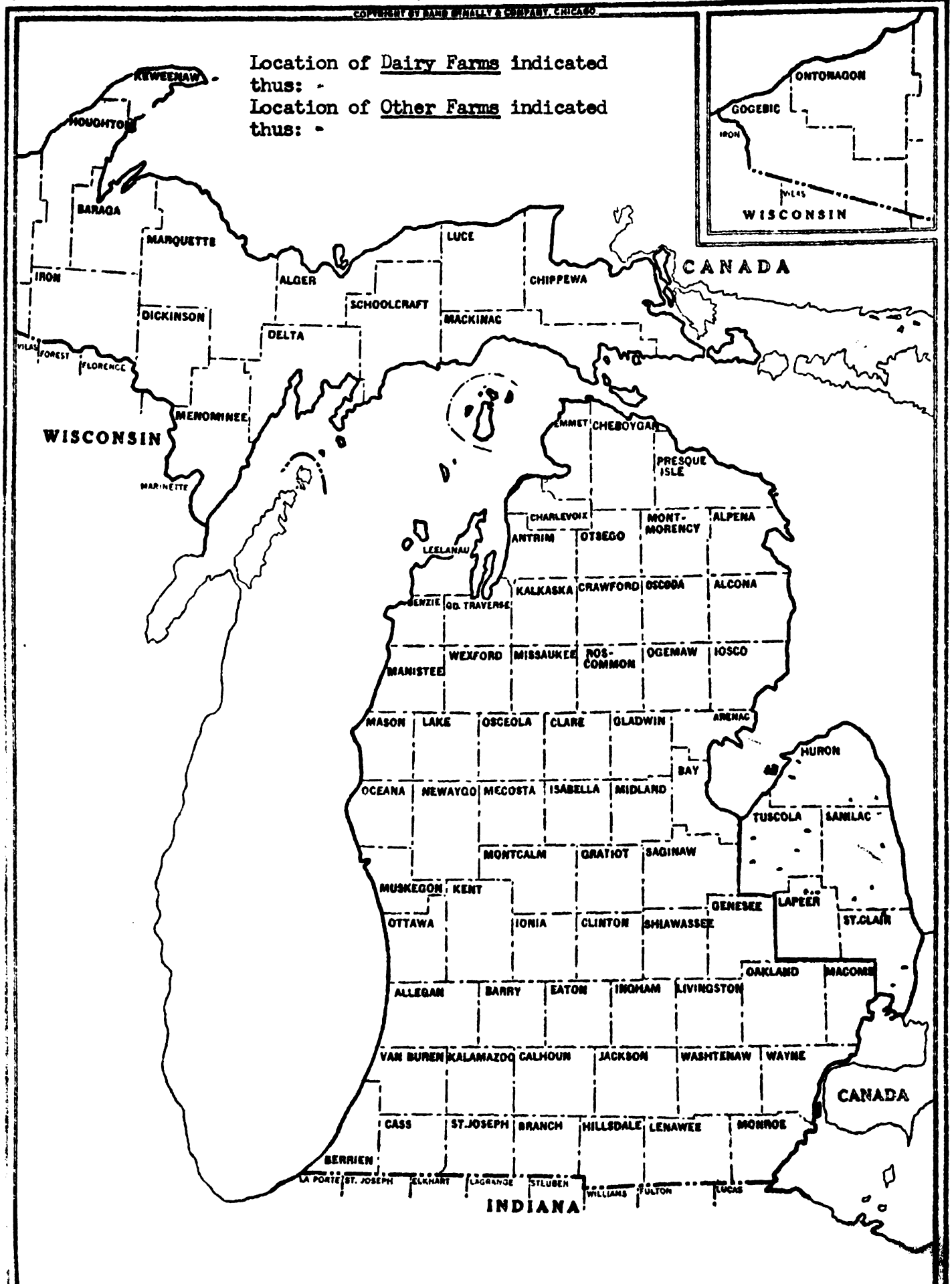
		Class:	(A) Small	(B) Medium	(C) Large
	Sub-class				
(1)	Dairy	Grade A	7	(8)	13
		Grade B	5	6	4
(2)	Hog		0	1	2
(3)	Dairy-Hog	Grade A	0	0	4
		Grade B	2	4	1
(4)	Other		7	(10)	5

In this paper programming models will be developed for the medium-size Dairy grade A, and the medium-size Other[c] groups (circled in Table III-I) and further discussion relates to these two only. The approximate location of each farm within these groups is indicated on the map overleaf.

The Representative Farm

The next step involved the synthesis of a "representative" farm from the characteristics of the farms in the respective sub-groups. If an attribute was held in

[c] For the sake of terminological clarity Other farms are referred to henceforth as Cropping farms.



common by more than 50% of the farms concerned, then that attribute was deemed to be "representative", e.g. growing or not growing dry beans, full-time farming as opposed to part-time farming. Such characteristics are outlined in Table III-2.

Table III-3 shows the make-up of each group more specifically, and allows comparison of various quantitative features between the two. A full list of the assets attributed to each of the representative farms is to be found in the Appendix, Table 12.

(See page 16 for Table III-2).

Table III-2 Qualitative Characteristics of the Representative Farms.

Class:	Medium-size Dairy, Grade A	Medium-size Cropping.
Tenure: Owned	X	X
Operating: Full-time	X	X
Cropping:		
1st year corn for grain	X	X
Corn for silage	X	O
Oats	X	O
Wheat	X	X
Dry Beans	O	X
Hay, baled	X	X
Rotational pasture	X	O
Livestock:		
Dairy cattle	X	O
Other livestock	O	O
Dairy facilities	X	O
Family labour[d]	X	O

(X = representative, O = non-representative.)

[d] This excludes the operator and his wife.

Table III-3 Quantitative Characteristics of Farms in Each Type-group

	Medium-size Dairy, Grade A.		Medium-size Cropping.	
Tenure: % owning land	100		100	
% renting in land	25		20	
Operation: % full-time farms	75		60	
	% of farms growing crop	Acreage per farm	% of farms growing crop	Acreage per farm
Cropping				
Corn	100	19	60	13
Oats	87	17	40	6
Wheat	87	17	80	20
Dry beans	37	27	90	39
Sod	100	35	80	32
Total tillable acres		104		97
[e] Other		29		13
Livestock				
Dairy cows, no.		17		0
Young dairy stock, no.		16		0
Stanchion housing capacity (cows)		23		0
Tower silo capacity (ton)		114		0
Labour Family members		1		0
Capital Position ($1000)[f]				
(1) Gross Farm Investment		42.0		35.9
(2) Net Farm Investment		37.6		34.6
(3) (2) as a % of (1)		89.5		96.4
(4) Net total of operator's capital available for farming		37.9		36.5
(5) (4) as a % of (1)		90.2		101.7

[e] Includes woodland, permanent pasture, land used for buildings, etc.

[f] See page 20 for definition of terms.

Description and Comparison of the Representative Farms

1. Tenure

On both types of farms the land is owned by the operator, and no additional acres are rented. In the sample only two farms from each group rented extra acres.

2. Nature of Operation

In the Dairy group the representative farmer is engaged full-time on his farming operation. Only one fourth of those operators whose farms were sampled have part-time off-farm jobs. Off farm employment is more common, however, in the Cropping group in which 40% of the operations are part-time. This relative difference between the two groups is to be expected since crop production is a much less tying occupation than caring for livestock, particularly during the winter months.

3. Crop Production

There is a more uniform crop production pattern within the Dairy than the Cropping group. All Dairy farms grow corn and a sod crop, while nearly all produce oats and wheat. Of the Cropping farms, a large majority specialize in dry bean production while sod crops (mainly hay, which is sold off) and wheat are also widely grown. Corn is produced on 60% of these farms.

According to the yields and levels of fertilizer application reported, it would appear that either the

Cropping farms are located on better soil than the Dairy farms, or the level of technical skill exercised on the latter is lower. This tentative conclusion is derived from figures which suggest that the rate of fertilizer application on Cropping farms is relatively low in relation to the yields obtained when compared to similar estimates with respect to Dairy farms.
(See Appendix Table 13)

4. Livestock

The representative dairy farm carries no livestock other than those associated with milk production. Forty percent of the farms in the group, however, have a poultry flock, the average size being 140 birds. There is no livestock on the representative cropping farm, and here only a small minority of farms in the group carry any poultry.

5. Labour

Neither of the representative farms employs hired labour, regular or seasonal. Only on the Dairy farm is there family labour available other than the operator and his wife. Family members working on the farm part-time only are regarded as being available and counted as whole units in Table III-2.

6. Machinery and Equipment

Farmers in each group either own, or share in the

ownership of, the usual array of machinery to be found on farms following the type of cropping pattern illustrated here. Of the main items of equipment needed, all but a corn-picker are available on the Dairy farm, and similarly on the representative cropping farm with the additional exception of a field chopper. Each farm carries two tractors. On Dairy farms the practice of hiring machinery services, both from contractors and to other farmers, is more common than in the Cropping group. A list of some specific items of available equipment appears in Appendix Table 12.

7. Housing and other Livestock Facilities

The representative dairy farm has a stanchion barn to hold 23 cows, and a tower silo of 114 tons capacity. It has neither a bulk tank nor a pipeline milker. There are no livestock facilities on the representative cropping farm.

8. Capital Position

The analysis in Table III-3 shows the gross and net position of the farm as a business and also the amount of operator's capital invested elsewhere which could be withdrawn from its current use and made available for purposes of expanding the farm business. The terms used are defined as follows:

(a) Gross farm investment = total value of all farm assets.

(b) Net farm investment = (a) less farm debts.

(c) Net total of operator's capital available for farming = (b) plus non-farm capital which could be transferred to farming, less non-farm debts which have to be paid out of farm income prior to the expansion of the business. This net figure is really the effective supply of operator's capital, including transferable ex-farm investments.

The equity position of the farmer, shown as a percentage in Table III-3 is expressed in two ways.

9. Sources of Income

Sixty-three percent of farms in the Dairy group receive 75% or more of their gross farm revenue from the sale of milk and related products, such as the sale of dairy heifers and calves. The remaining farms in the group earn 75% of their gross farm revenue from a combination of milk sales and cash crop sales, with the former being the more important.

All the farms in the Cropping group derive at least 75% of their gross farm revenue from the crop sales.

The Representative Farm Concept

The method which has been followed in developing the description of the representative farm has the advantage over simple averaging of being more realistic in that it

avoids the need for including attributes which are held by only one, or a small number, of farms. Thus, if two or three farms were growing barley the average farm would have a small barley acreage, whereas the representative farm would have none. On the other hand, by considering attributes in isolation , as has been done here, some loss of descriptive accuracy occurs in cases, for example, where fewer than 50% of farms have either a beef or a poultry enterprise, but where more than 50% have one or the other of these two supplementary enterprises. However, few such difficulties are encountered in the present study, due perhaps to the nature of the data.

The condensing of a type group of farms in an area into one "representative" farm leads to the development of problems of aggregation. While it is practicable for the individual farmer to continue to expand the acreage which he farms so long as he is willing and able to pay the market price demanded for land, the representative farmer, being a composite of all farmers in his group, cannot expand beyond the limits laid down by the relationship between the number of units going out of business, the amount of land being sold off by other farmers, land taken up for industrial uses, etc. Similar problems apply to the acquisition of resources such as seasonal labour, and to estimating prices which the farmer receives, and the costs of the resources which he purchases. It has not

been possible, within the framework of the technique now being used, to consider these problems in this study. Prices and costs remain at fixed levels regardless of output or scale, and with the exception of land (see page 40) it has been assumed that resources are available in sufficient quantities to satisfy requirements.

THE MODEL

Introduction to the Representative Farm Model

The remainder of the paper will be devoted to a consideration of the programming model and to discussion and interpretation of the results obtained. The basis for each model will be the resources now available to the particular representative farm, and the production alternatives considered to be feasible on technological grounds. Since the economic rationale behind any program should be evolved endogenously by the model itself, in theory any number of alternatives could be considered. The ones chosen, however, have been selected with an eye to such factors as maintenance of soil fertility, accessibility of markets, and soil and climate considerations.

Under the assumed conditions, the only factor which limits the expansion of a farm business is the farmer's ability to secure credit and to meet the interest payments on the sum borrowed. The model developed allows increasing applications in physical terms of all resources, except for some categories of labour and land. Obviously, there is a biological limit to the amount of family labour available, and an argument will be forwarded later for restricting the amount of land which can be purchased.

The 117 constituent activities and 64 resource restrictions upon which the model is based are listed in

Appendix Tables 3 and 4 respectively.

Model for the Farm Representative of the Dairy Group

This model, since it includes essentially the same features as that for the Cropping group will be discussed in detail, and comment on the form of the second model will be restricted to features not held in common by both models and arising from the rearrangement of activities, or the use of different coefficients within the same column vectors. For purposes of exposition the various activities and the related resource restrictions will be dealt with in terms of the "sets" into which they naturally tend to fall.

