ECONOMIC ALTERNATIVES OF BEEF ENTERPRISES ON OREGON WHEAT-FALLOW FARMS

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

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ECONOMIC ALTERNATIVES OF BEEF ENTERPRISES ON OREGON WHEAT FALLOW FARMS

Chapter I

INTRODUCTION

The Problem

Shaniko, a small town in southern Wasco County, was one of the largest inland wool shipping centers in the United States at the turn of the century. Today a few empty warehouses, a bar, and an amiable bartender are all that remain to remind one of those earlier years. Shifts in population and subsequently in demand brought a marked change in livestock production in eastern Oregon. The increase in population induced an increase in demand for beef all along the West Coast and was largely responsible for the increase in cattle production throughout eastern Oregon and other sections of the West. Decline in the demand for lamb followed closely the increase in demand for beef. Portland cattle slaughter prices which before World War II were below slaughter prices in the mid-western markets are now usually above prices in these markets. Cattle from feed lots as far east as Colorado are moving into west coast markets. The impact of these changing economic conditions on the cattle industry of Oregon is of growing interest to Oregon farmers, especially in the light of recent agricultural policy programs and proposals.

Beef production in the Columbia Basin presents a problem both as a "felt need" and as a "theoretical optimum." The term "felt need" refers to the doubt, confusion, or uncertainty facing individuals or society (13, p. 14). Doubt and uncertainty exist in the minds of many wheat farmers because of the current "price-cost squeeze" and because, due to wheat acreage control, many farmers have been "forced" to divert 35% of their cropland to the production of barley, "forced" in the sense that barley offers the next best alternative to wheat (1, pp. 2-5). Any decline in current income will encourage farmers toward an enterprise that will provide a more permanent year around operation, will spread work more evenly throughout the year, and will thus provide a more efficient use of resources. A cattle enterprise should offer just such an opportunity. Today there is much talk of expanding feeder operations, and many farmers may soon be faced with decisions about cattle in this area. Farmers will want to know more about the various types of cattle operations, about problems involving returns, risk, management, and labor.

A "theoretical optimum" is defined by economic principle (13, p. 15) and can be visualized here in a geographic or regional framework. A brief look at the map indicates that ranchers throughout the wheat areas of

Washington and Oregon are very favorably located for the Portland, Seattle, and Spokane markets. Farmers in Umatilla County and in other sections of the Palouse wheat region have been able to take advantage of a ready supply of by-product feeds such as pea vine silage and feeds from the irrigated areas to feed out cattle to slaughter weights. But in the wheat areas to the west of Umatilla County cattle are generally raised as feeders and not for slaughter. Favorable market location, the ready supply of home grown feed, and a nearby supply of feeders from the range land to the south would lead one to believe that perhaps greater profits could be realized by many farmers in the area through feeding out cattle to slaughter weight. Feeders now being raised in eastern Oregon are being shipped into Washington, Idaho, California, Colorado and the mid-west for fattening (24, p. 5). An increase in feeding operations in the wheat-summer fallow area would be complementary in providing a nearby outlet for feeders produced on the range.

Thus a "felt need" may exist among farmers searching for greater resource efficiency and increased incomes. A "theoretical optimum" can be achieved by integration of production between feeder raising and fattening areas.

The Hypothesis

It is the purpose of this paper to examine the beef cattle enterprise on farms in the wheat-summer fallow area bordered by Wasco County on the west and Umatilla County on the east. Several representative cattle operations will be studied in order to determine differences in returns, and income variability. The hypothesis is that <u>over the long run these farmers will find more profit in feeding out cattle to slaughter weight rather than in selling feeders</u>.

Socio-economic factors have encouraged the existing pattern of cow-calf and cow-yearling operations throughout most of the wheat-summer fallow farming area. Rancher experience has been along this line. Feeding requires a higher degree of managerial ability, more capital, and more labor. Risk and uncertainty is another important factor affecting decisions in the selection of enterprise. One cannot isolate risk and uncertainty from the alternatives or measures to combat risk and uncertainty such as diversification and flexibility.

As a corollary to the above hypothesis, farmers, if made aware of differences in profit and income variability among cattle enterprises, would be in a better position to make decisions. Increased profits should prove an incentive for many farmers without a high degree of risk aversion to expand feeding operations.

The alternate hypothesis is that feeder enterprises are not more profitable in the long run than cow-calf and cow-yearling operations on wheat-fallow farms. There is no way of showing that the degree of risk involved outweighs the difference in profit because there is no way of measuring risk preference for the individual farmer. The farmer can be shown a series of alternatives and make a choice based upon his individual preference.

In order to test this hypothesis it was necessary to develop a methodological approach or to establish a model to measure differences in returns and variability in incomes. To compare returns it was decided to use budgets and to supplement this budgetary analysis with a relatively new technique in production economics, linear programming. Budgets were employed by establishing a model farm for the study area. Data necessary for budgeting and programming were gathered through a farm survey and through secondary sources. Regardless of the measure of income variability employed it would be necessary to gather historical price data to obtain incomes over a number of years.

The following chapter describes the study area. Chapter three deals in greater detail with the methodological approach. In chapters four through six the analytical tools are first discussed and the results obtained from the use of them presented and analysed. The results are summarized in the final chapter.

Chapter II
THE STUDY AREA

The Land

The wheat-summer fallow area of eastern Oregon lies in five counties bordering the Columbia River. The Cascade Mountains rise to the west, the Blue Mountains to the east, and to the south lies the Umatilla Range. The land along the banks of the Columbia rises abruptly to an elevation of 500 feet and then gradually increases in altitude to as much as 2500 feet in the foot hills along the southern edge of the wheat farming area. This gently rolling land is frequently interspersed with deep canyons such as those cut by the John Day and the Dechutes Rivers. In this broken and hilly topography land is often too steep to crop and can be utilized only for grazing.

A typical farm will have 900 to 1600 acres of crop land and a varying amount of range or grazing land. With respect to the cropland, while farmers have a comparative advantage for raising wheat, government control measures have forced about 35% of the land into the production of barley. Studies are already underway to determine what effect "soil bank" measures will have on crop production. Barley does not grow well in this region, but it is widely accepted as the best alternative to wheat (1, pp. 2-5 and

22, p. 54). Soil, climate, and topography are, of course, closely interrelated in their influence upon crop yields. Wheat yields fluctuate widely from 15 bushels per acre in some areas and in some years to 30 bushels per acre in others. Barley yields follow the same pattern usually varying from 20 to 35 bushels per acre. For most of the region annual rainfall is 10 to 15 inches. As one moves from areas of low rainfall (10 inches or less) to areas of higher rainfall (15 inches or more) the soil becomes less sandy, more compact, shallower, and less permeable (23, p. 23). These latter soils not only receive more moisture, but hold more moisture, and are thus better suited for raising wheat. Driving south through Gilliam County one can observe the sandy soil in the dry region around Arlington near the Columbia River. Rex wheat is the common variety in this area. Further south near Condon average annual rainfall increases, Golden (Forty Fold) is the common variety of wheat, and average yields increase.

What holds true for production of crops holds true also for production of range though this is not as easily measured. Most farmers maintain some cattle to utilize this range. A recent survey of a representative group of wheat farms in Sherman, Gilliam, and Morrow Counties (23, p. 26) showed that on approximately one half of the farms range land constituted 20% of the acreage or less. On the

