A LINEAR PROGRAM ANALYSIS OF GRADE A DAIRY
FARM ORGANIZATIONS IN THE OKLAHOMA
METROPOLITAN MILK MARKETING AREA

By

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CHAPTER I

INTRODUCTION

In Oklahoma, as is true in other areas of the country, dairying is rapidly changing its technology from a labor intensive enterprise to a more highly mechanized enterprise. Oklahoma dairying is changing from a manufacturing milk production business to the more highly specialized Grade A type of milk production. With these changes, average milk production per cow is increasing, there are more cows per farm, and fewer farms than formerly. The changes are requiring the dairyman to use more capital, better management, and to produce larger volumes of milk in order to fully utilize the large investments in the dairy enterprise.

Oklahoma is a slightly surplus milk producing state, according to the 1958 Supplement to Dairy Statistics published by the United States Department of Agricultural Marketing Service. United States per capita consumption of all dairy products, expressed in milk equivalent, was 694 pounds in 1958. Oklahoma per capita consumption of milk equivalent was 620.6 pounds. United States per capita consumption of fluid milk and cream for 1958 was 345 pounds and for milk products 349 pounds of milk equivalent. The per capita consumption of fluid milk and cream in Oklahoma is 329 pounds and for milk products 291.6 pounds of milk equivalent. The reason for the difference in consumption is based on the difference in per capita income and income elasticities[1] affecting demand for milk

[1] Anthony S. Rojko, The Demand and Price Structure for Dairy Products, U.S.D.A., Tech. Bulletin No. 1168 (1957), p. 105.

products. Oklahoma per capita income in 1958 was 15.4 percent less than United States per capita income. The income elasticities are .3 for fluid milk, .36 for butter, -.99 for American cheese, and 3.06 for other milk products. With Oklahoma's population at 2,399,603 and rising, this means that at least 1,489,193,621 pounds of whole milk equivalent is consumed by Oklahomans each year. In 1958, there was produced and made available in Oklahoma 1,513,000,000 pounds of milk for human consumption. According to these figures there is a 1.6 percent surplus of milk produced in the state.

The most important segment of the milk produced for market is Grade A. Of the total 1.513 billion pounds of milk equivalent produced in Oklahoma in 1958, approximately 760 million pounds were delivered to plants and dealers as Grade A milk. In addition to this quantity there was approximately 145 million pounds delivered to plants and dealers as Grade C. Another 165 million pounds of milk were consumed on the farm and 423 million pounds sold as farm skimmed cream, and retailed by farmers as whole milk. Approximately 2,450 Grade A producers of the Oklahoma Metropolitan Milk Marketing Area delivered 436 million or 57.36 percent of the 760 million pounds delivered as whole milk. The other 1,100 Grade A producers in the state produced and delivered to plants and dealers 324 million pounds of Grade A milk. Approximately 2,500 Grade C producers delivered the 145 million pounds of manufacturing milk. The remaining 608 million pounds of milk equivalent is produced by small volume producers and family milk cows. A rough estimate of the number of these producers at this time is 57,000. A total of two cows per farm producing 5,333 pounds per cow would produce this much milk.

The total value of farm-produced milk in 1958 as estimated by the United States Department of Agriculture was $63,705,000. This is an increase of $12,437,000 over the value reported in 1954 by Oklahoma State Experiment Station, Leaflet L-29 by Houston E. Ward.

Supply and demand relations between production and consumption within the state of Oklahoma indicate that there is essentially a balance between production and consumption. There is no need for increased supplies of milk at this time. There is however a need for efficient production of the existing quantity of milk produced in the area from the standpoint of the producer as well as the consumer. This thesis deals with individual producer efficiency and does not attempt to deal with macro-problems as such. Its purpose is to determine efficient workable input coefficients, and it uses linear programming[2] to determine optimum farm organizations.

Usefulness of the Study

Oklahoma historically is not a dairying state. Very few of the present dairymen are second generation Grade A producers and many dairymen have been in the business less than 10 years. The type of dairying practiced in the past used dual purpose type cattle which could be used in a beef business when beef prices were high and as milk cows when beef prices were relatively low. Consumer demand for fluid milk is luring many Grade C producers into Grade A production. The buildings, equipment, and quality of cattle needed for Grade A production require higher investments than for Grade C production. Once this investment is made, the

[2]For a discussion of linear programming, see Heady and Chandler, Linear Programming Methods (Iowa, 1958), or R. Dorfman, Mathematical or "Linear" Programming, A Non-Mathematical Exposition. American Economics Rev., Vol. 43 (1953), p. 797.

change from beef to dairy and vice-versa can no longer be made without incurring losses due to the fixed costs of owning specialized equipment. The Grade A milk producer is much more fixed in his business than the Grade C producer was. The salvage value of the investment is much less than acquisition cost and changes are more expensive to make. With the larger investments, larger outputs are possible and often necessary in order to realize the efficiency required to justify the cost. The technology associated with bulk tanks and pipe line milkers is making possible increased labor efficiency which releases operator time for production of more milk or for employment elsewhere.

Because of the changed technology and market conditions the decision to become a Grade A producer, or to expand the present Grade A business, is difficult to make. Since this type of milk production in Oklahoma is relatively new, very little information is available to the Oklahoma dairyman as to the requirements of various inputs per unit of milk produced. Information of this nature would be valuable to dairymen in the planning stages of dairy farming.

Many established Oklahoma dairymen are at the threshold of expanding their present dairy operation. Others are going completely out of business. Still other farmers are viewing the possibilities of getting into Grade A dairying. The questions confronting all are: (1) How big should the farm dairy enterprise be? (2) What are the requirements for milk production in Oklahoma?, and (3) How may resources be combined in order to obtain maximum income?

Producers with small herds and producers who do not possess the necessary land, high producing cattle, a reasonably inexpensive feed supply, or the desire to expand the present dairy business on their farms may be thinking of alternative uses for the resources which they own. This does not necessarily mean that small producers will be forced to grow larger or to stop producing milk. It does mean, however, that small volume producers might have the possibility of turning their efforts from milk production to other enterprises or to other phases of dairying such as producing replacements, forage, and grain for more income.

With known prices and technology there can be found, using linear programming, the combination of all inputs and outputs which yields the largest possible returns for a given situation. Such information will allow the operator to visualize the advantages of expansion, contraction, or maintenance of the present business. This information can show the dairyman not only the quantities of various factors he should be using in order to maximize returns for his particular situation, but also the areas in which he should be specializing. Once the possibilities of resource use are determined and an optimum combination of these activities found, the Oklahoma dairyman will be able to use his resources most effectively in the milk production business.

Method of Collecting Information

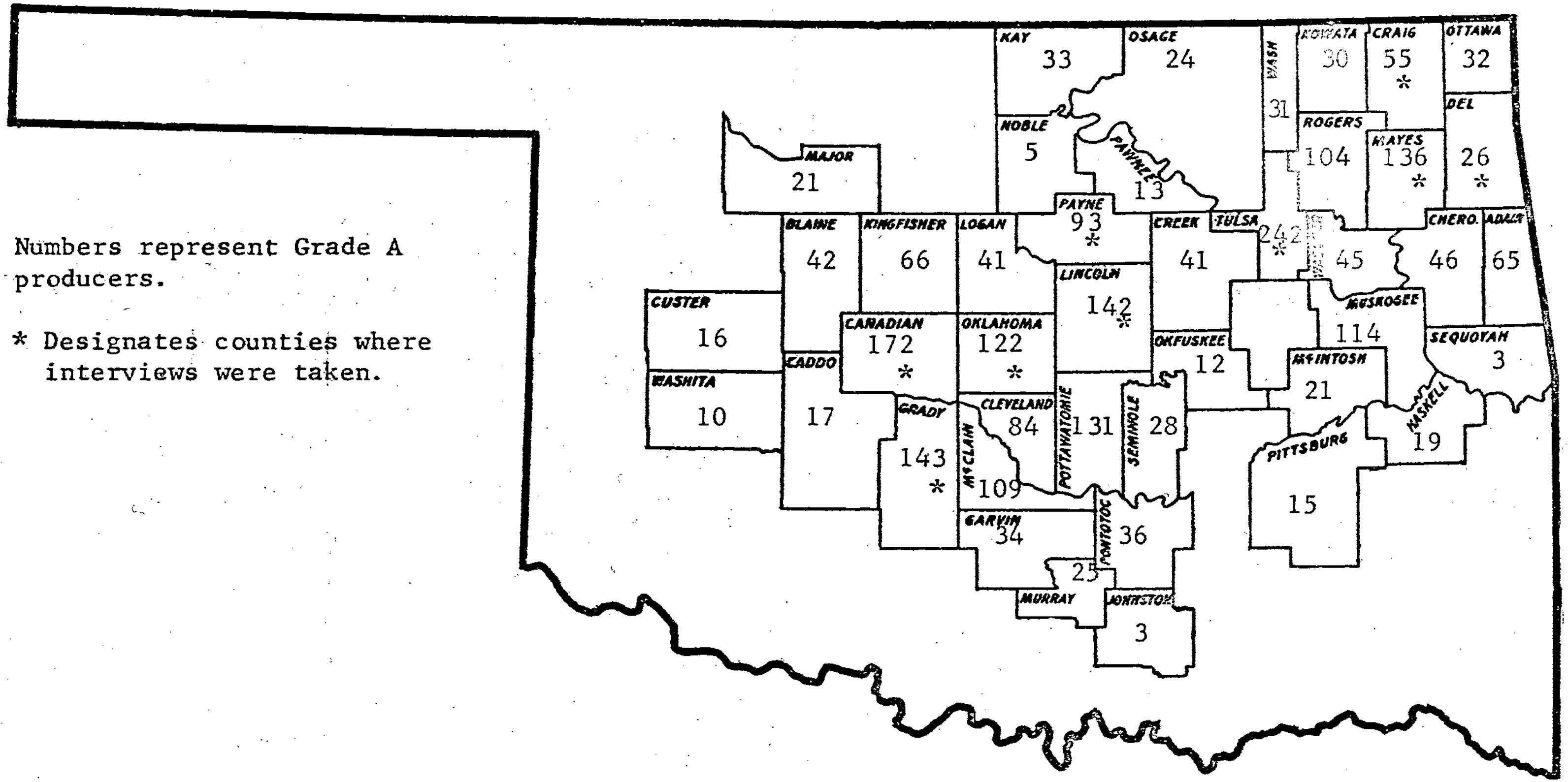
The empirical content of this thesis is based on what 44 apparently successful Grade A milk producers in the Oklahoma Metropolitan Milk Marketing Area were doing. These producers were located through county agents, extension personnel, and farmers themselves. The criterion for selection was that the producer be Grade A and milking at least 20 cows for a full lactation of 300 days per year.

Area

The study was limited to Payne, Lincoln, Oklahoma, Grady, Canadian, Craig, Delaware, and Mayes counties of the Oklahoma Metropolitan Milk Marketing Area shown in Figure 1, page 7. The counties sampled appeared to have an interest in and capacity for producing Grade A milk and are representative with respect to conditions under which most of the Grade A milk is produced in the area. There are, however, some differences in the types of pastures used within the area. Dairymen in the northeastern counties have a larger proportion of their total permanent pasture land in wooded areas and use some grasses and legumes not found in the central part of Oklahoma, such as, yellow hop and lespedeza. The total land requirement is not appreciably different, nor does the cultivated pasture cost appear to be any higher or lower per cow. Dairymen in the central Oklahoma counties in the vicinity of Canadian, Grady, and Oklahoma showed a greater desire to produce more grain due to the topography and quality of the land on which they are located. Dairy management practices, feeding levels, or the equipment used in dairying did not vary significantly between the two land types and no distinction among practices can be justified when considering alternatives for dairymen in each area.

Approach to the Problem

The case study approach to the problem was used. During the spring and summer of 1959, 44 established producers were interviewed and their farming businesses studied. Estimates of complete investments in livestock, buildings, farming equipment, and specialized dairy equipment were obtained. Farm sizes, the normal cropping program, and the complete costs and returns records for 1958 were obtained from each producer interviewed.



Numbers represent Grade A producers.

* Designates counties where interviews were taken.

Figure 1. The Oklahoma Metropolitan Milk Marketing Area (1958)

Source: Marketing Service Information, Oklahoma Metropolitan Milk Marketing Administrator, AMS, USDA, (November, 1958).

This information was combined with secondary data including normal average yields for crops, labor for crop production, seeding and fertilizer rates for the studied area, farm machinery depreciation rates, upkeep expenses on farm machinery, and costs of buildings and their maintenance to determine typical input coefficients for the area.

Questions as to practices used both in dairy husbandry and crop production were asked. Labor required for the actual dairy enterprise was determined separately from other requirements for farm labor. Barn and yard layouts were observed and some actual timing of various chore work was done to determine the time required for the various chores in order to determine the labor input coefficients under various herd sizes.

CHAPTER II

CHARACTERISTICS OF DAIRYING IN THE OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

This chapter discusses characteristics of the farms observed and points out the most widely used practices. From this information, resource availability will be determined and budget coefficients derived for analysis in Chapter IV.

Feeding Practices

Feeding practices, methods, and levels varied among the producers and among the different areas in the study. Underwood[1] reported in 1956 that there were 60 kinds of grazing materials used in the production of milk in Oklahoma. In the present study, it was found that there were five major types of pastures used by the producers interviewed. They were native unimproved pastures, native improved pastures, sudan, small grain-vetch, small grains, and other pastures. Rye-vetch was the most widely used small grain-vetch pasture. Alfalfa and Bermuda grass were used, but not extensively. Most of the small grain used for pasture was later harvested for grain, but in a few widely scattered instances the crop was grazed out completely. Sudan and small grain-vetch are planted each year. Sudan is a summer pasture planted during the first two weeks of May and grazed from June 15 to August 15. Small grain-vetch, on the farms studied, was planted about September 1 or 15 and grazed from October 1 to the following March or April depending upon the severity of the winter and on whether the same

[1]F. L. Underwood, Economic Survey of Resources Used by Dairy Farmers in Oklahoma, Oklahoma Experiment Station Bulletin, B-42, p. 9.

ground was used for the sudan summer pasture. Many dairymen were practicing double cropping on their temporarily established pastures. Through a system of rotation and the staggering of planting dates, the transition from the winter pasture to the summer pasture can be made without losing valuable grazing time when the same ground is used for both crops. Several dairymen indicated that they were following this practice and were quite happy with the results. Others expressed desires to use such a system or had used it but for unaccounted reasons were not presently doing so.

The small grain grazing season for Oklahoma dairymen begins November 15 and lasts to March 15. On the farms studied, maximum wheat allotments were planted, but only 20 of the 44 farms studied had allotments. Of the 45.5 percent of the sample planting wheat the average acreage per farm was 81.6 acres or for total producers interviewed 37.09 acres. Twenty-four of the 44 interviewed were producing feed grains. The average acreage for the 54.5 percent of producers producing feed grains was 84.4 acres or for total producers the average acreage was 46.04 acres. Of the total 3,658 acres of small grains found on the 44 farms observed, the producers estimated that from 70 to 90 days winter grazing for the dairy herd could be expected each year. On a per farm basis this amounts to 83.14 acres. Small grains planted for harvest and the vetch-small grain pastures constitute the winter pasture programs for the producers interviewed.

The small grains provide the late fall and winter pasture. When the small grain grazing season ends, the vetch in the small grain-vetch pastures can be more heavily grazed, thus providing a succulent feed until native grasses can be used.

The native pastures were usually on fairly rough land and in many cases partly covered with blackjacks, which do not lend themselves to good grazing by high quality dairy cows. However, native pastures, especially those which could be improved by the overseeding of other grasses and legumes, were used to fill in between the cultivated pasture grazing periods for the milking herd. It seemed to be a uniform practice to use native pastures especially through the summer grazing season for replacement stock. Frequently native pasture was the only pasture used for young dairy stock. In other cases, native pasture plus some small grain pasture during the winter months provided replacement stock pasture.

Underwood[2] found a total of 53 separate materials being hand fed to dairy cows in Oklahoma in 1950. The Grade A producers interviewed in this 1959 study were using quite a variety of roughages and concentrates. Alfalfa hay was by far the most widely used dry roughage. Much of the alfalfa was produced on the farm where it was fed. Other significant kinds of hay used were prairie, oat, sudan, lespedeza, and a small amount of Bermuda grass hay. Sorghum was the most widely used silage material, with corn being second in popularity. Several varieties of sorghums were used, but Sugar Drip and Atlas Sargo were preferred. Because of the extensive use of alfalfa hay and sorghum silages, the linear program solutions in Chapter IV assume that alfalfa was the sole source of dry roughage and sorghum silage the only silage used.

On the farms producing their own grain, oats were used most widely with barley running a poor second and grain sorghum being used occasionally. Therefore, the linear programs in Chapter IV assume that oats are the grain used.

[2]Ibid., p. 14.

Producers who were buying grain most often purchased a 16 percent protein mixture with very little preference as to the major carbohydrate content. For purposes of this study, the difference in feeding value and cost per ton of the three possible feed grains was not great enough to require separate consideration. Oats in 1958 were slightly higher per ton, approximately $3.00 when compared on a nitrogen free extract basis. Some profit maximizing farmers might prefer purchasing grain sorghums to producing oats. Producers who were purchasing grains indicated that as prices changed they did shift from one to the other of the three: oats, barley, or grain sorghum. However, the cost difference generally is not large enough to make this a major decision and oats are considered as the source of feed grain in the analysis of Chapter IV.

Twenty-four of the 44 producers interviewed (or 54.5 percent) were producing all of their hay. Thirteen (or 29.5 percent) were feeding home produced and purchased hay and seven of the 44 (or 15.9 percent) were buying all the hay used by their dairy enterprises. One dairyman was producing alfalfa hay as a cash crop. Thirty-five (or 79.5 percent) of these same producers were using silage. Only two producers were buying silage.

Sixteen of the producers interviewed were producing all the concentrates fed to the dairy cattle, six were using a combination of home production and buying of concentrates, and 22 were buying all the concentrates used. This breaks down into 36.3 percent producing all concentrates, 13.6 both producing and buying and 50 percent buying all their grains. The most popular and widely used protein supplement purchased for mixture with home-grown grains was cottonseed meal. In 1958, soybean meal was twenty cents per hundred weight lower in cost, but dairymen in this area did not use it. Transportation of the concentrates to the farms by feed dealers was usually done by the bulk method with a small discount, usually from $1.00 to $1.50 per ton, on the purchase price. Usually a two-week supply was delivered each time, but some of the larger producers received deliveries as often as once per week.

Dairy Farm Farmsteads

Dairy farm farmstead buildings consisted of a milking barn or parlor, metal and frame granaries, a hay storage shed, silos, machine sheds, and cattle shelters. The milking barns had feed and milkrooms attached. Trench silos outnumbered upright silos two to one, and only one-half the farms had machine sheds. Cattle shelters were found on about two-thirds of the farms.

The milking barns are of two types, stanchion and elevated stall. Many variations of the latter were in the interest of labor saving arrangements. For the most part, the construction of the milking barn is of masonry, usually concrete blocks. Technological developments such as the pipe-line milking system and bulk tanks have been adapted to both types of barns, but usually cost less when put into elevated stall-type barns due to the shorter distances to the milkroom and a greater per unit use of the stalls and milkers.

Usually a concrete holding pen adjoining the entrance way was used for holding the cows before admitting them into the barn. This facilitates milking and aids in keeping clean barns.

The technological developments adopted in the past few years have made the dairy chore work much easier in most cases and reduced the amount of time required per cow per year by approximately one-third, according to the labor estimates given by the producers interviewed. The programmed solutions discussed in Chapter IV assume the use of a parlor-type barn, pipe-line milkers, and bulk milk tanks.

Hay storage buildings for the most part are of pole or permanent pole-type construction open on all sides with a metal roof. This type barn was liked by the dairymen, and provided adequate shelter for hay.

Of the 44 producers interviewed, 77 percent had grain storage available. An allowance was made for such buildings in the analysis in Chapter IV. Since round metal bins were the kind most often found, this is the type assumed.

The temporary trench silo is inexpensive and can be used or left unused, as the silage program requires, at relatively little cost. Upright silos cost a great deal more to construct and maintain, but offer an advantage in many cases in ease of feeding. With an upright silo, the operator usually avoids the winter mud associated with many trench silos. Much work has been done with regard to the making and storage of silage in various types of silos in recent years. Findings have indicated that an expensive structure is not required in order to have good silage.

Silage users can reduce silage costs through the use of trench-type silos in more than one way. Besides the initial construction costs for the silos, the equipment required to fill the two types of silos is different. The upright type requires a blower; the trench type can be filled by dumping the loaded vehicle directly into the pit. Some operators claim a labor saving along with a lower investment in silage-making equipment, when using trench silos. The solutions discussed in Chapter IV assume the trench silo method of making and storing silage.

The decision of whether or not to invest in a machine shed confronts each individual dairyman. The success of the dairy does not appear to be highly correlated with farm machine shelter. The lack of shelter does usually result in a higher repair cost per year, but it is questionable as to whether this cost outweighs the machine shed investment and maintenance.[3] Values other than monetary, such as farmstead appearance and an indoor place in which to repair breakdowns during bad weather may offset the building costs and justify a machine shed and repair shop. Fifty-two percent of the producers interviewed were using machine sheds. The results in Chapter IV assume the use of machine sheds..

Dairy cattle shelter in Oklahoma is another question of choice for each individual producer. About two-thirds of the dairymen interviewed were using some kind of shelter for the milking herd. The pole and permanent pole-type structures were most widely used, along with lean-to sheds, and various other occasional shelters during severe winter weather. All shelter used was of the free choice type allowing the cattle to enter at will and be free to move about in the yards for water and exercise. Windbreaks seem to be of as much value as elaborate buildings insofar as total production is concerned. Producers with absolutely no shelter had as high an average production per cow as those with barns in which to house the dairy cattle. Old buildings, space emptied as hay is fed from hay barns, and special calf housing buildings were used for baby calf-housing until the calf was large enough to be placed with older stock. Around 40.9 percent of the producers interviewed were not using shelter

[3]F. C. Fenton, G. E. Fairbanks, The Cost of Using Farm Machinery, Kansas Experiment Station Bulletin No. 74.

for the young stock. Windbreaks in severe weather are certainly desirable, but expensive housing is not a necessity. A conservative investment for shade and shelter is used in the budgets from which the input coefficients for the programs in Chapter IV are derived.

Land

The land observed on the 44 dairy farms is of two general types, native pasture and cropland. The proportion of cropland to native pasture is 2.6:1. Most of the native pasture was not suitable for any kind of tillage practices and often was given no attention whatsoever other than fencing. The cropland ranged from good bottomland to poorer upland.

The average land size of all farms observed was 507.36 acres. The range was from 152 to 1,340 acres. The average size of farm land owned was 390.47 acres and the remaining 117 acres were rented. For the 20 cow herd the average size of farm was 160 acres, the 25 cow herd 280, the 32 cow herd 380, and 46 cow herd 500, the 60 cow herd 540, and the 84 cow herd 680 acres. The dairymen interviewed fell into the following ownership categories: 12 or 27.2 percent owned all the land on which they operated, 27 or 61.3 percent were part owners and part renters of the land they operated, and five or 11.3 percent rented all the land they used. Of the 22,294 acres operated by the 44 producers, 8,600 or 38.50 percent was rented. The farmers who were renting land in were renting 64.62 percent as much land as they owned. The programs in Chapter IV have been allowed to rent in exactly as much of each type of land as is owned by the business. This would allow doubling the present land quantity.

For the dairymen interviewed, there was a high correlation between herd size and acres of farm land used. Most of the land on dairy farms was used in close relation to the dairy enterprise either as pasture or in other dairy feed production capacities. The major exception is that of wheat production.

The wheat allotments were estimated according to the averages of the allotments used by the 44 dairymen interviewed classified according to size of dairy herd. The small farms and the large farms were not producing wheat, so the programs in Chapter IV do not include wheat allotments for these dairy farms.

Labor

The 44 dairymen interviewed were, with two exceptions, working full time in their dairy business. One exception was a producer working full time in town and helping the family part time to run the dairy farm. The other was a family operation in which the operator produced the feed and did the feeding while the wife did the milking.

The labor load seemed to fall into two seasonal periods of the year. The months from October 1 to March 31, are considered as the winter labor period during which one-half the operator's labor is available. During this season little time is required for crop production, but the peak milking and feeding load occurs.

The period from April 1 to September 30 requires the time needed by the dairy herd along with the time needed by the various crop and pasture programs carried on on the dairy farm. The early part of this period requires crop planting time along with approximately the same dairy herd time as is required during the winter months. The spring and early summer months are considered the heavy labor load months, but as summer approaches and part of the herd begins to dry up for the coming freshening period, operators find themselves with less pressing requirements for livestock labor.

Most of the operators interviewed were handling their labor requirements with family help and small quantities of hired help. Of the 44, six hired no labor, 26 hired 500 hours or less, four hired from one-third to one-half man, seven hired one full man, and one hired two full men. The operators reported that they worked approximately 3,000 hours per year, and this is the basis for the operators labor supply used in the programs in Chapter IV. Family labor can be used to meet the labor requirements designated by the programs and will be paid the farm wage rate.

Capital

The estimated value of the dairy businesses studied ranged from $24,000 to $120,000. Capital is used for two purposes: (1) investment and (2) operating capital to service the investment and meet current expenses. The investment items on the dairy farms observed were land, buildings, cattle, farm machinery, and specialized dairy equipment. The services required by these investments are taxes, insurance, repairs, supplies, feed inventories, fuel, labor, and professional services. As size of herd increased, investment per cow in fixed equipment and buildings decreased which implies certain economies of scale.

Capital for services may be obtained in part from current income, but feed and supply inventories were financed for a year in advance. The dairymen interviewed indicated that they were able to meet one year's operating expenses in advance. This meant that quantities of cash ranging from around $1,700 to $5,000 were available to the producers on the farms observed depending upon the size of dairy herd. Reference to Appendix Tables A-I through A-XIII and text Tables II and III, pages 29 and 31, will give the budget coefficients and their prices as defined for the linear programs in Chapter IV.