Cropping Set

This set is composed of the various crop sequences and crop buying, selling and transfer activities which constitute the series of processes or activities $P_1 \ldots P_{52}$, and the resource restrictions (b_i) which must be considered in carrying out these activities. Table IV-1 illustrates the general form of the set.

(1) Crop Sequences

Since the general model is considered in terms of alternative systems of enterprises rather than of the individual enterprises themselves, the possible cropping patterns have been expressed in four series of related

Table IV - 1. Cropping Set in Summary

	Cropping Sequence	Crop Conversion Ac. Basis	Crop Conversion Feed Value Basis	Crop Sale	Crop (a) Purch.	Fertilizer Purch.
Land	+					
Corn	-		+	+		
Oats	-	-				
Wheat	-	+				
L'stock grain equiv.			-		-	
L'stock roughage equiv.						
Fertilizer	+	-				-
Labour	+					
Machinery Services	+					
Capital	+	-			+	+

(a) In order to prevent a "bookkeeping" type transaction resulting, say, in the conversion of purchased corn grain to corn silage, crops purchased are led into the feed equivalent equation rather than directly into the individual crop supplies.

productive activities. This method suffers from the disadvantage that it is less flexible than where a number of different crops could be combined together in the solution, in one of a large number of possible permutations. This latter system, however, fails to take account of complementary effects between different cropping enterprises, and also must make use of a device to allow for the inclusion of rotational practices as a means of maintaining soil fertility. Some flexibility has been introduced into the method used in this paper, in that substitution is possible between similar kinds of crops, e.g. small grain crops, within a particular rotation. Thus, if barley growing proves to be more profitable than oat production under a certain set of circumstances, this condition will be made manifest by the introduction of P_{12} into the solution. Since the acreage of wheat grown is limited by government production control programmes, the model includes a wheat restriction equation limiting the acreage of wheat to 17 acres in the case of the Dairy farm, and 20 acres for the Cropping farm. These were the acreages grown in the respective groups in 1958. Allowance has also been made for proportionate expansion or contraction of this restriction according to whether extra land is bought or sold. Where a substitution activity comes into action involving acreage transfer from, say, oats to wheat, the relevant coefficient in the wheat restriction equation is

positive and acts as a direct restraint on the acreage of wheat which can be grown. The equivalent coefficients in the crop sequence activities, however, are such that the restriction limits the acreage of any particular sequence to a certain maximum amount. In the case of the Dairy farm, for example, in a six course sequence the acreage limit would be: 6 x 17 acres, if wheat constituted one of the six courses.

Substitution among the sod crops is handled in similar fashion.

The differing resource requirements of the substitutable crops are reflected in the value of the technical coefficients appearing within the respective column vectors.

In constructing this part of the model the initial step was to ascertain the representative type of soil for the group. It was not possible to define in detail the soil types on each individual farm since information of this sort was not obtainable at the micro level in all cases, but from the several sources consulted[6] an indication of the

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6. Elton B. Hill and Russell Y. Mawby, Types of Farming in Michigan, Special Bulletin 20, Michigan State College Agricultural Experiment Station, September 1954.

   Michigan Agricultural Experiment Station, St. Clair County and Tuscola County Soil Maps, 1926 and 1929 respectively.

   Department of Soil Science, Sanilac County Aerial Photographs, Michigan State University.

general soil type was obtained. Predominantly, the soils belonged in the Sims, Parkhill, Brookston series of loams, but other soil types including Montcalm, Onaway and Angelica were also represented. The four crop sequences indicated were considered to be suited to the representative soil type, and they cover a range of possible cropping alternatives from no. (1) which has two courses of recognised cash crops and no sod, to no. (4) which is constituted 100% of feed-type crops and has 40% in sod. Some portion of the forages, of course, may be sold off the farm. The crop sequences are:

(1)	(2)	(3)	(4)
Corn	AA	AA	AA
Oats	Corn	Corn	AA
Beans	Oats	Oats	Corn
Wheat	AA		Corn
	Beans		Oats
	Wheat		

(2) Fertilizer Rates and Crop Yields

There are two levels of fertilizer application and crop yields associated with each cropping sequence. The first of these is based on the input of fertilizer actually used on farms in 1958, and the crop yields secured in the same year. To obtain the fertilizer rates used in the study an average was taken, over all farms growing the crop, of the amounts applied. This was then expressed in terms of N, P, and K and an aggregate was arrived at for each cropping sequence. In the Dairy group an allowance

was made for soil nutrients obtained through farmyard manure being returned to the soil, it being assumed that about 200 tons was available annually for this purpose.

A second activity was then established for each cropping sequence by specifying another rate of fertilizer usage and related crop yield level. Here the fertilizer coefficients reflect the rate of application which is recommended[7] for the particular soil type (assuming that the latter is high in P and K), and the yields are those expected to be associated with this rate. This doubling up on fertilizer activities causes a complication to arise with respect to the substitution activities referred to earlier. Because, since there is uncertainty as to which of the two sets of rotations will be represented in the solution, there is similar doubt as to the change in fertilizer usage and crop output to express in the coefficients. The values used correspond to those applicable under the recommended conditions.

(3) Transfer Activities

These include the expression of forage output in terms of roughage equivalents, (= 1000 lb. AA hay) and grain output in the form of grain equivalents, (= 1000 lb. corn), and add a further note of flexibility to the model.

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7. Department of Soil Science and Horticulture, Fertilizer Recommendations for Michigan Crops, Extension Bulletin E-159, Co-operative Extension Service Michigan State University, June 1959.

Since the grains have varying feed values depending upon the type of livestock being considered the grain equivalent coefficients reflect their separate values for four broad groups of livestock, i.e. dairy, beef, hogs, and poultry. The livestock activities under consideration will draw on these general roughage and grain resource restrictions rather than directly on the individual feeds.

In order to guard against the introduction of inadvisable practices into the solution, such as feeding to hogs unlimited quantities of oats, certain restrictions are introduced later to take care of nutritional limitations which an unmodified system would ignore. Thus, for any animal type the ration chosen will be one which reconciles the two aims of profit maximization and nutritional expediency.

Dairy Set

The milk production activities represent alternative lines of production, distinguished on the basis of type of housing facilities (i.e. stanchion or loose housing) and management practices (i.e. summer pasturing or dry lot). Replacement heifers are home-bred.

A milk selling activity is introduced to facilitate the introduction of variation in the price received for milk.

It has been estimated[8] that cattle and calves

8. L.M. Turk, and A.G. Weidemann, "Farm Manure", Michigan State College Co-operative Extension Service, Section of Soil Science, Extension Bulletin 300, June 1949, p.7.

excrete 13.5 tons of fresh manure annually per 1000 lb. live weight. It follows, then, that the use of purchased artificial fertilizers will be lower on livestock farms than on purely cropping farms where comparable crop yields are being obtained. Consequently, all livestock producing activities in this model have been credited, through the appropriate coefficient, with an estimated value of the manure which they produce.[g] This estimate is based on the quantity of fresh manure excreted with deductions made to allow for losses in handling, and for the leaching and run-off losses which are assumed to be incurred before the plant can make use of the nutrients supplied. The latter have been reduced to the form of lb. of N, P and K.

The relevant dairying activities and restrictions are outlined in Table IV-2.

Livestock Feed Restriction Set

A ceiling has been set on the amount of oats which can be fed to beef stock and to hogs, and, since the inclusion of a small amount of oats in the poultry ration is deemed to be valuable,[9] a fixed quantity of this grain (10%) constitutes part of the poultry feed.

The beef and hog feed restrictions ensure that, respectively, not more than one third and one fifth of the grain ration will be taken up by oats. These proportions

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g. Appendix Table 14.

9. Frank B. Morrison, Feeds and Feeding, Twenty-First Edition, 1949, (Morrison Publishing Co., New York), p. 495.

Table IV - 2 Dairy Set in Summary

	Milk Production: Stanchions			Milk Production: Self-feeding Loose-Housing		Heifer Calf Sales	Heifer Rearing	Heifer Sales	Cow Purch.	Cow Sales	Milk Sales	Housing & Equipment Purch.
	Rat.(1)	Rat.(2)	Rat.(3)	Dry Lot	Pastured							
Dairy Feed Equiv.	+	+	+	+	+		+					
Pasture	+	+	+		+		+					
Cows	+	+	+	+	+				−	+		
Heifers	+	+	+	+	+		−	+				
Calves	−	−	−	−	−	+	+					
Housing and facilities	+	+	+	+	+							−
Milk	−	−	−	−	−		+				+	
Labour	+	+	+	+	+		+					
Fertilizer	−	−	−	−	−		−					
Capital	+	+	+	+	+	−	+		+	−	− (b)	+
Capital restriction (a)									+	−		+

(a) This restriction is explained in the footnote to Table IV-8

(b) Since the price of milk is a variable while the capital coefficient remains constant the latter is accurate only at the initial price. At higher price levels it is under-valued.

were arrived at on the basis of estimates supplied by Morrison[10].

Table IV-3 illustrates the nature of the hog feed restriction.

Table IV-3 Hog Feed Restriction Set

	Oats to hog grain	Barley to hog grain	Wheat to hog grain	Corn to hog grain
Hog grain equiv.	-10	-10	-10	-10
Hog grain equiv. restriction	+10	- 2.5	- 2.5	- 2.5

Grain for feeding to livestock can be drawn upon only indirectly through the various grain equivalent restrictions, e.g. Dairy Grain Equivalent, Beef Grain Equivalent, etc. Conversion to grain equivalents is provided for through the various crop conversion activities, operating on a feed value basis (see Table IV-1, and activities 16-28, Appendix Table 3).

By virtue of the "Hog grain equivalent restriction" illustrated above, a quantity of oats can be converted to hog grain only if four times that quantity of barley, or wheat, or corn, or a composite of these is also being used for hog feeding, i.e. oats can take up not more than one fifth of a hog ration.

The other livestock feed restrictions perform similar functions.

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10. Ibid., Chapters XX, XXI.

Beef Set

Alternative beef activities include rearing homebred feeders to 400 lb. and 850 lb. and selling at either weight; feeding homebred or purchased steers to finishing from these starting weights, with, in the case of the lighter feeders, two different time periods for finishing. Beef housing is considered to be restrictive in this model and a beef housing equation has been incorporated.

Table IV-4 illustrates the general form of the beef set.

Hog and Poultry Set

Provision has been made for considering hog rearing and hog fattening separately. One or two litters per sow per annum may be produced and the progeny either fattened, or sold at weaning. Alternatively, feeder pigs may be purchased and finished in either of two time periods. The periods coincide with those which would be utilized by the homebred spring and fall-born litters, were these to be finished on the farm. All operations are assumed to take place on dry lot.

Two egg producing activities are considered, one assumes that replacements will be purchased, and the other that they will be home reared. Replacement is on an annual basis.

The general form of the set is outlined in Table IV-5.

Table IV-4 Beef Set in Summary

	Rearing Feeders	Selling Feeders	Purchasing Feeders	Fattening
Beef Feed Equiv.	+			+
Pasture	+			
Feeders	-	+	-	+
Labour	+			+
Fertilizer	-			-
Capital	+		+	+

Table IV-5 Hog and Poultry Set in Summary

	Rearing Feeders	Buying Feeders	Fattening	Egg Production
Hog grain equiv.	+		+	
Poultry grain equiv.				+
Feeder hogs	-	-	+	
Housing & facilities	+		+	+
Labour	+		+	+
Fertiliser	-		-	-
Capital	+	+	+	+

Livestock and Feed Facilities Set

This set provides for the acquisition of livestock housing and associated equipment, and of forage storage facilities in the form of tower silo space. Dairy heifer housing has not been considered as a restriction and no acquisition activity for this facility has been included. There are activities, however, for the purchase of dairy stanchion or loose housing accommodation, hog farrowing and fattening quarters, and poultry housing. Since there are few farms which could not keep at least a few head of poultry without having to buy a poultry house or building materials the representative farm is credited with accommodation for 150 birds. It is also assumed that up to 20 fattening cattle could be finished without the need arising to acquire more accommodation than is at present available.

Machinery and Equipment Set

This consists of two main groups of activities, selling and buying with reference to the use and supply of machinery services.

The resource restriction is expressed in terms of machine acres per annum. A rigorous approach to the problem of machinery capacity would entail collection of data on the lengths of plowing, planting and harvesting periods to which farmers in a particular area were limited, through the physical conditions of the soil, climate and elevation associated with their operation. It would also involve the

study of the week to week climatic conditions in the area over certain critical periods. Account would then have to be taken of rates of work, operating width and speeds of the relevant range of implements and machinery; and finally, an estimate would have to be developed of the labour hours which are available for work on the land itself. While it might be possible to obtain data on theoretical machinery performance and on labour hours available it was felt that the data on meteorology was not sufficiently detailed to justify precise methodology of this type. What was considered to be a more realistic approach was followed in that various estimates, gathered from reports on actual usage of machines, and of annual capacities in terms of acres were used to synthesize performance figures roughly approximating Michigan conditions.[11] These estimates form the basis of the b_i values.