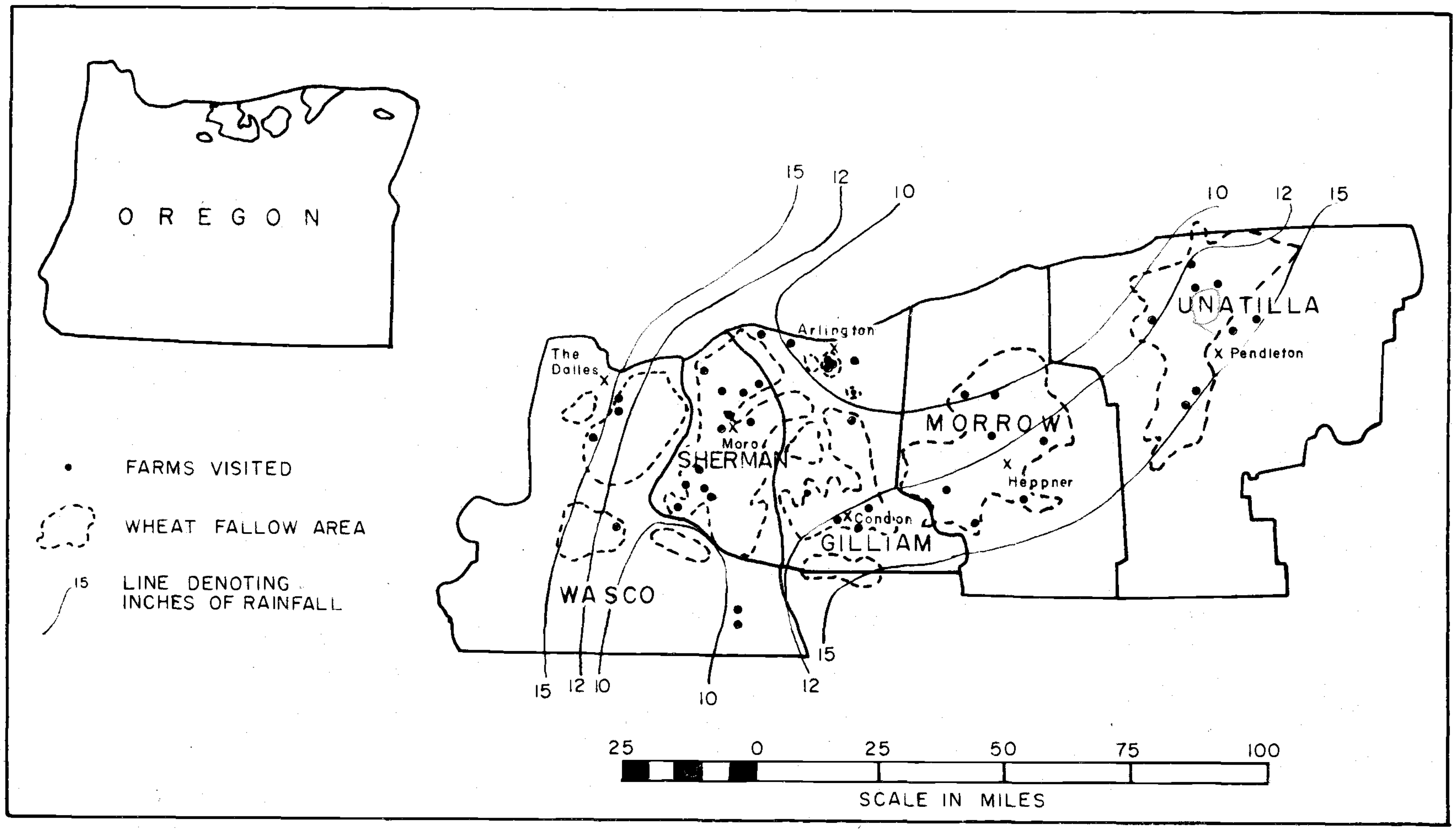

Figure 1. The study area, showing the location of the individual farms visited and the wheat-fallow producing regions in the Columbia Basin, Oregon, 1936. (23, p. 5)

remaining one half range land constituted 20% to 75% of farm acreage. On an average one third of the farm was in range. It is not uncommon, however, to find farms where 50% or more of the land is suited only for grazing. According to survey data collected in 1948 (23, p. 27), 28% of all wheat farmers kept less than twenty head of cattle, 27% kept 20 to 49 head, 21% kept 50 to 99 head, 9% kept 100 head or more. With the "forced" increase in barley production since 1951 undoubtedly the trend has been toward more cattle per ranch.

Capital

Only the cattle and sheep ranches of the Southwest and the large cotton plantations of the Mississippi Delta can compare with the wheat area of the Pacific Northwest in amount of capital invested per farm. The average investment is greater than $100,000. Land value is the major item in this figure, There is a saying that there are three ways to acquire a farm: through "matrimony", "patrimony", or "parsimony". High capital requirements have practically eliminated this latter method of acquisition in the wheat area of Oregon. As might be expected, a large amount of the land is rented. Between $10,000 and $15,000 is normally invested in machinery. Again this is high compared with other farming areas.

It is difficult to determine the capital position or degree of indebtedness of individual farmers. Every indication at present is that as a whole they are in a relatively favorable capital position. They appear to have the capital resources necessary to expand their cattle operations were this to prove profitable. Losses in cattle in the past year, however, have tended to influence loaning agencies. The grain surplus problem might affect these agencies too, although the government has stood firm on $2.00 wheat to date.

Labor

An average wheat farm with a section or two of crop land generally employs two full time men (operator plus hired man or operator plus member of family) and some seasonal labor. A good hired man is not easily found and not easily held. There is a period during the winter when the work load drops off tremendously, and often repairing machinery and equipment becomes the major task. Many operators admit that they keep a small beef herd not to make money but to give the hired man work the year round. A farmer may even be willing to sustain some loss in returns to the cattle in order to keep a good hired man.

Labor not only of the hired man but also of the operator might be used to advantage with a cattle enterprise.

Most cattle operations require the maximum amount of labor during the winter. If a cow herd were maintained there might be some small degree of competition for the labor resource during the fall and spring months, but by and large a cattle enterprise serves very nicely to distribute labor requirements more evenly through the year.

Management

Since the pioneer days most farm managers in the Columbia Basin have been concentrating on raising wheat. Historically wheat has been the principal crop, livestock has been a secondary enterprise. Even though wheat farmers consider themselves "ranchers", the cattlemen are generally found to the south and east of the wheat-fallow area. Wheat farmers for the most part have handled a cow-calf enterprise, often holding the calves over until spring. The principal feeds are hay, chaff, and pasture or range. A small amount of labor is used and a small amount of management ability is required for an enterprise of this nature.

However, there are farmers to be found scattered throughout the area who take a considerable interest in the cattle enterprise. Many of them in feeding out cattle demonstrate a high level of managerial ability. The cattle operations that have been selected for study represent two distinct levels in managerial requirements. Only 25% of the farmers interviewed were handling enterprises that required managerial capacity in the upper bracket.

Students of farm management have been confronted eternally with the difficulty of measuring managerial ability.[1] One would like to know, what percentage of the farmers could be expected to have the capacity to handle successfully a given alternative. For example, what percentage of those farmers not now engaged in feeding out cattle could adopt a feeder cattle enterprise? There are some farmers who are not capable of feeding more than twelve pounds of grain daily to cattle; others are able to feed over twenty pounds. The measurement of management is still a great challenge in production economics.

Common Practices

Cattle are maintained on the majority of ranches, and all types of cattle operations exist. There are some ranchers that sell calves as weaners; others that have no range, no cow herd, and force feed cattle with twenty

[1]This is not alone the problem of the agricultural economist, however. Too often there has been a tendency to divorce the question of what makes a good farm manager from that of what makes a good business manager.

pounds or more of barley a day. There are all sorts of combinations in between these two extremes. One or two buy old cows and feed them out; a few raise purebred stock. No two managers operate the farm in exactly the same way. However, for the purpose of this study, seven representative cattle operations were synthesized from the available data. These operations, which vary from cow-calf with no feeding to straight feeder enterprises, are discussed at greater length in the next chapter.

Cow herds usually receive relatively little care and attention. They are wintered for approximately one hundred days often on chaff alone, though many ranchers prefer to feed hay during calving. The calves are dropped from January through March and the cows turned to range around the first of April. As soon as the grain is harvested the cows have access to stubble. They are generally free to wander in the fallow fields throughout the season. Ranchers employ a minimum of specialized cattle equipment especially when calves are not fed out. Various methods are employed for collecting chaff to be fed out during the winter. Some ranchers have hay balers, but as often as not hay is cut with a binder and then chopped. In the feeder operations such specialized cattle equipment as scales and hammer mills are often found.

Grain hay is most commonly raised except in the irrigated areas. The hay is cut in July before regular grain harvest. Recently many ranchers have intentionally overplanted their wheat allotment and cut grain hay to form a right-of-way for combining equipment around the edges of their fields. Hay and grain fed to cattle is almost entirely home grown. Barley is the common feed grain, although many prefer a mixture of wheat, barley, and oats. For those feeding heavily, oats often provide a more satisfactory starting ration.

Cattle in the wheat-fallow region often suffer from neglect and poor management. This is exemplified by overgrazed ranges, poor breeding programs, low calf crop percentages, and light weaning weights found on many ranches. This is perhaps to be expected in an area concerned primarily with raising a cash grain crop. The cattle operation is serious business for some but often provides too small a percentage of the total income to be of much concern to others.

Chapter III
METHODOLOGY

Source of Data

Information used in this study came from both primary and secondary sources. Primary data was collected by means of a farm survey conducted in the summer of 1956. A survey was made of fifty farmers in the five counties bordering the Columbia River from Wasco County on the west to Umatilla County on the east. The survey was designed to provide information concerning cattle operations in the area, the practices that were being followed, the resources that were in use, and the additional resources that might be available.

In collecting data from farmers to use in determining input-output ratios or production standards, the farms should be so selected as to provide adequate information on all enterprises which are to be considered. This entails securing information on the common practices and on those that are less frequently found as well, for these latter practices may yield a higher level of efficiency. In our situation it was necessary to obtain adequate information not only on the common place cow-calf and cow-yearling operations, but also on the less frequently found feeder enterprises. Random sampling is of no value in this situation, for with random sampling one runs the risk of obtaining inadequate information on the newer and less common practices. For this reason a purposive sampling was used.