Appendix Tables B-I, B-II, and B-III list the buildings and equipment items of investment found on the farms studied. Only the machines and equipment necessary for efficient operation of the herd sizes programmed are considered. The farmers interviewed reported that their farm machinery on the average was four years old, specialized dairy equipment three, and buildings six. These ages were used to determine book value and to determine collateral value for the purpose of borrowing money. Equity conditions will be established and discussed in Chapter III.

The farmers interviewed implied that large equities were being acquired in the businesses they were currently operating, but that any expansion would have to be financed with borrowed capital.

Cattle

The breed of cattle found most often on the farms studied was grade Holsteins. There were three exceptions to this however; one farm used Jerseys, one used milking shorthorns and one used Aryshires. There were three farms using purebred Holsteins. Because of the observed popularity of Holsteins, this is the breed selected in this study.

The level of productivity of the cows used is very important to the farm income derived from dairying. Average production per cow per year on the farms studied ranged from 7,200 to 13,000 pounds. The dairymen interviewed and grouped according to herd size gave their average production per cow as being that shown in Chapter III, Table I, page 24.

Small producers apparently did not believe they could afford to own the higher producing cows and large producers apparently could not maintain high average production per cow due to the large number of cows they used. The highest producing cows were found in the medium sized herds. The estimated value of producing cows was fairly consistent on all farms. The average selling and purchase prices used in this study may be found in Appendix Table A-XV.

Herd replacements were produced on the farm where they were used with only an occasional exception. Three dairymen were producing high quality replacements for sale. The programs in Chapter IV will investigate alternative methods of herd replacement.

Both natural and artificial breeding methods were used. Producers using the artificial breeding method preferred it over the natural breeding method, and quite a few producers who were not using it expressed a desire to do so as soon as it was made available satisfactorily to them. Although only 34.1 percent of the producers interviewed were using the artificial insemination method, it is the method assumed in this study.

CHAPTER III

A DISCUSSION OF TECHNIQUES AND MODELS USED, WITH SPECIFIED RESOURCES AND INPUT COEFFICIENTS, FOR THE OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

The resource conditions and production practices found on Grade A dairy farms located in the Oklahoma Metropolitan Milk Marketing Area were discussed in Chapter II. The remainder of this thesis will be based upon the observations made in that section. This chapter deals with the linear programming model used, the resource limitations, and the technical coefficients needed to obtain the results presented in Chapter IV.

The variety of means used by dairymen to obtain feed cannot be handled in detail in a study of this kind. Certain reasonable observations must be made. For example, of the many ways to provide dry forage to dairy cattle, it is reasonable to base the analysis on an assumption that all dairymen use alfafla hay. For analytical purposes, the following assumptions have been abstracted from the observations discussed in Chapter II.

Native pasture and two kinds of cultivated pasture (sudan and rye-vetch) are used in milk production. Alfalfa hay and sorghum silage provide the remainder of the roughage needed. Oats are combined with cottonseed meal to make a 16 percent protein concentrate ration to be fed to dairy cows and herd replacements. Parlor type milking barns, bulk tanks and pipeline milkers will be used on the dairy farms discussed in Chapter IV. A labor supply of 3,000 hours is associated with each operator. Wheat allotments will be given only those farms, classified by herd size, on which wheat was observed. From these abstractions, originating in Chapter II, specific resource supplies and input coefficients will be determined and IBM linear program 0.1.006 used to determine optimum farm organizations.

Linear Programming Models

Linear programming is a tool which may be used to allocate scarce farm resources among their most profitable uses. Since the dairy farmer's objective is to maximize profits, he is interested in a dairy farm organization for which (1) total revenue exceeds total cost and (2) any feasible change in the farm organization costs more than the change is worth. The linear programming procedure selects from among all possible farm organizations one which meets these two conditions.

The linear programming model used is a profit maximizing one. The profit equation to be maximized is of the general form

$$\pi = \sum_{j=1}^{41} c_j P_j$$

where the c_j's are either net revenues per unit of output or net costs per unit of input. The P_j's are the activities which appear in the profit equation. Although there are 41 activities, not more than 16 may appear in a final solution.

This model has 16 linear restrictions with 41 unknowns. The restrictions insure that the quantity of resources used exactly equals the quantity available for use. There is opportunity to add to the resources on hand by either buying or renting in the quantity needed or to dispose of any resources on hand by either selling, renting out, or leaving idle. Idle equipment incurs fixed costs in the models used. Linear programming requires two types of information: (1) initial quantities of resources which are fixed and may become limiting must be determined and (2) the per unit requirement of all resources in all uses or activities must be estimated. This information is used in writing the linear equations. The resource requirements are summarized in the equations found in Appendix Tables C-II through C-VII for each herd size studied. The initial quantities assumed for fixed factors as are listed in Appendix Table C-VIII.

Resources

Table I gives the specific level of each resource available for use by herd size for the programs in Chapter IV. It includes land, capital, liabilities, net worth, available credit, and equipment capacities which may be used in the dairy business.

It was assumed that not every dairyman is operating at his optimum output, but that he wishes to do so and will borrow the necessary capital with which to expand if expansion increases total profit. His assets could be used as collateral to obtain additional capital at market rates of interest determined by institutions such as federal land banks, private banks, production credit associations, and other commercial lending agencies.

The available credit section of Table I gives the quantities of credit available to each herd size. Two levels of equity were assumed, a 60 percent equity position and a 90 percent position. The equity position of United States farmers reported by the Board of Governors of the Federal Reserve System in their July, 1959 Bulletin, page 725, is approximately 90 percent. This is the basis for the 90 percent equity position. The 60 percent position is arbitrarily assumed in order to allow a comparison of the availability of capital upon expansion of dairy

TABLE I

RESOURCES AVAILABLE BY FARM SIZE AND EQUITY SITUATION ON DAIRY FARMS STUDIED IN THE OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Units	Budget Series: 20 Cows 60% Equity	20 Cows 90% Equity	25 Cows 60% Equity	25 Cows 90% Equity	32 Cows 60% Equity	32 Cows 90% Equity	46 Cows 60% Equity	46 Cows 90% Equity	60 Cows 60% Equity	60 Cows 90% Equity	84 Cows 60% Equity	84 Cows 90% Equity
Land	Acres												
Native pasture	Acres	60.00	60.00	148.00	148.00	140.00	140.00	200.00	200.00	180.00	180.00	240.00	240.00
Cropland	Acres	100.00	100.00	114.00	114.00	200.00	200.00	274.00	274.00	320.00	320.00	440.00	440.00
Wheat allotment	Acres	0.	0.	18.00	18.00	40.00	40.00	26.00	26.00	40.00	40.00		
Total Capital	Dollars	32,364.35	32,364.35	41,761.73	41,761.73	65,331.67	65,331.67	78,833.48	78,833.48	91,635.08	91,635.08	118,992.90	118,992.90
Permanent													
Land and improvements	Dollars	18,713.50	18,713.50	26,953.50	26,953.50	45,322.10	45,322.10	51,425.00	51,425.00	58,878.00	58,878.00	71,478.00	71,478.00
Dairy equipment	Dollars	2,672.73	2,672.73	2,672.73	2,672.73	3,543.02	3,543.02	4,176.33	4,176.33	4,492.02	4,492.02	4,917.58	4,917.58
Farm machinery	Dollars	4,529.80	4,529.80	4,529.80	4,529.80	5,049.85	5,049.85	7,204.14	7,204.14	7,235.04	7,235.04	12,960.05	12,960.05
Temporary													
Cattle	Dollars	4,800.00	4,800.00	6,000.00	6,000.00	7,680.00	7,680.00	11,000.00	11,000.00	14,400.00	14,400.00	20,160.00	20,160.00
Supplies	Dollars	944.60	944.60	1,201.50	1,201.50	1,452.16	1,452.16	2,217.18	2,217.18	2,293.80	2,293.80	3,025.68	3,025.68
Crop production	Dollars	703.72	703.72	804.61	804.61	1,659.55	1,659.55	1,628.34	1,628.34	1,593.17	1,593.17	1,663.09	1,663.09
Hired labor	Dollars	0.	0.	0.	0.	625.00	625.00	1,182.50	1,182.50	2,742.50	2,742.50		
Liabilities	Dollars	12,945.74	3,236.43	16,464.69	4,216.17	26,132.67	6,533.16	31,533.39	7,883.35	36,654.03	9,163.51	47,597.16	11,899.29
Value of owner's equity	Dollars	19,418.61	29,127.91	25,297.04	37,945.56	39,199.00	58,798.51	47,300.09	70,950.14	54,981.05	82,471.58	71,395.74	107,093.61
Available credit	Dollars												
6 percent	Dollars	0.	8,927.00	0.	13,303.60	0.	22,920.00	0.	25,543.00	0.	29,107.00	0.	34,560.00
8 percent	Dollars	2,020.00	6,350.00	3,221.00	6,950.10	6,287.00	8,694.00	4,735.00	11,722.00	5,256.00	13,688.00	5,630.00	19,200.00
12 percent	Dollars	1,472.00	1,812.00	1,472.00	1,811.92	1,641.00	2,020.00	2,341.00	2,882.00	2,351.00	2,894.00	4,212.00	5,184.00
16 percent	Dollars	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
20 percent	Dollars	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Milk production capacity[1]	Cows	27.00	27.00	25.00	25.00	33.00	33.00	46.00	46.00	64.00	64.00	88.00	88.00
Production per cow	Lbs.	9,000.00	9,000.00	9,400.00	9,400.00	9,600.00	9,600.00	9,600.00	9,600.00	9,300.00	9,300.00	8,800.00	8,800.00

[1]Maximum capacity of initial equipment.

farms in Oklahoma. Many dairymen are or have been in an equity position of less than 90 percent and people interested in getting into the dairy business most likely will begin with something less than 90 percent equity. Being mindful, however, of the fact that personal quantities rather than ownership often determine the quantity of credit available to farmers, the capital supply schedule facing the situations under consideration are determined by the farmers' equity positions.

Six sources of credit available to Oklahoma dairy farmers were examined. The Federal Land Bank makes loans at six percent interest on the unpaid balance per year of quantities up to a maximum of 65 percent of the owned land and improvements. Banks, Production Credit Associations, and Milk Producers' Associations lend money to farmers at interest rates of seven and one-half to eight percent interest per year on the unpaid balance on collateral such as livestock and equipment, up to a maximum of around 80 percent of the operator's equity. Equipment dealers arrange for finance at ten to 12 percent interest on the unpaid balance for items purchased from them. Consumers' credit also offers capital at somewhat higher interest rates of which 16 and 20 percent have been assumed for use in this study. Equal quantities of this credit were allowed each budget series. The effect of this type of credit will be discussed in later sections of this study.

In order to determine just how much credit was available for each farm operation programmed in Chapter IV, net worth was established. Land was valued at $50.00 per acre for native pasture land and $120.00 per acre for cropland for each dairy farm size considered. Cattle were valued at $200 per animal unit. This is the value of the springer as she enters the herd. One cow or two heifers are considered to equal an animal unit. Buildings, specialized dairy equipment, and farm machinery are considered at book value under the assumptions that the life of farm buildings is 20 years, dairy equipment and farm machinery 10 years, and that the present buildings are six years old, dairy equipment three years old, and farm machinery four years old. New values and costs for these items are given in Appendix Tables B-I, B-II, and B-III.

The next step was to determine the quantities of capital which could be borrowed by using land and improvements, cattle, specialized dairy equipment, and farm machinery. The dairyman is limited to the quantities he can borrow against the assets he owns. It has been assumed in this study that the 60 percent owner can borrow up to 50 percent on his land and improvements at six percent interest, compared with 65 percent if he were a 90 percent owner. Both equity levels have been allowed 50 percent on their cattle at eight percent interest. On specialized dairy equipment and farm machinery, the 60 percent owner has been allowed 65 percent loan compared with 80 percent granted to the 90 percent owner. Loans on specialized dairy equipment and one-half the farm machinery may be obtained at eight percent interest. Loans on the remaining farm machinery cost 12 percent interest. All 60 percent equity businesses are initially in debt for all their available six percent credit and part of their eight percent credit. Hence, operators with relatively small equities must pay higher interest rates for additional borrowed money. This greatly limits the additional quantity available as Table I shows.

The sum of all temporary capital, including investments in cattle, supplies, crop production, and hired labor, Table I, is used as the operator's initial capital supply. The reason for including investments in cattle on hand in the capital supply is to allow the addition of cows to the herd in as simple a manner as possible. It is merely an algebraic manipulation (adding equal quantities to both sides of the capital equation) to allow expansion to maximum capacity of existing equipment without introducing another milk production activity. Since the value of the cattle is included in the supply of capital, the capital requirement for each milk producing activity includes the value of one cow plus enough capital to care for that cow for one year (Appendix Tables A-I through A-VII).

The quantity of milk which may be produced with existing equipment is directly related to the size of the bulk tank. The average use over the year of the bulk tank is 65 percent of its capacity. Haulers desire that the tank be large enough to hold five milkings on the every-other-day pickup schedule, instead of the actual four milkings handled, in order to insure that one milking will not be lost in case of delayed pickups. Based on monthly average milk production in Oklahoma, peak capacity is required during the flush period occuring in May and June. During the month of May, 12 percent of the total milk produced in Oklahoma each year is produced and sold. June production is lower than May production, but higher than the other months. This means that during the May and June flush season, the bulk tank would be filled to capacity if the hauler were late and the fifth milking were put into the tank. During dry seasons and just before the freshening period the bulk tank would not be filled to capacity.

Activities for Consideration

Forty-one activities or processes are considered in this linear programming model. They are either production processes, disposal processes or idle processes. The production processes produce goods for sale or inputs to be used in the production of goods for sale. The purchasing processes buy needed inputs and the disposal processes allow existing resources to be sold rather than to be employed on the farm during the current production period. The idle processes allow resources to be left unused at no cost or return. The 41 activities are listed in Appendix Table C-I.

Input-Output Relations

After resources are defined and quantities established, the resource requirement for each activity must be determined. Using this information, equations can be written and a tableau constructed for linear programming purposes.

By referring to Appendix Tables C-II through C-VII, the specific equations and coefficients may be found for each herd size studied and for each process considered. Appendix Tables A-I through A-XII give the derivation of the coefficients for P_1 through P_5 for each of the herd sizes considered. Appendix Table A-XIII gives capital requirements for P_6 (hay production), P_8 (oat production), and P_{19} (wheat production). Appendix Tables A-XIV and A-XV give yields, labor requirements, planting rates, and fertilizer requirements for the crop producing activities.

Table II gives some of the resource requirements by herd size. Feed inputs per cow did not vary with herd size. They average 1.9 tons alfalfa hay equivalents, four tons silage, and a 1:4 grain ratio for each cow.

TABLE II. INPUTS PER COW FOR THE FARM SIZES STUDIED AND BUDGETED IN THE OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items Per Cow	Budget Series by Herd Size 20 Cow	25 Cow	32 Cow	46 Cow	60 Cow	84 Cow
Tons Hay (Alfalfa Equiv.)	1.9	1.9	1.9	1.9	1.9	1.9
Tons Silage	4.0	4.0	4.0	4.0	4.0	4.0
Tons Oats	.90	.93	.95	.95	.91	.87
Tons Protein Supplement	.23	.25	.25	.25	.24	.23
Acres Silage Land	.67	.67	.67	.67	.67	.67
Acres Native Pasture	3.70	3.70	3.70	3.70	3.70	3.70
Acres Sudan Pasture*	.86	.86	.86	.86	.86	.86
Acres Rye-Vetch Pasture*	.86	.86	.86	.86	.86	.86
Labor						
Winter	50.92	48.92	44.92	38.92	38.92	38.92
Summer	47.62	40.62	37.62	38.62	33.62	33.62
Replacements	.20	.20	.20	.20	.20	.20
Supplies and Fees						
Breeding Fees	7.00	7.00	7.00	7.00	7.00	7.00
Veterinarian	4.00	4.00	4.02	3.50	3.31	3.13
Utilities	6.50	6.47	6.32	6.06	6.00	6.35
Milkroom Supplies	4.79	4.83	5.00	5.03	4.82	4.49
Misc. Expense	3.92	3.31	3.62	2.95	2.27	2.01
Taxes	2.50	2.50	2.50	2.50	2.50	2.50
Total Supplies & Fees	28.71	28.11	28.46	27.04	25.90	25.48

*The sudan and rye-vetch pastures are planted on the same land, one being a winter pasture and the other a summer pasture.

Silage and cultivated pastures are treated as perfect complements of cows. Their cost per cow for each herd size appears in Appendix Tables C-II through C-VII. Hay and oats may either be produced or purchased depending upon the profitability of either practice. Land productivity is held constant because it is not related to herd size.

Labor is correlated with herd size. The total quantity needed per cow is given in Table II for each herd size considered. Appendix Tables A-I through A-XII give the breakdown of labor use for P_1 through P_5.

Supplies and fees given in Table II were reported by the dairymen interviewed and appear in Appendix Tables A-I through A-XII in the capital row. There appeared to be tendencies toward economies to scale but for some items (milkroom supplies) this did not hold true. The variation might be random or the possibility exists that these should be constant. However, the averages of the herd sizes studied were used as reported by the dairymen interviewed, both for cows and herd replacements. Breeding fees of $7.00 per head are most frequently charged by artificial inseminators in this study. In only a few cases were the artificial rates reported either higher or lower, the range being from $6.00 to $8.00. Taxes per animal unit were held constant for all sizes of herds at $2.50 per head for dairy cattle. This varies quite a bit between school districts, but this figure was reported by several county tax accessors' offices as being fairly representative in the area studied.

Table III supplies the requirements for herd replacement production. Appendix Tables A-VII through A-XII give the derivation of the coefficients appearing in P_5.

Capital requirements for all processes need further explanation. The c_j's (net revenue or net cost per unit) will be discussed along

TABLE III. INPUTS USED PER HEAD BY FARM SIZE IN HERD REPLACEMENT PRODUCTION FROM BIRTH TO 24 MONTHS OF AGE BOTH FOR FARM DAIRY HERD REPLACEMENT AND FOR DAIRY HERD REPLACEMENT FOR SALE TO OTHER DAIRYMEN AS HERD REPLACEMENTS, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Budget Series					
Items Per Replacement	Units	20 Cow	25 Cow	32 Cow	46 Cow	60 Cow	84 Cow
Hay	Tons	2.00	2.00	2.00	2.00	2.00	2.00
Silage	Tons	3.75	3.75	3.75	3.75	3.75	3.75
Oats	Tons	.34	.34	.34	.37	.38	.34
Protein Supplement	Tons	.09	.09	.09	.11	.12	.09
Milk	Lbs.	410.00	400.00	400.00	370.00	350.00	405.00
Native Pasture* (1)	Acres	4.00	4.00	4.00	4.00	4.00	4.00
Native Pasture* (2)	Acres	5.50	5.50	5.50	5.50	5.50	5.50
Silage Land	Acres	.62	.62	.62	.62	.62	.62
Labor							
Winter	Hours	16.80	15.82	15.90	13.20	12.00	10.80
Summer	Hours	17.4	16.85	16.90	15.10	14.30	13.50
Supplies & Fees							
Taxes	Dollars	2.50	2.50	2.50	2.50	2.50	2.50
Vet.	Dollars	4.00	4.00	4.02	3.50	3.31	3.13
Breeding	Dollars	7.00	7.00	7.00	7.00	7.00	7.00
Misc. Expenses	Dollars	3.92	3.31	3.62	2.95	2.27	2.01
Death & Disease Loss	Dollars	7.40	8.00	8.90	7.75	8.00	7.00
Total Supplies & Fees	$	24.82	24.81	26.04	23.70	23.08	21.64
Calf Cost	$	25.00	25.00	25.00	25.00	25.00	25.00

*Native pasture no. 1 coefficient is used for replacement production used to replace the farm dairy herd. No. 2 is used for replacement production for sale off the farm, as a source of farm income.

with an explanation of the derivation of capital requirements for each process.

The capital requirements for the four milk producing activities are given in Appendix Tables A-I through A-VI. The items shown in these tables are considered to be adequate to care for the producing cow for one year. Adjustments must be made to compensate for the value of the cow and any additional equipment needed for the expansion activities. Since P_1 and P_2 use existing equipment, these activities only need the value of the cow to complete total capital requirements. The expansion activities P_3 and P_4 require, in addition to the quantities required by P_1 and P_2, capital allowances to purchase equipment and buildings needed for expansion.

The quantities of capital required for expansion were determined as follows. The milk production capacity equation allows for an average over the year of 65 percent of existing bulk tank capacity to be used before purchasing any additional capacity. A full bulk tank does not necessarily mean that all other equipment is being used to its maximum. Appendix Table B-VI shows the difference in farm machinery, dairy equipment, and buildings for the various farm sizes studied. For a business already in operation as these organizations are, questions arise in regard to expansion costs. After determining maximum capacity, Appendix Table C-VIII P_{39}, and the quantities of capital available for use, Table I, then the possible expanded herd size could be anticipated. By using Appendix Table B-VI, this gives the per cow capital requirement for expansion to any anticipated size. This quantity is added to capital requirements for P_1 to obtain requirements for P_3, and to the requirements for P_2 to obtain requirements for P_4. Once maximum capacity is reached activities P_1 or P_2 can grow no larger. If additional milk production is profitable, then the expansion activities P_3 and P_4 will be considered. This means that any expansion will have to pay the added fixed costs as well as bear current operating expenses.

The net revenue for P_1 was determined by subtracting from gross revenue per cow consisting of milk, cull cow sales, and calf sales, the total in the capital column Appendix Tables A-I through A-VI depending upon herd size desired. Income from P_3 must also pay fixed costs of expansion. Those costs consist of depreciation (10 percent per year) and service charges amounting to five percent of initial investment per year. Therefore net revenue from P_3 is less than net revenue from P_1 by 15 percent per year of expansion requirements for overhead capital. The net revenue for P_2 was determined by subtracting from gross revenue, consisting of milk and calf sales the totals of the capital columns in Appendix Tables A-I through A-VI depending upon herd size desired less an additional \$10.00 per cow per year to build a replacement reserve so that at the end of five years the cull cow plus the replacement reserve would buy a herd replacement. Revenue from P_4 must also pay fixed costs of expansion. It is less than that from P_2 by an amount of 15 percent of expansion costs per cow per year.

The requirements for P_5 are determined directly from the line two totals of Appendix Tables A-VII through A-XII. More native pasture is required for this activity than for replacements produced for farm use because replacements for farm use can graze the native pasture used for cows during the summer months while the cows graze cultivated pasture.

If replacements were being produced for sale the cows would not be around to leave native pasture idle during dry seasons when extra pastures were needed, therefore, larger quantities are needed at all times. Extra buildings and equipment would be needed if herd replacements were produced for sale in addition to production for farm use. This is the reason for the inclusion of the capital requirements for buildings and equipment.

The capital requirement and variable cost per unit for P_6 (hay production) are equal and appear by herd size in Appendix Table A-XIII. For P_7 the capital requirement equals the cost of a ton of hay. Therefore, c_j and the capital requirements are equal. Activity eight for oat production is similar to activity six for hay. The variable cost of producing oats per unit appears in Appendix Table A-XIII. Activity nine allows oats to be purchased at $37.50 per ton but requires only one-26th of the total capital spent for oats since deliveries are made every two weeks. Activities 10 and 11 are for hiring winter and summer labor at the wage rate per hour of $1.00 and $1.25, respectively. Family labor may be used at the same wages. Activities 12 and 13 allow the operator to work off the farm at net wages per hour of $.70 and $.95 during winter and summer periods, respectively.

P_{14} and P_{15} allow native pasture and cropland to be rented in at $3.00 and $7.00 per acre, respectively. The c_j's and capital requirements are equal to each other for these activities. Restriction equations keep both activities from more than doubling present farm size.

P_{16} and P_{17} allow native pasture land and cropland to be rented out at a gross revenue of $3.00 and $7.00, per acre, respectively. A gross revenue is used here because fixed costs of owning land (taxes and fence upkeep) are charged the operation whether used by the farm or rented out. Capital requirements are negative bacause transactions are made at the beginning of the year and the capital is available for use by the dairy farm.

P_{18} allows cropland to be planted to native pasture equivalent. One-third acre of cropland pasture produces one acre of native pasture equivalent. Its net cost and capital requirements are the costs of planting one-third acre of sudan plus one-third acre of rye-vetch pasture each year, and are tabulated in Appendix Table A-XIII.

P_{19} is the wheat production activity subject to the wheat allotment restriction. Net revenue per acre is obtained by subtracting variable costs from gross revenue. Variable costs appear in Appendix Table A-XIII, and are the capital requirements per acre. Activity 20 allows the transfer of wheat allotment to total cropland at no cost if the land used for wheat production could be put to other uses and obtain more profit than from wheat.

Activities 21 through 25 are capital transfer activities allowing capital to be borrowed at the various interest rates charged and transferred to the capital use equation. Capital is measured in \$100 units in Appendix Tables C-II through C-VII and interest is indicated in dollars per year per \$100 of borrowed capital. Activities 26 through 41 are slacks allowing any or all of the 16 resources to be left idle if use is not profitable.

The 16 linear restrictions insure that all requirements are met for any resources needed by the activities appearing in any solution. They also make sure that what is used equals what is available for use plus or minus any acquisition, disposal or idleness of any resource. Standard programming procedure uses the profit equation to calculate the revenues minus costs and give the net revenue of the optimum organization. A modification of this method will be used in this study. Fixed costs incurred by the initial dairy farm will be deducted from this value in order to determine the net farm income. The determination of these costs will be discussed in the following section.

Fixed Cost Determination

Farm Machinery

Appendix Table B-I shows the farm machinery necessary and adequate to operate the dairy farms studied. It has been assumed that dairymen are not interested in doing custom work for other farmers since only three percent of the sample indicated plans to do this kind of work; however, some dairymen rely on the use of their neighbors' machinery and labor in order to get some of their own work done.