The farm machinery inventories have been split into two sets, one of which consists of "specific" machines such as cornpickers, grain drills, etc., and the other of more general use items such as ploughs and harrows. The services from the former group are expressed as resource restrictions, but no acquisition activities have been provided for machines already on the farm, since it is assumed that their present capacities are sufficient to

11. Appendix Table 15.

deal with any acreage of particular crops falling within one of the crop sequences specified, up to a total farm size of at least 180 acres. The figures shown in Appendix Table 15 support this assumption. There are, however, acquisition activities for cornpickers in the case of the representative dairy farm, and for cornpickers and field choppers in the case of the Cropping farm.

All machinery falling within the "specific" class can be salvaged, but it has been assumed that more general equipment now owned will be retained so long as the farming operation is continued. As will be shown later, the conditions of this study do not permit the sale of land beyond 80 acres per farm, so unless the remaining land stands idle this assumption would seem to be a realistic one.

Some thought was given to the possibility of including activities relating to the hire of machinery from contractors, but it was decided to exclude these. From a study of the resources listed in Appendix Table 12, it is evident that the representative farmer has available all the equipment which he needs, which suggests reliance on contract work is light. From a pure economic viewpoint it may well pay the farmer, under certain circumstances, to hire rather than buy, whatever machinery he needs. This fails to take into account, however, certain aspects of contract work which weigh against this practice, one of them being the timeliness with which work should be carried

out. It is often the case that when one farmer in an area requires the services of a contractor, other farmers also make similar demands in the same time period. This can lead to delays in carrying out operations and consequently to less efficient farming and the build up of frustration on the part of the farmer.

Where there is any doubt about the quality of contract work similar trends develop. The farmer would rather do a good job of work using his own equipment than risk hiring a contractor to do a poor job.

There is another reason also which relates to the concept of the representative farm. This is that a possible theoretical solution might involve sale of all farm equipment and purchase of contractors' services for all operations. For obvious reasons this would be an unrealistic state of affairs for groups of farmers to enter into, although it would be practicable for the individual.

For these reasons therefore it was decided to omit contract work from the model.

Table IV-6 indicates the general form of the set.

Labour Set.

The labour section of the questionnaire was formulated in terms of the hours which the operator and family were willing to work on the farm. Since the responses, particularly in the case of part-time operators,

Table IV-6

Machinery and Equipment Set in Summary

	Sale	Purchase
Machine Services		
Capital	+	-
Capital Restriction (a)	-	+
	-	+

(a) This restriction is explained in the footnote to Table IV-8.

appeared to refer to hours actually worked rather than hours of labour available, the following technique was employed. An average was taken of the hours per week, by periods, which full-time farmers spent working at their farm business.[h] This figure was then applied to part-time operators and to those family members engaging, to some degree, in work off the farm, if their labour potential appeared to be equal to that of the operator. Labour on offer from other family members such as wives, parents and children was then studied and divided into two groups. That falling within the first group was added to the previously computed labour hours giving the total farm labour supply available for either farm or ex-farm employment. This group contains a measure of that part of the work potential of such family sources as children attending high school, students of college age, the farmer's wife herself, etc., judged to be available for ex-farm employment. The second group takes account of

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[h] This figure refers to the operator's manual and to his managerial time flow which together are arbitrarily estimated to be equal to that of a full-time manual worker. To safeguard against an operator's selling his managerial time element off the farm a top limit of 90% per farm has been placed on the operator's saleable labour. The 10% is included within the category of labour which accounts for the difference between the labour supply and restriction equations. Implicit in this situation is the assumption that the farmer, though willing to hire all necessary labour, is unwilling to rid himself completely of his farm-home interests. This assumption may not be valid, but it is felt that in many cases ties other than economic ones may be a strong motivating force behind such an attitude.

labour from these same sources which probably can be applied only to direct operations in connection with the farm itself. It was felt, for instance, that while a farmer's wife with a young family might be willing and able to look after a few head of poultry or to tend to chores around the barnyard, she would be reluctant to take on off-farm duties, unless extreme circumstances prevailed. The same sort of reasoning was applied to labour supplied by young people attending college or high school. Being held responsible for odd chores in the morning or evening, prior to and after attending class respectively, is somewhat different from taking on regular part-time employment for the same number of hours daily. In the case of youngsters attending college, however, the time which they spent on agricultural labour during the summer vacation was added to the figure measuring total farm labour available for off-farm work. The labour salvage restrictions, therefore, have the value of the labour restrictions over the comparable periods, reduced by the number of labour hours available for farm work only.

No quality differential was made among the classes of labour discussed above, nor between these and hired labour. The latter can be hired yearly or over certain time periods, regular labour between April and October and November to March, and seasonal labour over separate two-monthly periods between April and October, with the

exception of August which has a specific restriction. Since the representative farm has no hired labour this cannot be salvaged, but family labour may be sold off up to a maximum allowed by the series of labour restrictions already discussed.

In arriving at the labour supply restriction a total of 15% of the actual man-hours spent on farm work was deducted to cover maintenance work not directly associated with any particular activity. Deductions were weighted on a monthly basis.[12]

The general form of the set is illustrated in Table IV-7.

Land, Credit and Capital Set

Land is a unique resource in that there is a specific limit on the amount which is available to agriculture, and particularly to agriculture considered regionally. Not only is there not a virtually unlimited supply of land available for cultivation, but the normal flow of resource ownership traffic in farming is reversed, the farmer having to go to the land rather than vice versa. These attributes attaching to agricultural land form the basic rationale behind the treatment of the factor in this study. For present purposes it is hypothesized that the

12. Frick, Y.E. and Burkett, W.K., Farm Management Reference Manual, Cooperative Extension Service, University of New Hampshire, September 1953, p. 50.

Table IV-7 Labour Set in Summary

	Regular Lab. Hire	Seasonal Lab. Hire	Labour Sale	Lab. Consuming Activity
Labour	-	-	+	+
Labour restriction			+	
Capital	+	+	-	

representative farmer cannot buy all the land which he desires, even though he is willing to pay a price above that currently ruling in the real estate market. The reasons for this assumption are covered in part by the discussion above, but also depend upon the singular and personal relationship which links man to the land, and in particular to the land in the community in which he enjoys membership. Influences other than economic ones, e.g. social, sentimental, bind farmers to soils which, from a pure economic angle, would be better utilized in some modified fashion.

There is, however, a fluid element to land resource use in agriculture including the continual transfer of ownership rights as some farmers go out of business and others enter the field or expand the land area over which they already operate. Hence, a compromise procedure has been followed in this paper whereby provision has been made for the representative farmer to increase or reduce the size of his farm by the purchase or sale of land respectively, up to a limit of 80 acres in either direction. Thus, he can neither expand his operation ad infinitum, nor can he sell out completely.

It is realised that farm land is often bought and sold in the form of complete business units, but to allow the representative farmer to go out of business is to be at odds with the general approach used up to this point. One

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difficulty which does arise, however, is that, since land transference is assumed to take place by parcels rather than by complete farms, it cannot be further assumed that buildings for livestock or crop storage are also transferred, and therefore land purchase does not automatically add to the capacity of buildings in current use on the farm receiving the addition.

Two land acquisition activities are considered, one on a mortgage basis, the other by land contract. The conditions attaching to the former specify a downpayment of 55%,[13] and annual interest at 5%. For land contract purchases the equivalent rates are 10% and 6% respectively. In both cases the loan is repayable over a 20 year period.

Credit is considered to be available from two sources, one based on mortgage security, the other on chattels. Land mortgage credit is available at 5.5% interest up to a limit of 45% of the value of the land. The interest on chattel credit is higher (6.5%) and the limit to which credit can be obtained, 50%, is also slightly above that for mortgage credit. The latter is repayable over a 20 year period and chattel credit over three years.

Capital currently being used in farming can be "sold" and one activity provides for this.

The general form of this set is outlined in Table IV-8.

13. Conditions governing the cost of credit acquisition are those specified by Hildebrand, Op. Cit., pp. 9-10.

Table IV-8 Land, Credit, and Capital Set in Summary

	Land Purch.	Land Sale	Credit Acqu.	Capital Sale.
Land	-	+		
Land sale & purchase restriction	+	+		
Capital	+	-	-	+
Credit Acqui. Restriction			+	
Capital Restriction (a)	+	-	-	+

(a) The value of this restriction is equal to the amount of capital initially available for long-term investment and to meet operating expenses. But, while certain activities add to the supply of working capital during the year, only a few add to the supply of capital initially available, e.g. land sale. Thus the funds available for investment are limited by the initial supply of capital and the additional amounts which can be obtained, in order to institute activities, from sources such as land sale and credit acquisition.

Some Technical Aspects Discussed.

1. The Capital Coefficients

Capital can be treated in several ways.[14] The method used here is to regard the capital coefficient for an activity as expressing the combined need of that activity for investment capital and operating cash expenses. It represents the initial charge incurred by the activity for investment in durable assets and also the annual cash outlay required to meet the direct costs involved in carrying out that activity.

Certain activities add to the supply of capital, but for most the relevant coefficient has a positive sign. The former class includes salvage activities such as the sale of equipment or the sale of land which add to the capital supply at the beginning of a period of production. Other activities such as milk selling realize a return within a relatively short time after the start of the production period and the profit from such operations becomes available to meet future cash expenses. Such activities have been treated in compromise fashion here by allocating one half of the net revenue/unit earned to the capital supply, e.g. milk selling, labour salvage. The majority of the activities, however, draw upon the capital

14. For an alternative method to that used here see: Dean E. McKee, Earl O. Heady, and G.H. Scholl, Optimum Allocation of Resources Between Pasture Improvement and Other Opportunities on Southern Iowa Farms, Research Bulletin 435, Agricultural Experiment Station, Iowa State College, January, 1956.

supply without adding to it during the current production period. In general the rule which has been followed is that if an activity adds to the capital initially available for operation, the capital stock is credited with this amount. If the activity generates a flow type of income throughout the season, one half of the amount is credited through the capital equation. Activities which draw on capital without adding to the supply until the end of the production period are consumers of capital only. Expenses such as depreciation and land tax which do not have to be met until the end of the year appear in the net revenue equation, but not in the capital equation because they are paid for out of net earnings and do not detract from the capital supply over the production period.

The capital coefficients in the land purchase and sale activities were derived from the farmers' own estimates of the current real estate value of their land and buildings.[i] This figure was adjusted to 1954-58 values and then a 25% deduction was made to meet the assumption that land would be purchased or sold without buildings. For each group the purchase price estimate is an average of the modified sale value of the land for all other farms in the sample. The selling price of land is the average modified market value for the land in the group upon which the representative farm is based.

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[i] See Appendix Table 16.

2. The C_j (Net Revenue) Coefficients

Each unit of an activity is priced, positive or negative as the case may be, according to the market value of that unit, with a deduction for direct cash expenses. The resulting net figure constitutes the activity's C_j value. Where there is no revenue the C_j value is equal to the sum of direct cash expenses. Overhead costs such as taxes, insurance and depreciation are also entered in the net revenue equation.

To allow for costs of haulage, commissions, etc., incurred in marketing products, a differential of approximately 10% has been placed on the prices at which a farmer can buy and sell a product, e.g. the selling price of oats is $ 2.00 per cwt. and its purchase price $ 2.20 per cwt.

Labour services are also differentially priced. The basic value used was the average wage paid to workers in manufacturing in Saginaw City and Flint during the 1954-58 period.[j] The equivalent agricultural rate was estimated at 75% of the urban level. Johnson[15] has estimated that: "if per capita farm incomes are 68% of per capita non farm incomes, labour of equivalent earning ability would be receiving the same real returns in the two

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j. See Appendix Table 17.

15. See next page.

sectors of the economy". He developed this figure on the basis of such factors as relative age composition of the two populations, purchasing power of incomes, etc. His study is based on the situation as of 1950. Other arguments could be cited to support raising or lowering the rate chosen by taking account of such factors as the spiritual and physical advantages associated with country life; or alternatively the social and cultural opportunities afforded to urban dwellers and denied, at least in part, to ruralites. These factors, however, while they may be relevant, are difficult to quantify and their effects have been omitted from the calculation.

Seasonal labour is charged at a higher rate than regular labour, the difference being $ 0.10 per hour. It is felt that the inconvenience suffered by seasonal workers in job transference, and the lack of security involved in seasonal work ought to be compensated for. The respective rates assume that there is no quality variance between seasonal and regular labour.

Finally, labour sold off the farm is credited with a wage rate of $ 1.65 per hour. This provides some allowance for the cost incurred by farm family members in travelling to and from their place of employment.