It was necessary to employ the assistance of county agents in selecting ranches to insure that a proper number of feeder operations was included in the survey. All ranches visited raised cattle. Detailed information was recorded on the cattle enterprises which included such data as feeding programs, equipment used, dates of cattle purchases and sales, costs and returns. Information on the grain operation was also obtained. This survey formed the basic guide for establishing the seven cattle enterprises for which budgets were used. A typical size of ranch, with reference to labor and capital as well as to land, was developed from information gathered in the survey and from previous studies of this area.[2] This procedure is commonly referred to as the "synthetic method" of studying farm organization and is one of the best methods devised for use in combination-of-enterprise research. The synthetic method makes use of all available information that has any

[2]Nairn (22) developed a typical wheat ranch for the region. Wallace (28) set up a representative wheat-cattle operation in Umatilla County. Information was also available from Pawson's (23) work for the Department of Agriculture on conservation farming in the Pacific Northwest wheat area.

bearing on the problem at hand. It is unavoidably forward looking (2, p. 131).

Feed prices and indexes of prices paid were gathered from publications of the Oregon Crop and Livestock Reporting Service in Portland (25). Cattle prices were obtained through the North Portland stockyard and through the "Livestock Marketing News," published weekly by the United States Department of Agriculture. Yardage and commission rates were also obtained at North Portland. The Willamette Tariff Bureau provided the source of trucking rates.

Feed rations were developed and rates of gain established from the information collected directly from farmers by the survey. These rations were submitted to county agents, farmers, and members of the Animal Husbandry Department for review and recommendations. Suggestions were considered and rations altered in some instances. A complete description of the rations appears in the Appendix.

Prices

Decisions regarding price and production must be made in formulating budgets. Because prices fluctuate, considerable uncertainty is naturally involved in the handling of prices. But further difficulty is encountered when one considers that the cost of production is not the same for any two farmers. There is no "average cost of production". In most studies, however, it is necessary to employ an average cost of production in the absence of a more suitable alternative. Because this study required budgeting over a number of years it was not possible to use cost of production. Some thought was given to developing a cost of production for the year 1956 and carrying this cost back on an index of prices paid, but this was ruled out in favor of the market prices for resources used in production. Market prices were used for home-grown feeds. This is realistic in the sense that most ranchers are faced with the same hay and grain market price. Hence the price charged for feed becomes an opportunity cost.

While it is important to estimate accurately the absolute returns and costs for a single enterprise, we are more concerned with the relationship of costs and returns between enterprises. Any change in the price of feed will alter the inter-enterprise cost relationship. For example, an over-estimation of the price of barley would increase costs more in those operations feeding more heavily. In the budgetary analysis care is taken to point out the difference in cost relationships caused by using market price instead of cost of production.

Cattle prices were difficult to obtain. The Portland market carried weekly prices for slaughter grades.

However, very few feeder cattle move through the Portland market. Until 1952 no records were kept of feeder prices. The lack of available data on feeder cattle made it necessary to estimate Portland prices from Kansas City feeder prices. A multiplier was computed by comparing monthly Portland and Kansas City feeder prices for the four years that were available, 1952-1956. The multiplier was applied to the Kansas City prices for the other twenty one years. Kansas City was chosen because Kansas City prices correlated more closely with the Portland market than either Chicago or Omaha, the other two markets for which prices were available. The weakness of such a system of price calculation is obvious. However, it is perhaps reasonable to assume that the price and demand relationship that has existed between the Portland and Kansas City market for the past five years is more reliable for estimating future price than the relationship for the entire twenty five years. The demand for cattle in the two regions and thus cattle price relationships have changed markedly in twenty five years.

Costs were determined for the year 1955 for several minor expenses such as depreciation and repairs and the costs for previous years estimated by using an index of prices paid. Price data for all inputs and outputs has been estimated as accurately as possible. It should be understood, however, that much of the available information is incomplete.

Labor and Range Data

Labor is not charged in the budgets because the opportunity cost for the use of labor elsewhere during the winter months was considered to be zero. This means that it was assumed farmers in this region usually have no opportunity for off farm employment during the winter months. This would not apply to all individuals of course. However, as labor does become a limiting resource, it was necessary to develop labor coefficients for linear programming. Labor requirements were obtained from several sources, but chiefly from United States Department of Agriculture publications, the most recent of these being, "Labor Used for Livestock", by Reuben Hecht published in May 1955 (17, 18).

In order to determine the size of operation it was necessary to estimate the carrying capacity of the 1500 acres of available range. The opinions of county agents and farmers were considered and a figure of approximately twenty seven acres per head decided upon. Of course, range carrying capacity varies widely throughout the region and from year to year.

Method of Analysis

Analysis of data is broken down into three sections which comprise the following three chapters, Budgeting, Linear Programming, and Income Variability. A typical ranch was first synthesized, which consisted of two sections (1280 acres) of cropland and 1500 acres of rangeland. From available primary and secondary data seven representative cattle operations were established. Thirty five per cent of the cropland was in barley in line with current practices and in all cases this home grown barley provided sufficient feed for the cattle enterprise.

Nearly 20% of the operators interviewed sold their calves as weaners at 300 to 500 pounds, grade "good" (Enterprise A). The majority of ranchers, however, held the calves through the winter, selling them in the early spring at 500 to 700 pounds as medium to good feeders (Enterprise B) or turning them out to pasture and selling them off grass in mid-summer at 550 to 750 pounds (Enterprise C). There was a group of farmers who fed 10 to 14 pounds of grain a day to calves, selling them in the spring for feeders or for slaughter at 700 to 800 pounds, good to choice (Enterprise D). A few bought calves and fed them out in the same manner (Enterprise E). These two enterprises were frequently combined where ranchers supplemented the home raised feeders with purchased feeders. Other operators carried calves through the winter and fed them out the following fall on 15 to 20 pounds of grain per day, selling them in the winter as 900 to 1100 pound good to choice slaughter animals (Enterprise F). Yearlings were bought in the fall and fed out in the same manner (Enterprise G). Combinations of the above were also used.

With these seven enterprises singled out, budgets for the past twenty five years were formulated (Chapter IV). The twenty five year period was chosen to include a complete cattle cycle and to include depression prices. The objective was to compare incomes among enterprises. Linear programming was introduced to lend a depth and flexibility to the income comparison not possible under simple budgetary analysis (Chapter V). While in the budgets the past ten and twenty five year periods were summarized separately, the coefficients from programming were derived from only the past ten years. The demand and price situation in the cattle industry of Oregon since the war may be more reliable and useful in estimating the future trend. Finally, because farmers are interested in degree of uncertainty as well as size of income, statistical analysis was used to compare income variability for the cattle enterprises and for the cattle combined with wheat (Chapter VI).

Chapter IV

THE BUDGETS

The Budgeting Technique

The analysis of data is handled in this chapter through the process of budgeting. Budgeting is one of the oldest, most useful, and most widely employed techniques in production economics. Formalized budgeting as we know it today was first introduced, or evolved, in the early part of this century, although farmers utilized the budgeting process long before this. The purpose of the budget is to aid in planning future farm operations. As a result, budgets are frequently used to compare alternatives, to compare expected production requirements, input and output differences, and different farming methods. The budget as a formalized plan, systematizes the thought or decision making process which is the backbone of farm management.

Budgets can be very simple or very complex and thus can be adapted to meet the needs of either the farmer or the research worker. A farmer who makes a very hasty calculation either in his head or on scratch paper is carrying out a simplified form of partial budgeting. On the other hand, a research worker may spend months gathering data to make a complete farm budget. Many farmers have neither the time nor the training required to develop a complete farm budget. However, the partial budget will prove an adequate decision making guide in handling the majority of minor farm problems.

Budgets consist primarily of input-output data or information of both physical and monetary requirements and returns. The budgeting process converges on two figures, receipts and expenses, total receipts and expenses in the case of complete budgeting, and additional receipts and expenses in the case of partial budgeting. The time required to formulate a budget restricts the individual, be he farmer or research worker, in the number of alternatives that he can select for consideration. For example, a corn belt farmer would not compare the returns from all possible rotations. He eliminates all but two or three rotations, selecting these on the basis of practicality or desirability in terms of his entire operation. In doing this he selects a number of points on a production possibility curve or surface.