When deciding whether to own a machine or to hire the use of a machine, the volume of use must be considered in comparison to custom rates charged. With each machine there is a definite cost per year of owning and operating it. This is made up first of depreciation which is determined by length of useful life and trade-in value, insurance, taxes, repairs, and cost of operation. E. A. Tucker, Odell L. Walker, and D. B. Jeffrey in Oklahoma Experiment Station Bulletin No. 473, Custom Rates for Farm Operations in Oklahoma, July, 1956, have discussed the issue of owning versus hiring farm machinery. Based on the custom rates used in their work the farm machinery needed by dairymen was selected. When estimated costs of operation plus yearly ownership costs per acre exceeded custom rates for the area studied, then custom rates were charged. With the variation in machine prices and individual farm preferences, the farm machinery program could vary from that used here. Each operator should be aware of the costs involved and act according to his own situation.

The basic assumptions used in this study to determine the cost of owning and operating farm machinery are: all machines are set up on a ten year depreciation schedule and the average age of machines on dairy farms is four years. The former assumption was made in order to determine yearly cost and the latter in order to determine book value.

Appendix Table B-IV gives the computation of the fixed costs of owning and operating farm crop producing machinery. Appendix Table B-V shows the same consideration of equipment used primarily with the dairy herd and needed whether crops are produced or not.

Total costs of using the machinery presented in Appendix Table B-I by herd size are subtracted from the net revenues derived in the programmed solutions for each budget series. By doing this, machinery costs are treated as fixed costs and the farmer is charged the full amount of ownership whether the machinery is used to maximum capacity or not.

Specialized Dairy Equipment

Specialized dairy equipment includes equipment which cannot be used for anything except milk production. Appendix Table B-II gives the items considered and the investment for each initial farm size studied, identified by herd size. Fixed costs of owning and using this type of equipment were determined in the same manner as those costs for farm machinery.

Although the equipment considered has not been on farms long enough to determine its length of life, a ten year straight line depreciation schedule was used. The reasons for choosing this schedule was because dairymen interviewed indicated that their planning horizon was for not more than ten years and they desired to have investment recovered in this length of time if not sooner. A salvage value of ten percent of new cost was assumed and the remainder divided equally over the ten-year period. Maintenance and repair expenses used were computed at 2.0 percent of original cost.[1]

An annual insurance rate of .64 percent of initial cost and tax rate of .74 percent were deducted from total returns as fixed costs incurred through the use of specialized dairy equipment.[2] Fixed costs incurred through the use of dairy equipment were treated in the same manner as those incurred through the use of farm machinery. The total costs are deducted from total income in order to account for ownership costs incurred regardless of use. If production were expanded, the expansion activity's net revenue per cow would be lowered by the amount of fixed cost added with the addition of the equipment necessary to care for the one cow. In this manner, the cost of ownership entered into the decision of increasing the dairy business on the dairy farm.

Dairy Farm Buildings

Buildings for the dairy farm are costly to own and operate. Appendix Table B-III itemizes the estimated building costs for structures adequate

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[1] Fred Allen Mangum, Costs and Returns of Bulk Milk Tanks on Dairy Farms in the Oklahoma City Milkshed, (Unpub. M. S. thesis, Oklahoma State University, 1958), Appendix Table II, p. 106.

[2] Ibid., p. 106.

to house the dairy operation by budget series on the farm organizations presented in Chapter IV. The Grade A dairy barn is the most important structure on Oklahoma dairy farms.

The useful life of buildings was considered in this study to be twenty years with no salvage value. This means that a depreciation rate of five percent per year is charged to the dairy enterprises. With normal use, a maintenance and repair cost of 1.5 percent[3] of new cost was assumed. An insurance rate of .5 percent[4] of new cost was charged and a tax rate of 1.0 percent[5] of new cost was also added to fixed cost and deducted from the program's gross income.

Fences and Land Taxes

An estimate of fences required was made for each initial farm situation. The estimates were: (1) for the 20 cow herd 2.5 miles, (2) the 25 cow herd 4.5 miles, (3) the 32 cow herd five miles, (4) the 46 cow herd 6.5 miles, (5) the 60 cow herd seven miles and (6) the 84 cow herd 10.5 miles. The estimated construction cost per mile is $500 with a useful life of 20 years. No salvage value is assumed.

Taxes on land were assumed at $.50 per acre for native pasture and $1.00 per acre for cropland. There is a wide variation in tax rates within the area so definite figures were difficult to obtain. The error in the figures used is believed to be less than $30 per farm per year.

[3] H. J. Barre and L. L. Sammet, Farm Structures (New York, 1950), p. 404.

[4] Ibid., p. 404.

[5] Ibid., p. 404.

No interest was charged as a fixed cost to any items since returns are considered to be the result of human labor and capital investment. Interest charges are handled separately for each individual program in Chapter IV.

CHAPTER IV

PROGRAMMED RESULTS

Chapter II dealt with the resources owned or controlled by dairymen, and Chapter III with the resource requirements for milk production in the Oklahoma Metropolitan Milk Marketing Area. In this chapter the question of "How may resources be combined in order to obtain the maximum income from them?" will be discussed and some findings presented. Questions dealing with the method of herd replacement, the source of feed used by the dairy whether farm produced or purchased, and possible expansion of the dairy business will be examined within the framework and assumptions discussed in Chapter III. Capital usage and returns will be analyzed and the results discussed when capital is varied. Land usage will be treated in an identical manner to capital and analyzed along with other resources used.

Each herd size will be considered in turn. Changes from the initial organization to the resulting optimum farm organizations will be presented. It will be shown that the most profitable dairy farm organization depends upon the initial assumptions about herd size, land availability, and indebtedness.

A brief explanation of some of the features of the program used may be of value at this point. IBM linear program 10.1.006 gives a range of linearity for each activity appearing in its optimum solution. "The limits of the cost coefficient over which the solution is optimal is of obvious value. The implication is that if all other cost coefficients remain fixed, the cost coefficient of the activity in question may change to any value within the stated range without affecting optimality. The limiting activity column indicates which activity will enter the basis if a limit on the cost coefficient is exceeded. It cannot be predicted which activity will leave the basis."[1] The shadow price indicates the reduction in net revenue resulting from the inclusion of one unit of any activity not appearing in the optimum solution. The opportunity cost of each activity may be determined by parts from the final matrix elements of that activity in which are shown the changes away from the optimal solution which would occur if one unit of any activity not appearing there were to be included. After subtracting actual cost or revenue from opportunity cost, linear programs determine which available activity adds the greatest quantity to net revenue and chooses this activity as a possible component of an optimum organization and maximum revenue. Through a repetition of this process, the maximum revenue is found. When no other activity can increase the value of the profit function, an optimum is said to exist under the restrictions used.

A few comments on some special treatments of a few questions of particular interest will be of value to the reader.

Since the farm organizations considered are assumed to be consistent with the goals of dairymen who are interested only in the dairy business and possibly small acreages of wheat, other farm enterprises have not been considered. For those dairymen who might be interested in producing cash crops, alfalfa hay appears to be a good one provided (1) land

[1]O. R. Perry and J. S. Bonner, Linear Programming Code for the Augmented 650, File Number 10.1.006.

of suitable fertility and drainage is available and (2) weather conditions do not hinder the curing of alfalfa hay. The kind of land needed is of river bottom quality, which has the ability to supply water during dry summer seasons. The type of weather needed is that which will allow curing of the early and late cuttings so that the entire growing season may be utilized to produce at least three cuttings and preferably four of the high quality legume hay.

Large acreages of alfalfa land are not found in the area studied so alfalfa production as a cash crop was not considered as a part of the usual farm organization. Most of the dairymen interviewed were producing enough alfalfa hay to supply the dairy herd. In this study the question of alfalfa production as a cash crop will not be conclusively answered, but in any farm organization which rents out cropland the possibility of using this land in alfalfa production as a cash crop might be considered. Reference will be made to these opportunities in the text of this chapter.

Since the program used states the limits over which a cost may vary before causing a change in the optimum organization, the upper limit of this range might be used to determine what the use of a resource is worth to the business. Particular attention will be given hired labor from this point of view in order to place a value on the operator's labor. The operator's labor is valued at what he is willing to pay hired labor before giving up the use of any. In this manner, net farm income can be divided between the operator's labor and management, and returns to the operator's capital.

Appendix Tables C-II through C-VII give the initial linear programming tableau of each herd size considered and the supply of resources used in each case.

Reference to Appendix Tables D-I through D-VII will enable the reader to observe the initial land and capital situations and the results of each program, including the level of each activity and its identification. Text tables throughout the chapter will present and explain the items of most importance.

The Twenty Cow Herd Alternatives

Sixty Percent Equity Opportunities

The dairyman located in the Oklahoma Metropolitan Milk Marketing Area who has a 20 cow producing herd and the necessary land on which to produce the feed to maintain it has little chance to employ himself or his capital effectively in order to provide an acceptable level of living for his family. Table IV and Appendix Table D-II, case 10, illustrates this. His business is valued at $32,364.35 and, at the 60 percent equity level, his net worth is $19,418.61 with liabilities of $12,945.74 and a net farm income of $3,162.12. This is barely an operator's wage at $1.00 per hour with practically no returns to capital. If the operator owns 90 percent equity in the business, his income is higher by the interest difference only, but still affords a low income compared to labor and capital inputs.

When the initial situation 60 percent equity standing is programmed, case 11, Table IV, it is found that by increasing the herd size to the maximum capacity of the bulk tank, farm income increases $1,654.84. This means adding seven cows and the operating capital to care for them. Appendix Table D-II, case 11, itemizes and identifies each activity appearing in the optimum organization when land is available for renting into the business.

TABLE IV. PROGRAMMED RESULTS FOR A 20 COW HERD HAVING 60 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Situation 60% Equity	Land Rent In Opportunity 55.51% Equity	No Land Rent In Opportunity 55.60% Equity
		Case Number		
	Unit	10	11	12
Herd Size	Cows	20	27	27
Replacements for Use	A.U.	4	5.4	5.4
Total Capital	$	32,364.35	34,949.24	34,948.35
Net Worth	$	19,418.61	19,418.61	19,418.61
Liabilities	$	12,945.74	15,530.63	15,529.74
Change in Liabilities	$	0	2,584.89	2,584.00
Change in Farm Income	$	0	1,654.84	1,213.37
Increased Debt Turnover Ratio	$	-	1.56	2.13
Depreciation Reserve	$	1,278.32	1,278.82	1,278.82
Hired Labor	Hours	0	143.00	148.00
Land Use				
Native Pasture	Acres	60.00	120.00	60.00
Cropland				
Wheat	Acres	0	0	0
Hay	Acres	15.30	20.70	20.70
Silage	Acres	15.80	21.40	21.40
Feed Grains	Acres	25.50	34.40	14.60
Sudan Pasture	Acres	17.20	23.20	23.20
Rye-Vetch Pasture	Acres	17.20	23.20	23.20
Other Pasture	Acres	10.00	.50	0
Rented In	Acres	0	0	0
Rented Out	Acres	16.20	0	0
Total Land Used	Acres	143.80	220.00	160.00
Income	$	6,160.05	8,044.27	7,592.02
Total Fixed Costs	$	2,149.41	2,149.41	2,149.41
Total Interest	$	848.52	1,077.90	1,067.12
Net Farm Income	$	3,162.12	4,816.96	4,375.49

All herd replacements are produced on the farm. All roughages and grains are farm produced also, but oats would be purchased if the cost of production increased from $18.12 to $18.87 per ton. Any oats purchased would decrease net farm income by $.75 per ton which is not a significant amount and probably means that this producer is indifferent as to whether he buys or produces oats. He is much more definite in his hay production enterprises since any bought would lower net farm income by $10.48.

Any replacements produced for sale would lower net farm income by $40.45 per head produced. A decrease in replacement prices of $13.00 per head for farm use would cause this dairyman to purchase instead of produce replacements. The components of this figure are: the increased use of 1.99 tons of hay, $26.09 of 12 percent interest capital, the release of 16.79 hours of winter labor for off-farm employment, the use of 3.54 acres of rented cropland, and .34 tons of oats. This production process would require 1.83 additional acres of cropland be planted to pasture and 30.18 additional hours of summer labor be added to the present farm organization.

Native pasture land is rented in and would be rented even at $10.16 per acre. The dairy using this organization is not interested in acquiring the use of cropland. Total land use has increased by 60 acres of native pasture and 16.2 acres of cropland. Summer hired labor is needed in order to produce the feed needed by the dairy, but there is an excess of operator's winter labor and he may work part time in town. Summer labor would be paid $1.41 per hour before doing without it. Table IV shows land use for each of the cases discussed in this section.

The value of the new business is $2584.00 greater than the original 60 percent equity one. If the operator decides to pay himself at the rate of the maximum he could pay the hired hand during the summer, $1.41 per hour, and $1.00 per hour during the winter labor season, his salary would be $3,615 leaving $1,201.96 or 6.18 percent return to his equity.

If the assumption is made that no additional land is available to this operator, case 12, Appendix Table D-II, we find that practically the same organization is attained. Full use is made of the original land supply, but a higher percentage of cropland is used than in case 11 which uses more total land. Part of the grains are now purchased and the released grain land planted to pasture. Labor use is practically the same with only five hours increased use by this organization. The same ranges of linearity prevail for all activities including capital. Income has increased over the initial organization, but not quite so much as was the case when more land could be used. If the same salary is given this operator as previously, $3,615.00, then returns to equity are only 3.9 percent.

The depreciation reserve is equal in all cases presented in Table IV since no additional equipment has been added. This quantity can be applied to debt repayment or saved to replace worn-out machinery. Any of the farm income not needed for family living may be applied to debt repayment. This makes possible the use of credit and acquisition of larger businesses. The increased debt turnover ratio in Table IV for case 11, shows that the additional debt incurred could be repaid by the increased income in 1.56 years for case 11 and 2.13 years for case 12.

Twenty Cow Herd Ninety Percent Equity Opportunities

If the 20 cow herd size dairy farmer begins with 90 percent equity, his income is higher due to interest savings. Case 13, Table V, shows

TABLE V. PROGRAMMED RESULTS FOR A 20 COW HERD HAVING 90 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Unit	Initial Situation 90% Equity	Land Rent In Opportunity 83.4% Equity	No Land Rent In Opportunity 83.60% Equity
		Case Number		
		13	14	15
Herd Size	Cows	20	27	27
Replacements for Use	A.U.	4	5.4	5.4
Total Capital	$	32,364.35	34,949.24	34,948.35
Net Worth	$	29,167.91	29,167.91	29,167.91
Liabilities	$	3,236.43	5,821.32	5,820.43
Change in Liabilities	$	0	2,584.89	2,584.00
Change in Farm Income	$	0	1,729.13	1,282.34
Increased Debt Turnover Ratio	$	-	1.49	2.01
Depreciation Reserve	$	1,278.82	1,278.82	1,278.82
Hired Labor	Hours	0	143.30	148.00
Land Use				
Native Pasture	Acres	60.00	120.00	60.00
Cropland				
Wheat	Acres	0	0	0
Hay	Acres	15.30	20.70	20.70
Silage	Acres	15.80	21.40	21.40
Feed Grains	Acres	25.50	34.40	14.60
Sudan Pasture	Acres	17.20	23.20	23.20
Rye-Vetch Pasture	Acres	17.20	23.20	23.20
Other Pasture	Acres	10.00	.50	20.50
Rented In	Acres	0	0	0
Rented Out	Acres	16.20	0	0
Total Land Used	Acres	143.80	220.00	160.00
Income	$	6,160.05	8,044.27	7,592.10
Total Fixed Costs	$	2,149.41	2,149.21	2,149.21
Total Interest	$	194.18	349.27	343.89
Net Farm Income	$	3,816.46	5,545.59	5,098.80

the business size in cattle, capital, and land for this operation. Appendix Table D-III, case 13, gives itemized the activities in which he is engaged. When the same resources used for the 60 percent owner are combined with the larger quantities of credit made available by a larger equity in the business, the organizations attained are practically identical. The only variation is in costs of credit, ranges of linearity, and shadow prices. This operator does not appear to be quite so close to dispersing his business and moving to town as the 60 percent owner. He has the opportunity to borrow at six percent interest whereas the 60 percent owner had no choice but to pay higher prices for the use of capital. With this exception, there are no differences in the restrictions between the businesses operated by the 60 and 90 percent equity owners.

In case 14, Table V, all feed is produced on the farm. Milk production to the maximum capacity of the bulk tank takes place using farm produced herd replacements. The maximum quantity of native pasture land is rented in, but there is no desire for additional cropland. Purchased replacements would not be considered until their price relative to all other prices dropped $18.75 per head from their present level of $220 per head. No replacements would be produced for sale since any produced would lower net farm income by $26.66 per head. The major portion of opportunity cost of this activity is labor and land use. Cropland would have to be planted to pasture and the extra labor hired. Farm hay production is very stable since the cost of production could double to $16.76 per ton before this activity would be discontinued. Oats are not quite so stable since only a $2.64 increase in their cost of production would cause the purchasing of oats to be considered.

No winter labor is hired but summer labor could command a price of $1.84 per hour before the operator would do without it. If this value is used as the value of the operator's summer labor and $1.00 per hour as the value of his winter labor, his labor income would be $4,260.00 per year. This leaves an equity return of $1,285.59 or 4.4 percent. Farm income has increased by $1,729.13 over the 90 percent initial situation.

Using the same capital restrictions and limiting the 20 cow herd sized farm to the land it owns, the farm organization attained is practically the same as that attained when renting in land. The only difference is that cropland must be planted to pasture to provide enough for the larger herd. Formerly, it could be rented in. The same system of feed production is carried out as was done when these restrictions were imposed upon the 60 percent owner, case 11, Table IV.

Farm produced herd replacements are used for milk production and would continue to be used until their price dropped from $220.00 to $207.74. None would be produced for sale since such activity would lower net revenue by $33.77 per head and no expansion would take place because of the high investment costs per cow. Returns to expanded activities are not great enough to recover the fixed costs; therefore, the activity is not profitable at the low volumes to which this producer is limited.

Net farm income for case 15 has increased by $1,282.34 over the initial situation. Herd size, herd replacement, and feed procurement are identical to case 12, Table IV.

By the same reasoning as was previously used to determine the operator's labor income, his salary would be $4,260.00 per year. For this farm organization, the returns to owned capital are $838.80 or 2.87 percent.

The increased debt could be repaid in 1.5 and 2.01 years for cases 14 and 15, respectively, if additional farm income only were applied to debt repayment. Of course, a dairyman would need to decide for himself what his opportunities of other investments were and relate this to personal and family goals. It appears that since expansion beyond existing capacity is costly, larger incomes might be obtained from additional investment capital if it were employed elsewhere. He is paying six percent interest for money now and if he cannot get more elsewhere then he can pay off his present debts. The lack of efficiency of dairy businesses of this size appears to be the reason for the resulting low returns to capital and labor.

The Twenty-Five Cow Herd Alternatives

Sixty Percent Equity Opportunities

Table VI, case 20, gives the initial business organization for a 25 cow herd with 60 percent ownership by the operator. Although net farm income is modest, the potential dairy business for an operator with this set of resources is much brighter than the previous one discussed.

No additional land is needed for this equity situation because when additional land can be rented, Table VI, case 21, none is. The herd size is expanded on existing land beyond the 25 cow maximum capacity by four cows, making a dairy herd of 29 producing animals. A small amount of land is rented out both of native pasture and cropland. No cash crops other than wheat were programmed in this analysis. Alfalfa hay is a potentially profitable cash crop if cropland available is of high quality and weather conditions are suitable. An alternative use for the cropland

TABLE VI. PROGRAMMED RESULTS FOR A 25 COW HERD HAVING 60 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Unit	Initial Situation 60% Equity	Land Rent In Opportunity 55.44% Equity	No Land Rent In Opportunity 56.34% Equity
		Case Number		
		20	21	22
Herd Size	Cows	25	29	28
Replacements for Use	A.U.	5	5.8	5.6
Total Capital	$	42,161.74	45,527.27	44,793.85
Net Worth	$	25,297.04	25.297.04	25,297.04
Liabilities	$	16,464.69	19,830.22	19,096.80
Change in Liabilities	$	0	3,365.53	2,632.11
Change in Farm Income	$	0	456.31	376.24
Increased Debt Turnover Ratio	$	-	7.37	6.58
Depreciation Reserve	$	1,278.82	1,449.82	1,407.07
Hired Labor	Hours	0	131.70	181.00
Land Use				
Native Pasture	Acres	112.00	130.50	126.00
Cropland				
Wheat	Acres	18.00	18.00	18.00
Hay	Acres	19.10	22.20	21.50
Silage	Acres	19.80	22.90	22.10
Feed Grains	Acres	32.80	38.10	36.80
Sudan Pasture	Acres	21.50	24.90	24.10
Rye-Vetch Pasture	Acres	21.50	24.90	24.10
Other Pasture	Acres	0	0	0
Rented In	Acres	0	0	0
Rented Out	Acres	56.80	6.00	9.80
Total Land Used	Acres	224.20	256.60	248.50
Income	$	8,747.29	9,729.29	9,426.49
Total Fixed Costs	$	2,260.41	2,516.89	2,452,41
Total Interest	$	1,047.64	1,316.85	1,258.20
Net Farm Income	$	5,439.24	5,895.55	5,715.88

not needed by the dairy might be in the production of alfalfa hay for sale.

Capital costing eight percent interest is borrowed and used to expand the business but none costing over 11.29 percent interest will be used. The 11.29 percent is the upper limit on the range of linearity for the eight percent capital borrowing activity, P_{22}, and is meaningful only if all other costs and returns remain the same.

The farm organization achieved is one producing herd replacements, roughage, and grain. Any oats purchased off the farm would lower net farm income by $.97 per ton. Oats would continue to be produced until their cost per ton increased from $18.12 to $19.13. Since this is not a large difference, the dairyman is practically indifferent as to which method he uses.

Any herd replacements produced for sale would lower net farm income by $3.01 per head produced and sold. The main item making up this loss per replacement is foregoing the income from .21 cows added by the expansion milk producing activity. This means that if one cow were removed approximately four replacements could be produced for sale and farm income would be reduced by about $12.00.

Herd replacements would be produced on this farm until their cost increased by $39.15 per head or their price decreased by the same amount. The deciding component of this activity is that the difference in income from P_1 and P_2 outweights the savings in replacement production on the farm. The cost of off-farm produced replacements is the deciding factor. The opportunity to use replacement production resources for milk production does not offer enough extra income to pay the difference between purchased and farm produced replacements. It is more economical to produce one's own than to buy them in this situation.

For the 60 percent equity owner who has the opportunity to rent land and borrow money with which to expand, a larger business is desirable. A larger quantity, 32 acres of owned land is used, but none is rented in. Percent ownership in the new business is less, but net farm income is greater by $456.31. The increased debt could be repaid in 7.37 years without sacrificing any present income. Since labor hired would be paid $1.62 during the summer season and $1.56 during the winter season before any changes would be made, the operator might consider this to be the value of his labor and management. At these rates, his annual salary would be $4,785.00 leaving $1,110.52 returns to equity. This is a return to owner's capital of 4.3 percent which is approaching respectable returns to capital and labor.

If rental land is not available, the final farm organization is one cow smaller than when land can be rented. Land use is essentially the same as case 21. There is a possibility that the cropland rented out could be planted to a cash crop such as alfalfa hay. The difference in net farm income is only $56.39 between the two organizations. Total land use is slightly less, 8.1 acres for case 22, Table VI, than for case 21. Shadow prices are identical for all activities in both optimum organizations as are ranges of linearity in both cases. For all practical purposes the two organizations are identical. Neither has expanded beyond the limits of the eight percent credit available because any further use of higher priced capital would cost more than it returns.

Ninety Percent Equity Opportunities

Case 23, Table VII, shows the initial farm organization for the 25 cow size dairy when 90 percent of the value of the business is owned by the operator. Returns are greater by the difference in interest savings between this farm and the 60 percent owner's returns. The farms are otherwise identical. When the 90 percent owner was allowed to rent in land, he did so, renting in both pasture and cropland, Appendix Table D-III, case 24, P_{14} and P_{15}. Cropland's upper limiting cost would have been $7.71 per acre and native pasture's $9.66. At costs above these limits, adjustments would probably result in the use of less land. Total land use has increased 187 acres, of which 134.8 are rented.

The herd size attained is one of 48 cows with the necessary herd replacements being produced on the farm. All feed, including grain, is produced on the farm. The increased herd size requires that 2,144 hours or approximately two-thirds man equivalents of labor be hired and paid $1.57 and $1.62, respectively, per hour for winter and summer before altering the optimum organization in anyway.

Any oats purchased would lower net farm income by $.97 per ton which means that slight price changes could cause pruchase rather than production of oats. Hay production is much more stable because costs of production could increase from $7.44 per ton to $17.59 before hay purchases would be considered. Any hay purchased would lower net farm income by $10.39 per ton.

Replacement production is also very stable since either decreased efficiency of production or a lower price of replacements would need to amount to $39.80 per head in order to cause this producer to consider

TABLE VII. PROGRAMMED RESULTS FOR A 25 COW HERD HAVING 90 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Situation 90% Equity	Land Rent In Opportunity 60.3% Equity	No Land Rent In Opportunity 68.4% Equity
			Case Number	
	Unit	23	24	25
Herd Size	Cows	25	48	41
Replacements for Use	A.U.	5	9.6	8.2
Total Capital	$	42,161.74	62,826.71	55,412.37
Net Worth	$	39,945.56	37,945.56	39,945.56
Liabilities	$	4,216.17	24,881.14	17,466.80
Change in Liabilities	$	0	20,664.97	13,250.63
Change in Farm Income	$	0	1,513.31	811.00
Increased Debt Turnover Ratio	$	-	13.65	16.33
Depreciation Reserve	$	1,278.82	2,144.30	1,963.60
Hired Labor	Hours	0	2,144.30	1,263.60
Land Use				
Native Pasture	Acres	112.00	216.00	148.00
Cropland				
Wheat	Acres	18.00	18.00	18.00
Hay	Acres	19.10	36.80	32.00
Silage	Acres	19.80	36.00	33.00
Feed Grains	Acres	32.80	63.20	0
Sudan Pasture	Acres	21.50	41.30	35.30
Rye-Vetch Pasture	Acres	21.50	41.30	35.30
Other Pasture	Acres	0	0	12.10
Rented In	Acres	0	66.80	0
Rented Out	Acres	20.80	0	0
Total Land Used	Acres	224.20	411.30	280.00
Income	$	8,639.29	13,032.48	11,288.53
Total Fixed Costs	$	2,260.41	3,735.17	3,286.33
Total Interest	$	252.97	1,640.10	1,048.00
Net Farm Income	$	6,143.90	7,657.21	6,954.20

purchasing replacements. No replacements would be produced for sale since such activity would lower net farm income by $3.01 per head produced and sold. The major part of this being that .21 of a cow in P_3 be given up for each replacement produced for sale. If one cow were removed, five replacements could be produced but a net loss of $15.00 would occur. Small price changes could cause replacements to be produced for sale and this producer is practically indifferent between milk production and commercial replacement production.