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15. (See page 45) D. Gale Johnson, "Labor Mobility and Agricultural Adjustment", Agricultural Adjustment Problems in a Growing Economy, North Central Farm Management Research Committee, The Iowa State College Press, Ames, Iowa, 1958, p. 164.

THE OPTIMUM SOLUTIONS

Much of the discussion which follows could be based with equal relevance on either representative farm model. Consequently, where there is common ground, duplication is avoided by illustrating the argument in terms of one farm type only.

Since the results data has been received in greater detail for the Cropping Farm than for the Dairy Farm, discussion is more heavily weighted towards the former.

THE CROPPING FARM

Summary

The optimum plan indicates that, under the specified conditions, and irrespective of the level of milk price within the range programmed, the representative farmer should:-

(a) Increase the scale of his business by buying 35 acres more land.

(b) Follow a simple 3-crop rotation, allotting the land to corn, hay and wheat in the ratio 2: 2: 1.

(c) Invest in hog housing, using hogs as corn convertors.

(d) Hire seasonal labour during the summer and engage in off-farm work over the same period.

(e) Buy a corn picker.

(f) Make full use of the available mortgage credit facilities.

The activities constituting the basis are identical for each of the five levels of milk prices, in terms both of the actual activities and the level at which each operates. Appendix Table 1 shows the relevant detail.

Organization of Production

A. Cropping: Apart from a negligible two acres all the land is cropped according to Sequence (4), except that wheat is substituted for oats. Fertilizers are applied at the recommended levels.

Table V-1 gives a comparison between the 1958 cropping pattern on the representative farm and that indicated in the optimum solution.

Table V-1. The 1958 and Optimum Cropping Patterns.

Crop	1958 Pattern	Optimum Pattern
Corn	10 acres	52½ acres
Oats	1 acre	-
Wheat	20 acres	27 acres
Beans	37 acres	½ acre
Hay	29 acres	52 acres
Total	97 acres	132 acres

The main difference, apart from the increase in farm size, is that there is virtually no place for dry beans in the optimum plan. Otherwise the remaining major crops,

corn, wheat and hay, should continue to be grown. Corn becomes more important relative to hay, the acreage of which expands more, proportionally, than the area under wheat.

Since the cropping activities are defined in terms of crop sequences rather than as single crops it is difficult to explain why Sequence (4) should be preferred to Sequence (1). The latter has a higher proportion of conventional cash crops than the other. It may be that corn and wheat are the two most profitable crops and that Sequence (4) provides for a greater acreage of these two together than any other sequence. Apparently it is more profitable to utilize labour and corn in hog production than to cash in on these resources directly by marketing the corn as grain and hiring more labour off the farm.

On average, over all the farm acres, the cost of chemical fertilizer is $ 4.25 per acre. Chemical fertilizers are considerably supplemented by the manurial output from the hog unit.

Corn - 52 acres are grown. All the corn produced on the farm is fed to hogs. Its value in this use (the MVP) is $ 27.1 per 1000 lb., compared to a value of $ 21.6 (corn salvage D_j) which could be earned per 1000 lb. sold.

Wheat - The crop takes up 27 acres. All of it is marketed as grain and earns $ 32.3 per 1000 lb. Expansion of production is limited by the wheat acreage restriction.

This was set at 20 acres prior to the acquisition of more land, which allowed the restriction level to be raised. If wheat quotas could enter into trade it would be worth the farmer's while to pay up to $ 11. to allow him to grow an extra acre of wheat.

Dry Beans - The optimum plan provided for ½ acre of dry beans. The crop is cashed and is valued at its market price of $ 73.6 per 1000 lb.

Hay - The whole hay crop, from 52 acres, is sold off the farm, the value of the crop being its market price of $ 21.7 per ton.

B. Livestock Activities: Hog production is the sole livestock activity. Feeders are raised from 22.3 sows on the 2-litter system and finished on the farm. They are marketed in February and in August. The annual output is 359 fat hogs. In order to house the hogs both farrowing and fattening accommodation is required.

The MVP attaching to spring feeders is $ 11.3 per hog, while that of fall feeders is $ 9.6. In each case the figure represents the potential value attaching to the fattening of feeders rather than leaving them in disposal. The disparity in values is related to the value in use of hog fattening labour which is greater in spring than in the fall, i.e. labour freed in the spring has greater earning capacity in its next most profitable use than it has during the winter.

Resource Organization

Labour - The optimum plan provides for both the hire of seasonal labour, and for family labour to engage in off-farm work. This may seem an anomaly, but it derives from the definition of the labour hire and salvage activities. Family labour can be salvaged only in "batches" of hours spread uniformly (by months) over two periods, April to October, and November to March. Seasonal labour, on the other hand, can be acquired over shorter periods, i.e. in April and May, or June and July, or August, or September and October, or in all of these periods. In order, therefore, to allow the employment of family labour off the farm during the summer, seasonal labour must be employed to free family workers in the busy months of that period, which are April to July. From April to October, off farm employment competes successfully with farming outlets for 1,117 hours of farm labour, although this means that 662 hours of seasonal labour must be acquired.

The taking up of non-farm employment opportunities suggests that the scale of farming, as governed by capital availability, is too small to allow profitable employment of all family labour on the holding.

Summer labour in the period April to August is valued at $ 2.40 per hour. This is the sum of the wage to seasonal labour and interest on this at 30% (see capital section), i.e. $ 1.85 + (1.85 x $\frac{30}{100}$) = $ 2.40

September and October labour is worth $0.63 per hour.

Labour used in the period January to March has an MVP of $3.16 per hour. This is a measure of the return which would be earned from work off the farm, which accounts for 84 hours. There is a surplus of farm labour during November and December, and a scarcity from January to March. None of the surplus, however, can be salvaged because of the "batch" type arrangement for the hire of family labour. This permits November-December and January-March labour to be hired off in the ratio of two hours of the former to three of the latter. Thus labour salvage in November-December is precluded, unless one and one half times that amount of labour is available for sale during January to March. This explains why 84 hours from the latter period are hired off and only 56 hours of November and December labour.

Conversely each hour of January-March labour placed in disposal takes with it two-thirds of an hour of November-December labour, and it is this complementary effect which accounts for January-March labour having an MVP of $3.16. Labour salvage in this period has a C_j of $1.65 and each hour put into disposal results in a loss of net revenue as follows:

$1.65 + (1.65 x $\frac{2}{3}$) = $2.75

Plus Interest at 30% on half of this

i.e. $2.75 + ($\frac{2.75}{2}$ x $\frac{30}{100}$)

= $3.16

Since less than half of the saleable labour hours are committed to off-farm work the labour salvage restrictions are slack, and so have zero value.

An analysis of labour use, by periods, as indicated in the optimum plan, is given in Table V-2 overleaf.

Table V-2.

Labour Utilization

Period	Initial Level	Hired	Salvaged	Available for work on farm	Use Analysis					
					Rotat. (1)	Rotat. (4)	Hog Rearing	Hog Fattening	Slack	Total
Jan.-Mar.	628 hrs.	-	83	545	-	-	400	145	-	545
Apr.-May	686 hrs.	289	319	656	7	349	229	71	-	656
June-July	707 hrs.	369	319	757	7	493	114	143	-	757
August	368 hrs.	4	160	212	-	27	114	71	-	212
Sep.-Oct.	694 hrs.	-	319	375	6	197	172	-	-	375
Nov.-Dec.	479 hrs.	-	55	424	2	104	114	145	59	424

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Machinery and Equipment - Table V-3 indicates that the attainment of profit maximization involves considerable sales of machinery.

Table V-3. Machinery and Equipment Utilization.

Initially Available		Bought	Sold	Used	MVP($)
Tractors	1235 hrs.	-	417 hr.	818 hr.	0.63 per hr.
Corn Planter	100 M.A.	-	47 M.A.	53 M.A.	0.77 per M.A.
Grain Drill	125 M.A.	-	98 M.A.	27 M.A.	1.06 per M.A.
Cultivator	200 M.A.	-	147 M.A.	53 M.A.	0.23 per M.A.
Combine	170 M.A.	-	142 M.A.	28 M.A.	2.34 per M.A.
Mower	200 M.A.	-	148 M.A.	52 M.A.	0.45 per M.A.
Baler	150 M.A.	-	98 M.A.	52 M.A.	3.02 per M.A.
Field Chopper	- M.A.	-	-	-	8.00 per M.A.
Corn Picker	- M.A.	52 M.A.	-	52 M.A.	5.86 per M.A.
Side Delivery Rake	100 M.A.	-	48 M.A.	52 M.A.	1.10 per M.A.

M.A. = Machine Acre

In practice, excluding machinery hire, machinery can be bought and sold only in complete units, e.g. one tractor. It is not practicable, therefore, to sell 417 tractor hours, nor to buy 52 corn picker machine acres.

The optimum solution does not indicate that any item of equipment be sold outright, so the representative farmer should retain his present range of equipment, and to it add one corn picker.

Since the theoretical notion of buying or selling equipment in the form of machine acres is not acceptable in practice, the level of net revenue, as stated in the optimum plan is unrealistic. Comparing the net revenue earned from machinery salvage (i.e. no. of units sold x MVP) with the extra cost of buying a complete corn picker (i.e. 90 machine acres, rather than 52) it appears that net revenue is over-estimated by $968. on this account.

Assuming that the representative farmer would rather own the necessary range of machinery than be reliant on contractors, underutilization is the result. Crop acreages could be considerably expanded without putting undue strain on the machinery and power capacity of the farm. The answer to this problem of over-capitalization might take the shape of formation of farmer syndicates, each of which would own the required items of equipment. An increase in the practice of sharing particular items with neighbours would also help to cut the overhead costs, per farm, of ownership.

In common with contract arrangements, however, both of the above suggestions have their disadvantages. Without some recognised agreement concerning maintenance and responsibility for repairs, or where <u>real</u> co-operation is lacking, such systems can be short-lived.

<u>Land</u> - Both purchase and sale of land enter into the optimum solution. The explanation for this is that land

is sold in order to raise capital, with which a greater area of land can be acquired on the contract system. Each acre of land sold realises $240, while contract purchase requires only $19. per acre of capital plus annual repayment instalments, insurance, etc., of $15.61. It is doubtful whether, in practice, such an arrangement would ever operate - it is permitted here within the context of the model, and reflects the representative farmer's scarcity of capital, and his need for more land.

The net acquisition is 35 acres, the land purchase and sale restriction preventing further transactions of this sort. The level of this restraint is 80 acres, which is the sum of 57½ acres purchased and 22½ acres sold. The optimum size of the representative farm is thus 132 acres.

The MVP indicates that if the purchase and/or sale restriction was raised to 81 acres, net revenue would be increased by $26.30. Land is valued at $45.40 which means that it would pay to rent additional land at this price.

Capital and Credit - Credit is obtained both directly, through land mortgage, and indirectly through activities such as the hire of family labour and sale of machinery. The farm is mortgaged up to the limit of $10,633.

Milk production is penalized in a sense at a price of $35. per 1000 lb. and upwards, since the negative coefficient in the capital equation of the milk selling

activity remains at a value of $15. for all milk price levels. This results in under-pricing of milk at all levels except $30. per 1000 lb.

The MVP of capital stands at $3. per $10. invested. This represents interest of 30% at the margin. Since chattel credit costs $37.60 per $100. borrowed, it does not pay to acquire further capital by this route. If the ceiling imposed on mortgage credit could be raised, a $10. increase at the margin would show a return of $2.20.

Capital salvage (i.e. off-farm investment) does not enter into the optimum plan since capital so utilized has an interest earning potential of only 3½%. The D_j coefficient for this activity indicates that for each $100. of capital taken out of the farm business and invested at 3½%, net revenue would suffer by $26.6. This figure represents the difference between the return which could be earned in either use.

Net Revenue.

As programmed	$18,796
Less Overstated on machinery trading	968
Adjusted Net Revenue	$17,828

To translate "Net Revenue" into terms of "Net Farm Income" the following adjustments must be made:

(1) Deduct $2703. representing off-farm labour earnings.

(2) Deduct a charge covering overhead costs not allowed for in the program, i.e. cost of materials required for maintenance work on buildings, drains, etc., and items such as insurance on buildings.

Assume that $1,000. meets these charges.

Adjusted Net Revenue	$17,828
Less $2,703 1,000	3,703
(Derived) Net Farm Income	$14,125

This works out at $107. per tillable acre, compared with an average net farm income of $32. per acre, earned by cropping and dairy farmers in the Thumb Area in 1958. The gap of $75. per acre between actual income levels and the potential level points to failure on the part of the farmer to attain the levels of technical and organizational efficiency represented in the model. This result is to be expected, however, for the following reasons.

Firstly, the level of technological efficiency is assumed to be high for all activities. This means that the representative operator is capable of employing and will employ the "best" practices currently known for any of the alternatives that are taken into consideration. This condition would not be realized in practice since only rarely is a farmer capable of applying a uniformly high

degree of skill to all his possible alternative activities.