An individual, even with only a minimum of experience in budgeting, soon becomes keenly aware of the limitations of the budget. Budgets, because they produce results that are cardinal and not ordinal in nature, appear to the casual observer to be very objective, but are, in fact, highly subjective. Therefore, two research workers may analyze a problem taking pains to be scientifically objective, and reach a very different conclusion. This is because individuals make different estimates about the nature of things. Because budgets are so susceptible to biases of this sort, it would be expected that most reliable results would generally be presented by the worker most familiar with the problem at hand. He is better equipped to make meaningful estimates. In part, knowledge "gaps" may be filled in by secondary sources. For example, in studying livestock, information on feeding requirements may be obtained from the Animal Husbandry Department. However, there is no substitute for a first hand knowledge of the study area.[3]

The budget must predict the future with available historical data. Estimates are made of prices, production, and resource requirements. Appropriate prices and quantities are difficult to determine due to the uncertainty involved. An illustration of this can be seen in the influence of weather on the application of fertilizer to wheat. A

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[3]This is an excellent argument for requiring research workers new in the field to make a survey of the study area. The knowledge of the agricultural economist is often too broad, the knowledge of the individual farmer often too narrow. A survey is frequently more valuable as a means of familiarizing the worker with the practices and problems of the study area than as a source of data. Too many times information is collected and analyzed solely from secondary sources. The worker is unfamiliar with the region he is studying. Estimations and assumptions are often illogical, and, as a consequence, results are of little meaning or value. A good research worker should not be afraid to get his feet muddy in acquiring a basic understanding of his work.

change in the amount or the time of rainfall may completely alter the production function or input-output relationship. Further, price relationships that have held in the past may not necessarily be valid for the future. Where assumptions are incorrect, errors may be compounded. For example, if both the price and yield of wheat were overestimated, the error would be multiplied in the gross returns.

The input-output relation for the conventional budget is linear. All costs and returns can be allocated on a per unit of output basis, such as cost per head or returns per hundredweight. But obviously, as the size of enterprise changes the cost per unit of output changes in many cases, and where this is true the input-output relationship is, in actuality, not linear. Consequently, budgets are not well adapted to handling problems in scale.

Synthesizing the farm business is dependent on input-output data for segments of the production process. These linear segments, illustrated by lines A, B, and C in Figure 2, are, in a sense, standards of performance because they are over simplified views of production functions. These simplified linear production functions interesect points (a, b, and c) on the real production function in Figure 2. Standards of performance are chosen to form a segmented production function because, as one economist dicussing the New England dairy industry has stated, "adequate

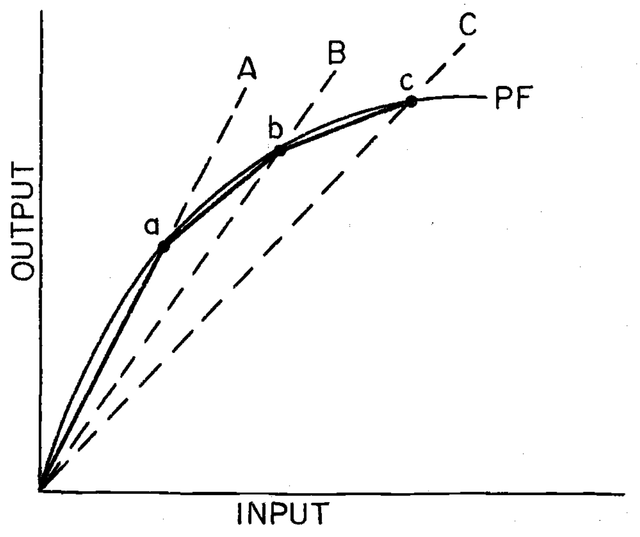

Figure 2. A production function intersected by three production processes

physical production functions are not now available, nor will they be available in the near future unless there occurs a marked change in agricultural research." (12, p. 1060)

The budget does not take into consideration degrees of managerial ability. As with the situation at hand, different enterprises may require different levels of management. The optimum solution obtained through budgeting may be completely out of the range of ability of many farm managers. Perhaps results presented in budget form should lay greater emphasis on the differences in management requirements and on the ways of acquiring the needed ability.

Finally, the best alternative under the budget is the one which gives the highest return. The goal of profit maximization is being viewed critically by many agricultural economists. Firm and household are more closely united in farming than in any other occupation. Values other than profit maximization play a significant role in family-firm decision making. However, selecting profit maximization as the primary goal has considerable merit. Using a goal other than profit, such as utility, would require the development of indifference curves that would differ for each individual farm. This task has been, to date, insurmountable. Maximization of profit is often complementary to many of the other goals that farmers seek, household appliances for the wife, an education for the son, more leisure time. Therefore, when a farmer is actually performing a task or is "on the job" he generally wants to be efficient, to earn the highest returns for the use of his time and labor. A choice may arise on a given day as to whether to farm or to go fishing. Once the decision is made to farm, it behooves the farmer to work toward the goal of profit maximization in order that he may afford more time for fishing in the future. It follows that a farmer making the decision to raise cattle should be concerned with the type of cattle operation that will bring him the highest monetary return.

The strength of the budget lies as much in the interpretation of results as in the accuracy and reliability of the information presented. The single-valued expectation has limited application, and therefore the analysis and interpretation of results should embody a certain amount of flexibility. It should further be kept in mind that budgets are used for comparative purposes. The relative figures are more important than the absolute figures, for we are concerned with selecting the best from a number of alternatives. In spite of its limitations, budgeting provides one of the best guides to decision making.

Presentation of Budgets

The budgets are presented in a series of tables on the following pages. Table 1 sets forth the basic resources available and those required for production in each of the seven enterprises. The source and method of selection of this information has been discussed in the previous chapters. Briefly, land consists of two sections of cropland and 1500 acres of range with a carrying capacity of approximately one animal unit for twenty-seven acres of range. Rangeland in most of the cattle country is the critical limiting resource that constricts the size of a cow herd in much the same manner that labor requirements frequently limit the size of a dairy herd. Labor consists of the farm operator plus a hired man. The full time of one man can be devoted to the cattle enterprise during the winter months. The capital listed is that for the cattle enterprise alone, as the equipment expenses for crops is embodied in the market price used for grain and hay.

Tables 2 and 3 present the budgets for the ten year period, 1946-1956, and for the twenty five year period, 1931-1956 respectively. The explanation of costs and returns for the budgets is given in the footnotes following Table 3. However, a word should be said about the use of fixed and variable costs. To begin with, only variable costs are important in decision making once the commitment for fixed costs has been made (13, p. 330). In our situation it was necessary to adjudge which costs were fixed once it was decided to raise cattle. But the problem does not end here, for there are certain fixed costs associated with a cow herd that are not associated with feeding, the primary one being the charge for fencing. Likewise, equipment is used in feeding that a cow-calf operator would not need, a hammer mill, for example. Consequently, the fixed costs will vary depending upon the enterprise. The enterprises combining cow herd with feeding will have the highest fixed costs.

No fixed cost was charged for rent or taxes on rangeland. It was assumed, as Table 1 indicates, that, even

Table 1. Resources and Production for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon

Item	Unit	A	B	C	D	E	F	G
		Enterprises						
Land use								
Rangeland	Acre	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Cropland 1/	Acre	1,280	1,280	1,280	1,280	1,280	1,280	1,280
Barley	Acre	224	224	224	224	224	224	224
Wheat	Acre	416	416	416	416	416	416	416
Fallow	Acre	640	640	640	640	640	640	640
Livestock (Jan. 1) 2/								
Beef cows	No.	45	45	36	45	--	33	--
Bulls	No.	2	2	2	2	--	2	--
Calves	No.	--	32	25	32	--	23	--
Replacement yrlings, calves	No.	12	12	10	12	76	10	--
Yearlings	No.	--	--	--	--	--	22	42
Inventory value (start of feeding period) 1946-56	Dol.	8,005	11,296	9,187	11,296	6,754	11,443	6,494
1931-56	Dol.	4,808	5,500	5,541	5,500	4,121	6,873	3,931
Feed requirements								
Hay - 1 ton per acre	Ton	48	87	69	74	62	76	21
(20% carryover)	Acre	48	87	69	74	62	76	21
Barley - 3/4 ton per acre	Ton	1.8	6.6	5.1	31.6	70.7	26.5	39.7
	Acre	3	9	7	42	94	34	53
Required cropland	Acre	51	96	76	116	156	110	74
with 1 yr. fallow		102	192	152	232	312	220	148
Production								
Hay - 1 ton per acre	Ton	48	87	69	74	62	76	21
Barley - 3/4 ton per acre	Ton	132	103	116	113	122	111	152
Wheat - 27 bu. per acre	Bu.	11,232	11,232	11,232	11,232	11,232	11,232	11,232
Beef 3/	Lb.	19,600	24,400	22,500	30,480	58,140	28,050	44,550
Equipment - 1955-56 prices								
Fencing @ $250 per mile	Dol.	4,000	4,000	4,500	4,000	0	4,500	0
Barns and sheds	Dol.	7,000	7,000	7,000	8,000	7,000	8,000	5,000
Gates, chutes, corrals and feed bunkers	Dol.	800	1,200	1,200	1,600	1,600	1,600	1,000
Sprayer	Dol.	--	--	--	225	225	225	225
Hammer mill	Dol.	--	--	--	150	150	150	150
Squeeze chute	Dol.	--	--	--	225	225	225	225
Scales	Dol.	--	--	--	--	600	--	600
Total - in 1955-56 prices	Dol.	11,800	12,200	12,700	14,200	9,800	14,700	7,200
- in 1946-56 prices	Dol.	10,390	10,842	11,183	12,504	8,629	12,944	6,340
- in 1931-56 prices	Dol.	7,178	7,421	7,726	8,638	5,962	8,942	4,360
Total Capital - equipment and livestock								
1946-56	Dol.	18,395	22,038	20,370	23,800	15,383	24,387	12,834
1931-56	Dol.	11,986	12,921	13,267	14,138	10,083	15,815	8,291
Annual labor requirement 4/	Hr.	789	1,034	1,175	1,333	1,322	1,254	643

1/ Based on a wheat allotment at 65% of cropland.
2/ Numbers based on 27 acres per animal unit with $5,000 available in 1956 to buy feeders for E and G.
3/ The description of enterprises in the appendix shows how these figures were obtained.
4/ See 18, p. 12 and 17, p. 64.