By increasing the size of business, net farm income could be increased by $1,513.31 per year over the 90 percent equity initial situation's income. Capital would be borrowed at costs up to 11.29 percent interest with which to expand and operate the business but no higher prices would be paid. The total value of the expanded dairy business is $62,826.71 of which the operator owns 60.3 percent, or $37,945.56. If his salary is equal to the price he would be willing to pay labor before giving up the use of any labor hired, he could take $4,785.00 of the $7,657.21 of farm income as returns to labor and $2,872.21 as returns to equity. This is a 7.56 percent return to capital owned by the operator. The increased debt could be retired by increased income in 13.65 years.

If the operation is limited to the land initially owned, the change is of the same nature as when land was available for renting in. Land does, however, limit the size of the herd which in turn provides less income than could be realized when more land was available. Table VII, case 25, gives the financial statement of the business showing changes from the original farm organization. All the capital needed can be borrowed at six percent interest, but 6.87 percent is the maximum this dairyman can afford to pay.

Milk production practices utilize farm produced herd replacements and would continue to do so unitl the costs of purchased replacements decreased by $14.50 or inefficiencies of replacement production increased cost by $14.50 per head. All roughages needed are produced on the farm and part of the grain needed is produced. The land needed to produce all grain is not available, so some grain is purchased. The price for oats would have to increase $1.80 per ton before any adjustments would be made in this particular organization.

At the optimum organization the producer would be willing to pay $10.45 per acre for the use of native pasture land, and $9.23 per acre for the use of cropland, if any were available. Winter labor would be paid $1.13 per hour before doing without any of it and summer labor $1.42. At these wage rates, the operator's salary would be $3,825.00 leaving a return of $3,129.20, or 8.24 percent, to equity. The operator owns 68.4 percent of the new $55,412.37 business but has incurred a debt of $17,466.80 instead of the original $4,216.17. With the depreciation reserve and the available $3,129.20 returns to capital a $5,092.02 payment on the principal could be made the first year thus making possible, if business over the next three years were equally as good, repayment of the debt in 3.4 years. If increased income only were used to repay the increased debt, the time required would be 16.33 years. Repayment schedules would need to be considered when deciding to incur this debt, and a satisfactory one arranged.

When a large amount of low cost capital is available for expansion, it is profitable to obtain and operate larger dairy farms. However, loans must be offered at conservative rates of interest before the use of borrowed funds will be attractive at this level of operation.

The Thirty-Two Cow Herd Alternatives

Sixty Percent Equity Opportunities

In order to answer the question, "In what manner should resources be combined in order to obtain the maximum revenue from them?" for the dairyman having a 32 cow herd and the necessary land on which to produce pasture and all the necessary silage, hay, and grain needed by his dairy operation, first let us consider this dairyman's initial 60 percent equity situation.

He currently has 32 producing cows and six herd replacements, case 30, Table VIII. His total farm value is $65,395.68 of which 60 percent is owned by him. If he operates at this level for one year, his total investment will not change but at the end of the year he will be able to make a $1,479.47 interest payment, cover all expenses and have $7,184.34 as a labor, management, and capital income. This may be used to retire debt and support the farm family. Appendix Table D-IV shows additional details about each activity.

Suppose this operator wishes to use his present resources in a combination such that his returns will be the maximum obtainable, assuming that he can rent land in and borrow additional capital. Case 31, Table VIII shows the organization attained. The herd would increase in size to 44 cows and nine replacement heifers. The total value of the business has increased by $7,688.51 the value of the added cows and the additional investment and operating capital to care for them. At the end of one year's operation, total income has increased by $2,915.76 over the initial 32 cow herd size. As a result of borrowing capital with which to expand, the owner would have only 53.2 percent equity in the new business.

TABLE VIII. PROGRAMMED RESULTS FOR A 32 COW HERD HAVING 60 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Situation 60% Equity	Land Rent In Opportunity 53.2% Equity	No Land Rent In Opportunity 54.8% Equity
			Case Number	
	Unit	30	31	32
Herd Size	Cows	32	44	40
Replacements for Use	A.U.	6	9	8
Total Capital	$	65,395.68	73,084.19	71,225.57
Net Worth	$	39,237.40	39,237.40	39,237,40
Liabilites	$	26,158.27	33,846.78	31,988.16
Change in Liabilities	$	0	7,688.51	5,829.89
Change in Farm Income	$	0	996.75	713.20
Increased Debt Turnover Ratio	$	-	7.71	8.17
Depreciation Reserve	$	1,517.06	1,940.34	1,786.42
Hired Labor	$	500.00	1,288.50	1,132.50
Land Use				
Native Pasture	Acres	140.00	198.00	140.00
Cropland				
Wheat	Acres	40.00	40.00	40.00
Hay	Acres	24.50	33.66	30.60
Silage	Acres	25.30	34.95	31.60
Feed Grains	Acres	40.80	0	51.10
Sudan Pasture*	Acres	27.52	37.80	34.40
Rye-Vetch Pasture*	Acres	27.52	37.80	34.40
Other Pasture	Acres	1.30	0	13.30
Rented In	Acres	0	0	0
Rented Out	Acres	80.00	93.60	39.00
Total Land Used	Acres	300.00	344.40	341.00
Income	$	11,403.63	13,706.44	13,047.26
Total Fixed Costs	$	2,739.82	3,374.74	3,143.86
Total Interest	$	1,479.47	2,150.61	1,945.86
Net Farm Income	$	7,184.34	8,181.09	7,957.54

*Double crop.

An important difference between the initial situation and the expanded one is that while the production of feed grains has stopped, the producer is practically indifferent as to whether he produces or buys the oats needed. The program indicates that only an $.11 per ton increase in the purchase price would cause production to be considered. This farmer would, however, produce all the roughage needed by his dairy herd and rent in 58 acres of native pasture. He is able to pay up to $3.66 per acre per year for the use of native pasture land, but there is no desire for cropland at $7.00 per acre. The new organization uses 44 acres more land than the original did, but still rents out 93.6 acres of cropland which might be used for a cash crop of alfalfa if the land were suitable.

The organization attained would require that 1,288.5 hours of labor be hired. The employer could afford to pay as much as $1.06 per hour for winter labor and $1.74 per hour for summer labor before cutting back his herd size and operating without the hired labor.

Herd replacements needed by the farm would be produced on the farm. No replacements would be purchased until the price per head dropped from $220.00 to $186.50 per head. The practice of raising herd replacements is stable since replacement prices probably will not drop this much relative to costs of producing them on the farm. No replacements would be produced for sale since each one produced would lower net farm income by $11.00 per head. In order to produce one replacement for sale the income from .22 cows in the expansion activity P_3 would have to be foregone. The use of cropland, native pasture land, hay, oats, and labor would have to be diverted to replacement production from milk production which yields larger incomes than replacements do.

Since the producer is already in debt for all the available six percent credit, he must pay higher prices for any capital borrowed. This program finds that it would be profitable to borrow \$7,688.51, Appendix Table D-IV, case 31, $P_{22} + P_{23}$, and pay up to 14.76 percent interest for the use of this quantity of money. All the available eight and 12 percent credit were used but no 16 or 20 percent interest rate loans would be considered. Along with the available \$4,549.04 on hand at the beginning of the period and the revenue received from the land renting out activity, the borrowed funds helped to finance and operate the expanded business. Current income pays the interest. It also pays for most of the feed purchases due to the practice of purchasing a two-week supply of concentrates at a time.

When the assumption is made that no land is available for rental in the neighborhood, the best farm organization is similar to the organization having opportunity to rent land in. The differences are that expansion was not carried quite so far and that grain was produced on the farm. Net farm income is only \$123.55 less than when land could be rented in.

Table VIII, case 32, gives the herd size, total investment, hired labor, land usage, and net farm income for this situation. The farmer in case 32 is using 41 acres more land than the one in case 30. Cases 31 and 32 are using approximately the same total land but 31 has a higher percentage of pasture land. Appendix Table B-IV, cases 31 and 32, give additional details of each activity appearing in the optimum solutions.

As a result of limited land, capital productivity has decreased to 11.4 percent compared to 14.76 percent for case 31. Winter labor productivity increased to \$1.62 per hour and summer labor decreased to \$1.63

per hour. All oats are produced on the farm but purchased oats would lower net farm income by only \$.94 per ton. Herd replacements would continue to be produced for farm use until their price fell from \$220.00 per head. Any replacements produced for sale would lower net farm income by \$36.89 per head. It would be interesting to trace the opportunity cost on some of this.

If one replacement were produced for sale, the income from .25 cows in the expansion activity would have to be given up which amounts to \$77.97. Along with this, \$1.61 worth of oats would have to be added, \$15.49 income from rented out cropland foregone, \$18.96 worth or 15.17 hours of summer labor added, 1.44 acres of additional cropland planted to pasture at a cost of \$21.34, 1.4 tons of hay added at a cost of \$10.39, and 3.47 hours of winter labor added at a cost of \$3.47. The total opportunity cost amounts to \$149.23. When comparing this with the expected net revenue of \$112.34 from this activity, the loss would be \$36.89 per replacement produced up to 16 replacements. No precise predictions can be made beyond 16 without further analysis, but the opportunity cost would probably increase beyond that level and replacement production would be even less favorable.

Native pasture land would be rented in at \$9.39 per acre if available, but cropland would not be considered at all. Even though land is scarce, it would be more profitable to rent cropland out at \$5.97 per acre than to plant it to pasture at a cost of \$14.79 per acre and use it in the dairy business.

The implications are that a dairyman in the situation outlined above should increase his herd size to the maximum capacity of his present equipment and expand production using farm produced herd replacements for his present as well as expanded milk producing activities. He would need to examine carefully his grain production enterprises and adjust either to a grain purchasing program or a grain producing one, depending upon his own efficiency in feed grain production. All the existing wheat allowment should be used and all roughages and pasture should be produced on the farm for maximum profits.

Thirty-Two Cow Herd Ninety Percent Equity Opportunities

When considering the 32 cow herd with the owner's equity at 90 percent, it is found that more expansion beyond maximum capacity occurs than when equity is only 60 percent. The initial 90 percent equity organization differs from the 60 percent equity organization by indebtedness only. This reduces interest payments to creditors and thereby increases net farm income by the amount of the reduced interest cost, in this case $1,187.10. The initial size and organization of the dairy farms are identical.

When the operator with the same land, management, and equipment has the opportunity to use more borrowed money than before, he does so. Since he owns more equity in the business, he has an opportunity to borrow larger quantities of capital at lower interest rates than his 60 percent equity counterpart.

The largest herd size attained is a 73 cow herd, case 35, Table IX. Assumptions underlying this organization do not allow land to be rented in, but the 80 acres of land rented out in the initial situation are used in the expanded organization. Native pasture would be rented in by this business at $11.21 per acre if it were available, and cropland at $13 if it were available. Fifty-four acres of cropland are planted to pasture

TABLE IX. PROGRAMMED RESULTS FOR A 32 COW HERD HAVING 90 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Situation 90% Equity	Land Rent In Opportunity 60.7% Equity	No Land Rent In Opportunity 60.5% Equity
		Case Number		
	Unit	33	34	35
Herd Size	Cows	32	70	73
Replacements for Use	A.U.	6	14	8
Total Capital	$	65,395.68	96,918.05	97,126.08
Net Worth	$	58,836.11	58,836.11	58,836.11
Liabilities	$	6,539.56	38,061.93	38,269.96
Change in Liabilities	$	0	31,522.37	31,730.40
Change in Farm Income	$	0	2,887.13	1,720.99
Increased Debt Turnover Ratio	$	-	10.91	18.43
Depreciation Reserve	$	1,517.06	2,940.82	3,056.26
Hired Labor	Hours	500.00	4,088.10	3,911,50
Land Use				
Native Pasture	Acres	140.00	280.00	140.00
Cropland				
Wheat	Acres	40.00	40.00	19.00
Hay	Acres	24.50	53.60	52.00
Silage	Acres	25.30	55.40	53.00
Feed Grains	Acres	40.80	89.44	0
Sudan Pasture*	Acres	27.52	60.20	62.70
Rye-Vetch Pasture*	Acres	27.52	60.20	62.70
Other Pasture	Acres	1.30	11.70	54.00
Rented In	Acres	0	70.30	0
Rented Out	Acres	80.00	0	0
Total Land Used	Acres	300.00	590.30	380.00
Income	$	11,403.63	18,435.78	17,513.45
Total Fixed Costs	$	2,739.82	4,875.46	5,048.62
Total Interest	$	392.37	2,401.75	2,472.40
Net Farm Income	$	8,271.44	11,158.57	9,992.43

*Double crop.

to satisfy the pasture needs of the expanded herd. An acre of cropland rented out would reduce net farm income by $6.00 per acre.

Total investment has increased by $31,730.40 over the initial organization. The resulting increased herd size requires 3,911.5 more hours of labor than the initial organization. The expanded organization is approximately a 2.25 man labor one with the owner having 60.5 percent equity.

Feeding practices have changed from producing feed grains to purchasing all concentrates. However, all roughages needed by the dairy are still produced on the farm. Any oats produced would lower net farm income by $5.89 per ton. Any hay purchased off the farm would lower net farm income by $8.19 per ton. Compared to previous farm losses of $.11 per ton by the oat activity, it is fairly stable for this farm. Hay would continue to be produced until the cost exceeded $9.21 per ton and oats would continue to be purchased until the cost exceeded $41.80 per ton without changing the farm organization.

Oat production would require that 1.32 acres of wheat be given up for each ton produced. This would lower wheat income by $25.37. One ton of oats produced on the farm would, however, release a ton purchased in town and make available $37.50 for other uses. The difference between the $37.50 and the foregone $25.37 is $12.13 which in this case is a saving to the operation before the oat production costs are accounted for. Since it costs $18.12 to produce a ton of oats, the net loss as a result of engaging in the activity is $5.89 per ton.

Milk production with the existing capacity uses purchased herd replacements. If herd replacement prices increased by $3.30 per head, it would not matter to this producer whether he purchased or produced those needed. By the same token, increased efficiency of producing herd replacements by $3.30 per head would have the same effect. This producer is practically indifferent as to which he does. The expansion production activity uses farm produced replacements and would continue to do so until either farm production became $20.75 less efficient or replacement prices decreased by this amount.

Any replacements produced for sale would lower net farm income by $52.41 per head produced. The main item making up this loss would be the displacement of cows in P_3, the expanded milk producing activity. Seven replacements would displace one cow and result in a loss of $366.87.

Total capital borrowed is $31,730.40 of which $22,920.00 costs six percent interest and $8,810.40 costs eight percent interest. All of it would be borrowed even if it cost 8.54 percent interest, but none would be borrowed at higher rates to achieve this particular farm organization.

Total fixed costs have increased due to the increased investment required by the expanded farm organization. Since larger quantities of capital are borrowed, interest payments have increased also but the final net farm income is greater by $1,720.99 than that of the initial 90 percent equity organization. Summer labor is worth $1.35 per hour and winter labor $1.08 per hour, because prices up to these quantities could be paid without changing the final organization. The value of the operator's labor might be considered to equal these values. This would make his annual salary $3,645.00, case 35, leaving $6,347.43 returns to capital and assets owned by him or 10.7 percent return to equity.

If the dairyman is able to rent land in, the final organization is not a great deal different in size than the one confined to the initial land holdings. Total land usage is 290 acres more than in the initial organization and 210 acres greater than case 35. Approximately 47 percent of total cropland used is native pasture in this and the initial organization. All herd replacements are produced on the farm. Now that land is available oats are produced. Herd size is only 70 whereas it was previously 73.

The organization attained is essentially a 2.5 man one, but labor could be paid higher wages than in case 35, Table IX. Winter labor could command a price of $1.62 per hour and summer labor a wage of $1.63 per hour before this operator would cease to hire it or change his farm organization in any way. This means that a yearly salary of $4,875.00 could be paid one hired hand and $1,768.00 paid a part-time hand without changing the organization of the business.

Capital would be paid 11.40 percent interest before passing up the opportunity to use it. Oats would be produced until the cost of production increased from $18.12 to $19.10 per ton. Hay would be produced until its cost of production increased $5.93 per ton. Any oats purchased would decrease net farm income by $.94 per ton produced, which probably means that this producer is indifferent as to which method he uses.

Total income has increased by $2,887.13 over the initial 32 cow herd and returns to the operator's 60.7 percent equity are 8.98 percent. Assuming the operator's salary to be $4,875.00, which is the highest price labor could be paid before decreasing its use, return to equity is 13.8 percent, or $5,283.57.

The operator who has credit available to him can, in the cases just discussed, use borrowed funds advantageously to expand his existing farm organization. The expanded size of business, of course, has greater costs, but the greater returns outweigh the added costs and a larger income can be realized from the resources used. This dairyman has more than doubled his dairy farm business and increased his net farm income by $2,887.13. The increased debt could be repaid from increased farm income in eight to nine years. Through this period no sacrifice of present income would need to be made and at the end of the period a higher family income would be possible from the larger business.

The Forty-Six Cow Herd Alternatives

Sixty Percent Equity Opportunities

With a business valued at $78,833.49 an Oklahoma Metropolitan Milk Marketing dairyman would be able to milk 46 cows and, with the aid of a one-third time hired man, produce the feed and herd replacements needed by his operation. If he owned 60 percent of this business, he could expect a net farm income of $9,933.16. Case 40, Table X shows the financial structure, land use, and income for this dairy farm. Appendix Table D-V, case 40, gives itemized each activity in which this particular dairyman is engaged. If the dairyman owned 90 percent equity in the same business, total returns would be larger by the amount paid out in interest. Case 43 in Table XI and Appendix Table D-V gives the same information for the 90 percent owner as case 40 does for the 60 percent owner.

Both operators are at the maximum capacity of their bulk tanks during the flush milk producing season. By examining cases 40 and 43 in Appendix Table D-V it can be seen that more credit is available than is being used, therefore, the opportunity for expansion exists. First

TABLE X. PROGRAMMED RESULTS FOR A 46 COW HERD HAVING 60 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Unit	Initial Situation 60% Equity	Land Rent In Opportunity 53.05% Equity	No Land Rent In Opportunity 53.72% Equity
		Case Number		
		40	41	42
Herd Size	Cows	46	62	60
Replacements for Use	A.U.	9.2	12.4	12
Total Capital	$	78,833.49	88,279.38	87,295.97
Net Worth	$	47,300.09	47,300.09	47,300.09
Liabilities	$	31,533.39	40,979.28	39.995.87
Change in Liabilities	$	0	9,445.89	8,462.48
Change in Farm Income	$	0	1,274.57	688.41
Increased Debt Turnover Ratio	$	-	7.41	12.29
Depreciation Reserve	$	2,036.07	2,506.15	2,447.39
Hired Labor	Hours	1,056.00	2,269.06	2,185.94
Land Use				
Native Pasture	Acres	200.00	279.00	200.00
Cropland				
Wheat	Acres	26.00	26.00	26.00
Hay	Acres	35.26	47.53	46.00
Silage	Acres	36.41	49.08	47.50
Feed Grains	Acres	62.17	0	0
Sudan Pasture	Acres	39.56	53.32	51.60
Rye-Vetch Pasture	Acres	39.56	53.32	51.60
Other Pasture	Acres	2.3	0	23.30
Rented In	Acres	0	0	0
Rented Out	Acres	72.30	125.64	106.36
Total Land Used	Acres	401.70	454.93	394.40
Income	$	14,982.67	18,333.75	17.432.31
Total Fixed Costs	$	3,547.19	4,252.31	4,164.17
Total Interest	$	2,008.42	2,873.77	2,646.17
Net Farm Income	$	9,933.16	11,207.67	10,621.97

consideration for expansion will be given the 60 percent equity operation. The largest business attained is when land is available for use by the operation through renting opportunities. The resulting optimum farm organization is given by case 41, Table X. The activities appearing in the optimum organization are located in Appendix Table D-V, case 41.

The farm organization attained is one using farm produced roughages and purchased grains. Herd replacements are produced on the farm for both the original and expansion milk production activities. A decrease in price of $45.30 per head would create a desire to buy the needed replacements for activity P_3. Since this is approximately a 22.7 percent decrease, the replacement production activity for the farm use is stable.

If either the grain, roughage, or replacement activities were changed, here is what would happen to net farm income. Any oats produced on the farm would lower net farm income by $2.19 per ton produced. Winter labor gained by such activity would amount to 1.82 hours but 2.63 hours of summer labor would need to be added. An amount of 1.21 acres less of cropland would be needed. Less hay would be needed, .101 tons, and 1.04 tons less of purchased oats would be used because .04 cows in the expanded activity would be given up per ton of oats added. This would release .19 acres of native pasture also. However, the savings obtained from the above items in this farm organization are $2.19 less than the cost of farm producing one ton of oats.

Twenty-five acres of oats produced would displace one cow. The resulting loss would be $54.75. If hay were purchased off the farm, a loss of $15.10 per ton would result: .72 hours of winter labor would be saved by the organization, .37 acres more cropland could be rented out, 3.05 hours less of summer labor would need be hired, 1.03 tons less of farm produced hay would be used and .017 tons less oats would need be purchased. The reason for the lower feed and labor requirements are that .0173 cows would have to be given up for each ton of hay purchased. This would also release .078 acres of rented in native pasture. The foregone income from milk production is less than the value of the gained resources but the cost of purchasing one ton of oats exceeds the gain by $15.10.

One replacement produced for sale would lower net farm income by $7.64. Most of this loss would be due to giving up .23 cows to make room for each replacement. That is, approximately four replacements displace one cow.

Labor would be paid $1.23 per hour during the winter season and $1.48 per hour during the summer before giving up any of its use. If the operator's salary for this farm were set at the price he would pay labor before doing without it, his labor income would be $4,065.00, leaving a return to capital of $7,142.67, or 15.1 percent returns to equity.

All the available credit was used in the optimum organization, and interest rates of 21.35 percent could be paid before any capital which was used would go unused. The increased debt, $9,445.89 could be repaid in 7.4 years from increased revenues alone, therefore, no sacrifice of present income need be made in order to acquire the larger business.

When the 60 percent owner is restricted to the land he owns, case 42, Table X and Appendix Table D-V, his optimum farm organization is similiar to the one attained when land was available for renting. However, the expanded herd size is two cows smaller. The needed pasture is obtained by planting cropland to pasture and renting out less cropland. Total land use is 59 acres less than case 41 and 5 acres less than the initial farm was using. Feeding practices are the same for both expanded farms. Feed supply comes from farm produced roughages and off farm purchased grains. Herd replacements are still produced by the farm but since land is scarce relative to capital the activity is not so stable as before. Smaller price changes would cause purchase, the difference now being only \$17.80 per head for P_1 and P_3.

The shadow prices for hay are \$14.52 per ton, for oats production \$.72 per ton and for herd replacements for sale \$40.46 per head. This means that net farm income would be reduced by the above amounts per unit for any of those units produced. All are fairly stable except oats. This producer is practically indifferent as to whether he produces or buys them.

Labor is worth to him at the margin, \$1.13 and \$1.36 per hour for winter and summer labor, respectively. If his own labor is paid at this rate, his annual salary would be \$3,735.00 leaving \$6,886.97 or 14.56 percent return to equity.

Liabilities have been increased from \$31,533.39 to \$39,995.87 but with the returns to capital and depreciation reserve being applied to debt repayment, \$9,334.36 could be repaid the first year. If increased farm income alone were used to repay increased debt a period of 12 years would be required to completely liquidate the debt.

Ninety Percent Equity Opportunities

Table XI, case 43 gives the initial situation and the adjustments using the two land restrictions imposed upon the 90 percent equity organization. Appendix Table D-V, case 44, shows the optimum when land

TABLE XI. PROGRAMMED RESULTS FOR A 46 COW HERD HAVING 90 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Unit	Initial Situation 90% Equity	Land Rent In Opportunity 58.95% Equity	No Land Rent In Opportunity 60.47% Equity
		Case Number		
		43	44	45
Herd Size	Cows	46	106	106
Replacements for Use	A.U.	9.2	21.2	4.4
Total Capital	$	78,833.49	120,342.86	116,418.74
Net Worth	$	70,950.14	70,950.14	70,950.14
Liabilities	$	7,883.35	49,392.72	45,468.60
Change in Liabilities	$	0	41,509.37	37,585.25
Change in Farm Income	$	0	3,540.02	3,620.85
Increased Debt Turnover Ratio	$	-	7.49	10.38
Depreciation Reserve	$	2,036.07	3,798.87	3,651.97
Hired Labor	Hours	1,056.00	6,038.00	5,473.88
Land Use				
Native Pasture	Acres	200.00	400.00	200.00
Cropland				
Wheat	Acres	26.00	26.00	0
Hay	Acres	35.26	81.27	69.40
Silage	Acres	36.41	83.92	72.70
Feed Grains	Acres	62.17	0	0
Sudan Pasture	Acres	39.56	91.16	90.30
Rye-Vetch Pasture	Acres	39.56	91.16	90.30
Other Pasture	Acres	2.30	25.67	68.70
Rented In	Acres	0	6.76	0
Rented Out	Acres	72.30	77.00	0
Total Land Used	Acres	401.70	714.78	501.10
Income	$	14,982.67	26,706.84	24,524.27
Total Fixed Costs	$	3,547.19	6,191.39	6,147.32
Total Interest	$	473.00	3,507.15	3,287.52
Net Farm Income	$	11,468.58	17,008.60	15,089.43

can be rented in and case 45 shows the optimum organization when the land renting opportunity does not exist.