Secondly, the level of managerial business skill is assumed to be high, i.e. if a more attractive line of production is open to the operator he will follow it rather than adhere to his current plan. The model automatically chooses that organization which maximizes profit levels, and thus the latter will reach a magnitude greater than that to which the farmer can aspire with his limited human knowledge of economic conditions and restricted capacity for taking advantage of such knowledge as he does possess. Additionally, it is doubtful whether the representative farmer aims at attaining profit maximization. It is more probable that he has several composite notions of desired standards of living, the resource supplies and organization required to attain these under differing economic circumstances, and the amount of mental effort involved in operating such an organization. It is within this framework that he adjusts his farm plan.

The linear programming solution, then, is what a "robot" farmer would achieve if he were faced with the prescribed conditions. It is the 100% efficiency level organization of an "economic" farmer, and represents what should be aimed at to obtain as large an income as possible, rather than what is likely to be achieved.

THE DAIRY FARM

Summary

The optimum plans for the three milk price levels, $30, $35, and $40 per 1000 lb. are identical, and are similar to that for the Cropping Farm. A markedly different plan, including dairying, is introduced at the $45 price level, and a further marginal revision occurs at the $50 level. Full details are given in Appendix Table 2.

I. At $30, $35 and $40 per 1000 lb. Milk.

Organisation of Production.

A. Cropping: Sequence (4), with fertilizer applied at the recommended level, is the basis for the cropping plan. The acreage transfer activities, however, have operated to substitute wheat and barley for oats. Table V-4 gives a comparison of the 1958 acreage and cropping pattern on the representative farm with that indicated in the optimum solution.

Table V-4. The 1958 and Optimum Cropping Patterns at $30, $35 and $40 per 1000 lb. Milk.

Crop	1958 Pattern	Optimum Pattern
Corn	24 acres	55 acres
Oats	20 acres	-
Wheat	17 acres	22 acres
Barley	-	5 acres
Sod (Hay and Pasture)	43 acres	(Hay) 55 acres
Total	104 acres	137 acres

The principal difference between the two patterns is that the optimum plan excludes oat production, while the area under corn becomes relatively more important. A small acreage of barley is introduced. Part of the general rise in crop acreage (excluding oats) results from the increase in farm size.

The average fertilizer cost per acre of the farm works out at $8.37. In addition, feed residues from the hog unit contribute significantly to crop manurial requirements.

Corn - The crop takes up 55 acres. It is harvested as grain and all of it is used for hog feeding.

Wheat - 22 acres are grown. The increase of 5 acres compared to 1958 represents the maximum expansion in wheat acreage as defined by the wheat restriction equation. All the wheat is marketed as grain.

Barley - 5 acres are grown. The grain is retained for feeding to hogs. In the absence of a wheat restriction it is likely that the barley crop would be dropped in favour of wheat.

Sod - 55 acres are down to alfalfa hay, all of which is sold off the farm.

B. Livestock Activities: Hogs are the only form of livestock appearing in the optimum plan. The hog unit consists of 25 sows rearing 2 litters per annum each, with all of the progeny being finished on the farm. The annual

output of fat hogs is 394. Capital is invested in both farrowing and fattening housing and equipment sufficient to accommodate a unit of the size indicated.

Resource Organization

Labour - Labour is both hired and salvaged. From November to March off-farm employment accounts for 595 hours of family labour. In the summer period, April to October, the equivalent figure is 1703 hours. In order to allow off-farm work on this scale 869 hours of seasonal labour are required during the summer. Table V-5 illustrates labour utilization by periods.

As in the case of the Dairy Farm the labour salvage restrictions are slack.

Machinery and Equipment - One item of equipment, the field chopper, is sold outright. Portions of the capacity of all the others are also "salvaged", but the addition to net revenue arising therefrom is false, for reasons already discussed in relation to the Cropping Farm. To allow for over-estimation from this source, and for under-statement of costs in regard to the purchase of 55 machine acres of cornpicker, net revenue should be reduced by approximately $946.[k]

k. MVPs of limiting resources are not available for the Dairy Farm, therefore this figure cannot be accurately estimated since interest on capital is unknown. For want of a better figure a rate of 30% was used. This is the marginal return on capital in the case of the Cropping Farm.

Table V-5 LabcurUtilization at $30, $35, and $40 per 1000lb. Milk

Period	Initial Level	Hired	Salvaged	Available for work on farm	Use Analysis				
					Rotat. (4)	Hog Rearing	Hog Fattening	Slack	Total
Jan.-Mar.	954	-	357	597	-	439	158	-	597
Apr.-May	743	465	487	721	392	251	78	-	721
June-Jul.	886	404	487	803	522	125	156	-	803
August	474	-	243	231	28	125	78	-	231
Sep.-Oct.	859	-	487	372	184	188	-	-	372
Nov.-Dec.	750	-	238	512	110	125	158	119	512

Land - Land purchase and land sale both enter into the optimum solution, the former at 56.7 acres and the latter at 23.3 acres, i.e. a net acquisition of just over 33 acres.

Capital and Credit - The farm is mortgaged up to the limit, but chattel credit is not drawn upon at all. The original dairy cattle stock, consisting of 17 cows, 8 heifers, and 6 calves, are sold off, bringing in funds which can be used for long-term investment.

Net Revenue		
As programmed	-	$23,525
Less Overstated on machinery trading	-	946
Adjusted Net Revenue		$22,579

To express "Net Revenue" in terms of "Net Farm Income" the following adjustments must be made:-

(1) Deduct $4,929, representing off-farm income of $3,792 and interest on this of 30% (see footnote regarding interest rate, page 62).

(2) Deduct a charge covering overhead costs not allowed for in the program, (as for the Cropping Farm) say $1,000.

Adjusted Net Revenue		$22,579
Less	$4,929 1,000	5,929
(Derived) Net Farm Income		$16,650

This averages out at $122 per tillable acre, compared to the actual 1958 figure for farms in the area of $32.

The same comments on the level of Net Revenue are pertinent here as those made in relation to the Cropping Farm (pages 50-52).

II. At $45 per 1000 lb. Milk.

Organization of Production.

A. Cropping: Basically, the cropping pattern follows Sequence (4), fertilizer usage being at the recommended level. The cropping program is as follows:

Corn	56 acres
Corn silage	6 acres
Wheat	26 acres
Barley	5 acres
Hay	27 acres
Pasture	34 acres
Total	154 acres

The optimum farm size is 154 acres, and compared to the $40 level, most crop acreages have risen proportionally.

Corn - The crop takes up 62 acres, of which 6 acres is harvested as silage for feeding to the dairy cows. The grain from 56 acres is fed on the farm through the dairy and hog units.

Wheat - The acreage under wheat is expanded as far as the acreage restriction will allow. The whole crop is marketed as grain.

Barley - Just over 5 acres are grown, as opposed to just under 5 acres at the $40 per 1000 lb. milk level.

Hay - As previously, the crop is grown for sale, but on a reduced scale, 27 acres compared to 55.

Pasture - 34 acres of the farm are down to pasture, fulfilling the grazing needs of the cows during the summer.

B. Livestock Activities: Both a dairy unit and a hog unit are maintained on the farm. The former consists of 23 dairy cows, plus replacement followers, housed in a stanchion barn. Eighteen of the 23 are fed at the higher rate (level III) and the remaining 5 are on level II. To bring cow numbers up to 23, which is the cow capacity of the dairy barn, 6 animals have to be purchased.

The herd is fed during the winter on corn silage, corn grain, and purchased barley. Annual output is 243,661 lb. milk.

The hog unit comprises 19 sows. The progeny are held on the farm for fattening. The hogs are maintained on farm-grown corn, and 302 are finished each year.

Resource Organization

Labour - Owing to the heavy man hour requirements of the dairy cows no family labour can be spared for off-farm work during the period November to March inclusive, even although

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the hog unit has been reduced. From April to October, only 820 hours are spent on work off the farm compared to 1703 hours in the previous plan, but seasonal labour requirements are reduced to 675 hours from 869 hours. This, again, is a reflection of the labour demands of the dairy unit.

Labour utilization is shown in detail in the accompanying Table V-6.

Machinery and Equipment - Machinery "salvage" is on a slightly larger scale than in the previous case because of the introduction of pasture into the crop sequence. The field chopper is, in this instance, required for handling the corn silage, and no item of equipment is sold outright.

On account of machinery "sale" net revenue is too high by $1,649.

Land - The net acquisition is 40 acres, 7 acres more than at the $30 milk price level. Since milk production contributes to working capital, so easing the capital shortage, there are more funds available for land purchase.

Capital and Credit - Full use is made of mortgage credit facilities. Chattel credit is not drawn upon.

Net Revenue.

	As programmed	- $23,927
Less	Overstated on machinery trading	- 1,649
	Adjusted Net Revenue	$22,278

Labour utilization at $45 per 1000 lb. Milk

Table V-6 Labour Utilization at $45 per 1000 lb. Milk

Period	Initial Level	Hired	Salvaged	Available for work on farm	Use Analysis					
					Rotat. (4)	Hog Rearing	Hog Fattening	Dairying	Slack	Total
Jan.-Mar.	954	-	-	954	-	336	122	496	-	954
Apr.-May	743	494	234	1003	440	192	60	311	-	1003
June-Jul.	886	181	234	833	411	96	120	206	-	833
August	474	-	117	357	14	96	60	119	68	357
Sep.-Oct.	859	-	234	625	222	144	-	259	-	625
Nov.-Dec.	750	-	-	750	111	96	122	324	97	750

To express "Net Revenue" in terms of "Net Farm Income", the following adjustments must be made:-

(1) Deduct $1,759 representing off-farm income of $1,353 and interest on this at 30% (see footnote on page 62).

(2) Deduct a charge covering overhead costs not allowed for in the model. Say, $1,000 as previously.

(Adjusted) Net Revenue		$22,278
Less	$1,759	
	1,000	2,759
(Derived) Net Farm Income		$19,519

On 154 acres this represents $127 per tillable acre.

III. At $50 per 1000 lb. milk.

The optimum plan is almost identical to the previous one. The only significant difference is that all the dairy cows are fed at the higher level of concentrate feeding. This involves reducing the corn silage acreage by ½ acre and increasing corn (for grain) by a corresponding amount; buying about 7,000 lb. extra barley for feeding to the cows; and a slightly higher output of milk. Net Revenue rises to $25,167 compared to $23,927 at the $45 price level for milk.

APPRAISAL OF THE MODEL AND SUMMARY OF RESULTS.

The problem under consideration is an involved one and necessitated the construction of a fairly complex set of activities and resource restrictions. Hindsight, in the light of the optimum solutions, indicates that some simplification could have taken place without detracting from the value of the results obtained. For instance, certain restrictions, such as those relating to family labour salvage, and a number of activities including egg production and machinery salvage could have been omitted altogether. On a primo facie basis it is difficult to argue, economically, for a reduction in cultivable area per farm, so the land salvage activity might have been omitted.

Nevertheless, it would have been dangerous to have made modifications such as these without there being sound precedent for so doing. Any future study, involving conditions similar to those discussed, could probably be stated in somewhat simpler terms since the general direction of organizational change has been indicated. Unnecessary resource restrictions could be excluded and the range of activities limited to these lines which have been shown to be relevant.

Within the terms of the present study, however, the model has been satisfactory. The original aim was to construct a broad overall picture of optimum resource

allocation under prescribed conditions, and such a picture has emerged. Under the assumed prices and coefficients for the other enterprises it is concluded that unless milk realizes between $40 and $45 per 1000 lb., operators of medium sized dairy farms in the Thumb Area will find milk production less profitable than production of wheat, corn, and hogs. Cropping farmers in this area, whose units fall within the medium size group, should stay out of dairying since milk production would be relatively unprofitable, even at a price of $50 per 1000 lb. Again, the pattern of production should be wheat, corn and hogs.

The differing solutions for the farm types at the higher milk price levels can be explained by reference to the capital position. Capital is the limiting factor in each case. At higher milk price levels the Dairy Farm is better placed for a switch to milk production than the Cropping Farm which has no existing dairying facilities. Provision of these would involve considerable capital expenditure and consequently milk would have to attract a higher price than has been allowed for in this study in order to equate the return on capital invested in dairying to that being earned from wheat, hog, and hay production at the assumed price levels.