Table 2. Budgets for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956

Item 1/	Unit	A cow-calf	B cow-yearling	C cow-long yearling	D cow-calf feeder	E calf feeder	F cow-yearling feeder	G yearling feeder
Variable costs	Dol.							
1. Feed cost for cows		901	901	727	901	-	611	-
2. Initial cost of feeders		-	-	-	-	6754	-	6494
3. Feed cost for replacements		334	334	278	334	-	278	-
4. Feed cost for yearlings		-	1086	849	-	-	780	-
5. Feed cost for feeders		-	-	-	2432	5770	1421	2842
6. Salt and veterinary		48	65	54	82	78	70	43
7. Yardage, comm, trucking		153	201	173	212	400	142	283
8. Death loss		89	89	89	89	173	147	148
9. Taxes and interest cattle		534	637	566	649	182	632	172
10. Int. Depcn. Repairs on equipment		246	281	326	405	317	448	88
11. Total variable cost		2305	3594	3062	5105	13679	4529	10070
Fixed costs	Dol.							
12. Int. Depreciation and Repairs on equipment		792	792	792	845	546	845	546
Total costs								
13. Total expenses		3097	4386	3854	5950	14220	5374	10616
Returns	Dol.							
14. Home use		177	237	277	378	378	293	293
15. Sold as feeders or for slaughter		2598	3550	3188	5664	13972	5342	10683
16. Cows sold for slaughter		1101	1079	917	1098	-	917	-
17. Gross returns		3876	4866	4382	7140	14350	6552	10976
18. Net returns		779	480	528	1180	130	1178	360
19. Reciprocal returns		117	-182	-134	518	-532	516	-302
20. Returns/$100 all costs		125	111	114	120	101	122	103
21. % return on variable costs	%	68	35	43	40	5	45	9
Gross returns to resources	Dol.							
22. Per $100 feed fed		314	210	236	195	115	212	117
23. Per 100 acres cropland		7600	5069	5765	6155	9202	5956	14832
24. Per 100 hours labor		491	471	373	535	1086	522	1707
25. Per $1000 capital in livestock and equipment		373	290	345	571	1663	506	1731
Net returns to resources	Dol.							
26. Per $100 feed fed		63	21	28	32	02	38	13
27. Per 100 acres cropland		1527	500	695	1017	83	1071	486
28. Per 100 hours labor		99	46	45	89	09	94	56
29. Per $1000 labor in livestock and equipment		75	45	47	94	15	91	57

1/ Footnotes at the end of Table 3 explain the items.

Table 3. Budgets for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1931-1956

Item	Unit	A	B	C	D	E	F	G
		cow-calf	cow-yearling	cow-long yearling	cow-calf feeder	calf feeder	cow-yearling feeder	yearling feeder
Variable costs	Dol.							
1. Feed cost for cows		595	595	482	595	-	405	-
2. Initial cost of feeders		-	-	-	-	4121	-	3931
3. Feed cost, replacements		223	223	186	223	-	187	-
4. Feed cost, yearlings		-	727	571	-	-	525	-
5. Feed cost, feeders		-	-	-	1682	3990	982	1965
6. Salt and veterinary		38	51	42	64	59	54	33
7. Yardage, comm. trucking		122	151	133	169	319	115	230
8. Death loss		55	55	55	55	106	90	91
9. Taxes		310	372	332	380	106	369	99
10. Interest, depreciation, repairs on equipment		169	191	225	280	219	311	61
11. Total variable cost		1512	2365	2026	3448	8920	3038	6410
Fixed costs	Dol.							
12. Interest, depreciation, repairs on equipment		547	547	547	584	377	584	377
Total costs								
13. Total expenses		2059	2911	2573	4032	9297	3622	6787
Returns								
14. Home use		110	149	176	238	238	179	179
15. Sold as feeders or for slaughter		1585	2229	2020	3576	8822	3273	6546
16. Cows sold for slaughter		689	680	574	688	-	574	-
17. Gross returns		2384	3058	2770	4502	9060	4026	6725
18. Net returns		325	138	197	470	-237	406	-62
19. Reciprocal returns		248	-39	20	293	-414	229	-239
20. Returns/$100 all costs		116	105	108	112	97	111	99
21. % return on variable costs	%	58	29	37	31	2	33	5
Gross returns to resources	Dol.							
22. Per $100 feed fed		291	198	224	180	227	192	342
23. Per 100 acres cropland		4675	3185	3645	3881	5809	3660	9088
24. Per 100 hours labor		302	296	236	338	685	321	1046
25. Per $1000 capital in livestock and equipment		332	412	359	521	1520	450	1557
Net returns to resources	Dol.							
26. Per $100 feed fed		40	9	16	19	-6	19	-2
27. Per 100 acres cropland		637	144	259	405	-152	369	-84
28. Per 100 hours labor		41	13	17	35	-18	32	10
29. Per $1000 labor in livestock and equipment		45	19	25	54	-40	45	-14

Footnotes - Tables 2 and 3

Row:

1/ Feed cost for hay and chaff for cows and bulls. The price of hay is the average price for the six month period October through March when hay is actually fed. Oregon "all hay" price was used. The value of chaff based on current prices for hay and chaff is approximately one sixth that of hay. Prices for barley and cottonseed meal were determined in the same manner as those for hay. Feed rations are shown in the Appendix.

2/ Initial cost of feeders purchased at the market.

3/ Feed cost for yearlings and two year old replacements.

4/ Feed cost for yearlings carried over to be fed out.

5/ Feed cost for feeders.

6/ Salt prices were taken from Oregon prices paid by farmers. Cows were allowed two pounds of salt per month. Yearling sold in the early spring were allowed .5 pounds per month. Yearlings held until July were allowed .75 pounds per month. Replacements and yearlings held through the year were allowed one pound per month. Weaner feeders held during the winter were allowed .5 pounds per month. Long yearling feeders were allowed one pound per month during the year.

Feeders were charged a veterinary expense of $1 per head. All others except weaner calves sold in November were charged fifty cents per head.

7/ Yardage, commission, and trucking fees are based on tariffs and charges levied at the Portland Union Stockyards. Trucking charge is based on the ICC rates between the Dalles and Portland from 1950 to 1955 and carried back on an index of prices paid during the years before 1940.

8/ Death loss is 2% throughout. Death loss before weaning, is, of course, normally higher than 2%. Allowance is made for this by a weaning average of 86%, 4% below the average calving rate of 90%.

9/ Taxes on 1955 livestock are based on the inventory value of the cows and one half of the animals carried over. Generally a large percentage of animals carried through the winter do not appear on tax records. Assessed value was taken at 30% of true value and a milage rate of 50 was used. Taxes were progressively lowered until they reached zero in 1945-46. While farmers were undoubtedly taxed before this date, charges were deemed to be insignificant.

Interest on cattle was figured at 6% for the cow herd and 7% for yearlings and feeders. Value of yearlings and feeders was taken at the beginning of the feeding period.

10/ Part of the interest, depreciation, and repairs on equipment was charged as a variable cost though the majority of this expense was classified as fixed. An interest rate of 5% and depreciation rate of 25 years was used, this period being somewhat long for many of the items of equipment and somewhat short for buildings. In addition to this approximately $100 was allowed to buy materials for repairs in 1955. These costs were carried back through the twenty five years by the use of a United States index of prices paid for buildings and fencing material.