The largest net farm income is attained when land is available for renting. That farm organization, case 44, Table XI, is one which produces all its own roughage and herd replacements, but purchases oats. Hay and replacement production are fairly stable but oat production is not. Fairly large hay and herd replacement price changes would not affect the production of either hay or herd replacements. The upper limits of linearity for hay is $6.62 per ton. Decreases in replacement prices of $17.80 per head would need to occur in order to change the operation from a producing to a purchasing one. However, only a $.69 per ton decrease in oat prices or increase in production costs would cause purchasing of oats to be advantageous.

All the native pasture land available for rent would be used at costs up to $10.41 per acre before giving up the use of any of it. A small amount of cropland would be rented, 6.76 acres, and planted to pasture along with 19 acres of owned cropland. All the available six, eight, and twelve percent interest capital would be borrowed. Losses would result from using more capital at higher prices.

Winter labor could be paid $1.12 per hour and summer labor $1.36 before cutting back herd size from the attained 106 cows. At these wage rates, the operator's salary is $3,720.00 leaving of the net farm income a $13,288.60 return to capital. The expanded business is worth $120,342.86 of which $70,950.14 or 58.95 percent belongs to the operator. Return to equity is 4.63 percent. Although a debt of approximately $50,000.00 has been made against the business the increased debt load could be retired by increased income in 7.49 years, Table XI.

When the business is restricted to the land owned by it, case 45, Table XI, a different type of expansion takes place. Production using the existing equipment uses some farm produced herd replacements and some purchased replacements. Expansion occurs using purchased replacements only. Feed acquisition is identical to the previously discussed organization and all activities are more stable than for the previous case. Hay production costs would have to increase by $3.90 per ton before hay purchases would be considered. Purchased oat costs would have to increase by $6.31 per ton before oat production would be considered. Replacement production is less stable, however, since very small changes, only a few cents, in their costs would shift from producing to buying and vice-versa. This producer is practically indifferent as to which method he uses. However, no replacements would be produced for sale, because this activity would reduce net farm income by $57.00 per head produced and sold. Borrowed capital is worth to the operator 12.46 percent. This price would be paid before changing the attained farm organization.

The size of farm attained requires the use of approximately 2.8 men's time each year. It uses 100 acres more cropland than the initial organization was using. The hired labor would be paid $1.13 and $1.53 for winter and summer labor, respectively, before reducing the use of labor. At these rates the operator's salary would be $3,990.00. This leaves a return to owner's capital of $15,149.34 or 21.35 percent. This operator may wish to pay himself higher wages since his job involves managing a $118,835.64 business of which he owns 60.47 percent. His liabilities associated with the new business are $45,468.60. With the net farm income he has, repayment schedules can be met and the loan repaid in about five years with little difficulty. A longer repayment schedule would be needed, 10.38 years, if the expanded business were to be self liquidating.

Appendix Table D-V, case 45, gives the level of each activity appearing in the optimum solution.

The Sixty Cow Herd Alternatives

Sixty Percent Equity Opportunities

Table XII gives the initial situation and resulting farm organization for the 60 cow operator with the resources described in Chapter II and assuming 60 percent ownership. Appendix Table D-VI, cases 50, 51, and 52 give itemized the components of each of the farm organizations investigated within this framework.

For the initial situation, the operator is producing all his feed and herd replacements but is not utilizing all the cropland. The total value of the business is $91,635.09 of which he owns $54,981.05. He receives a net farm income of $11,391.96, case 50, Table XII. Appendix Table D-VI, case 50, shows that there is also some unused credit which possibly could be used to expand the business.

By allowing the business to rent in land, linear programming gives an optimum farm organization, case 51, Table XII, which is 21 cows larger than the initial operation, uses 233.6 acres more land of which 160 is native pasture and returns $3,381.00 more income. The expansion occured through P_3, the milk producing activity, using farm produced herd replacements. All the feed is still produced on the farm but more cropland is used because the herd has increased in size. The 13.9 acres disposed of through rental might be used for cash crops, such as alfalfa

TABLE XII. PROGRAMMED RESULTS FOR A 60 COW HERD HAVING 60 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Unit	Initial Situation 60% Equity	Land Rent In Opportunity 53.8% Equity	No Land Rent In Opportunity 53.8% Equity
		Case Number		
		50	51	52
Herd Size	Cows	60	81	80
Replacements for Use	A.U.	12	16.2	16
Total Capital	$	91,635.09	102,177.11	102,029.80
Net Worth	$	54,981.05	54,981.05	54,981.05
Liabilities	$	36,654.03	47,048.74	47,196.05
Change in Liabilities	$	0	10,542.02	10,394.71
Change in Farm Income	$	0	3,381.02	1,785.07
Increased Debt Turnover Ratio	$	-	3.07	5.91
Depreciation Reserve	$	2,839.57	3,009.57	2,999.57
Hired Labor	Hours	2,498.31	4,235.10	4,229.66
Land Use				
Native Pasture	Acres	180.00	360.00	180.00
Cropland				
Wheat	Acres	40.00	40.00	40.00
Hay	Acres	46.00	62.10	61.33
Silage	Acres	47.50	64.12	63.33
Feed Grains	Acres	72.69	105.43	66.28
Sudan Pasture	Acres	51.60	69.66	68.80
Rye-Vetch Pasture	Acres	51.60	69.66	68.80
Other Pasture	Acres	30.00	1.50	60.00
Rented In	Acres	0	0	0
Rented Out	Acres	67.45	13.91	-
Total Land Used	Acres	467.79	701.46	539.74
Income	$	18,707.50	23,531.12	21,912.71
Total Fixed Costs	$	4,972.00	5,227.00	5,212.00
Total Interest	$	2,343.54	3,553.14	3,523.68
Net Farm Income	$	11,391.96	14,772.98	13,177.03

hay. The maximum quantity of native pasture is rented in at three dollars per acre and would continue to be used at costs up to $11.17 per acre. Cropland would not be considered at any price, since the limiting factor is capital. All the available credit is used and would be used at interest rates up to 28.71 percent before preventing the expansion of this operation.

The feed production activities are stable. The cost of producing hay would have to increase by $12.77 per ton before this activity would be reduced, and oats production costs increased by $4.52 per ton before considering the purchase of grains. Replacement production costs would have to increase by $22.20 per head before purchases would be considered for expansion.

No replacements would be produced for sale since the production of one would lower net farm income by $51.21. The major part of this cost is the loss of income from .35 cows for each replacement added. Three replacements would displace one cow if replacements were raised for sale resulting in a net decrease of $153.63.

Labor hired for winter use could be paid $2.19 per hour, and for summer use $2.20, before any would be released. The operation attained is approximately a 2.33 man one. If the operator chooses to use the above rates as the value of his labor and management, his salary will be $6,585.00 leaving of net farm income $8,187.98 returns to his capital. The rate of return to his equity is 14.89 percent.

The value of the expanded herd is $102,177.11 of which there has been incurred a debt of $47,048.74. The increased debt could be repaid with increased returns alone in three years.

If the operation is restricted to the land it owns, a herd size of only one cow smaller than the previously discussed one is reached. Total cropland used is 72 acres more than the initial herd uses. Since no pasture land may be rented in, cropland is planted to pasture and some of the needed grains are purchased. All roughages, however, are produced on the farm and all herd replacements are farm produced.

All available credit is used and up to 25.08 percent interest would be paid in order to use it. Replacement production for sale would reduce net farm income by $58.09 per head. The major portion of the loss comes from the foregone income of .29 cows per replacement produced. Labor could command a wage of $1.57 per hour during the winter and $1.95 during the summer on this farm.

Returns to the operation are smaller than returns from one using more native pasture due to the requirement of pasture planting on cropland. However, returns are greater by $1,785.07 than they were for the initial organization. This operator could claim a salary of $5,280.00 for his efforts and have $7,897.03 return to his equity to use in debt repayment. Case 52, Table XII, shows the structure of the farm organization attained.

Ninety Percent Equity Opportunities

For consideration of the same initial organization with a larger equity and more available credit, see case 53, Table XIII. Income is greater by the interest difference between this farm and the one in case 50, Table XII.

When the operator has the opportunity to rent in land, case 54 Table XIII, the dairy farm attained is one which produces all its

TABLE XIII. PROGRAMMED RESULTS FOR A 60 COW HERD HAVING 90 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Situation 90% Equity	Land Rent In Opportunity 58.97% Equity	No Land Rent In Opportunity 70.03% Equity
		Case Number		
	Unit	53	54	55
Herd Size	Cows	60	148	114
Replacements for Use	A.U.	12	29.60	12.80
Total Capital	$	91,635.09	139,842.20	117,761.42
Net Worth	$	82,471.58	82,471.58	82,471.58
Liabilities	$	9,163.51	57,370.72	35,289.84
Change in Liabilities	$	0	48,207.21	26,126.33
Change in Farm Income	$	0	11,786.03	5,120.61
Increased Debt Turnover Ratio	$	-	4.09	5.12
Depreciation Reserve	$	2,839.57	3,679.57	3,339.57
Hired Labor	Hours	2,498.31	10,418.67	6,522.13
Land Use				
Native Pasture	Acres	180.00	360.00	180.00
Cropland				
Wheat	Acres	40.00	40.00	0
Hay	Acres	46.00	113.47	80.00
Silage	Acres	47.50	117.17	84.00
Feed Grains	Acres	78.01	179.04	0
Sudan Pasture	Acres	51.60	127.28	98.04
Rye-Vetch Pasture	Acres	51.60	127.28	98.04
Other Pasture	Acres	30.00	102.00	97.67
Rented In	Acres	0	316.50	0
Rented Out	Acres	67.45	0	0
Total Land Used	Acres	473.11	1,038.96	540.44
Income	$	18,707.57	34,231.96	26,145.75
Total Fixed Costs	$	4,972.00	6,232.00	5,722.00
Total Interest	$	549.81	4,162.17	2,117.38
Net Farm Income	$	13,185.76	24,971.79	18,306.37

roughages and herd replacements but, due to the size of the herd and shortages of land, some oats must be purchased. The upper limits of the ranges of linearity on native pasture renting and cropland renting in are $12.29 and $10.95, respectively. Practically all the available credit is used and could command a price of 25.08 percent interest before this operation would decrease its use. Total land used is 565.8 acres more than the initial situation uses.

Hay production is stable because doubling the cost of production would not cause it to be discontinued. Oat production is also fairly stable, since a cost increase of $4.52 per ton would need to occur before production would be affected. Replacement production for P_1 is fairly stable. Prices could range over very wide areas before affecting it, but for P_3 much smaller price change, $12.30 per head, would cause replacement purchases to be considered.

No herd replacements would be produced for sale since such activity would lower net farm income by $58.09 per head produced. The herd size attained is 148 cows and, with the feed production included, 4.47 men working 3,000 hours each per year are needed to meet the labor requirement. Winter labor is worth $1.57 per hour and summer labor $1.95. Setting the operator's salary at the price he would be willing to pay labor before giving up its services he could take a $5,280.00 salary and leave $19,691.79 returns to capital to be applied toward repayment of the $57,370.62 debt. The increased debt could be recovered through increased earnings in 4.09 years.

Total value of the attained organization is $139,842.20 of which the owner has 58.9 percent equity.

Case 55, Table XIII gives the optimum structure attained when the 90 percent owner is confined to the land he owns. All owned land is used. The herd size attained is only 114 cows compared to the 148 when land was available for use through renting. However, the dairy farm is somewhat different. Maximum capacity of the existing bulk tank is produced using farm produced herd replacements, but the expanded activity uses purchased replacements. All roughages are produced on the farm but all grains are purchased, and would continue to be until their price exceeded $62.41 per ton. Any oats produced on the farm would reduce net farm income by $33.76 per ton.

Replacement production is stable at its present level of use. A $54.80 price change would be needed in order to consider replacement purchases. Replacement purchases are also stable at their present level of use since a price increase of $43.60 would be needed to make replacement production be considered. The only explanation which can be conceived for this is that land is too scarce to use for replacement production since .91 cows would have to be given up for each replacement added.

Any hay purchased would lower net farm income by $2.31 per ton. This is the first program indicating that hay purchases might be considered. Replacement production for sale, however, is not considered since any produced and sold would lower net farm income by $111.46.

Since land is limited, all the available credit was not used. The highest interest rate used in the program is eight percent, so the value of capital at the margin is eight percent.

Approximately seven and one-sixth men are needed to handle the labor required by this operation. Winter labor could be paid $2.95 per hour and summer labor $3.70 before any changes in the farm organization would be made. At these rates the manager's salary would be $9,975.00 which would leave $8,331.37 return to equity or 10.1 percent.

Total value of the expanded operation is $117,761.42 of which the operator owns 70.03 percent. Repayment of the $35,289.84 debt could be made on almost any reasonable repayment schedule obtained by using returns to capital and depreciation reserves. The increased debt could be retired in 5.12 years with the use of increased income alone. This is a reasonable repayment schedule to undertake, so expansion could take place whether additional land were available or not.

The Eighty-Four Cow Herd Alternatives

Sixty Percent Equity Opportunities

The largest herd size category observed in the Oklahoma Metropolitan Milk Marketing Area had an average herd size of 84 cows. The largest herds observed were 116 and 130 cows. Both were producing all their feed and herd replacements.

When the quantity of resources controlled by the 84 cow organization are combined optimally under the land and capital restrictions used in this study, the largest herd size attained is a 197 cow one using approximately 1,336 acres of land. For all practical purposes it is believed, with rather conclusive evidence, that a dairy herd requiring more than two sections of land in the area studied is impractical. The physical size hampers the efficient use of time and equipment when using the practices found in this study. Larger dairy herds can definitely be conceived, but the technology of handling them would change from that used in this study to some other feeding system, probably a drylot one. Probably most dairy farm families would not desire or be able to expand into this highly specialized business requiring tremendous quantities of capital. In the event that a dairy farmer did wish to become a part of this type of dairying, he probably should investigate the possibilities of pooling his resources with those of other farm families and operate as a cooperative.

This last herd size takes us to the extent of expansion opportunities using the technology used by the dairymen represented here. A new model would be needed in order to pursue the possibilities of larger, more efficient businesses.

Table XIV, cases 60, 61, and 62 give the structure of the 84 cow dairyman who owns 60 percent of his business. At the 60 percent equity level, operating with enough excess capacity to allow adding four cows before adding any more equipment, his net farm income is $14,060.44. The initial operation is a 2.46 man one which produces all the feed needed by the herd and the necessary herd replacements to maintain the herd. Not quite all the cropland is being used and not all the available credit is being used as can be seen in case 60, Appendix Table D-VII.

When this operator is allowed to rent land, the optimum farm organization, case 61, Table XIV, expands to 109 cows and rents in all the pasture land available. No additional cropland would be used at any price since not all that is owned is used and some of it is rented to a neighbor. Total land usage is 286.1 acres more than for the initial organization. The use of native pasture has doubled. All the capital offered is borrowed and would continue to be used even if it cost 28.21 percent interest.

TABLE XIV. PROGRAMMED RESULTS FOR A 84 COW HERD HAVING 60 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Situation 60% Equity	Land Rent In Opportunity 54.20% Equity	No Land Rent In Opportunity 53.79% Equity
			Case Number	
	Unit	60	61	62
Herd Size	Cows	84	109	108
Replacements for Use	A.U.	16.8	21.8	21.6
Total Capital	$	118,992.90	131,435.22	132,714.88
Net Worth	$	71,395.74	71,395.74	71,395.74
Liabilities	$	47,597.16	60,039.48	60,319.14
Change in Liabilities	$	0	12,442.32	12,721.98
Change in Farm Income	$	0	4,066.61	2,030.13
Increased Debt Turnover Ratio	$	-	3.05	6.26
Depreciation Reserve	$	2,928.09	3,138.09	3,128.09
Hired Labor	Hours	4,386.30	6,382.37	6,456.87
Land Use				
Native Pasture	Acres	240.00	480.00	240.00
Cropland				
Wheat	Acres	0	0	0
Hay	Acres	64.40	83.57	82.80
Silage	Acres	69.30	86.29	85.50
Feed Grains	Acres	104.02	134.96	97.73
Sudan Pasture	Acres	72.24	93.74	92.88
Rye-Vetch Pasture	Acres	72.24	93.74	92.88
Other Pasture	Acres	46.00	3.50	82.00
Rented In	Acres	0	0	0
Rented Out	Acres	88.10	39.00	0
Total Land Used	Acres	595.96	882.00	680.91
Income	$	22,462.98	28,240.49	26,244.94
Total Fixed Costs	$	5,309.55	5,624.55	5,609.55
Total Interest	$	3,092.99	4,488.89	4,544.82
Net Farm Income	$	14,060.44	18.127.05	16,090.57

The business is one which produces all its own feed and herd replacements with production activities which are very stable based on costs of production. The cost of producing hay could go to $19.52 per ton before purchases would be considered. Oat costs of production could reach $16.10 before any would be purchased, and herd replacement prices would need to decrease $36.90 before any purchases would be considered.

Any oats purchased would lower net farm income by $5.26 per ton, hay by $16.03 per ton and any herd replacements produced for sale by $42.96 per head produced and sold.

This farm requires the labor of 3.1 men per year. The 2.1 hired hands could be paid $2.11 per hour during the winter months and $2.16 during the summer months before reducing herd size due to labor expense. If the operator uses these wage rates as his salary, he could receive for his labor $6,409.00. This would leave $11,718.05 or 16.41 percent returns to equity.

By using capital income and depreciation reserves to repay debt, the $60,039.48 liabilities could be repaid in at least five years provided the business did this well in each successive year. The increased debt itself could be repaid from increased income in three years.

When land is not available for rental into the business, case 62, Table XIV, the herd size attained is only one less than when land rental opportunities are available. However, a different feed procuring method is used. All roughages are still farm produced but, since more pasture is needed, part of the oats production is given up to the pasture production and 27.26 tons of oats are bought. In this farm organization, no land is rented out.

All herd replacements are farm produced and very well established. Either production cost increases or sale price decreases must occur amounting to approximately $25.00 per head in order to cause herd replacement purchases. No herd replacements would be produced for sale, however, since such an enterprise would lower net farm income by $51.27 per head.

Just a little more labor is needed by this organization than the previous one, because more pasture must be planted than the previous herd required. This is a 3.15 man organization; whereas, the other was a 3.1 man one. Labor on this farm would not be paid quite so much as the previous farm could, only $1.43 for winter help and $1.79 for summer help.

All capital available was borrowed and the limits to which the operator could go in order to get the use of this capital is 23.82 percent interest.

The salary of the manager, if computed at the maximum wage rate hired hands could command, is $4,830.00 leaving to this particular operator's capital a return of 15.77 percent or $11,060.57. Debt repayment schedules could be met without any difficulty. However, the increase in farm liabilities could not be repaid by increased income as fast as the previously discussed farm's could be. The debt is practically the same but it would take twice as long to repay it.

Ninety Percent Equity Opportunities

Moving from 60 percent equity to a 90 percent equity on the same dairy farm, case 63, Table XV and Appendix Table D-VII, the effect of differences in indebtedness level may be seen. The quantity of credit available to this operation offers more possibility for expansion.

TABLE XV. PROGRAMMED RESULTS FOR A 84 COW HERD HAVING 90 PERCENT INITIAL EQUITY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Situation 90% Equity	Land Rent In Opportunity 59.26% Equity	No Land Rent In Opportunity 71.96% Equity
			Case Number	
	Unit	63	64	65
Herd Size	Cows	84	197	145
Replacements for Use	A.U.	16.8	39.4	11.4
Total Capital	$	118,992.90	180,707.83	148,816.44
Net Worth	$	107,093.61	107,093.61	107,093.61
Liabilities	$	11,899.29	73,614.22	41,722.82
Change in Liabilities	$	0	61,714.93	29,823.53
Change in Farm Income	$	0	14,657.48	5,335.06
Increased Debt Turnover Ratio	$	-	4.21	5.59
Depreciation Reserve	$	2,928.09	4,018.09	3,498.09
Hired Labor	Hours	4,386.30	14,442.18	8,843.88
Land Use				
Native Pasture	Acres	240.00	480.00	240.00
Cropland				
Wheat	Acres	0	0	0
Hay	Acres	64.40	151.03	99.43
Silage	Acres	69.30	155.96	103.80
Feed Grains	Acres	104.02	243.92	0
Sudan Pasture	Acres	72.24	169.42	124.70
Rye-Vetch Pasture	Acres	72.24	169.42	124.70
Other Pasture	Acres	46.00	135.50	114.03
Rented In	Acres	0	412.64	0
Rented Out	Acres	88.10	0	0
Total Land Used	Acres	595.96	1,335.83	681.95
Income	$	22,462.98	43,461.32	30,442.45
Total Fixed Costs	$	5,309.55	6,944.55	6,164.55
Total Interest	$	713.96	5,419.82	2,503.37
Net Farm Income	$	16,439.47	31.096.95	21,774.53

By allowing land to be rented in, case 64, Table XV, a 197 cow herd using 1,335 acres of land is reached. The optimum combination of the resources available results in a dairy farm which produces all its feed and herd replacements. In order to carry on this operation, the labor of 5.8 men working 3,000 hours each per year is required. Labor could be paid $2.11 and $2.16 per hour during winter and summer, respectively, before the farm organization would be changed.

The feed production activities are stable at this level of operation. Also replacement production for farm use is stable since price decreases of approximately $36.90 per head would have to occur before purchasing would be considered. Any oats bought would lower net farm income $5.26 per ton, hay bought, $16.03 per ton, and replacements produced for sale $42.96 per head.

All capital available would be borrowed at interest rates up to 28.21 percent. At the level of efficiency attained by this size of herd milk production seems to be a profitable business.

All native pasture land available would be rented in at costs up to $10.94. Cropland is rented in but not to the limit allowed. The reason for this being that capital became limiting before land. It could be paid $11.78 per acre before giving up any use of it.

The value of the business attained is $180,707.83 of which the operator has an equity of 59.26 percent. Liabilities have been increased to $73,614.22 which with the annual net farm income of $31,096.95 could be repaid in reasonable lengths of time. Increased income could retire the increased debt in 4.21 years.

At the upper limits of wage rates, the operator's salary is $6,116.00 which leaves $24,980.95 returns to the operator's capital. It is conceivable that at this level of operation the services of some managerial help above the full-time operator's may be needed. Certainly beyond this size of business another manager would need to be hired. Just where the limit of one man's managerial capacities on Oklahoma dairy farms is reached is not known. Since no herds of this size were observed in the sample, no inferences can be drawn from the population studied. However, with the wage limits being as high as they are, competent help could be acquired without altering the nature of the optimum organization. Costs would, however, be greater and net farm income somewhat smaller.

When the same organization is restricted to the land it owns, case 65, Table XV, the resulting herd size is only 145 cows. Grain production has been replaced by grain purchases, but hay and other roughages would continue to be produced on the farm.

It is interesting to note, that production up to the maximum capacity of the existing bulk tank is produced with purchased replacements, but that expansion uses farm produced replacements. Each activity seems to be fairly stable in that per unit costs of up to \$17.65 per replacement could occur before any changes would be made.

Fairly large price changes would have to occur before this producer would produce oats for dairy feed, buy hay for dairy feed, or reduce labor use. He would be willing to pay \$58.88 per ton for oats and \$8.60 per ton for hay production before changing either activity. The present cost of oats is \$37.50 per ton and hay \$4.27 per ton. Labor could be paid \$2.71 per hour during the winter and \$3.48 per hour during the summer.

By using an optimum combination of resources on the land owned and using borrowed money, income can be increased by \$5,335.06 over the initial 90 percent equity situation. However, the use of twice as much land increases income $14,657.48. The operator's equity in case 65 is 71.96 percent. Since land is not available to allow further expansion, he cannot profitably use all of his available six percent credit.

Any dairyman considering this size business should carefully study his own particular input coefficients and make sure that he can produce as efficiently as the farms presented here. At points of less efficiency, the degree of expansion would be less and maybe even impossible. Although possibilities for a profitable business appear to be good, sound management and financial backing could not be overstressed.

CHAPTER V

INTERPRETATIONS

In Chapter IV the results of each individual program were discussed. In this chapter a broader view of the programmed results will be presented and some interpretations of the results made.

Factors Affecting Expansion

The results of the programs of various dairy farm sizes indicate that a dairyman in business to maximize profits must fully utilize his fixed dairy equipment if he uses it at all. For all cases programmed, net revenues were realized from production using the existing equipment to maximum capacity, but in some cases net revenues were small. In most cases it was profitable to expand production beyond maximum capacity of existing equipment. The cases which could not expand were the small businesses of 20 cows. The businesses of around 25 cows could expand somewhat if land and capital were available. The dairymen with 25 cows or less would probably be able to obtain more income from their resources if they looked elsewhere than dairying for a place to use them.

Price decreases of $.50 per hundredweight would not force the dairymen represented by the programmed solutions to go out of business, but such decreases would certainly decrease net revenues to a level that labor and investment returns would be low. This much price decrease relative to all other prices would certainly make opportunities for investment and employment elsewhere be considered but fixed costs incurred by the dairy equipment might still keep the dairymen producing.

Under present price cost conditions a cow producing 7,700 pounds of milk per year would pay her way in the dairy herd, and wages and capital returns for the dairymen would be only $1.00 per hour and four percent.

Once the profitability of using existing equipment was established the next questions were: Is expansion profitable and if so to what degree, and what were the effects on expansion of (1) initial size, (2) available capital, and (3) available land. The ability of the manager is a fourth factor which was not directly examined in this study but is probably correlated to initial herd size and manifested through dairy farm efficiency.

Logically speaking, larger more efficient businesses are the results of higher quality management than smaller less efficient businesses when all other factors are equal. Good managers may be managing small businesses, but good managers tend to acquire larger more efficient operations in time. As the size of business increases, economies to scale are obtained and the complexity of the larger operation requires the skills of a good farm manager.