Table 1. Representative Cropping Farm - Basis Activities (1) in Optimum Solutions

Activity No.	Description	Unit	Optimum Scale at $30 to $50 per 1000 lb Milk
2	Rotation (1), recommended fertilizer usage	4 ac.	0.50
8	Rotation (4), recommended fertilizer usage	5 ac.	25.97
13	Crop acreage transfer, oats to wheat	1 ac.	26.47
27	Feed value conversion, corn to hog grain equivalent	10000 lb.	25.91
35	Wheat sale	1000 lb.	72.82
37	Dry beans sale	1000 lb.	0.96
38	Hay sale	1 ton	207.78
53	Nitrogen (N) purchase	100 lb.	37.42
54	Phosphate (P) purchase	100 lb.	34.62
55	Potash (K) purchase	100 lb.	19.14
82	Hog production, sow and 2 litters	2 litters	22.88
83	Hog production, fat hogs, 225 lb., August	8 hogs	22.30
84	Hog production, fat hogs, 225 lb., February	8 hogs	22.59
91	Hog farrowing housing and equipment acquisition	1 sow	22.88
92	Hog fattening housing and equipment acquisition	1 feeder	180.72
96	Seasonal labour hire, April and May	10 hours	28.92
97	Seasonal labour hire, June and July	10 hours	36.93
98	Seasonal labour hire, August	10 hours	0.36
100	Family labour salvage, November to March	15 hours	9.23
101	Family labour salvage, April to October	14 hours	79.81
102	Tractor services salvage	10 hours	41.69
103	Corn planter services salvage	10 M.A. (2)	4.71
104	Grain drill services salvage	10 M.A.	9.80
105	Cultivator services salvage	10 M.A.	14.71
106	Combine services salvage	10 M.A.	14.25
107	Mower services salvage	10 M.A.	14.81
108	Baler services salvage	10 M.A.	9.81
110	Side delivery rake services salvage	10 M.A.	4.76
111	Corn picker services acquisition	5 M.A.	10.49
113	Land purchase by contract	1 ac.	57.43
114	Credit acquisition, land mortgage	$10.	1063.30
117	Land sale	1 ac.	22.57
	Disposal Activities		
	Hog grain restriction	1000 lb.	64.77
	Hog fattening housing, May to August	1 feeder (3)	2.29
	Poultry housing	1 bird (")	150.00
	November and December labour	1 hour	59.26
	Labour salvage restriction, January to March	1 hour	480.91
	Labour salvage restriction, April and May	1 hour	314.76
	Labour salvage restriction, June and July	1 hour	335.76
	Labour salvage restriction, August	1 hour	181.38
	Labour salvage restriction, September and October	1 hour	322.76
	Labour salvage restriction, November and December	1 hour	379.61
	Chattel credit restriction	$1.	2884.00
	Capital restriction	$10.	817.90

(1) Excludes activities operating at zero level.

(2) M.A. = Machine Acres.

(3) The livestock units used express the stock holding capacity of the housing.

Table 2. Representative Dairy Farm - Basis Activities (1) in Optimum Solutions

Activity No.	Description	Unit	Optimum Scale at $ per 1000 lb. Milk $30, $35, $40	$45	$50
8	Rotation (4), recommended fertilizer usage	5 ac.	27.46	30.79	30.82
9	Crop acreage transfer, corn to corn silage	1 ac.	-	6.00	5.65
10	Crop acreage transfer, wheat to barley	1 ac.	4.80	5.30	5.30
13	Crop acreage transfer, oats to wheat	1 ac.	27.46	30.79	30.82
14	Crop acreage transfer, hay to pasture	1 ac.	-	34.29	-
22	Feed value conversion, barley to dairy grain equivalent	1000 lb.	-	15.26	15.27
24	Feed value conversion, barley to hog grain equivalent	1000 lb.	1.26	-	-
25	Feed value conversion, corn to dairy grain equivalent	1000 lb.	-	56.80	60.60
27	Feed value conversion, corn to hog grain equivalent	10000 lb.	27.13	21.78	21.60
29	Feed value conversion, corn silage to roughage equivalent	10 tons	-	1.00	8.47
35	Wheat sale	1000 lb.	61.19	68.82	68.90
38	Hay sale	1 ton	219.70	109.17	108.31
49	Barley purchase - for dairy cattle	1000 lb.	-	20.89	27.67
53	Nitrogen (N) purchase	100 lb.	34.43	42.10	42.26
55	Potash (K) purchase	100 lb.	19.22	17.56	17.59
58	Milk production, stanchions, ration (2)	10010 lb.	-	4.95	-
59	Milk production, stanchions, ration (3)	10840 lb.	-	17.90	23.00
66	Dairy heifer production	1 heifer	-	-	0.65
67	Dairy heifer sale	1 heifer	8.00	-	-
68	Dairy cow purchase	1 cow	-	5.86	6.00
69	Dairy cow sale	1 cow	17.00	-	-
70	Dairy heifer calf sale	1 calf	6.00	16.29	16.30
71	Milk sale	1000 lb.	-	243.66	249.31
82	Hog production, sow and 2 litters	2 litters	25.07	19.23	19.08
83	Hog production, fat hogs, 225 lb., August	8 hogs	24.44	18.75	18.60
84	Hog production, fat hogs, 225 lbs., February	8 hogs	24.75	18.99	18.84
91	Hog farrowing housing and equipment acquisition	1 sow (3)	25.07	19.23	19.08
92	Hog fattening housing and equipment acquisition	1 feeder(")	198.00	151.90	150.69
96	Seasonal labour hire, April and May	10 hours	46.48	49.40	49.48
97	Seasonal labour hire, June and July	10 hours	40.42	18.08	18.00
98	Seasonal labour hire, August	10 hours	0.03	-	-
100	Family labour salvage, November to March	15 hours	39.65	-	-
101	Family labour salvage, April to October	14 hours	121.66	58.61	58.62
102	Tractor services salvage	10 hours	38.37	44.00	44.11
103	Corn planter services salvage	10 M.A. (2)	4.51	3.84	3.84
104	Grain drill services salvage	10 M.A.	9.75	9.42	9.42
105	Cultivator services salvage	10 M.A.	14.51	13.84	13.84
106	Combine services salvage	10 M.A.	14.25	13.92	13.92
107	Mower services salvage	10 M.A.	14.51	17.27	17.30
108	Baler services salvage	10 M.A.	9.51	12.27	12.30
109	Field chopper services salvage	10 M.A.	15.00	14.40	14.44
110	Side delivery rake services salvage	10 M.A.	4.51	7.27	7.29
111	Corn picker services acquisition	5 M.A.	10.98	11.12	11.20
113	Land purchase by contract	1 ac.	56.65	64.97	65.05
114	Credit acquisition, land mortgage	$10.	913.50	913.50	913.50
117	Land sale	1 ac.	23.35	15.03	14.95
	Disposal Activities				
	Hog grain restriction	1000 lb.	70.97	54.44	54.01
	Silo capacity	10 tons	11.40	-	0.67
	Stanchion housing	1 cow (3)	23.00	0.14	-
	Hog fattening housing, May to August	1 feeder (")	2.51	1.92	1.91
	Poultry housing	1 bird (")	150.00	150.00	150.00
	August labour	1 hour	-	68.15	68.69
	November and December labour	1 hour	118.46	96.62	95.13
	Labour salvage restriction, January to March	1 hour	507.11	864.00	864.00
	Labour salvage restriction, June and July	1 hour	306.37	558.57	558.53
	Labour salvage restriction, August	1 hour	167.69	293.78	293.77
	Labour salvage restriction, September and October	1 hour	232.37	484.57	484.53
	Labour salvage restriction, November and December	1 hour	364.07	602.00	602.00
	Chattel credit restriction	$1.	7060.00	7060.00	7060.00
	Capital restriction	$10.	818.30	527.57	530.21

(1) Excludes activities operating at zero level.

(2) M.A. = Machine Acre.

(3) The livestock units used express the stock holding capacity of the housing.

Table 3. Activity Identities and C_j Values. D_j Values for Cropping Farm @ ¢30 per 1000 lb Milk

Activity Number	Description	Unit	C_j(¢)	D_j(¢)	*
1	Rotation (1), with actual fertilizer usage	4 Ac.	-64.8	33.0	
2	Rotation (1), with recommended fertilizer usage.	4 Ac.	-64.8	-	
3	Rotation (2), with actual fertilizer usage.	6 Ac.	-83.8	112.9	
4	Rotation (2), with recommended fertilizer usage.	6 Ac.	-83.8	4.3	
5	Rotation (3), with actual fertilizer usage.	3 Ac.	-37.1	59.2	
6	Rotation (3), with recommended fertilizer usage.	3 Ac.	-37.1	7.1	
7	Rotation (4), with actual fertilizer usage.	5 Ac.	-59.5	105.0	
8	Rotation (4), with recommended fertilizer usage.	5 Ac.	-59.5	-	
9	Crop Acreage transfer, corn to corn silage.	1 Ac.	- 6.3	120.8	
10	Crop acreage transfer, wheat to barley.	1 Ac.	3.6	5.7	
11	Crop acreage transfer, wheat to oats.	1 Ac.	3.6	-	
12	Crop acreage transfer, oats to barley.	1 Ac.	0	5.7	
13	Crop acreage transfer, oats to wheat.	1 Ac.	- 3.6	-	
14	Crop acreage transfer, hay to pasture.	1 Ac.	5.3	53.4	
15	Crop acreage transfer, hay to grass silage.	1 Ac.	- 1.8	-	
16	Feed value conversion, oats to dairy grain equivalent.	lb. 1,100	0	17.5	
17	Feed value conversion, oats to beef grain equivalent.	lb. 10,000	0	28.4	
18	Feed value conversion, oats to hog grain equivalent.	lb. 13,000	0	118.0	
19	Feed value conversion, wheat to dairy grain equivalent.	lb. 1,000	0	16.9	
20	Feed value conversion, wheat to hog grain equivalent.	lb. 10,000	0	52.2	
21	Feed value conversion, wheat to poultry grain equivalent.	lb. 1,000	0	14.8	
22	Feed value conversion, barley to dairy grain equivalent.	lb. 1,000	0	9.3	
23	Feed value conversion, barley to beef grain equivalent.	lb. 1,100	0	-	
24	Feed value conversion, barley to hog grain equivalent.	lb. 11,000	0	-	
25	Feed value conversion, corn to dairy grain equivalent.	lb. 1,000	0	11.7	
26	Feed value conversion, corn to beef grain equivalent.	lb. 10,000	0	-	
27	Feed value conversion, corn to hog grain equivalent.	lb. 10,000	0	-	
28	Feed value conversion, corn to poultry grain equivalent.	lb. 1,000	0	9,5	
29	Feed value conversion, corn silage to roughage equivalent	10 ton	0	-	
30	Feed value conversion, hay to roughage equivalent.	1 ton	0	18.9	
31	Feed value conversion, grass silage to roughage equivalent.	10 ton	0	61.2	
32	Feed value conversion, pasture to roughage equivalent.	1 AC.	0	-	
33	Corn salvage.	lb. 1000	21.6	5.5	
34	Oats salvage.	lb. 1000	20.0	9.9	
35	Wheat salvage.	lb. 1000	32.3	-	
36	Barley salvage.	lb. 1000	18.6	6.0	
37	Dry beans salvage.	lb. 1000	73.6	-	
38	Hay salvage.	1 ton	21.7	-	
39	Corn acquisition - for dairy cattle	lb. 1000	23.8	15.6	
40	Corn acquisition - for beef cattle.	lb. 1000	23.8	3.9	
41	Corn acquisition - for hogs	lb. 1000	23.8	3.9	
42	Corn acquisition - for poultry	lb. 1000	23.8	13.4	
43	Oats acquisition - for dairy cattle	lb. 1000	22.0	14.6	
44	Oats acquisition - for beef cattle.	lb. 1000	22.0	1.5	
45	Oats acquisition - for hogs.	lb. 1000	22.0	7.8	
46	Wheat acquisition - for dairy cattle.	lb. 1000	35.5	30.8	
47	Wheat acquisition - for hogs.	lb. 1000	35.5.	19.1	
48	Wheat acquisition - for poultry	lb. 1000	35.5	28.7	
49	Barley acquisition - for dairy cattle.	lb. 1000	20.5	11.3	
50	Barley acquisition - for hogs.	lb. 1000	20.5	2.0	
51	Barley acquisition - for poultry	lb. 1000	20.5	2.0	
52	Hay acquisition.	lb. 1000	-23.8	28.2	
53	Nitrogen (N) acquisition.	lb. 1000	-17.0	-	
54	Phosphate (P) acquisition.	lb. 100	-11.0	-	
55	Potash (k) acquisition.	lb. 100	- 6.0	-	
56	Silo acquisition.	10 tons capacity	- 7.0	34.4	
57	Milk production, stanchions, ration (1)	lb. 9,275	-22.0	10.8	
58	Milk production, stanchions, ration (2)	lb. 10,010	-22.0	-	
59	Milk production, stanchions, ration (3)	lb. 10,840	-22.0	-	
60	Milk production, loose housing, dry lot, ration (1)	lb. 9,275	-26.0	10.8	
61	Milk production, loose housing, dry lot, ration (2)	lb. 10,010	-26.0	-	
62	Milk production, loose housing, dry lot, ration (3)	lb. 10,840	-26.0	-	
63	Milk production, loose housing, pastured, ration (1)	lb. 9,275	-26.0	14.8	
64	Milk production, loose housing, pastured, ration (2)	lb. 10,010	-26.0	3.9	
65	Milk production, loose housing, pastured, ration (3)	lb. 10,840	-26.0	3.9	
66	Dairy heifer production.	1 heifer	-27.0	-	
67	Dairy heifer salvage.	1 heifer	175.0	-	
68	Dairy cow acquisition.	1 cow	- 8.0	-	
69	Dairy cow salvage.	1 cow	8.0	100.0	-100.0
70	Dairy heifer calf salvage.	1 calf	24.0	28.1	
71	Milk salvage.	lb. 1000	30.0	-	
72	Beef feeder calf production lb. 400	1 calf	15.0	29.6	
73	Beef feeder calf salvage, lb. 400	1 calf	95.0	41.6	
74	Rearing beef feeders, lb. 400 to 850	1 feeder	- 6.0	-	
75	Beef feeder lb. 850 salvage.	1 feeder	165.0	3.7	

Table 3 (Contd.)