Footnotes - Tables 2 and 3 (Continued)

11/ Total variable costs is a summation of Rows 1 through 10.
12/ See footnote 10.
13/ Total expenses is a summation of Rows 11 and 12.
14/ Two head of cattle were set aside for home use. The value of these animals was included in gross returns.
15/ All prices of animals sold for slaughter (cattle from Enterprises D, E, F, and G) were based on Portland prices for good and choice slaughter animals. Feeder prices were based on Portland prices for the years 1951-52 to 1955-56. Calf prices were based on Portland prices for the seasons 1952-53 to 1955-56. For the years prior to 1951 feeder and calf prices were determined by multiplying Kansas City prices by a constant factor. Weekly cattle quotations were used for the actual date of sale shown under the description of cattle enterprises in the Appendix.
16/ Cattle prices were based on an annual average of prices for cows sold in Portland.
17/ Gross returns are calculated by adding Rows 14, 15, and 16.
18/ Row 18 minus Row 13 gives net returns.
19/ Residual returns are computed by subtracting the average of the seven net incomes found in Row 18 from each of the net returns figures. This average is $662 for Table 2 and $177 for Table 3.
20/ Returns per $100 all costs are obtained by dividing gross returns, Row 17, by total expenses, Row 13.
21/ Per cent return on investment is a return above variable costs and is calculated by dividing the sum of net returns and fixed costs, Row 18 and Row 13, by total variable costs, Row 11.
22/ Gross returns per $100 feed costs are obtained by dividing Row 17 by the sum of the numbers found in Row 1, 3, 4, and 5.
23/ Required cropland is found in Table 1.
24/ Required labor is found in Table 1.
25/ Total capital in equipment and livestock is found in Table 1.
26/ Required feed grain is divided by net returns in Row 18.
27/ See footnote 26.
28/ See footnote 26.
29/ See footnote 26.

without a cow herd, range would still be present but would lie idle. This implies that, just as with winter labor, there would be no alternative use for range.

By definition the distinction between fixed and variable costs is precise. A variable cost changes with output, a fixed cost does not. However, both fixed and variable costs are usually associated with a given piece of equipment. This means that costs for most items of equipment increase with an increase in size of operation, but not proportionally. Hence, it is necessary to make a somewhat arbitrary split between fixed and variable costs with respect to equipment investment, depreciation, and repairs.

Finally, allocation of equipment costs between enterprises presents a difficult problem. Fencing costs are an excellent example. How much of the cost for fencing should be charged to the wheat, how much to the cattle? This is almost impossible to determine. Sixteen, and, in two instances, eighteen miles of fencing were charged to the cattle enterprise. This is below the estimate of fencing requirements for the ranch, twenty to twenty-four miles. The additional fencing requirements were charged to the wheat.

Analysis of Budgets

In an analysis of budget net return is of paramont import. A comparison of the budgets of Table 2 (1946-1956) with those of Table 3 (1931-1956) indicates that the difference between the two time periods is largely one of absolute rather than of relative amounts. In other words, all enterprises show a considerable drop in income when the twenty five year period is compared with the ten year period. This is to be expected, as income figures for an entire business cycle (1931-1956) are being compared with an average of incomes for a post-war boom period. Relative changes or changes in the relation of income among enterprises do occur, however, and these can best be observed by comparing the residual income figures in Table 2 and Table 3. The residual income is calculated for the two time periods by subtracting the average income of the seven enterprises from the net income of each of the enterprises. The average residual income for the seven enterprises for each of the time periods then becomes zero. The effect is to remove the difference in income for the time periods caused by changes in the general price level, putting incomes on a common plane, and thus facilitating the comparison among enterprises in the two time periods.

In the first three enterprises the cattle are not fattened to slaughter weights. The cow-calf operation (A) appears to be more profitable than carrying weaners over for sale either in the spring (B) or summer (C). Two observations will, however, lead to a qualification of this conclusion. First, it must be remembered that for all of the feeds a market price was used. Most producers are capable of raising grain and hay at costs less than market price. Where this is the case, using market price gives a relative disadvantage to those operators doing the most feeding. This can be seen in Table 4 where income variation is shown with variations in cost of production for feed. Note that as the cost of production declines the incomes for B, yearlings sold in April, and C, yearlings sold in July, rise with respect to A, calves sold as weaners. The enterprises that show the greatest comparative gains are those with feeders (D-G). Nevertheless, it is not unrealistic to use the market price for feeds, for an increase in feeding means a drop in grain income for farmers. The normal alternative is to sell barley if it is not fed or if hay is not raised in its stead. Hence, the market price represents an opportunity cost.

The second observation concerns the price spread. For the ten year period, 1946-1956, the figures which were selected showed no spread in price per hundredweight for fall and spring cattle. For the twenty five year period, 1931-1956, the spread was approximately $1.00 per hundredweight. The price spread may be normally larger than these figures indicate. Price for feeder cattle is usually low in the fall in eastern Oregon when cattle are moving off the range. This is the reverse of the pattern in the midwest where the heavy demand for feeders draws cattle into the area and forces up the price.

An error in the price spread may be introduced in any one of three ways. First, the limited number of observations in the Portland market, which handles very few feeder cattle (24, p. 8) may give a false picture of demand and price. Second, the demand pattern for feeder cattle in Portland may vary from that in eastern Oregon. Finally, the sharp decline in cattle prices during the relatively short period from 1951 to 1953 may have distorted the demand and income pattern. Average prices received by Oregon farmers per hundredweight of beef (25) fell from a high of $29.50 in February 1951 to $13.20 in October 1953. By eliminating the two seasons, 1951-52 and 1952-53, and averaging the incomes of the remaining eight years in the ten year period, 1946-1956, the following results are obtained for the three enterprises: A, weaner calves--$668, B, April yearlings--$670, C, July yearlings--$798. The effects of this operation on all enterprises are shown in Table 4. Suffice to say, any of the above mentioned factors could erase the apparent income advantage of cow-calf operations over yearling enterprises. Nevertheless, it hardly seems profitable for a farmer to hold weaners during the winter if he intends only to sell them in the spring without feeding them out.

It is appropriate here to mention the activities of the recently established Federated Livestock Corporation of the Pendleton Grain Growers. During the season 1955-56 they began a cattle "wintering" program. Calves and yearlings were bought off the range in the fall by the Corporation and custom wintered on a half dozen farms in the region surrounding Pendleton. In the spring they were turned into the feed lot. Falling prices and an unusually hard winter contributed greatly to the failure of the first year's "wintering" operation. However, losses incurred were more than recovered by profits realized when these animals were fed out to slaughter weights in the spring and summer. Further evidence on the profitability of carrying over calves and yearlings will be forthcoming from future "wintering" operations of the Federated Livestock Corporation.

Enterprises D through G handled feeder cattle. Decisions are difficult for the man feeding out cattle. Many farmers are scared out of feeding by initial failure. This situation is exemplified by the farmers who, watching profits flow in from feeding in the late forties and early fifties, entered the cattle business after prices had begun to fall. The farmers who made money feeding cattle in the wheat-fallow area during the past year were few and far between.

There seems to be no formula for successful cattle feeding unless it is "trial and error". Some farmers have been feeding twenty pounds or more of grain daily to cattle without a sign of difficulty ever since they have been in the business. However, most of the good cattle feeders survived a period of blunders and mistakes when profits were "burned up" in bloated animals and cattle "going off feed". Eventually they acquired the necessary skill, although no single feed ration provided the key to success.[4]

Calves are fed out for slaughter in Enterprises D and E. Long yearlings are fattened in Enterprises F and G. There is a considerable contrast, as shown in the budgets, between the cow-feeder (D and F) and the purchased feeder (E and G) operations. Cow-feeder operations show considerably more profit although it appears to make little

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[4]In the feeding ration least is known at present about the feeding value of chaff. This is, of course, of more importance to those who maintain cow herds as a feeder ration contains little or no chaff. The chaff in the Oregon-Washington wheat area is of relatively high quality, and many cow herds are wintered on chaff alone. There is considerable controversy as to whether or not this should be done.

difference whether calves (D) or yearlings (F) are fattened.[5] The choice between either of the cow-feeder enterprises (D and F) or either of the purchased feeder enterprises (E and G) rests more on management considerations than on differences in returns from the use of the other resources. Feeding operations give rise to profits of two sorts, "margin profits" and "feeding profits" (15, pp. 283-284). The farmer who is better at feeding than at marketing will do better with younger, lighter cattle where profits are made from fattening with an efficient rate of gain. The farmer who understands markets best will do better with heavier animals for the profit will come largely through change in value of the initial weight.

The budgets indicate that those raising purchased feeders are at a tremendous disadvantage. The fact that no charges were made for the use of winter labor and range is in part responsible for the lower relative returns of these feeder enterprises. Opportunity costs for the use of labor and range were taken to be zero. Feeder cattle use less labor and no range in comparison with the other enterprises.

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[5]The rations, while selected as nearly as possible on the basis of actual feeding practices and checked with the Department of Animal Husbandry, would appear to be slightly biased in favor of the older animals (Enterprises F and G) when compared with Idaho experimental results (21, p. 15).

Thus, range is a "free" resource for those that maintain cow herds, "free" because it was assumed that range would lie idle on the purchased feeder farms. It should also be reiterated that feeder cattle are at a greater relative disadvantage when the market price for home grown feeds is used (see Table 4).

There are, in fact, few farmers who maintain only purchased feeder cattle in the wheat-fallow area. On most farms visited where only fattening was being carried on, there was little or no range. Extenuating circumstances appear to have given these purchased feeder operations a slight economic advantage. One operator had a friend working in the Portland market who did all of the buying and selling. Another bought feeders from his son-in-law. There were a handful of highly skilled cattle feeders that could likely as not show a profit in the poorest of years.