Management has been assumed constant within each farm size in this study. The managers of small inefficient businesses may acquire larger more efficient ones with the understanding that farm management can be learned. The operator who moves from a 20 to a 50 cow herd in order to be successful must either already have the management ability required or learn it. Experience is a good teacher but in the dairy business it is time consuming and costly. Farm management books, record books, and accounting methods should be considered standard tools of the dairy farm manager.

The initial size of the business affects expansion in two ways. The first is related to efficiency and the other to the amount of capital available for expansion and operation of the expanded business. In the models used, the capital for expansion was borrowed by using the business assets as collateral. Under these conditions a small business is limited to small quantities of credit. Efficiency affects expansion in this way. Small dairy farms have high per unit costs of fixed factors. With their small quantities of available capital, their steps of growth are small and per unit costs high. For this reason the operator of the 20 cow initial herd could not expand beyond the limits of existing capacity. Operators with larger herds having greater efficiency and more available credit were able to expand herd sizes by varying degrees.

Two levels of equity (60 percent and 90 percent) were assumed for each initial herd size. This in essence placed one of two possible capital supply curves before each operation. The supply curves were made up of capital costing six, eight, twelve, sixteen, and twenty percent interest. Interest rates were based on the kinds of collateral used and the lending agency making the loan. The 60 percent owner in all cases was already in debt for all his six percent credit and part of his eight percent credit. The 90 percent owner had available most of his six percent credit and all the remaining credit at various other interest rates. The two capital supplies were analyzed with two land supplies.

The land supplies were arbitrarily chosen to be (1) the initial farm and (2) rental of more land not to exceed the quantity of land owned. The effects of land and capital on expansion were joint in this study. If land could not be obtained the excess capital could not be used profitably and vice-versa.

Table XVI shows the percentage of expansion above the initial capacity for each herd size studied. Expansion here refers to P_3 and P_4 and does not include the number of cows added to reach maximum existing capacity. The quantity of capital available limited the expansion of large dairy herds having only 60 percent equity and large dairy herds having 90 percent equity which were limited by land. The cost of capital limited expansion in some cases. In the initial 60 percent equity cases of 46 cows or smaller further use of capital would have decreased incomes. Land and capital both were limiting to the initial 60 and 84 cow 60 percent equity businesses. Land alone limited expansion of all 90 percent equity business not having opportunity to rent land. Expansion doubled the original 90 percent equity dairy herds of 32 cows and larger, except for the initial 60 and 84 cow 90 percent equity business which could not rent land for dairy use. The 25 cow initial herd was expanded but not doubled.

TABLE XVI. EFFECTS OF LAND, CAPITAL, AND INITIAL HERD SIZE UPON THE PERCENT OF EXPANSION BEYOND INITIAL CAPACITY FOR HERD SIZES STUDIED, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Initial Equity	Land Rent	Initial Herd Size					
		20	25	32	46	60	84
60%	No	0	12	21	30	34	23
	Yes	0	16	34	34	28	25
90%	No	0	64	125	128	83	67
	Yes	0	92	115	130	140	129

About one-fourth of the programmed cases stopped using credit at eight percent interest. In practice this is the most popular source and cost of credit. Another fourth of the programmed cases were willing to pay very high interest rates for the use of capital. One-half the dairymen used financing made available by machinery dealers and dairy equipment suppliers.

The 60 percent initial equity dairy farms are willing to pay interest rates of 11 to 28 percent for the quantities of credit used. With larger quantities of capital available (90 percent equity level) the range in interest rates for the initial situations studied when additional land was available was from eight to 28 percent. However, when land was limited the interest rates exceeded 8.5 percent in only one case. The 46 cow initial herd would have paid 12.4 percent to obtain the use of the capital borrowed. This particular situation however added more cows under this technology than did any other. This organization was using the highest producing cows used anywhere in the study. Its labor and fixed equipment efficiency were not as high as the larger businesses' but its advantage of greater quantities of milk per cow allowed higher marginal costs to be paid before such costs exceeded marginal revenue.

TABLE XVII. MAXIMUM INTEREST RATES[1] WHICH WOULD BE PAID FOR THE USE OF THE CAPITAL BORROWED, BY INITIAL HERD SIZE STUDIED, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Initial Equity	Land Rent	Initial Herd Size 20	25	32	46	60	84
60%	No	12	11.2	11.4	16.7	25.1	23.8
	Yes	12	11.2	14.7	21.3	28.7	28.2
90%	No	8	6.8	8.5	12.4	8.0	6.0
	Yes	8	11.2	11.4	16.7	25.1	28.2

[1]Rates over 20 percent indicate that all available credit was used for that particular land and capital situation.

Credit Use

As a result of expansion by the use of borrowed capital, net farm income increased in every case. Of course, debt also increased and the next question is, can the increased debt load be handled without depriving the dairy farm family of its present level of living? This can best be determined by comparing the increased net farm income with the increased debt. If the increased income will meet the increase debt repayment schedules then the dairy farm reorganization can be made without diverting present income to repay still larger debts. Even if the turnover ratio is equal to the depreciation schedule, gains equaling the depreciation reserve will be made and at the end of the depreciation period the larger business will be owned entirely by its operator. Any further operation will be income increasing and will directly benefit the dairy farm family. Table XVIII gives the length of time required to repay the increased debt from increased income alone.

TABLE XVIII. NUMBER OF YEARS REQUIRED FOR INCREASED FARM INCOME TO REPAY INCREASED DEBT, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Land	Initial Herd Size					
Initial Equity	Rent	20	25	32	46	60	84
60%	No	2.13	6.58	8.17	12.29	5.91	6.26
	Yes	1.56	7.37	7.71	7.41	3.04	3.05
90%	No	2.01	16.33	18.43	10.38	5.10	5.50
	Yes	1.49	13.65	10.91	7.49	4.09	4.21

In most cases the turnover is rapid and repayment schedules could be met easily. In others repayment takes longer but repayment schedules could still be met. In still others, for example, the 32 cow 90 percent equity limited land operation, and the 46 cow 60 percent equity limited land situations, increased incomes are relatively low. Costs of expansion and operation are so high that increased debt could not be repaid before part of the equipment would need replacing even if repayment schedules could be arranged. This need not stop the operator from expanding becasue he still is accumulating the business and increasing net worth. However, other investments outside of dairying might return greater incomes. Limited land seems to be the deterring force here.

The conclusion from this turnover analysis is that the dairyman can increase his proprietorship through the use of borrowed capital. However, risks have not been accounted for in this study. Each individual operator needs to consider his own risk involved and plan accordingly. Farmers have a general tendency to discount risk heavily, especially those who have acquired a satisfactory farming business. They are relunctant to jeopardize years of toil for the promise of better incomes and often choose to operate business which do not fully employ their labor or resources rather than assume the responsibility of more debt.

It appears that many dairymen could increase their incomes by assuming moderate amounts of the risk involved. Modern businesses outside the agricultural industry rely on credit heavily for their growth needs. Blind borrowing is certainly not advisable and probably would be disastrous, but the planned use of credit certainly is another tool to aid the dairy farmer in the struggle for survival as a farming businessman.

Land Use

There was a greater demand for native pasture land than for cropland at the prices used in this study. Native pasture could be used without any cost or care. Although cropland planted to pasture produces three acres of native pasture equivalent for each acre planted, the cost of planting each year is greater than the rental fee of three acres of native pasture. Within the land assumptions used there was very little demand for cropland since the most important use of land was for pasture. Smaller quantities of feed producing land was needed in comparison to the acreages of pasture land needed. Approximately 73 percent as much cropland per cow was needed as native pasture land. Only two very large dairy farms with 90 percent initial equity rented in cropland in any significant quantities. Five of the 60 percent equity initial situations that were allowed to rent in native pasture land did so. Three used the maximum quantity allowed, but two did not have capital of sufficient quantities at low enough interest rates to be able to expand enough to use all that was offered. All six of the 90 percent owners having the opportunity to rent in land rented in native pasture. Five rented in all that was allowed but one found that it was not profitable to use all the native pasture offered. Prices of $8.00 per acre could have been paid for the use of the native pasture used before the dairy farms would have been indifferent between native pasture and cropland. For those farms using rented cropland, its price could have increased to $11.00 per acre before use would have been reduced.

Although in the past land has been considered a fixed factor of production, it is becoming more variable. Leases and rentals are opening up opportunities for farmers to acquire the use of land without having investments in it. In fact the leasing and renting of land is good business in a lot of cases. The operator is less fixed in farming and his capital can be placed in other factors of production rather than land investment. This type of operator purchases land services as he needs them rather than all at once. This is particularly a good arrangement for young farmers who have not accumulated sufficient capital to become land owners.

From the results of this study Oklahoma dairy farmers can use rented land to their advantage as a profit maximizing resource. The programmed results show additional pasture land to be more useful to the dairyman than cropland.

Dairy Farm Labor

Much of the dairy chore work is unpleasant and distasteful to many people. Many of the recent technological developments have been designed to ease the load of the dairy laborer and perform routine tasks. Pipe line milkers, bulk tanks, barn cleaners, and automatic feeders have done much to increase labor efficiency on modern dairy farms. However, human supervision and labor is still needed.

Eighty percent of the dairy farms observed were essentially family operations. The other 20 percent were hiring from one-half man to two full time men. In addition to the hired labor the operator spent about 3,000 hours each year in the dairy business. As herd size increased, the additional required labor was hired. The following table shows total labor for each capital and land situation.

As technology progresses and machines become more complicated, higher quality help will be needed. The dairymen interviewed indicated that the quality of help they needed could not be obtained at \$1.00 to \$1.25 per hour. They believed strongly that no higher wages could be paid. The results of the 24 cases programmed indicated that the following wages

TABLE XIX. LABOR REQUIREMENTS IN MAN EQUIVALENTS FOR EACH DAIRY HERD PROGRAMMED, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Initial Equity							
	60%				90%			
	A[1]		B[2]		A		B	
Initial Herd Size	Final Herd Size	Labor Needed	Final Herd Size	Labor Needed	Final Herd Size	Labor Needed	Final Herd Size	Labor Needed
20	27	1.04	27	1.04	27	1.04	27	1.04
25	29	1.04	29	1.06	48	1.71	41	1.82
32	44	1,42	40	1.37	70	2.36	73	2.30
46	62	1.76	60	1.72	106	3.04	105	2.82
60	81	2.41	80	2.40	148	4.47	114	3.17
84	109	3.12	108	3.15	197	5.82	145	4.94

[1] Land is available for renting in.

[2] Land is not available for renting in.

could have been paid for the quantity of labor hired without affecting the optimum organization of the dairy farm.

The large herds with better opportunities to expand could afford to pay the higher prices for labor. These wage rates indicate that laborers worth from $4,230 to $8,850 per year could be hired. On a non-farm industry wage basis comparison, the hourly rates are not appreciably different, but the number of hours work is larger. The non-farm industry laborer spends 40 hours per week or 2,000 hours per year at his job while the dairy laborer works 3,000 hours. Labor commanding these wages should be able to handle the present technical devices on most dairy farms. Where hired help is used there is a labor relations job to be handled by the employer. The temperment of both employer and employee enter the working relationship and cannot be measured or predicted by researchers. The

TABLE XX. MAXIMUM WAGES WHICH COULD BE PAID FOR WINTER (TOP) AND SUMMER (BOTTOM) LABOR IN THE FINAL SOLUTIONS FOR EACH CASE PROGRAMMED, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

		Initial Herd Size					
Initial Equity	Rent	20	25	32	46	60	84
60%	No	-	1.57	1.62	1.12	1.57	1.43
		1.41	1.62	1.63	1.36	1.95	1.79
	Yes	-	1.51	1.06	1.23	2.19	2.11
		1.41	1.62	1.74	1.48	2.20	2.16
90%	No	-	1.42	1.08	1.13	2.95	2.71
		1.84	1.13	1.35	1.53	3.70	3.48
	Yes	-	1.57	1.62	1.12	1.57	2.11
		1.48	1.62	1.63	1.36	1.95	2.16

employer must be able to delegate responsibility to his employees and expect and receive faithful service from them if his business requires hired labor services. Success in the dairy business depends upon timely as well as steady labor services.

Feed Procurement Methods

In all cases programmed farm produced roughages were used. Silage and pasture were complements of cows, so if any cows were kept for milk production then silage and pasture would be produced. Hay could have been purchased or farm produced whichever added the most to total profits. In the programmed optima the hay production activity appeared at a stable level. Costs of production would have to more than double in practically all cases before purchasing hay would be considered.

Alfalfa hay as a cash crop was not directly analysed in this thesis but it might be a possibility if land of suitable fertility were available. The producers interviewed were using alfalfa which they themselves produced, but in many instances there was not any additional alfalfa land available.

Small quantities of cropland were left unused by the dairy farm in some of the cases programmed. The use of this land for alfalfa hay as a cash crop might be profitable especially since hay making equipment is already owned and the additional cost of its use would not be great.

The procurement of feed grains consisted of both purchasing and farm production. The major determining factor was the availability of land in relation to capital. When capital was relatively plentiful and the expansion of milk production was profitable, larger portions of the available land for pasture and hay production were required leaving little or no land for feed grains. In these cases oats were purchased and fairly large prices could be paid for them before altering the farm organization. In other cases, when cropland was plentiful relative to low cost capital, farm production of oats took place. The oat production activity was not a stable one. Small price changes could cause a state of indifference as to which method was used. In some cases the accompanying wheat allotment requires machinery which can be used for other small grain production. If this condition did not exist then the production of other small grains on the farm would be even more costly because of complimentarity in machine use. The difference might be great enough to result in stronger preferences for purchase rather than production of feed grains.

Observations showed 50 percent of the dairymen purchasing all grains. The programs showed that 50 percent of the optimum organizations would be grain producing ones, 37.5 percent grain purchasing ones, and 12.5 percent using both methods. The cost of oats in 1958 in Oklahoma was lower than in 1957 or 1959. Increases in cost per ton ranging from \$.09 to \$5.50 would cause the dairy farmers to shift from buying to producing oats.

Only one case was definitely committee to oat purchase. This case was the 84 cow, 90 percent equity situation which could not get the required land. Costs per ton would have to be $21.00 higher before this producer would change. Prices per ton have fluctuated as much as $5.00 to $10.00 from season to season, therefore, the purchase or production of oats by dairymen is not a stable activity. Individual production efficiency must be considered and convenience weighed when making the procurement decisions. There is not a great deal of loss or saving involved whichever method is used.

Wheat Production on Dairy Farms

Although wheat is a profitable cash crop at present prices, the small quantities found on dairy farms do not add significant quantities of revenue to total farm income. All except two wheat allotments offered in the programs were used. The cases that did not use wheat allotments used the cropland released for roughage production for the dairy herd. Both farms were 90 percent equity limited land ones. If prices dropped by $.25 per bushel the 60 percent equity operators would use wheat allotment land in the dairy business. An $.11 per bushel decrease would cause the 90 percent owners to do likewise. There is complimentarity on these farms between the use of small grain producing equipment for wheat production and feed grain production. The discontinuing of wheat production would cause fixed costs of producing small grain feed crops to increase. Such occurrences would bring the dairy farms nearer to purchasing rather than producing feed grains.

Herd Replacements

Two methods of herd replacement were available to producers in the area studied. The methods were purchasing and farm production. The dairymen interviewed were producing most of their own replacements. The results of the programs indicated that farm production of herd replacements is generally the method which adds the most to total profits. Three producers found it profitable to use purchased herd replacements. A highly unlikely price decrease or farm cost of production increase of $35.00 per head would be needed to cause dairymen to be indifferent as to which method they used.

The reason for the stability of herd replacement production on farms is that the opportunity to use pasture, labor, feed, and capital required by replacements in the production of milk does not return enough additional revenue to pay the difference in cost between producing and purchasing herd replacements. For this reason, greater total profits can be obtained by the farm production of dairy herd replacements. The possibility exists that an efficient specialized herd replacement producer could offer high quality replacements at lower costs than are presently being asked for herd replacements.

There would be practically no traffic of herd replacements among the producers interviewed because all are looking for lower priced cattle to buy and are asking higher prices for any cattle they would sell than buyers will pay. The current source of any replacements pruchased is from areas outside of Oklahoma.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The major purposes of this study were to determine efficient workable input coefficients for Grade A milk production in the Oklahoma Metropolitan Milk Marketing Area and to use the coefficients to organize resource use in a manner such that maximum profits can be obtained by the dairy farmer.

The input coefficients were obtained by observing apparently successful Grade A dairies in the area and selecting the most commonly used practices and methods as a basis for linear programming. Linear programming was used to determine optimum farm organization for the various herd sizes studied.

The general characteristics of the dairy farms observed in this study are as follows. Dairymen were found to be producing practically all the roughages needed by their herds, only 15.9 percent of the sample were buying all the hay needed. Fifty percent of the dairymen were purchasing all concentrates needed, 36.5 percent were producing all concentrates needed, and 13.9 percent were producing and buying concentrates. Alfalfa, sorghum silage, and oats were the most commonly used hand-fed feeds. Sudan and rye-vetch pasture were used extensively as pasture crops. Native pasture was used to bridge between the summer and winter cultivated pastures and usually supplied all the grazing for young stock. With very few exceptions herd replacements used were farm produced. Approximately 80 percent of the farms depended entirely upon the family for labor. The other 20 percent were hiring full-time help.

This study examined three factors affecting expansion of farm size. The factors were: (1) initial size, (2) available credit, and (3) available land. Initial farm size influenced production through input efficiency and the quantity of available credit. Larger farms were characterized by lower per unit fixed costs and labor requirements. The value of the business determined the quality of credit available. Without the use of borrowed capital expansion would have been impossible on the farms studied. Either more land or a reorganization of initial land use was needed to make expansion possible. Additional land was obtained through rental. The usual reorganization of initial land involved discontinuing grain production and purchasing what was needed. The released land was planted to pasture and hay to feed the additional dairy cows.

Linear programming showed that the production of roughages on the farms where they were used, was the method contributing most to total profits. Production of herd replacements by the dairy farm would be more profitable than purchasing them in most cases. Most producers would be indifferent toward purchased or produced feed grains. Wage rates reflected that higher quality labor could be hired than was being used. All producers could pay at least $1.40 per hour for labor and some larger producers could pay as much as $2.50 per hour for a responsible hired hand. Many dairymen could increase their incomes from the dairy business through the use of more credit. It was found that about one-fourth of the present situations studied could use capital profitably even at 20 percent interest rates, one-half could profitably use consumer credit costing from 10 to 14 percent interest but the other fourth could profitably use time honored bank rates of six and eight percent only.

Dairy farms of less than 32 cows need to expand to about 60 cows or seek employment in other businesses. Their present levels of income are not as great as they might be if the capital they own were invested in other industries and their labor employed in town. Once expansion of the dairy herd occurs and the operator becomes an established Grade A dairyman, he cannot shift easily from dairy to beef when price changes occur, as Grade C producers do. Fixed costs keep the dairyman in the milk production business unless he chooses to salvage his dairy equipment and change farming businesses entirely.

All adjustments resulting from this study are output increasing. No doubt some dairymen will want to expand their present business and increase output while others will choose to contract or quit entirely. Any expansion by one dairyman would have to be offset by contraction by another to keep surpluses from occurring and/or prices from decreasing. If small producers are better off financially in other businesses then their exit from the dairy industry would allow other producers to expand, which enables them to increase their incomes. Expansions of output by all producers would create surpluses and/or reduce prices under the present market structure. The objectives of the needed adjustments on individual dairy farms are to supply the milk consumers of Oklahoma with a low cost food product and to enable the producers of this product, through maximum efficiency, to obtain the highest possible return from the resources they own.

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APPENDIX A

APPENDIX TABLE A-I

REQUIREMENTS PER COW IN A 20 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	1.9	-	$ -
Silage	-	.67	-	6.7	1.9	.9	11.12
Oats	-	-	-	-	-	.9	-
C.S.M.	-	-	-	-	-	-	16.56
W. Labor	-	-	48.00	-	-	-	-
S. Labor	-	-	-	38.0	-	-	-
Cult. Pasture	-	.86	2.92	2.92	-	-	14.08
Native Pasture	3.7	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	28.71
Per Cow Totals[1]	3.7	1.53	50.92	47.62	1.9	.9	70.47
Replacements[2]	.8	.12	3.36	3.48	.4	.068	16.76
Totals[3]	4.5	1.65	54.28	51.10	2.3	.968	87.23

[1]Coefficients used for P_2 except add $220 per cow to capital for capital requirements.

[2]In order to determine coefficients for P_1 and P_3 take .2 of line 1 totals of Appendix Table A-VII and add to per cow totals.

[3]Coefficients for P_1 except add $200 per cow to capital for capital requirements.

APPENDIX TABLE A-II

REQUIREMENTS PER COW IN A 25 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	1.9	-	$ -
Silage	-	.67	-	6.7	-	-	11.16
Oats	-	-	-	-	-	.93	-
C.S.M.	-	-	-	-	-	-	18.00
W. Labor	-	-	46.00	-	-	-	-
S. Labor	-	-	-	31.0	-	-	-
Cult. Pasture	-	.86	2.92	2.92	-	-	14.18
Native Pasture	3.7	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	28.11
Per Cow Totals[1]	3.7	1.53	48.92	40.62	1.9	.93	71.45
Replacements[2]	.8	.12	3.16	3.37	.4	.068	16.61
Totals[3]	4.5	1.65	52.08	43.99	2.3	.998	88.06

[1] Coefficients used for P_2 except add $220 per cow to capital for capital requirement.

[2] In order to determine coefficients for P_1 and P_3 take .2 of line 1 totals of Appendix Table A-VIII and add to these totals.

[3] Coefficients for P_1 except add $200 per cow to capital for capital requirement.

APPENDIX TABLE A-III

REQUIREMENTS PER COW IN A 32 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	1.9	-	$ -
Silage	-	.67	-	6.7	-	-	11.60
Oats	-	-	-	-	-	.9	-
C.S.M.	-	-	-	-	-	-	18.00
W. Labor	-	-	42.0	-	-	-	-
S. Labor	-	-	-	28.0	-	-	-
Cult. Pasture	-	.86	2.92	2.92	-	-	12.72
Native Pasture	3.7	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	28.46
Per Cow Totals[1]	3.7	1.53	44.92	37.62	1.9	.9	70.78
Replacements[2]	.8	.12	3.18	3.38	.4	.068	16.99
Totals[3]	4.5	1.65	48.10	41.00	2.3	.968	87.77

[1]Coefficients used for P_2 except add $220 per cow to capital for capital requirement.

[2]In order to determine coefficients for P_1 and P_3 take .2 of line 1 totals of Appendix Table A-IX and add to these totals.

[3]Coefficients for P_1 except add $200 per cow to capital for capital requirement.

APPENDIX TABLE A-IV

REQUIREMENTS PER COW IN A 46 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	1.9	-	$ -
Silage	-	.67	-	6.7	-	-	11.64
Oats	-	-	-	-	-	.95	-
C.S.M.	-	-	-	-	-	-	18.00
W. Labor	-	-	36.0	-	-	-	-
S. Labor	-	-	-	24.0	-	-	-
Cult. Pasture	-	.86	2.92	2.92	-	-	14.08
Native Pasture	3.7	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	27.04
Per Cow Totals[1]	3.7	1.53	38.92	33.62	1.9	.95	70.00
Replacements[2]	.8	.12	2.64	3.02	.4	.074	16.57
Totals[3]	4.5	1.65	1.56	36.64	2.3	1.024	87.76

[1]Coefficients used for P_2 except add $220 per cow to capital for capital requirement.

[2]In order to determine coefficients for P_1 and P_3 take .2 of line one totals of Appendix Table A-X and add to these totals.

[3]Coefficients for P_1 except add $200 per cow to capital for capital requirement.

APPENDIX TABLE A-V

REQUIREMENTS PER COW IN A 60 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	1.9	-	$ -
Silage	-	.68	-	6.7	-	-	5.16
Oats	-	-	-	-	-	.91	-
C.S.M.	-	-	-	-	-	-	18.00
W. Labor	-	-	36.0	-	-	-	-
S. Labor	-	-	-	24.0	-	-	-
Cult. Pasture	-	.86	2.92	2.92	-	-	13.96
Native Pasture	3.7	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	25.90
Per Cow Totals[1]	3.7	1.53	38.92	33.62	1.9	.91	63.02
Replacements[2]	.8	.12	2.4	2.86	.4	.076	15.21
Totals[3]	4.5	1.65	41.32	36.48	2.3	.986	78.23

[1]Coefficients used for P_2 except add $220 per cow to capital for capital requirement.

[2]In order to determine coefficients for P_1 and P_3 take .2 of line 1 totals of Appendix Table A-XI and add to those totals.

[3]Coefficients for P_1 except add $200 per cow to capital for capital requirement.

APPENDIX TABLE A-VI

REQUIREMENTS PER COW IN AN 84 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	1.9	-	$ -
Silage	-	.67	-	6.7	-	-	5.12
Oats	-	-	-	-	-	.87	-
C.S.M.	-	-	-	-	-	-	16.56
W. Labor	-	-	36.0	-	-	-	-
S. Labor	-	-	-	24.0	-	-	-
Cult. Pasture	-	.86	2.92	2.92	-	-	13.91
Native Pasture	3.7	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	25.48
Per Cow Totals[1]	3.7	1.53	38.92	33.62	1.9	.86	61.07
Replacements[2]	.8	.12	2.16	2.70	.4	.068	14.95
Totals[3]	4.5	1.65	41.08	35.32	2.3	.938	76.02

[1]Coefficients used for P_2 except add $220 per cow to capital for capital requirement.

[2]In order to determine coefficients for P_1 and P_3 take .2 of line 1 totals of Appendix Table A-XII and add to these totals.

[3]Coefficients for P_1 except add $200 per cow to capital for capital requirement.