Table 3 (Contd.)

Activity Number	Description	Unit	C_j(¢)	D_j(¢)	*
76	Finished steers, short-fed, lb. 950, salvage.	1 steer	201.0	66.3	
77	Finished steers, long-fed, lb. 950, salvage	1 steer	215.0	32.7	
78	Finished steers, purchased, lb. 1125, salvage.	1 steer	77.0	18.4	
79	Finished steers, home bred, lb. 1125, salvage	1 steer	258.0	-	
80	Beef feeders, lb. 400, acquisition.	1 feeder	-105.0	-	
81	Hog production, sow and 1 litter.	1 litter	97.0	121.1	
82	Hog production, sow and 2 litters.	2 litters	165.0	-	
83	Hog production, fat hogs, lb. 225, August.	8 hogs	260.0	-	
84	Hog production, fat hogs, lb. 225, February.	8 hogs	260.0	-	
85	Spring feeder hogs, lb. 50, acquisition.	1 hog	-14.0	6.9	
86	Fall feeder hogs, lb. 50, acquisition.	1 hog	-14.0	8.6	
87	Egg production, replacements purchased.	160 doz.	31.1	5.0	
88	Egg production, replacements home-reared.	160 doz.	39.5	-	
89	Dairy stanchion housing and equipment acquisition.	1 cow (2)	-15.0	106.1	
90	Dairy loose housing and equipment acquisitions.	1 cow (2)	-16.0	49.7	-17.2
91	Hog farrowing housing and equipment acquisition.	1 sow (2)	-16.0	-	
92	Hog fattening housing and equipment acquisition.	1 feeder (2)	- .63	-	
93	Poultry housing and equipment acquisition.	1 bird(2)	- .23	1.6	
94	Regular labour, November to March, acquisition.	15 hours	-26.25	5.7	
95	Regular labour, April to October, acquisition.	14 hours	-24.5	5.3	
96	Seasonal labour, April and May, acquisition.	10 hours	-18.5	-	
97	Seasonal labour, June and July, acquisition.	10 hours	-18.5	-	
98	Seasonal labour, August acquisition.	10 hours	-18.5	-	
99	Seasonal labour, September and October acquisition.	10 hours	-18.5	17.8	
100	Family labour, November to March salvage.	15 hours	24.75	-	
101	Family labour, April to October salvage.	14 hours	23.10	-	
102	Tractor services, salvage.	10 hours	3.8	-	
103	Corn planter services salvage.	10 M.A. (1)	2.3	-	
104	Grain drill services, salvage.	10 M.A.	3.4	-	
105	Cultivator services, salvage.	10 M.A.	1.2	-	
106	Combine services, salvage.	10 M.A.	15.0	-	
107	Mower services, salvage.	10 M.A.	1.5	-	
108	Baler services, salvage.	10 M.A.	16.0	-	
109	Field chopper services, salvage (acquisition for the Cropping farm.)	10 M.A. **	30.0	-	-11.4
110	Side delivery rake services, salvage.	10 M.A.	4.1	-	
111	Corn picker services, acquisition.	5 M.A.	- 8.5	-	
112	Land acquisition, by mortgage.	1 Ac.	- 8.67	18.4	- 8.42
113	Land acquisition, by contract.	1 Ac.	-16.16	-	-15.61
114	Credit acquisition, land mortgage.	¢10.	- 0.78	-	
115	Credit acquisition, chattel mortgage.	¢10.	- 3.76	0.7	
116	Capital salvage.	¢10.	0.35	2.7	
117	Land salvage.	1 Ac.	1.65	-	

(1) "M.A." - Machine Acre.

(2) The livestock units used here express the stock holding capacity of the housing.

* The figures in this column are C_j values for the Cropping Farm where these differ from those of the Dairy Farm shown in the main column.

Activity titles are uniform for both groups except for No. 109 which is Cropping farm acquisition, rather than a salvage activity. In this case the unit is 5 machine acres.

** Unit is 5 M.A. for the Cropping Farm.

Table 4. Resource Restriction Identities and Initial Values

Restriction Number	Description	Unit		Value: Dairy Farm	Value: Cropping Farm
1	Corn-grain	lb. 1000		0	0
2	Corn-silage.	10 tons		0	0
3	Oats.	lb. 1000		0	0
4	Wheat	lb. 1000		0	0
5	Barley	lb. 1000		0	0
6	Dry beans	lb. 1000		0	0
7	AA hay	1 ton		0	0
8	AA silage	10 tons		0	0
9	AA pasture.	1 Ac.		0	0
10	Wheat allotment restriction.	1 Ac.		17.0	20.0
11	Dairy grain equivalent.	lb. 1000		0	0
12	Beef grain equivalent.	lb. 1000		0	0
13	Hog grain equivalent.	lb. 1000		0	0
14	Poultry grain equivalent.	lb. 1000		0	0
15	Beef grain restriction.	lb. 1000		0	0
16	Hog grain restriction.	lb. 1000		0	0
17	Roughage equivalent.	lb. 1000		0	0
18	Silo capacity.	10 tons.		11.4	0
19	Dairy cows.	1 cow		17.0	0
20	Dairy heifers.	1 heifer		8.0	0
21	Dairy calves.	1 calf		6.0	0
22	Milk.	lb. 1000		0	0
23	Beef feeders, lb. 400	1 feeder		0	0
24	Beef feeders, lb. 850	1 feeder		0	0
25	Feeder hogs, Spring.	1 hog		0	0
26	Feeder hogs, Fall.	1 hog		0	0
27	Stanchion housing.	1 cow	(1)	23.0	0
28	Loose-housing.	1 cow	(1)	0	0
29	Farrowing housing.	1 sow	(1)	0	0
30	Hog fattening housing, May to August.	1 feeder	(1)	0	0
31	Poultry housing.	1 bird		150.0	150.0
32	N.	lb. 10		0	0
33	P.	lb. 10		0	0
34	K.	lb. 10		0	0
35	Labour, January to March.	1 hour		954.0	628.0
36	Labour, April and May.	1 hour		743.0	686.0
37	Labour, June and July	1 hour		886.0	707.0
38	Labour, August.	1 hour		474.0	368.0
39	Labour, September and October.	1 hour		859.0	694.0
40	Labour, November and December.	1 hour		750.0	479.0
41	Labour restriction, January to March.	1 hour		864.0	564.0
42	Labour restriction April and May.	1 hour		650.0	634.0
43	Labour restriction June and July	1 hour		793.0	655.0
44	Labour restriction, August.	1 hour		411.0	341.0
45	Labour restriction, September and October.	1 hour		719.0	642.0
46	Labour restriction, November and December.	1 hour		602.0	435.0
47	Tractor services.	1 hour		1235.0	1235.0
48	Corn planter services.	1 M.A.	(2)	100.0	100.0
49	Grain drill services.	1 M.A.		125.0	125.0
50	Cultivator services.	1 M.A.		200.0	200.0
51	Combine services.	1 M.A.		170.0	170.0
52	Mower services.	1 M.A.		200.0	200.0
53	Baler services.	1 M.A.		150.0	150.0
54	Field chopper services.	1 M.A.		100.0	0
55	Cornpicker services.	1 M.A.		0	0
56	Hog fattening housing, November to February	1 feeder	(1)	0	0
57	Side delivery rake services.	1 M.A.		100.0	100.0
58	Land.	1 Ac.		104.0	97.0
59	Land acquisition and salvage restriction.	1 Ac.		80.0	80.0
60	Chattel credit restriction.	$1.		7,060.0	2,884.0
61	Mortgage credit restriction.	$1.		9,135.0	10,633.0
62	Capital.	$10.		259.5	313.6
63	Beef housing.	1 animal	(1)	20	20
64	Capital Restriction.	$10.		259.5	313.6

(1) The livestock units used express the stock holding capacity of the housing.

(2) "M.A." = Machine Acres.

Table 5 Representative Cropping Farm-Marginal Value Products (¢) at the Various Milk Price Levels

Restriction Number	Description	Milk Unit Prices(¢)		M. V. P. (¢) 30	35	40	45	50
1	Corn-grain	lb. 1000		27.0	----------			x
2	Corn-silage.	10 tons		16.6	16.6	28.1	63.6	103.0
3	Oats	lb. 1000		29.9	----------			x
4	Wheat	lb. 1000		32.2	----------			x
5	Barley	lb. 1000		24.6	24.6	26.5	26.5	26.5
6	Dry beans	lb. 1000		73.5	----------			x
7	AA hay.	1 ton		21.6	----------			x
8	AA silage.	10 tons		70.3	70.3	70.3	70.3	75.0
9	AA pasture	1 Ac.		5.5	5.5	9.3	21.2	34.3
10	Wheat allotment restriction.	1 Ac.		10.9	----------			x
11	Dairy grain equivalent.	lb. 1000		15.3	17.4	26.5	26.5	26.5
12	Beef grain equivalent.	lb. 1000		27.0	----------			x
13	Hog grain equivalent.	lb. 1000		27.0	----------			x
14	Poultry grain equivalent.	lb. 1000		17.5	----------			x
15	Beef grain restriction.	lb. 1000		-	----------			x
16	Hog grain restriction.	lb. 1000		-	----------			x
17	Roughage equivalent.	lb. 1000		1.3	1.3	2.3	5.3	8.5
18	Silo capacity.	10 tons.		-	-	-	-	4.6
19	Dairy cows.	1 cow.		63.7	----------			x
20	Dairy heifers.	1 heifer.		175.0	175.0	175.0	212.3	257.9
21	Dairy calves.	1 calf.		55.7	53.0	31.5	27.6	27.6
22	Milk.	lb. 1000		34.5	39.5	44.5	49.5	54.5
23	Beef Feeders, lb. 400.	1 feeder		136.6	----------			x
24	Beef Feeders, lb. 850.	1 feeder		168.7	168.7	176.0	198.5	223.4
25	Feeder Hogs, Spring.	1 hog.		11.3	----------			x
26	Feeder Hogs, Fall.	1 hog		9.5	----------			x
27	Stanchion Housing.	1 cow	(1)	28.5	72.1	78.2	78.2	78.2
28	Loose-housing.	1 cow	(1)	51.8	95.4	101.5	101.5	101.5
29	Farrowing housing.	1 sow	(1)	112.0	----------			x
30	Hog fattening housing, May to August.	1 feeder	(1)	-	----------			x
31	Poultry housing.	1 bird		-	----------			x
32	N.	lb. 10		2.2	----------			x
33	P.	lb. 10		1.4	----------			x
34	K.	lb. 10		0.7	----------			x
35	Labour, January to March.	1 hour		3.1	----------			x
36	Labour, April and May.	1 hour		2.4	----------			x
37	Labour, June and July.	1 hour		2.4	----------			x
38	Labour, August	1 hour		2.4	----------			x
39	Labour, September and October.	1 hour		0.6	----------			x
40	Labour, November and December.	1 hour		-	----------			x
41	Labour restriction January to March.	1 hour		-	----------			x
42	Labour restriction April and May.	1 hour		-	----------			x
43	Labour restriction June and July.	1 hour		-	----------			x
44	Labour restriction August	1 hour		-	----------			x
45	Labour restriction September and October.	1 hour		-	----------			x
46	Labour restriction November and December.	1 hour		-	----------			x
47	Tractor Services.	1 hour	(2)	0.6	----------			x
48	Corn planter services.	1 M.A.		0.7	----------			x
49	Grain drill services.	1 M.A.		1.0	----------			x
50	Cultivator services.	1 M.A.		0.2	----------			x
51	Combine services.	1 M.A.		2.3	----------			x
52	Mower services.	1 M.A.		0.4	----------			x
53	Baler services.	1 M.A.		3.0	----------			x
54	Field chopper services.	1 M.A.		8.0	----------			x
55	Cornpicker services.	1 M.A.		5.8	----------			x
56	Hog fattening housing, November to February	1 feeder	(1)	4.3	----------			x
57	Side delivery rake services.	1 M.A.		1.1	----------			x
58	Land.	1 Ac.		45.4	----------			x
59	Land acquisition and salvage restriction	1 Ac.		26.3	----------			x
60	Chattel credit restriction.	¢10.		-	----------			x
61	Mortgage credit restriction.	¢10.		2.2	----------			x
62	Capital.	¢10.		3.0	----------			x
63	Beef Housing.	1 animal		-	----------			x
64	Capital Restriction.	¢10.		-	----------			x

(1) The livestock units used express the stock holding capacity of the housing.