A number of farmers supplement home raised cattle with purchased feeders. It is therefore important to make an analysis of the combination purchased feeder and cow-feeder enterprise. In considering a combination of enterprises, some of the fixed costs may be spread over a larger number of animals. Considerable time could be spent in budgeting combinations of the last four (cow-feeder and purchased feeder) enterprises, but this is a knotty problem which linear programming is well designed to handle.

Listed beneath the net incomes and residual incomes for the budgets (Table 2 and 3) are two rows of figures, returns per $100 all costs and percentage return on investment for variable costs. Returns for the use of operating capital are normally measured in the former manner in farm management studies. The latter set of figures are presented because they will appear again in the matrix for the continuous capital solution in linear programming (see Table 6). These two sets of returns tell essentially the same story. The cow-calf enterprise (A) has the highest return. This is not surprising but is important. If allowance is made for the biases of the nature suggested in the analysis of net returns, the percentage return on investment of variable capital will still remain highest for Enterprise A. This places the cow-calf enterprise in a very favorable position for the person with limited capital and with limited feeding skill. This statement will also be examined more thoroughly in the chapter on linear programming.

Returns to Resources

Farmers almost always have one or more limiting resources. Therefore, they must apply the principle of opportunity cost in enterprise selection and resource allocation if they are to maximize profits. This requires that enterprises be adopted for scarce resources that will bring the highest return. It is for this reason that a farmer with an extreme acreage restriction will adopt an enterprise that yields a high return per acre. As a guide to decision making, net returns to resources are more meaningful, for they give the most accurate indication of the efficiency of the individual resource. However, gross returns to resources are useful in that they indicate the "rate of turnover" or gross productivity of a resource. The resource turnover can be compared with other enterprises and checked against the net return to that particular resource. A low net return may indicate either a low gross productivity or high expenses. For example, the high gross return to capital for the purchased feeder enterprises and the low net returns tell us that expenses and not receipts are out of line.

Through the examination of net returns to resources the farmer has a ready guide to enterprise selection. The cow-calf enterprise (A) and the cow-feeder enterprises (D and F) are conspicuous in that they consistently give the highest returns for the use of resources. Net returns for individual resources can be compared with possible alternatives for their use other than in beef production. Net returns to cropland represents a figure over and above what could be obtained from the sale of feed on the market because market prices were used for feeds in the initial computations. Returns for labor can be compared with returns for the use of labor elsewhere, but there are probably few opportunities in the wheat-fallow area for making use of winter labor.

Income Comparisons Using Alternate Assumptions

Countless decisions must be made in formulating budgets, decisions in the realm of animal nutrition regarding rations and daily rates of gain, decisions in the realm of agronomy regarding forage and grain production, decisions like those that have been mentioned concerning costs and prices. The farmer lacks the time and money to carry on his own research and must seek the advice of the Extension Service and through the Extension Service the advice of the College. Often, however, although the best sources of information are tapped, the lack of data or intra-regional variability may leave wide margin for error.

In the process of establishing budgets which are intended as guides to production for a given region, any decision to adopt or discard a cost will change not only the returns within an enterprise, but also, and more important, the relative returns among enterprises. For example, lowering the cost of production for feed will raise the returns for those enterprises that use a large quantity of feed with respect to returns for those enterprises that use little feed. Likewise, attributing a given cost to an enterprise may be quite rational for one farmer but completely irrational for another. If a farmer has the opportunity to rent his rangeland, he must charge this cost for the use of range to his cow herd. However, if no opportunity of this sort exists, and range will lie idle if not grazed by the farmer's cows, then no cost need be charged for the use of rangeland.

Of course, all possible situations cannot be considered. This would mean analyzing each farm separately. The information which seemed most reliable and most indicative of existing conditions was used in obtaining the results presented in Tables 2 and 3. Table 4, however, presents some of the outcomes under alternate assumptions. The first row shows the "base incomes", computed for the years 1946-1956, taken from Table 2.[6] The second row shows the eight year average incomes (omitting 1951-52 and 1952-53) mentioned earlier in this chapter. Next is the row of incomes assuming a charge for the use of range based on returns from rented range. Following this is a comparison

[6]Post-war data are considered more meaningful in predicting any future results. The information for the twenty five year period was gathered primarily to assist in income variability analysis to be discussed in Chapter VI.

Table 4. A Summary of Returns using Alternate Assumptions in the Budgeting of Selected Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956

Item	Enterprises						
	A	B	C	D	E	F	G
Net returns							
Base	779	480	528	1180	130	1178	360
8 yr average	668	670	798	1322	768	1231	578
Rented range 1/	379	80	128	780	-	778	-
CP = .9MP 2/	890	712	613	1517	707	1489	644
CP = .8MP	1026	944	898	1913	1284	1796	928
CP = .7MP	1150	1176	1084	2280	1861	2105	1213
Rate of gain							
yearlings 2.7	-	-	-	-	-	1309	610
2.6	-	-	-	-	-	1243	485
2.4	-	-	-	-	-	1113	235
2.3	-	-	-	-	-	1047	110
weaners 2.2	-	-	-	1449	768	-	-
2.1	-	-	-	1314	449	-	-
1.9	-	-	-	1046	-189	-	-
1.8	-	-	-	912	-508	-	-
Returns per $100 all costs							
Base	125	111	114	120	101	122	103
8 yr average	125	115	121	122	105	123	105
Rented range	111	102	103	112	101	113	103
CP = .9MP	130	117	120	128	105	130	106
CP = .8MP	136	124	126	137	110	138	109
CP = .7MP	141	130	132	145	115	146	112
Rate of gain							
yearlings 2.7	-	-	-	-	-	125	106
2.6	-	-	-	-	-	123	104
2.4	-	-	-	-	-	121	102
2.3	-	-	-	-	-	119	100
weaners 2.2	-	-	-	125	106	-	-
2.1	-	-	-	123	103	-	-
1.9	-	-	-	117	99	-	-
1.8	-	-	-	115	96	-	-

1/ Pasture was estimated at $2 per head per month for six months with a charge taken out for maintenance. This came to $400 for 50 AUMs.

2/ Cost of production (CP) is equal to nine tenths of market price (MP).

of incomes using three levels of cost of production as a percentage of market price for grain and hay. As the cost of production for feed decreases, the incomes of those enterprises using the most feed show the greatest rise. Returns for the feeder enterprises (E and G) rapidly rise over returns for cow-calf and cow-yearling enterprises (A, B and C). However, returns per $100 all costs are still low.

Finally, Table 4 shows a series of different assumed rates of gain for weaner and yearling feeders. The results are self-explanatory. If, for example, a farmer was capable of obtaining only 2.3 pounds gain per day for yearling steers instead of the assumed 2.5 pounds, the income for Enterprise F (yearlings fed out) would fall well below that of Enterprise D (calves fed out). In the case where a farmer could put 2.2 pounds per day on calves with the selected ration (shown in the index), income of Enterprise D would rise above that of Enterprise F.

In summarizing, we have discovered through budgetary analysis that the cow-feeder enterprises (D and F) return the highest income. However, the greatest returns per dollar of cost are forthcoming from the cow-calf enterprise (A). It can be speculated that with severe capital and managerial restrictions Enterprise A may prove the more profitable operation. This could be shown for capital by assuming certain capital restrictions and rebudgeting. However, as will be seen in the next chapter, this problem can be more successfully attacked through linear programming. It will also be demonstrated that linear programming can lend greater depth and flexibility to the conclusions through its ability to handle enterprise combinations and to allow resources to be varied.

Chapter V

LINEAR PROGRAMMING

The Linear Programming Technique[7]

The analysis of cattle enterprises in the wheat-fallow region has been handled in the previous chapter through the conventional method of budgeting. This chapter deals with the application of a relatively new tool in agricultural production economics, linear programming. The technique, pioneered by Danzig, Leontief, Koopmans, and others during the past two decades, has only recently been applied in the field of agricultural economics.

Linear programming works within the same basic

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[7] In this section some of the basic concepts of linear programming are presented and linear programming is compared briefly with budgeting and marginal analysis. However, the reader's attention is called to a number of very excellent books and articles on this subject. Dorfman (10) presents one of the more thorough treatments of linear programming in his book, Application of Linear Programming to the Theory of the Firm. Dorfman (11) has also published an article on this subject in The American Economic Review. Heady (14) and Boles (3) published articles in successive issues of the Journal of Farm Economics (December 1954 and February 1955) setting forth the basic principles and simple mathematics of programming. Charnes, Cooper, and Henderson (9) in An Introduction to Linear Programming give a more detailed mathematical exposition. Numerous other articles have been written, some treating certain specific aspects of programming, others developing more fully the application of this tool. It will be some time before the potential and possibilities of linear programming have been adequately explored.

economic framework as budgeting. The central problem of economics is the allocation of scarce resources to maximize a predetermined objective, taken in this paper to be "profit". The standard method of formulating this central problem is through marginal analysis. Dorfman (11, pp. 797-798) points out that, while the concepts and methodology of linear programming are still in the formative stage, programming reformulates the central economic problem in such a manner as to be more useful for practical economic decisions. The programming process conforms more closely than marginal analysis with the decision making procedures followed in modern industry today. This view is supported by the fact that linear programming first appeared in the field of scientific management and not in economics.