APPENDIX TABLE A-VII

REQUIREMENTS PER HERD REPLACEMENT FOR REPLACEMENTS PRODUCED IN A 20 COW HERD BOTH FOR SALE AND FARM USE, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	2	-	$ -
Silage	-	.62	-	6.2	-	-	10.42
Oats	-	-	-	-	-	.34	-
C.S.M.	-	-	-	-	-	-	6.48
W. Labor	-	-	16.8	-	-	-	-
S. Labor	-	-	-	11.2	-	-	-
Native Pasture	4.0	-	-	-	-	-	-
Native Pasture	5.5	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	24.82
Calf	-	-	-	-	-	-	25.00
Milk	-	-	-	-	-	-	17.01
Buildings and Equip.	-	-	-	-	-	-	20.05
Totals[1]	4.0	.62	16.8	17.4	2	.34	83.73
Totals[2]	5.5	.62	16.8	17.4	2	.34	103.78

[1]This line used as coefficients for herd replacements produced for farm use (P_1, P_3).

[2]This line used as coefficients for replacements produced for sale, P_5.

APPENDIX TABLE A-VIII

REQUIREMENTS PER HERD REPLACEMENT FOR REPLACEMENTS PRODUCED IN A 25 COW HERD BOTH FOR SALE AND FARM USE, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	2	-	$ -
Silage	-	.63	-	6.3	-	-	10.46
Oats	-	-	-	-	-	.34	-
C.S.M.	-	-	-	-	-	-	6.48
W. Labor	-	-	15.82	-	-	-	-
S. Labor	-	-	-	10.55	-	-	-
Native Pasture	4.0	-	-	-	-	-	-
Native Pasture	5.5	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	24.81
Calf	-	-	-	-	-	-	25.00
Milk	-	-	-	-	-	-	16.60
Buildings and Equip.	-	-	-	-	-	-	20.05
Totals[1]	4.0	.63	15.82	16.85	2	.34	83.35
Totals[2]	5.5	.63	15.82	16.85	2	.34	103.40

[1]This line used as coefficients for herd replacements produced for farm use (P_1, P_3).

[2]This line used as coefficients for replacements produced for sale, P_5.

APPENDIX TABLE A-IX

REQUIREMENTS PER HERD REPLACEMENT FOR REPLACEMENTS PRODUCED IN A 32 COW HERD BOTH FOR SALE AND FARM USE, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	2	-	$ -
Silage	-	.63	-	6.3	-	-	10.87
Oats	-	-	-	-	-	.34	-
C.S.M.	-	-	-	-	-	-	6.48
W. Labor	-	-	15.9	-	-	-	-
S. Labor	-	-	-	10.6	-	-	-
Native Pasture	4.0	-	-	-	-	-	-
Native Pasture	5.5	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	26.04
Calf	-	-	-	-	-	-	25.00
Milk	-	-	-	-	-	-	16.60
Buildings and Equip.	-	-	-	-	-	-	17.65
Totals[1]	4.0	.63	15.9	16.9	2	.34	84.99
Totals[2]	5.5	.63	15.9	16.9	2	.34	102.64

[1]This line used as coefficients for herd replacement produced for farm use (P_1, P_3).

[2]This line used as coefficients for replacements produced for sale, P_5.

APPENDIX TABLE A-X

REQUIREMENTS PER HERD REPLACEMENT FOR REPLACEMENTS PRODUCED IN A 46 COW HERD BOTH FOR SALE AND FARM USE, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	2	-	$ -
Silage	-	.63	-	6.3	-	-	10.91
Oats	-	-	-	-	-	.37	-
C.S.M.	-	-	-	-	-	-	7.92
W. Labor	-	-	13.20	-	-	-	-
S. Labor	-	-	-	8.8	-	-	-
Native Pasture	4.0	-	-	-	-	-	-
Native Pasture	5.5	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	23.70
Calf	-	-	-	-	-	-	25.00
Milk	-	-	-	-	-	-	15.35
Buildings and Equip.	-	-	-	-	-	-	15.36
Totals[1]	4.0	.63	13.2	15.1	2	.37	82.88
Totals[2]	5.5	.63	13.2	15.1	2	.37	98.24

[1]This line used as coefficients for herd replacements produced for farm use (P_1, P_3).

[2]This line used as coefficients for herd replacements produced for sale, P_5.

APPENDIX TABLE A-XI

REQUIREMENTS PER HERD REPLACEMENT FOR REPLACEMENTS PRODUCED IN A 60 COW HERD BOTH FOR SALE AND FARM USE, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	2	-	$ -
Silage	-	.63	-	6.3	-	-	4.83
Oats	-	-	-	-	-	.38	-
C.S.M.	-	-	-	-	-	-	8.64
W. Labor	-	-	12.0	-	-	-	-
S. Labor	-	-	-	8.0	-	-	-
Native Pasture	4.0	-	-	-	-	-	-
Native Pasture	5.5	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	23.08
Calf	-	-	-	-	-	-	25.00
Milk	-	-	-	-	-	-	14.49
Buildings and Equip.	-	-	-	-	-	-	13.19
Totals[1]	4.0	.63	12.0	14.3	2	.38	76.04
Totals[2]	5.5	.63	12.0	14.3	2	.38	89.23

[1]This line used as coefficients for herd replacements produced for farm use (P_1, P_3).

[2]This line used as coefficients for herd replacements produced for sale, P_5.

APPENDIX TABLE A-XII

REQUIREMENTS PER HERD REPLACEMENT FOR REPLACEMENTS PRODUCED IN AN 84 COW HERD BOTH FOR SALE AND FARM USE, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Items	Native Pasture	Cropland	Winter Labor	Summer Labor	Hay	Oats	Capital
Hay	-	-	-	-	2	-	$ -
Silage	-	.63	-	6.3	-	-	4.80
Oats	-	-	-	-	-	.34	-
C.S.M.	-	-	-	-	-	-	6.48
W. Labor	-	-	10.80	-	-	-	-
S. Labor	-	-	-	7.2	-	-	-
Native Pasture	4.0	-	-	-	-	-	-
Native Pasture	5.5	-	-	-	-	-	-
Supplies & Fees	-	-	-	-	-	-	21.64
Calf	-	-	-	-	-	-	25.00
Milk	-	-	-	-	-	-	16.81
Buildings and Equip.	-	-	-	-	-	-	13.19
Totals[1]	4.0	.63	10.8	13.5	2	.34	74.73
Totals[2]	5.5	.63	10.8	13.5	2	.34	87.92

[1] This line used as coefficients for herd replacements produced for farm use (P_1, P_3).

[2] This line used as coefficients for replacements produced for sale, P_5.

APPENDIX TABLE A-XIII

SELECTED FACTOR COSTS PER UNIT[1] BY FARM SIZE FOR THE DAIRY FARMS STUDIED, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)[2]

Crops	Units	Budget Series					
		20 Cow	25 Cow	32 Cow	46 Cow	60 Cow	84 Cow
Wheat	Bushel	-	.68	.68	.68	.47	-
Alfalfa Hay	Tons	7.42	7.44	7.40	4.33	4.29	4.27
Silage	Tons	2.78	2.79	2.41	3.00	1.29	1.28
Oats	Bushel	.29	.29	.29	.29	.18	.17
Sudan-Pasture	Acre	6.78	6.85	6.78	6.78	6.71	6.68
Rye-Vetch Pasture	Acre	9.60	9.64	8.02	9.60	9.53	9.50

[1] Cost includes expenditures for seed, fertilizer, fuel and custom harvesting where applicable. The other costs including land, labor and equipment are accounted for by the program or included in total fixed costs subtracted from the functional value after an optimum is reached. See Appendix Table B-I to determine whether the harvesting machine is owned by the farm. If not owned, custom harvest rates have been used for that particular crop. See Appendix Table A-XIV for budget coefficients.

[2] Yields and costs were determined by farmer estimates, unpublished material by Capstick, Barr, and Tweeten, Oklahoma State University, and F. M. 92, Section 4, released by USDA. See Appendix Table A-XIV.

APPENDIX TABLE A-XIV

BUDGET COEFFICIENTS[1] AND COSTS FOR SELECTED FACTORS OF CROP PRODUCTION ON DAIRY FARMS, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Crop	Yield	Planting Rate	Seed Cost	10-20-10 Fertilizer Rate[2]	Custom Harvest Rates	Hours Labor Required
Wheat	18 Bu.	1 Bu.	$2.70 Bu.	100 Lbs.	$4.25 Acre	3.4 Acre
Alfalfa[3]	3 Tons	20 Lbs.	.32 Lb.	100 Lbs.	.16 Bale	7.0 Acre
Oats	36 Bu.	2.1 Bu.	1.30 Bu.	50 Lbs.	4.25 Acre	3.4 Acre
Sorghum Silage	6 Tons	7 Lbs.	6.38 Cwt.	100 Lbs.	10.00 Acre	10.0 Acre
Sudan Pasture	--	20 Lbs.	6.28 Cwt.	100 Lbs.	--	3.6 Acre
Rye-Vetch Pasture						
Rye	--	1 Bu.	.17 Lb.	50 Lbs.	--	3.6 Acre
Vetch	--	15 Lbs.	1.85 Bu.			

[1] Selected factor costs in Appendix Table A-XIII are determined from this table.

[2] Fertilizer cost shown in Appendix Table A-XV.

[3] Alfalfa stands last five years. Annual planting rate is five pounds per acre. Thirty bales equal one ton.

APPENDIX TABLE A-XV

PRICE OF INPUTS AND OUTPUTS APPLICABLE TO ALL DAIRYMEN STUDIED IN THE OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Input Costs			Output Prices	
Inputs	Unit	Cost	Product	Unit	Price
Alfalfa Hay	Ton	$22.00	Wheat	Bu.	$ 1.75
Oats	Ton	37.50	Milk (Farm Price)	Cwt.	4.15
Cottonseed Meal	Ton	41.40	Calves (Day Old)	Head	25.00
Fertilizer (10-20-10)	Ton	79.00	Cull Cows	Head	170.00
Gasoline	Gal.	.22	Herd Replacements	Head	200.00
Oil	Gal.	1.08	Alfalfa Hay	Ton	18.00
Herd Replacements	Head	220.00	Oats	Ton	35.00
Milk for Calves	Cwt.	4.15			

APPENDIX B

APPENDIX TABLE B-I

FARM MACHINERY USED BY BUDGET SERIES, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Machinery	Cost Per Unit	Budget Series					
		20 Cow	25 Cow	32 Cow	46 Cow	60 Cow	84 Cow
3-Plow Tractor	$2,623.68			$2,623.68	$2,623.68	$2,623.68	$2,623.68
2-Plow Tractor	2,183.28	$2,183.28	$2,183.28			2,183.28	2,183.28
3-14" Plows	387.45			387.45	387.45	387.45	387.45
2-14" Plows	273.60	273.60	273.60			273.60	273.60
8' Tandem Disk	345.92	345.92	345.92	345.92	345.92	345.92	345.92
Section Harrow (3 sect.)	118.08	118.08	118.08	118.08	118.08	118.08	118.08
Springtooth Harrow "	182.40	182.40	182.40	182.40	182.40	182.40	182.40
Cultivator (2 row)	305.28	305.28	305.40	305.28	305.28	305.28	305.28
Drill (13 x 7)	518.40	518.40	518.40	518.40	518.40	518.40	
Drill (15 x 7)	624.00						624.00
Forage Harvester (row attachment)	1,806.72					1,806.72	1,806.72
Mower 7'	364.00	364.80	364.80	364.80	364.80	364.80	364.80
Side Rake 8'	516.64	516.64	516.64	516.64	516.64	516.68	516.68
Baler (L.E.M.)	2,736.00						2,736.00
(Med. P.T.O.)	2,208.00				2,208.00	2,208.00	
Combine (7' pull)	2,350.40					2,350.00	2,350.00
Sprayer	192.00	192.00	192.00	192.00	192.00	192.00	192.00
Truck, 2-ton	3,000.00					3,000.00	3,000.00
Truck, 1-ton (3/4 dairy)[1]	2,400.00				2,400.00		
Truck, 1/2 ton (1/2 dairy)[1]	2,000.00	1,000.00	1,000.00	1,000.00			
Wagon (4 wheel)	201.60	201.60	201.60	201.60	201.60	403.20	403.20
Scraper Blade (5')	100.00	100.00	100.00	100.00	100.00	120.00	120.00
Manure Loader	384.00	384.00	384.00	384.00	384.00	384.00	384.00
Manure Spreader, 100 bu.	515.00	340.00	340.00	490.00	490.20	515.00	515.00
Grain Auger (16')	67.20					67.20	67.20
Tools & Misc.		240.00	240.00	300.00	400.00	600.00	600.00
		$7,266.00	$7,266.00	$8,030.25	$11,738.89	$19,465.49	$20,099.29

[1]Only one-half charged to the dairy farm operation.

APPENDIX TABLE B-II

SPECIALIZED DAIRY EQUIPMENT USED BY BUDGET SERIES, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Cost Per Unit	Budget Series					
		20 Cow	25 Cow	32 Cow	46 Cow	60 Cow	84 Cow
Bulk Tank							
250 gal.	$2,078.84	$2,078.84	$2,078.84				
375 gal.	2,750.00			$2,750.00			
400 gal.	2,704.58						
500 gal.	3,150.00				$3,150.00		
600 gal.	3,481.33						
700 gal.	3,570.00					$3,570.00	
800 gal.	3,912.50						
900 gal.	4,115.00						$4,115.00
1,000 gal.	4,379.66						
Water Heater							
30 gal.	89.95	89.95	89.95	89.95			
40 gal.	102.50				102.50		
50 gal.	114.95					114.95	
80 gal.	152.95						152.95
100 gal.	189.95						
Stainless Steel Vats	82.50	82.50	82.50	82.50	82.50	82.50	82.50
Pipe Line (foot)	18.75	450.00	450.00	562.50	750.00	750.00	750.00
Releaser	260.00	260.00	260.00	260.00	260.00	260.00	260.00
Washer	150.00			150.00	150.00	150.00	150.00
Milkers							
2-claw, pump & motor	250.00	250.00	250.00				
3-claw, pump & motor	283.50			283.50			
4-claw, pump & motor	326.00				326.00	326.00	326.00
5-claw, pump & motor	418.50						
Stalls (factory-made)	225.00	450.00	450.00	675.00	900.00	900.00	900.00
		$3,661.29	$3,661.29	$4,853.45	$5,721.00	$6,153.45	$6,736.42

APPENDIX TABLE B-III

FARMSTEAD BUILDINGS USED BY BUDGET SERIES, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Number of Cows	Cost Per Unit	Budget Series 20 Cow	25 Cow	32 Cow	46 Cow	60 Cow	84 Cow
Milking Barns[1]								
2-stall Parlor	20-30	$2,000.00	$2,000.00	$2,000.00				
3-stall Parlor	31-43	2,475.00			$2,475.00			
4-stall Parlor	46-92	2,700.00				$2,700.00	$2,700.00	$2,700.00
Holding Pens[2]		22.85	160.00	160.00	187.37	250.00	250.00	250.00
Fences, Gates, & Corrals			300.00	300.00	325.00	350.00	350.00	350.00
Shelter & Shade			500.00	500.00	600.00	600.00	700.00	700.00
Calf Housing[3]		20.00	200.00	200.00	320.00	500.00	500.00	500.00
Machine Shed[4]			500.00	500.00	500.00	700.00	1,100.00	1,100.00
Grain Storage[5]			730.00	730.00	1,540.00	1,220.00	2,400.00	2,400.00
Hay Storage[6]			500.00	500.00	600.00	700.00	970.00	970.00
Hay Feeders		120.00	120.00	120.00	240.00	360.00	360.00	360.00
Silo[7]			120.00	120.00	150.00	170.00	220.00	220.00
Silage Bunks		$50.00	75.00	75.00	150.00	200.00	250.00	250.00
			$5,305.00	$5,305.00	$6,703.37	$7,750.00	$9,540.00	$9,540.00

[1]Includes milkroom, feedroom, and elevated stalls.

[2]Concrete slabs, four inches thick; units used are yd.^{3}

[3]Individual pens.

[4]Estimated for each operation.

[5]Metal cribs adequate to hold enough grain produced on the farm to feed the dairy herd for one year.

[6]Pole sheds adequate to hold enough hay produced on the farm to feed the dairy herd for one year.

[7]Trench silo adequate to hold enough silage to feed the dairy herd for one year.

APPENDIX TABLE B-IV

FIXED COSTS OF OWNING AND OPERATING FARM CROP PRODUCING MACHINERY

Machine	Depreciation[1]	Repairs[2]	Taxes[3]	Insurance[4]	Total[5]
Tractor 3 Plow	$236.17	$91.82	$19.41	$16.79	$364.19
Tractor 2 Plow	196.49	76.41	16.15	13.97	303.02
3-14" Plow	34.87	27.12	2.71	2.47	67.17
2-14" Plow	24.62	19.15	2.02	1.75	47.54
8' Disk	31.03	10.37	2.55	2.20	46.15
Spk. Harrow	16.41	18.24	1.34	1.16	37.15
Spr. Harrow	10.62	11.80	.87	.75	24.04
Cultivator	27.47	10.68	2.26	1.95	42.36
Drill	56.16	9.36	4.61	3.99	74.12
Forage Harvester	162.61	72.27	13.36	11.62	259.86
7' Mower	32.83	12.77	2.70	2.34	50.64
Side Rake	46.49	10.33	3.82	3.31	63.95
Baler	246.24	82.08	20.25	17.51	366.08
7' Combine	211.50	70.50	17.39	15.04	314.43
Grain Auger	6.03	1.34	.50	.43	8.30
2-4 Wheel Wagons	36.28	6.05	3.05	2.64	48.02

[1] Trade in value equals 10 percent of original cost. The remaining value is divided equally over a 10-year period and appears in this column.

[2] Calculated as percent of new cost. Table XI, page 24, Kansas Experimental Station Bulletin 74.

[3] Taxes computed as .74 percent of new cost, Oklahoma Experimental Station Bulletin 473, Tucker, Walker, and Jeffrey, July, 1956.

[4] Insurance computed as .64 percent of new cost (Ibid.).

[5] Sum of depreciation, repairs, taxes, and insurance.

APPENDIX TABLE B-V

FIXED COSTS OF OWNING MACHINERY USED PRIMARILY WITH THE DAIRY ENTERPRISE

Machine	Depreciation	Repairs	Taxes	Insurance	Total
Sprayer	$ 17.28	$ 9.60	$ 1.42	$ 1.22	$ 29.52
Truck, 2 Ton	360.00[1]	130.00	50.30	80.00	620.30
Truck, 3/4 Ton	240.00	75.00	21.10	35.00	371.10
Truck, 1/2 Ton[2]	164.00	51.40	10.00	2.46	47.54
Scraper	10.80	2.40	.88	.76	14.84
Manure Loader	34.56	7.68	2.84	2.46	47.54
Manure Spreader	46.35	7.72	3.81	3.29	61.17
Tools and Misc.[3]	-------------10 percent of investment cost---------				

[1] Truck life is considered to be five years. Salvage value is equal to trade-in value at that time.

[2] One-half ton truck is considered to be used only half time for dairy. The other time it is used by the family.

[3] See Appendix Table B-I for investment by herd size studied.

APPENDIX TABLE B-VI

CHANGES IN INVESTMENT OF FARM MACHINERY, SPECIALIZED DAIRY EQUIPMENT AND BUILDINGS FOR CHANGES IN HERD SIZE, OKLAHOMA METROPOLITAN MILK MARKETING AREA, (1958)

Herd Size Changes	Maximum Existing Capacity	Farm Machinery	Dairy Equipment	Buildings	Total	No. Cows Added	Cost Per Cow
20-32	27	$ 764.25	$ 1,192.16	$ 1,428.37	$ 3,384.78	5	$676.95
20-46	27	4,472.89	2,059.71	2,445.00	8,977.60	19	472.50
20-60	27	12,199.73	2,492.16	4,235.00	18,926.89	33	573.54
20-84	27	12,833.29	3,075.13	4,235.00	20,143.42	57	353.39
25-32	25	764.25	1,192.16	1,428.37	3,384.78	7	483.54
25-46	25	4,472.89	2,059.71	2,445.00	8,977.60	21	384.64
25-60	25	12,199.73	2,492.16	4,235.00	18,926.89	35	540.76
25-84	25	12,833.29	3,075.13	4,235.00	20,143.42	59	341.41
32-46	33	3,708.64	867.55	1,056.63	5,632.82	14	402.34
32-60	33	11,435.48	1,300.00	2,806.63	15,542.11	28	555.07
32-84	33	12,069.04	1,882.97	2,806.63	16,758.64	51	328.60
46-60	46	7,726.84	432.45	1,790.00	9,949.29	14	710.63
46-84	46	8,360.40	1,015.42	1.790.00	11,165.82	38	293.83
60-84	64	633.56	582.97	0	1,216.53	20	60.82
60-100	64	633.56	847.57	644.00	2,125.13	34	62.50
60-200	64	3,394.36	6,648.97	3,284.00	13,327.33	136	98.00
84-100	88	0	264.60	0	264.60	12	22.05
84-200	88	2,760.80	5,801.40	2,640.00	11,202.20	112	100.00

APPENDIX C

APPENDIX C

This appendix contains part of the initial tableau of each program run for each herd size studied. The first row of figures in each table from C-II through C-VII contains the c_j for each process in the tableau. Table C-I identifies each process and gives the units by which it is measured. The remaining rows are linear equations governing resource use.

Tables C-II through C-VII are complete in every way except for the P_o column or resource supply and the identity section of the matrix. Table C-VIII supplies this information for all resource combinations considered in this thesis. For case number identification refer to Appendix Table D-I. For any case desired the column under that case heading is placed intact in front of the appropriate tableau making that tableau complete with resources and requirements. The code system explained in Appendix Table D-I will be of aid in the resource combinations shown in Table C-VIII. The identity is supplied by the program used for machine computation. For desk calculation an identity matrix would be required.

The resource columns in Table C-VIII identify each individual resource. The idle process for the resource is given also ranging from P_{26} (idle native pasture) to P_{41} (idle cropland available for rent).

APPENDIX TABLE C-I

IDENTIFICATION OF PROCESSES USED IN THE STUDY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

Process	Units	Activity
P_1	Cwt.	Produce milk with farm produced replacements.
P_2	Cwt.	Produce milk with purchased replacements.
P_3	Cwt.	Expand milk production with farm produced replacements.
P_4	Cwt.	Expand milk production with purchased replacements.
P_5	Head	Produce and sell one springing heifer for herd replacement.
P_6	Ton	Produce alfalfa hay for dairy feeding purposes.
P_7	Ton	Buy alfalfa hay for dairy feeding purposes.
P_8	Ton	Produce oats for dairy feeding purposes.
P_9	Ton	Buy oats for dairy feeding purposes.
P_{10}	Hour	Hire winter labor.
P_{11}	Hour	Hire summer labor.
P_{12}	Hour	Operator work off farm during winter.
P_{13}	Hour	Operator work off farm during summer.
P_{14}	Acre	Rent in native pasture.
P_{15}	Acre	Rent in cropland
P_{16}	Acre	Rent out native pasture.
P_{17}	Acre	Rent out cropland.
P_{18}	Acre	Transfer 1/3 acre cropland to native pasture equivalents.
P_{19}	Acre	Produce wheat.
P_{20}	Acre	Transfer wheat allotment to cropland for dairy use.
P_{21}-P_{25}	Dollars	Capital transfer activities.
P_{26}-P_{33}	Dollars	Idle farm resource activities.
P_{34}-P_{38}	Dollars	Allow available credit to go unused.
P_{39}	Dollars	Idle equipment capacity.
P_{40}-P_{41}	Dollars	Idle land rent activities.

APPENDIX TABLE C-II

INPUT REQUIREMENTS, PRODUCTION RATES AND EXPECTED REVENUES OR COSTS FOR THE ACTIVITIES CONSIDERED FOR THE 20 COW HERD[1], OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}
345.27	318.03	231.32	203.04	113.17	-7.42	-22.00	-18.12	-37.50	-1.00	-1.25	.70	.95	-3.00	-7.00	3.00	7.00	-5.59	0	0	- 6.00	- 8.00	-12.00	-16.00	-20.00
4.5	3.7	4.5	3.7	5.5									-1.00		1.00		-1.00							
1.65	1.53	1.65	1.53	.62	.33		1.32							-1.00		1.00	.33		-1					
0																		0	1					
54.28	50.92	54.28	50.92	16.8					-1.00		1.00													
51.10	47.62	51.10	47.62	17.4	2.33		4.48			-1.00		1.00					1.2	0						
2.3	1.9	2.3	1.9	2.0	-1.00	- 1.00																		
.968	.9	.968	.9	.34			-1.00	- 1.00																
287.23	290.47	759.73	762.97	103.78	7.42	22.00	18.12	1.44	1.00	1.25	-.70	-.95	3.00	7.00	-3.00	-7.00	5.59	0	0	-100.00	-100.00	-100.00	-100.00	-100.00
																				100.00				
																					100.00			
																						100.00		
																							100.00	
																								100.00
1.0	1.0																							
													1.00											
														1.00										

[1] Supplies for this set of equations are found in Table C-VIII (Cases 11, 12, 14, 15).

APPENDIX TABLE C-III

INPUT REQUIREMENTS, PRODUCTION RATES AND EXPECTED REVENUES OR COSTS FOR THE ACTIVITIES CONSIDERED FOR THE 25 COW HERD[1], OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}
361.04	333.65	296.92	269.53	113.65	-7.44	-22.00	-18.12	37.50	-1.00	-1.25	.70	.95	-3.00	-7.00	3.00	7.00	-5.61	19.26	0	- 6.00	- 8.00	- 12.00	-16.00	-20.00
4.5	3.7	4.5	3.7	5.5									-1.00		1.00		-1.00							
1.65	1.53	1.65	1.53	.63	.33		1.32							-1.00		1.00	.33		-1					
																		1.00	1					
52.08	48.92	52.08	48.92	15.82					-1.00	1.00														
43.99	40.62	43.99	40.62	16.85	2.33		4.48			-1.00		1.00					1.2	3.4						
2.3	1.9	2.3	1.9	2.0	-1.00	- 1.00																		
.998	.93	.998	.93	.34			-1.00	- 1.00																
288.06	291.45	715.56	718.95	103.40	7.44	22.00	18.12	1.44	1.00	1.25	-.70	-.95	3.00	7.00	-3.00	-7.00	5.61	12.22	0	-100.00	-100.00	-100.00	-100.00	-100.00
																				100.00				
																					100.00			
																						100.00		
																							100.00	
																								100.00
1.00	1.00																							
													1.00											
														1.00										

[1]Supplies for this set of equations are found in Table C-VIII (Cases 21, 22, 24, 25).