(2) "M.A." = Machine Acres.

NOTE: The horizontal lines indicate that the value shown is the same in each column covered by the arrow as that shown in ¢30. column. (Shown thus ----------x)

Livestock Feed Requirements.

Table 6. Milk Production - per Cow.

	Herd Pastured			Herd on Dry Lot		
Ration:	I	II	III	I	II	III
Corn (or equiv.) - lb.	1500	2500	4500	1500	2500	4500
Hay (or equiv.) - tons	3.25	2.95	2.20	6.25	5.95	5.20
Pasture - acres	1.5	1.5	1.5	-	-	-

Table 6 is based on figures presented in the following publication:

C. R. Hoglund A Budgeting Guide in Estimated Feed Inputs and Milk Production when 1200 pound Holstein Cows are fed Variable Quantities of Grain and Three Qualities of Roughage, Ag. Econ. No. 670, Michigan State University, January 16th 1957.

Livestock Feed Requirements

Table 7. Beef Production - per Head

	Rearing Feeder Calves	Rearing Feeder Steers	Finishing Short-Fed Steers	Finishing Long-Fed Steers	Finishing Heavy Steers
Corn (or equiv.) - lb.	590	200	3760	2370	1400
Hay (or equiv.) - tons	3.1	1.4	0.8	1.5	0.7
Pasture - acres	1.6	1.2	-	0.8	-
Protein supple. - lb.	-	-	557	249	143

Table 7 is based on data from the following sources:

Carroll V. Hess, Farm Budgeting Reference Manual, Cornell University Agricultural Experiment Station.

Victor E. Smith, A Linear Programming Analysis of Beef Feeding, Michigan State College, Agricultural Experiment Station Quarterly Bulletin, Vol. 37, No. 4.

Livestock Feed Requirements.

Table 8. Hog and Egg Production

Per:-	Sow and 1 litter	Sow and 2 litters	Fat Hog	160 doz. eggs. Replacements Purch.	160 doz. eggs. Replacements Reared
Corn (of equiv.) - lb.	1960	2690	550	610	810
Oats - lb.	-	-	-	82	137
Protein Supple. - lb.	376	520	102	200	270

Table 8 is based on d ata from the following sources:

J.A. Hoefer, H.F. Moxley, and R.E. Rust, Producing Pork in Michigan, Michigan State University, Co-operative Extension Service, Extension Bulletin 335.

James M. Nielson, Application of the Budget Method in Farm Planning, unpublished thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the Department of Economics, Harvard University.

Labour Requirements

Table 9. Crop Production - Hours per Acre.

	Jan.-Mar.	April-May	June-Jul.	Aug.	Sep.-Oct.	Nov.-Dec.
Corn - grain	-	6.0	2.5	-	1.5	2.0
Corn - silage	-	6.0	2.0	-	4.0	-
Beans	-	3.4	6.5	0.5	6.3	1.0
Wheat	-	0.5	2.0	-	4.5	-
Oats/Barley	-	5.0	2.0	-	-	-
A.A. - hay	-	0.5	6.0	0.5	-	-
A.A. - silage	-	2.5	5.7	1.8	-	-
A.A. - pasture	-	0.5	1.0	-	-	-

Source: Ibid., Tables 41 and 56.

Labour Requirements

Table 10. Livestock Production - Hours

Per	Jan.-Mar.	April-May	June-Jul.	Aug.	Sep.-Oct.	Nov.-Dec.
Dairy Cow, Stanchion Housing	21.7	13.6	9.0	5.2	11.3	14.2
Dairy Cow, Loose Housing, Dry Lot	17.4	10.8	7.2	4.2	9.0	11.4
Dairy Cow, Loose Housing, Pastured	17.4	11.4	7.8	4.5	9.5	11.4
Beef feeder calf, 400 lb.	7.8	5.3	1.0	0.7	3.0	5.2
Beef feeder, 400-850 lb.	2.4	1.7	0.6	0.6	-	3.0
Fat steer, 400-950 lb., short fed	3.3	3.4	3.2	-	-	1.1
Fat steer, 400-950 lb., long fed	6.6	3.3	2.2	2.2	4.4	3.3
Fat steer, 850-1125 lb.	1.7	-	-	-	1.7	3.4
Sow and 1 litter	17.5	10.0	5.0	2.5	5.0	5.0
Sow and 2 litters	17.5	10.0	5.0	5.0	7.5	5.0
Fat Hog, August	-	0.4	0.8	0.4	-	-
Fat Hog, February	0.8	-	-	-	-	0.8
10 Hens, Rearing replacements	3.3	3.0	2.9	1.7	2.4	2.0
10 Hens, Buying replacements	3.1	1.9	1.8	1.1	2.1	2.0

Table 10 is based on data from the following sources:

Extension Service in Agriculture and Home Economics, Illinois Farm and Home Development Reference Book, College of Agriculture, University of Illinois.
C.R. Hoglund and K.T. Wright, Reducing Dairy Costs on Michigan Farms, Agricultural Experiment Station Special Bulletin 376, Michigan State College, May 1952.

Hess, op. cit., Tables 20, 21.
Nielson, op. cit., Table 57.
Smith, op. cit.

Table 11. Market Prices.

The following list sets out the prices used in constructing the objective function. They relate to the period 1954-58.

Sale Prices.

		£
Per:	225 lb. barrow or gilt	43
	50 lb. feeder hog	13
	300 lb. fat gilt	50
	400 lb. fat sow	66
	400 lb. feeder calf	95
	850 lb. feeder steer	165
	950 lb. fat steer	233
	1125 lb. fat steer	271
	Cull beef cow	155
	1000 lb. milk	30, 35, 40, 45, 50
	Milk cow	170
	In calf heifer	180
	Dairy bred calf	24
	Cull dairy cow	160
	Dozen eggs	0.37
	Cull hen	0.50
	1 ton hay	21.70
	1000 lb. corn	21.60
	1000 lb. oats	20.00
	1000 lb. wheat	32.30
	1000 lb. barley	18.60
	1000 lb. dry beans	73.60
(Second Hand)		
	2-plow tractor	573
	2-row corn planter	180
	Grain drill	300
	2-row cultivator	75
	Combine (under 8 ft.)	487
	Mower	200
	Baler	700
	Field chopper	500
	Side delivery rake	225
	1 Acre land (Dairy Farm)	240
	1 Acre land (Cropping Farm)	214
	1 hour, family labour	1.65

Table 11 (contd.)

Purchase Prices

		£
Per :	In-pig gilt	60
	50 lb. feeder hog	14
	Breeding boar	75
	400 lb. feeder calf	105
	In-calf beef cow	200
	Beef bull	275
	Milk cow	185
	Replacement pullet	1.80
	Chick	0.33
	1 ton hay	23.80
	1000 lb. corn	23.80
	1000 lb. oats	22.00
	1000 lb. wheat	35.50
	1000 lb. barley	20.50
	100 lb. nitrogen	17
	100 lb. phosphate	11
	100 lb. potash	6
	1 hour regular labour	1.75
	1 hour seasonal labour	1.85
(New)	Corn picker	1245
	Field chopper	1897
	1 Acre land (Dairy Farm)	198
	1 Acre land (Cropping Farm)	190

Source: Agricultural Marketing Service, Agricultural Prices, January 1954 - December 1958, United States Department of Agriculture.
Earl I. Fuller, Alternatives for Increasing the Earning Power of Labour on Dairy Farms, thesis presented in partial fulfilment of Master's degree, Michigan State University, 1957.
Various machinery dealers in the Lansing area.
Discussions with members of staff of Michigan State University, Agricultural Economics Department.

Table 12. Assets and Resources Available on the Representative Farms.

	Dairy	Cropping
Silo Capacity (Ton)	114	0
Dairy cows	17.0	0
Dairy Heifers	8.0	0
Dairy Heifer Calves	6.0	0
Stanchion Housing Capacity (Cows)	23.0	0
Poultry Housing Capacity (Birds)	150.0	150.0
Labour, January to March (Hours)	954.0	628.0
Labour, April and May (Hours)	743.0	686.0
Labour, June and July (Hours)	886.0	707.0
Labour, August (Hours)	474.0	368.0
Labour, September and October (Hours)	859.0	694.0
Labour, November and December (Hours)	750.0	479.0
Tractors	2.0	2.0
Corn Planters	1.0	1.0
Grain Drills	1.0	1.0
Cultivators	1.0	1.0
Combines	1.0	1.0
Mowers	1.0	1.0
Balers	1.0	1.0
Field Choppers	1.0	0
Side Delivery Rakes	1.0	1.0
Land (Tillable Acres)	104.0	97.0
Capital ($)	2595.0	3136.0

Table 13. Actual Fertilizer Application and Crop Yields Obtained in 1958 on the Representative Farms.

	Dairy				Cropping			
	Yield/Ac.	Lb. (b)			Yield/Ac.	Lb.		
		N	P	K		N	P	K
Corn (Grain)	70 bu.	28	16	19	65 bu.	10	36	32
(a) Oats	72 bu.	15	33	32	88 bu.	11	38	26
Wheat	46 bu	22	48	40	59 bu.	24	36	32
(a) Dry Beans	21 bu.	20	35	26	22 bu.	11	22	19
Hay	2 ton	14	14	17	2 ton	0	0	0

(a) Oats and dry beans are not representative crops on the Cropping and Dairy farms respectively, but have been included here for purposes of comparison.

(b) Fertilizer has been adjusted on a per acre basis to take account of farmyard manure applied. The rate assumed is (per acre) Lb. 8 N
Lb. 5 P
Lb. 8 K

Table 14. Estimated Amounts of Farmyard Manure Produced Annually by Various Types of Livestock[a].

Lbs.	N	P	K
Dairy Cow	32	20	32
Dairy Heifer[b]	32	20	32
Beef Cow and Calf	32	20	32
Beef Stocker	16	10	16
Beef Feeder	24	15	24
Sow and 1 Litter to Weaning	3	2	3
Sow and 2 Litters to Weaning	6	4	6
Fattening Hog	2	1	2
10 Layers	5	7	2.6

(a) Estimates are based on the figures shown in Tables 6 and 7 of Illinois Farm and Home Development Reference Book, Extension Service in Agriculture and Home Economics, College of Agriculture, University of Illinois. These figures have been modified to allow for losses in handling and in run-off.

(b) Covers the period from birth to freshening.

Table 15. Estimates of Annual Machine Capacity and Expected Use (Machine Acres).

	Capacity(1)	Maximum Expected Use
Corn planter, 2-row	100	90
Grain drill, 13-hole	125	90
Cultivator, 2-row	200	90
Combine, 8 ft.	170	135
Mower, 7 ft.	200	42
Baler	150	42
Field Chopper	100	72
Side Delivery Rake	100	90

(1) Capacity figures based on estimates from various sources:

(a) U.S.D.A., The Farm Cost Situation, Agricultural Research Service, May 21, 1959, p. 38.

(b) Loc. Cit., Frick and Burkett, p. 36.

(c) Iowa State College Data, Doane's Agricultural Digest, September 1951, p. 365.

(d) F. Miller, Q.W. Lindsey, and A.C. George, "Cost of Operating Machinery on Nebraska Farms", University of Nebraska, College of Agriculture, Agricultural Experiment Station Bulletin Number 391, December 1948.

(e) Personal consultation with members of the Agricultural Engineering Department, Michigan State University.

Table 16. Estimated Farm Real Estate Values, by Counties[a]

	$ Per Acre
Huron	303
Lapeer	272
Sanilac	159
St. Clair	413
Tuscola	232

(a) These are the farmers' own estimates of the value of land and buildings at 1959 price levels.

Table 17. Comparison of Wage Rates in Agriculture and Industry.

	Manufacturing Industry		Agriculture[a]
	Flint	Saginaw	Michigan
($) Per Hour			
1954	2.23	2.05	1.00
1955	2.37	2.17	1.02
1956	2.41	2.20	1.06
1957	2.52	2.32	1.07
1958	2.68	2.43	1.06 (est.)

Sources: Employment and Earnings, United States Department of Labour, Annual Supplement Issue, Vol. 5, No. 11, Table SC-5, May, 1959.

Farm Labour, United States Department of Agriculture, Agricultural Marketing Service, Crop Reporting Board, January 10, 1958.

(a) Rates quoted are wages paid without board or room.

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