APPENDIX TABLE C-IV

INPUT REQUIREMENTS, PRODUCTION RATES AND EXPECTED REVENUES OR COSTS FOR THE ACTIVITIES CONSIDERED FOR THE 32 COW HERD[1], OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}
369.43	342.62	311.91	284.90	112.34	-7.40	-22.00	-18.12	-37.50	-1.00	-1.25	.70	.95	-3.00	-7.00	3.00	7.00	-4.93	19.26	0	- 6.00	- 8.00	- 12.00	- 16.00	- 20.00
4.5	3.7	4.5	3.7	5.5	0								-1.00		1.00		-1.00							
1.66	1.53	1.66	1.53	.63	.33		1.32							-1.00		1.00	.33		-1					
0	0	0	0	0	0												0	1	1					
48.02	44.92	48.02	44.92	15.9					-1.00		1.00						0							
41.00	37.62	41.00	41.00	16.9	2.33		4.48			-1.00		1.00					1.2	3.4						
2.3	1.9	2.3	1.9	2.0	-1.00	- 1.00											0							
.968	.9	.968	.9	.34	0		- 1.00	- 1.00									0							
287.73	290.78	672.62	675.63	102.64	7.40	22.00	18.12	1.44	1.00	1.25	- .70	- .95	3.00	7.00	-3.00	-7.00	4.93	12.26	0	-100.00	-100.00	-100.00	-100.00	-100.00
																				100.00				
																					100.00			
																						100.00		
																							100.00	
																								100.00
1.00	1.00																							
													1.00											
														1.00										

[1] Supplies for this set of equations are found in Table C-VIII (Cases 31, 32, 34, 35).

APPENDIX TABLE C-V

INPUT REQUIREMENTS, PRODUCTION RATES AND EXPECTED REVENUES OR COSTS FOR THE ACTIVITIES CONSIDERED FOR THE 46 COW HERD[1], OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}
370.07	342.64	326.00	298.57	114.81	-4.33	-22.00	-18.12	-37.50	-1.00	-1.25	.70	.95	-3.00	-7.00	3.00	7.00	-5.54	19.26	0	- 6.00	- 8.00	- 12.00	- 16.00	- 20.00
4.5	3.7	4.5	3.7	5.5									-1.00		1.00		-1.00							
1.65	1.53	1.65	1.53	.63	.33		1.32							-1.00		1.00	.33		-1					
																		1.00	1.00					
41.56	38.92	41.56	38.92	13.2					-1.00		1.00													
36.64	33.62	36.64	33.62	15.1	2.33		4.48			-1.00		1.00					1.2	3.4						
2.3	1.9	2.3	1.9	2.0	-1.00	- 1.00																		
1.024	.95	1.024	.95	.37			-1.00	- 1.00																
287.33	290.76	581.59	584.59	98.24	4.33	22.00	18.12	1.44	1.00	1.25	-.70	-.95	3.00	7.00	-3.00	-7.00	5.54	12.22	0	-100.00	-100.00	-100.00	-100.00	-100.00
																				100.00				
																					100.00			
																						100.00		
																							100.00	
																								100.00
1.00	1.00																							
													1.00											
														1.00										

[1]Supplies for this set of equations are found in Table C-VIII (Cases 41, 42, 44, 45).

APPENDIX TABLE C-VII

INPUT REQUIREMENTS, PRODUCTION RATES AND EXPECTED REVENUES OR COSTS FOR THE ACTIVITIES CONSIDERED FOR THE [illegible] COW HERD[1], OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}
365.79	337.00	350.79	322.00	121.98	-4.29	-22.00	-11.25	-37.50	-1.00	-1.25	.70	.95	-3.00	-7.00	3.00	7.00	-5.54	23.04	0	- 6.00	- 8.00	-12.00	-16.00	-20.00
4.5	3.7	4.5	3.7	5.5									-1.00		1.00		-1.00							
1.65	1.53	1.65	1.53	.63	.33		1.32							-1.00		1.00	.33		-1					
																		1.00	1					
41.32	38.92	41.32	38.92	12.0					-1.00		1.00													
36.48	33.62	36.48	33.62	14.3	2.33		4.48			-1.00		1.00					1.2	3.4						
2.3	1.9	2.3	1.9	2.0	-1.00	-1.00																		
.986	.91	.986	.91	.38		-1.00	-1.00																	
278.23	283.02	378.23	383.02	89.23	4.29	22.00	11.25	1.44	1.00	1.25	-.70	-.95	3.00	7.00	-3.00	-7.00	5.54	8.45	0	-100.00	-100.00	-100.00	-100.00	-100.00
																				100.00				
																					100.00			
																						100.00		
																							100.00	
																								100.00
1.00	1.00																							
													1.00											
														1.00										

[1]Supplies for this set of equations are found in Table C-VIII (Cases 51, 52, 54, 55).

APPENDIX TABLE C-VII

INPUT REQUIREMENTS, PRODUCTION RATES AND EXPECTED REVENUES OR COSTS FOR THE ACTIVITIES CONSIDERED FOR THE 64 COW HERD[1], OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}
348.18	319.13	341.86	304.13	123.29	-4.27	-22	-10.62	-37.50	-1.00	-1.25	.70	.95	-3.00	-7.00	1.00	7.00	-5.39			-6.00	-8.00	-12.00	-16.00	-20.00
4.5	3.7	4.5	3.7	5.5									-1.00				-1.00							
1.65	1.53	1.65	1.53	.63	.33		1.32							-1.00		1.00	.33							
41.08	38.92	41.98	38.92	10.8					-1.00		1.00													
35.32	33.62	35.32	33.62	13.5	2.33		4.48			-1.00		1.00					1.2							
2.3	1.9	2.3	1.9	2.0	-1.00	-1.00																		
.938	.87	.938	.87	.34			-1.00	-1.00																
276.02	281.07	376.02	381.07	87.92	4.27	22.	10.62	1.44	1.00	1.25	-.70	-.95	3.00	7.00	-3.00	-7.00	5.39			-100.00	-100.00	-100.00	-100.00	-100.00
																				100.00				
																					100.00			
																						100.00		
																							100.00	
																								100.00
1.00	1.00																							
													1.00											
														1.00										

[1]Supplies for this set of equations are found in Table C-VIII (Cases 1, 2, 4, 5).

APPENDIX TABLE C-VIII

RESOURCE SUPPLY[1] FOR EACH CASE PROGRAMMED OKLAHOMA
METROPOLITAN MILK MARKETING AREA 1958

Resources		Case Numbers																							
		11	12	14	15	21	22	24	25	31	32	34	35	41	42	44	45	51	52	54	55	61	62	64	65
Native Pasture	P_{26}	60	60	60	60	148	148	148	148	140	140	140	140	200	200	200	200	180	180	180	180	240	240	240	240
Cropland	P_{27}	100	100	100	100	114	114	114	114	200	200	200	200	274	274	274	274	320	320	320	320	440	440	440	440
Wheat Allotment	P_{28}	0	0	0	0	18	18	18	18	40	40	40	40	26	26	26	26	40	40	40	40	0	0	0	0
Winter Labor	P_{29}	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Summer Labor	P_{30}	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Hay	P_{31}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oats	P_{32}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capital	P_{33}	6448	6448	6448	6448	8005	8005	8005	8005	11480	11480	11480	11480	16028	16028	16028	16028	21030	21030	21030	21030	29637	29637	29637	29637
Borrow 6% Capital	P_{34}	0	0	8927	8927	0	0	13303	13303	0	0	22920	22920	0	0	25543	25543	0	0	29107	29107	0	0	34560	34560
Borrow 8% Capital	P_{35}	2020	2020	6350	6350	3221	3221	6950	6950	6287	6287	8694	8694	4735	4735	11722	11722	5256	5256	13688	13688	5630	5630	19200	19200
Borrow 12% Capital	P_{36}	1472	1472	1812	1812	1472	1472	1812	1812	1641	1641	2020	2020	2341	2341	2882	2882	2351	2351	2894	2894	4212	4212	5184	5184
Borrow 16% Capital	P_{37}	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Borrow 20% Capital	P_{38}	1000	1000	2000	2000	1000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1000	1000	1000	1000	1000	1000	1000	1000
Maximum Herd Size[2]	P_{39}	27	27	27	27	25	25	25	25	33	33	33	33	46	46	46	46	64	64	64	64	88	88	88	88
Rent Native Pasture	P_{40}	60	0	60	0	148	0	148	0	140	0	140	0	200	0	200	0	180	0	180	0	240	0	240	0
Rent Cropland	P_{41}	100	0	100	0	114	0	114	0	200	0	200	0	274	0	274	0	320	0	320	0	440	0	440	0

[1]Two land and two capital situations for each herd size programmed.

[2]Maximum herd size for existing equipment.

APPENDIX D

APPENDIX TABLE D-I

IDENTIFICATION OF CASES[1] USED IN THE STUDY, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Equity					
	60 Percent			90 Percent		
Herd Size	Initial Situation	Land Rent in Opportunities	No Land Rent in Opportunities	Initial Situation	Land Rent in Opportunities	No Land Rent in Opportunities
20	10	11	12	13	14	15
25	20	21	22	23	24	25
32	30	31	32	33	34	35
46	40	41	42	43	44	45
60	50	51	52	53	54	55
84	60	61	62	63	64	65

[1] The identification code numbers have two digits each of which has a separate meaning. The first digit refers to herd size and is read vertically in the above table, from one through six. The second digit refers to various situations within a herd size and is read from zero through five horizontally.

Case numbers are used for identification in the tables and text of Chapter IV and Appendix Tables D-II through D-VII. Appendix Table D-I will aid the reader in locating and identifying information for various herd sizes, and capital and land situations.

APPENDIX TABLE D-II

INITIAL SITUATIONS AND PROGRAMMED OPTIMA FOR THE 20 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Case					
	10	11	12	13	14	15
P_1	20.00	27.00	27.00	20.00	27.00	27.00
P_2						
P_3						
P_4						
P_5						
P_6	46.00	62.10	62.10	46.00	62.10	62.10
P_7						
P_8	19.30	26.10	11.10	19.30	26.10	11.10
P_9			15.00			15.00
P_{10}						
P_{11}		143.28	148.00		143.28	148.00
P_{12}		34.40	34.40		34.40	34.40
P_{13}						
P_{14}		60.00			60.00	
P_{15}						
P_{16}						
P_{17}	16.20			16.20		
P_{18}	30.00	1.50	61.50	30.00	1.50	61.50
P_{19}						
P_{20}						
P_{21}*	9,356.76	9,356.75	9,356.75	3,236.43	5,821.32	5,731.63
P_{22}*	3,588.99	5,609.00	5,609.00			
P_{23}		564.89	475.00			
P_{24}						
P_{25}						
P_{34}				8,927.00	6,342.10	6,431.70
P_{35}	2,020.00			6,350.00	6,350.00	6,350.00
P_{36}	1,472.00	907.10	996.79	1,812.00	1,812.00	1,812.00
P_{37}	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
P_{38}	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
P_{39}	7.00					
P_{40}	60.00			60.00		
P_{41}	100.00	100.00		100.00	100.00	
Income	5,311.53	6,966.37	6,524.90	5,965.89	7,695.00	7,248.22
Total Fixed Costs**	2,149.41	2,149.41	2,149.41	2,149.41	2,149.41	2,149.41
Net Farm Income	3,162.12	4,816.96	4,375.49	3,816.46	5,545.59	5,098.80

*The level of activities P_{21} and P_{22} for each case programmed has been increased by the amount of the debt of the initial capital situation since each program is a change from either a 60 percent equity situation or a 90 percent equity situation. See Appendix Table D-I for land and capital situations, and C-VIII for land and capital supplies.

**Fixed costs on original equipment. See Appendix Table B-IV.

APPENDIX TABLE D-III

INITIAL SITUATIONS AND PROGRAMMED OPTIMA FOR THE 25 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Case					
	20	21	22	23	24	25
P_1	25.00	25.00	25.00	25.00	25.00	25.00
P_2						
P_3		4.00	3.00		23.00	16.00
P_4						
P_5						
P_6	57.50	66.70	64.40	57.50	110.40	94.30
P_7						
P_8	24.90	28.90	27.90	24.90	47.90	
P_9						40.90
P_{10}		10.00			999.80	635.30
P_{11}		1,121.70	68.00		1,144.50	628.30
P_{12}			42.00			
P_{13}						
P_{14}					68.00	
P_{15}					66.80	
P_{16}	36.00	17.50	12.00			
P_{17}	20.80	6.00	9.80	26.80		
P_{18}						36.50
P_{19}	18.00	18.00	18.00	18.00	18.00	18.00
P_{20}						
P_{21}*	13,476.75	13,476.75	13,476.75	4,216.17	17,519.17	17,466.80
P_{22}*	2,987.94	6,353.47	5,620.05		7,361.97	
P_{23}						
P_{24}						
P_{25}						
P_{34}				13,303.60		52.37
P_{35}	3,221.00		588.89	6,950.10		6,950.00
P_{36}	1,472.00	1,327.00	1,472.00	1,812.00	1,400.03	1,812.00
P_{37}	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
P_{38}	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
P_{39}						
P_{40}	148.00	148.00		148.00	80.00	
P_{41}	114.00	114.00		114.00		
Income	7,699.65	8,155.93	8,099.54	8,404.32	9,917.62	9,214.61
Total Fixed Costs**	2,260.41	2,260.41	2,260.41	2,260.41	2,260.41	2,260.41
Net Farm Income	5,439.24	5,895.52	5,839.13	6,145.90	7,547.21	6,954.20

*The level of activities P_{21} and P_{22} for each case programmed has been increased by the amount of the debt of the initial capital situation since each program is a change from either a 60 percent equity situation or a 90 percent equity situation. See Appendix Table D-I for land and capital situations, and C-VIII for land and capital supplies.

**Fixed costs on original equipment. See Appendix Table B-IV.

APPENDIX TABLE D-IV

INITIAL SITUATIONS AND PROGRAMMED OPTIMA FOR THE 32 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Case					
	30	31	32	33	34	35
P_1	32.00	33.00	33.00	32.00	33.00	
P_2						33.00
P_3		11.00	7.00		37.00	40.00
P_4						
P_5						
P_6	73.50	101.00	92.00	73.50	161.00	157.70
P_7						
P_8	30.90		38.70	30.90	67.76	
P_9		42.60				68.40
P_{10}		613.00	420.80		1,861.40	1,093.50
P_{11}	500.00	675.50	711.73	500.00	2,226.70	2,008.00
P_{12}						
P_{13}						
P_{14}		58.00			140.00	
P_{15}					70.30	
P_{16}						
P_{17}	80.00	93.60	39.00	80.00		
P_{18}	4.00		40.00	4.00	35.00	162.00
P_{19}	40.00	40.00	40.00	40.00	40.00	19.00
P_{20}						21.00
P_{21}*	22,661.05	22,661.05	22,661.05	6,539.56	29,459.56	29,459.56
P_{22}*	1,497.68	7,784.68	7,327.57		8,602.37	8,810.40
P_{23}		1,401.51				
P_{24}						
P_{25}						
P_{34}				22,920.00		
P_{35}	6,287.00		457.11	8,694.00	9,160.00	
P_{36}	1,641.20	239.51	1,641.00	2,020.00	2,020.00	1,092.60
P_{37}	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
P_{38}	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
P_{39}	1.00			1.00		
P_{40}	140.00	82.00		140.00		
P_{41}	200.00	200.00		200.00	129.70	
Income	9,934.15	10,920.91	10,697.36	11,011.25	13,898.39	12,732.25
Total Fixed Costs**	2,739.82	2,739.82	2,739.82	2,739.82	2,739.82	2,739.82
Net Farm Income	7,184.33	8,181.09	7,957.54	8,271.43	11,158.57	9,992.43

*The level of activities P_{21} and P_{22} for each case programmed has been increased by the amount of the debt of the initial capital situation since each program is a change from either a 60 percent equity situation or a 90 percent equity situation. See Appendix Table D-I for land and capital situations, and C-VIII for land and capital supplies.

**Fixed costs on original equipment. See Appendix Table B-IV.

APPENDIX TABLE D-V

INITIAL SITUATIONS AND PROGRAMMED OPTIMA FOR THE 46 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Case					
	40	41	42	43	44	45
P_1	46.00	46.00	46.00	46.00	46.00	22.00
P_2						24.00
P_3		16.00	14.00		60.00	
P_4						59.00
P_5						
P_6	105.80	142.60	138.00	105.80	243.80	208.30
P_7						
P_8	47.10			47.10		
P_9		63.49	61.44		108.54	101.38
P_{10}	412.00	1,076.72	993.60	412.00	2,905.36	2,644.68
P_{11}	644.00	1,192.34	1,192.34	644.00	3,132.69	2,829.20
P_{12}						
P_{13}						
P_{14}		79.00			200.00	
P_{15}					6.76	
P_{16}						
P_{17}	72.30	125.64	106.36	72.30		
P_{18}	2.30		70.00	2.30	77.00	206.10
P_{19}	26.00	26.00	26.00	26.00	26.00	
P_{20}						26.00
P_{21}*	25,712.50	25,712.50	25,712.50	7,883.35	33,426.35	33,426.35
P_{22}*	5,820.89	10,555.89	10,555.89		11,722.00	11,722.00
P_{23}		2,341.00	2,341.00		2,882.00	2,868.21
P_{24}		2,000.00	1,386.48		1,362.37	
P_{25}		369.89				
P_{34}				25,542.90		
P_{35}	5,376.84			11,722.00		
P_{36}	2,341.34			2,882.00		13.79
P_{37}	2,000.00		613.52	2,000.00	637.63	2,000.00
P_{38}	1,000.00	630.11	1,000.00	1,000.00	1,000.00	1,000.00
P_{39}						
P_{40}	200.00	121.00		200.00		
P_{41}	274.00	274.00		274.00	274.24	
Income	13,480.35	14,754.86	14,169.16	15,015.77	20,555.49	18,666.34
Total Fixed Costs**	3,547.19	3,547.19	3,547.19	3,547.19	3,547.19	3,547.19
Net Farm Income	9,933.16	11,207.67	10,621.97	11,468.58	17,008.60	15,089.43

*The level of activities P_{21} and P_{22} for each case programmed has been increased by the amount of the debt of the initial capital situation since each program is a change from either a 60 percent equity situation or a 90 percent equity situation. See Appendix Table D-I for land and capital situations, and C-VIII for land and capital supplies.

**Fixed costs on original equipment. See Appendix Table B-IV.

APPENDIX TABLE D-VI

INITIAL SITUATIONS AND PROGRAMMED OPTIMA FOR THE 60 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	50	51	52	53	54	55
P_1	60.00	64.00	64.00	60.00	64.00	64.00
P_2						
P_3		17.00	16.00		84.00	
P_4						50.00
P_5						
P_6	138.00	186.30	184.00	138.00	340.40	242.20
P_7						
P_8	59.10	79.87	50.21	59.10	135.63	
P_9			28.67		10.30	108.60
P_{10}	979.20	1,846.92	1,805.60	979.20	4,615.68	3,090.48
P_{11}	1,519.11	2,388.18	2,424.06	1,519.11	5,802.99	3,431.65
P_{12}						
P_{13}						
P_{14}		180.00			180.00	
P_{15}					316.50	
P_{16}						
P_{17}	67.45	13.91		67.45		
P_{18}	90.00	4.50	180.00	90.00	306.00	293.00
P_{19}	40.00	40.00	40.00	40.00	40.00	
P_{20}						40.00
P_{21}*	29,438.00	29,438.00	29,438.00	9,163.51	38,270.51	35,289.84
P_{22}*	7,215.03	12,471.03	12,471.03		13,688.00	
P_{23}		2,351.00	2,351.00		2,894.00	
P_{24}		2,000.00	2,000.00		2,000.00	
P_{25}		935.02	787.71		518.11	
P_{34}				29,107.19		2,980.67
P_{35}	5,256.16			13,688.00		13,688.00
P_{36}	2,351.38			2,894.00		2,894.00
P_{37}	2,000.00			2,000.00		2,000.00
P_{38}	1,000.00	64.98	212.29	1,000.00	481.89	1,000.00
P_{39}	4.00			4.00		
P_{40}	180.00			180.00		
P_{41}	320.00	320.00		320.00	3.50	
Income	16,363.96	19,744.98	18,149.03	18,157.76	29,943.79	23,278.37
Total Fixed Costs**	4,972.00	4,972.00	4,972.00	4,972.00	4,972.00	4,972.00
Net Farm Income	11,391.96	14,772.98	13,177.03	13,185.76	24,971.79	18,306.37

*The level of activities P_{21} and P_{22} for each case programmed has been increased by the amount of the debt of the initial capital situation since each program is a change from either a 60 percent equity situation or a 90 percent equity situation. See Appendix Table D-I for land and capital situations, and C-VIII for land and capital supplies.

**Fixed costs on original equipment. See Appendix Table B-IV.

APPENDIX TABLE D-VII

INITIAL SITUATIONS AND PROGRAMMED OPTIMA FOR THE 84 COW HERD, OKLAHOMA METROPOLITAN MILK MARKETING AREA (1958)

	Case					
	60	61	62	63	64	65
P_1	84.00	88.00	88.00	84.00	88.00	
P_2						88.00
P_3		21.00	20.00		109.00	57.00
P_4						
P_5						
P_6	193.20	250.70	248.40	193.20	453.10	298.30
P_7						
P_8	78.80	102.24	74.04	78.80	184.79	
P_9			27.26			130.03
P_{10}	1,950.70	2,977.72	2,936.64	1,950.70	6,592.76	4,266.52
P_{11}	2,435.60	3,404.65	3,520.23	2,435.60	7,829.42	4,577.36
P_{12}						
P_{13}						
P_{14}		240.00			240.00	
P_{15}					412.64	
P_{16}						
P_{17}	88.10	39.00		88.10		
P_{18}	138.00	10.50	246.00	138.00	406.50	342.10
P_{19}						
P_{20}						
P_{21}*	35,739.00	35,739.00	37,739.00	11,899.29	46,459.29	41,722.83
P_{22}*	11,858.16	17,488.16	17,488.16		19,200.00	
P_{23}		4,212.00	4,212.00		5,184.00	
P_{24}		2,000.00	2,000.00		2,000.00	
P_{25}		6,600.32	879.98		770.93	
P_{34}				34,560.00		4,736.46
P_{35}	5,630.00			19,200.00		19,200.00
P_{36}	4,212.00			5,184.00		5,184.00
P_{37}	2,000.00			2,000.00		2,000.00
P_{38}	1,000.00	399.68	120.02	1,000.00	229.07	1,000.00
P_{39}	4.00			4.00		
P_{40}	240.00			240.00		
P_{41}	440.00	440.00		440.00	27.36	
Income	19,369.99	23,436.50	21,400.12	21,749.02	36,406.50	27,084.08
Total Fixed Costs**	5,309.55	5,309.55	5,309.55	5,309.55	5,309.55	5,309.55
Net Farm Income	14,060.44	18,127.05	16,090.57	16,439.47	31,096.95	21,774.53

*The level of activities P_{21} and P_{22} for each case programmed has been increased by the amount of the debt of the initial capital situation since each program is a change from either a 60 percent equity situation or a 90 percent equity situation. See Appendix Table D-I for land and capital situations, and C-VIII for land and capital supplies.

**Fixed costs on original equipment. See Appendix Table B-IV.

APPENDIX E

APPENDIX E

AUTHOR'S EVALUATION OF THE STUDY

The author recognizes that linear programming is a valuable tool, which can be used advantageously in farm and ranch planning. As some of the people who introduced linear programming into the field of agriculture have pointed out, one can budget to great length and not know if, when he has finished, all possible combinations have been observed and the most profitable one found. After a linear program analysis of any farm organization, the analyst knows with confidence that there can be no change made which will produce any more income from the resources at hand given the price and production restrictions.

The results obtained in this study are reasonable and workable for the area studied and can be of value to dairymen and extension personnel. For any variation in prices or inputs partial budgets can be constructed to account for the change.

The major problem encountered in the course of this study was that of obtaining accurate input coefficients. The task of obtaining this information proved to be a lenthgy one. In addition to this, the construction of the model and the actual programming were difficult to be handled with consistency. However, this does not reduce confidence in the results nor produce any regret that this problem was chosen for the master's thesis. I would recommend that similiar studies be narrowed considerably and planned more rigorously before launching the study. Linear programming model construction should be thoroughly understood and the mechanics of linear programming mastered before endeavoring to use the tool as a problem solving device. More difficulty was encountered in this phase of the study than in any other.

Usually the most thorough of plans overlooks important details and uncovers problems which may have serious consequences in succeeding steps of the study. This one was no exception. Some questions were omitted from the questionnaire which, if answered, could have supplied valuable information. For example, more information from the dairy farmers theselves about their financial arrangements would have been helpful. Questions pertaining to sources of credit, collateral-loan ratios, and repayment schedules should have been answered before undertaking the analysis. Even though the utmost care was taken to avoid ambiguous questions, a few appeared which caused extra work and delay. A question pertaining to feed and pasture requirements for replacement heifers was misunderstood by several interviewees. The wording probably could have been improved, but the information asked for appeared to be difficult for the dairymen to give.

Some related problems uncovered which need attention are: (1) economic feasibility of drylot dairying in Oklahoma, (2) credit policies of lending agencies affecting Oklahoma dairymen, (3) consideration of cash crops as alternative uses of resources for Oklahoma dairymen (especially alfalfa hay), and (4) the economic value of the keeping and interpreting of dairy farm records related to efficient dairy production must be somehow impressed upon dairy producers.

VITA

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Candidate for the Degree of

Master of Science

Thesis: A LINEAR PROGRAM ANALYSIS OF GRADE A DAIRY FARM ORGANIZATIONS IN THE OKLAHOMA METROPOLITAN MILK MARKETING AREA

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