Thus, the contention is that managers actually face problems in the linear programming framework. This means that a limited or finite number of production processes are open to the firm, and associated with each process is a relatively fixed class of equipment or set of resources. Some decisions in agriculture fit into this pattern, others do not. For example, a farmer can select from a series of processes for harvesting hay. Associated with each practice is a certain specific type of hay equipment, baler, field chopper, loader, buckrake. But, the same farmer may have an infinite number of choices confronting him in deciding the level of fertilizer application. However, the usefulness of linear programming is not ruled out in this latter case, for, even where the production function is continuous, the sacrifice in accuracy is often small enough to be justified by the wealth of time saved.

Matrix algebra provides the mathematical structure in programming whereby scarce or limited resources can be allocated among any number of enterprises or processes. Enterprises are considered and resources allocated simultaneously in such a manner as to secure the maximum profit solution. The process of "selection and combination of enterprise" and "allocation of resources", the very core of production economics, is handled in a most efficient manner.

Three basic concepts are required to formulate a problem in linear programming: resources, products, and production processes. The first two are concepts familiar in marginal analysis. The concept of a production process (or enterprise, or vector) while not the same as that of a production function is closely related. This relationship is illustrated in Figure 2 (page 28) where the production processes, linear functions A, B, and C intersect points (a, b, and c) on the production function (PF). Linear programming takes its name from the relationship expressed by these linear functions. The assumption is that for a given process costs increase proportionally with returns.

Figure 2 is a two dimensional diagram for one factor and one product. The seven cattle enterprises under consideration produce a single product, beef, although this beef varies in grade and quality. However, the feed ration consists of as many as five factors, range grass, hay, chaff, barley, and cottonseed meal, the combinations varying for each enterprise. Hence, the seven enterprises represent points on a multi-dimensional production surface which cannot be diagrammed. Just as with budgeting, any number of enterprises could have been chosen. But the researcher has resource limitations also and must weigh "added costs" against "added returns" in selecting enterprises for analysis.

The linear assumption is once again portrayed in Figure 3, a two dimensional diagram depicting combination of enterprise. The intersections of linear resource limitations define points (a' and b') on the transformation function or production possibility curve. As in Figure 2, the adjoining solid straight lines replace the curve forming a segmented transformation function.

The assumption of linearity is accompanied by two other basic assumptions in linear programming, and these also apply in budgeting: "divisibility" and "independence".

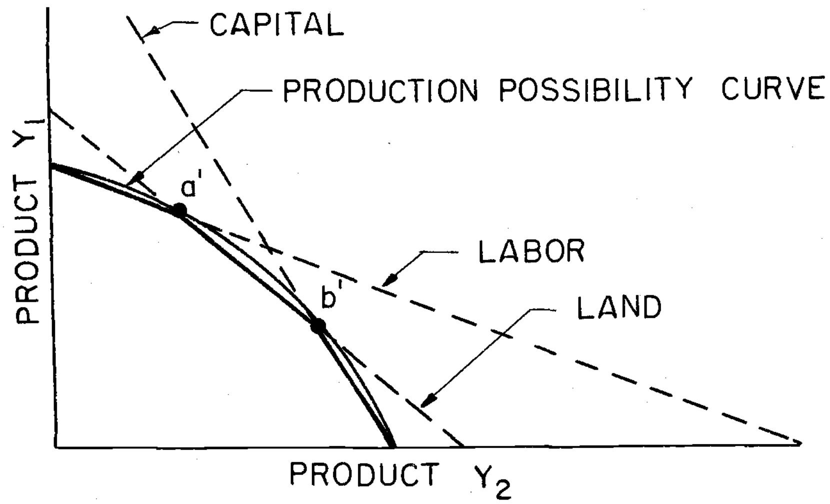

Figure 3. A production possibility curve defined by limiting resources for which the enterprises are in direct competition

"Divisibility" refers to the inputs: land, labor, and capital. For example, in this problem one acre of range or any number of acres up to 1500, the limit, could be used, and so too with units of labor and capital until their limits were reached. Rangeland could not, in fact, be divided without additional expense in fencing, but this presents no difficulty, for, as will be seen presently, the first process selected uses range to the limit.

"Independence" is sometimes referred to as "additivity". This concerns the relationship existing between enterprises. Enterprises are assumed to be competitive rather than supplementary or complementary. Hence, the income obtained from a combination of enterprises is merely a summation of the incomes obtained from separate, competing enterprises. This can be said to apply logically in the case of our seven enterprises which are all in competition for resources with the single exception that purchased feeders do not compete for rangeland.

In Chapter II it was emphasized that different cattle enterprises require different levels of management input. This fact was again mentioned in Chapter IV. Just like budgeting, linear programming operates under the assumption that farm managers could handle all enterprises with equal skill and success. This could be far from the truth.

It can be seen that linear programming requires the same information and makes the same assumptions as budgeting. Physical input-output data and prices must be known in order to estimate the relative profitability of alternatives on a selected unit basis. From these data coefficients can be developed which will define production within the physical and economic limitations established. However, the techniques differ basically in their method of handling alternatives and consequently in the number of alternatives or processes that can be simultaneously considered. In fact, linear programming gains its primary advantage over budgeting, and over marginal analysis as well, on a point of practicality, although this will depend somewhat on the problem at hand. The results attained through the application of the latter two techniques are often as reliable. However, the time involved in gathering and analyzing data through these two methods has greatly limited their application.

As Heady has pointed out (14, p. 1035), linear programming can "dip deeper" into problems. Thus, in many problems labor has been broken down into subclasses. Even more recently techniques have been developed for allowing resources and prices to vary, further increasing the flexibility of programming or the "depth to which programming can dip". This will be illustrated as the problem is presented in the next three sections.

In addition, one will find linear programming the superior guide when considering combinations of enterprises to maximize profit. Only skilled workers handling budgetary information can even approximate the solution that the programming process determines automatically. For linear programming selects the enterprise which offers the highest marginal returns and carries it forward until one of the resources becomes limiting. Then a selection is made based upon the new combination of resources which remain. This is continued until resource limitations prevent any further profitable expansion.

The success or failure of linear programming lies not in the mathematical computations, which can easily be checked for accuracy, but in the development of the coefficients. Just as in budgeting, if the input-output relationships assumed are inaccurate, the results obtained will be of little value. Coefficients are most difficult to establish because they must be based on some "average" standard of performance, when an "average" does not exist for an individual farm. The average does not describe the individual. This must be considered in the interpretation of findings.

In short, linear programming, by offering opportunity for the rapid and simultaneous consideration of a wider choice of alternatives becomes at once the more powerful tool in practical economics. The cumbersome procedure for budgeting has forced the orientation of budgetary analysis toward problems within the firm. Nevertheless, it should be emphasized that budgeting still has an important place in production economics and is often the more practical tool for handling small problems.

The Conventional Simplex Solution

The first program, presented in Table 5, employs the conventional simplex process with computational procedures as illustrated by Heady (14). Caldwell (5), in the first study using linear programming at Oregon State College, has given a clear presentation of the fundamental mathematics.

Table 5. A Simplex Solution in Linear Programing for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956.

Resources		P_0	P_8	P_9	C → Enterprise → P_{10}	8.0153 A Cow-Calf P_1	5.2131 B Cow Yrling P_2	5.8667 C Cow-Long Yrling P_3	6.6437 D Cow-Calf Feeder P_4	1.1627 E Calf Feeder P_5	7.2121 F Cow-Yrling Feeder P_6	2.0337 G Yrling Feeder P_7	R
Plan #1													
Capital	P_8	5000	1	0	0	11.7602	14.7295	13.6089	16.7487	23.5277	16.1462	22.6038	425.16
Rangeland	← P_9	1500	0	1	0	(7.6530)	6.1475	6.6667	4.9213	0	5.3476	0	196.00
Jan. Labor	P_{10}	240	0	0	1	.4891	.5779	.5067	.6138	.3725	.5793	.2413	490.70
	Z-C		0	0	0	-8.0153	-5.2131	-5.8667	-6.6437	-1.1627	-7.2121	-2.0337	0
Plan #2													
	P_8	2694.9500	1	-1.5367	0	0	5.2826	3.3642	9.1861	23.5277	7.9285	(22.6038)	119.22
8.0153	⇄ P_1	196.0016	0	.1307	0	0	.8033	.8711	.6431	0	.6988	0	unlim.
	P_{10}	144.1500	0	-.0639	1	0	.1851	.0807	.2993	.3725	.2376	.2413	597.38
	Z-C	1571.0108	0	1.0476	0	0	1.2256	1.1154	-1.4891	-1.1627	-1.6110	-2.0337	
Plan #3													
2.0337	→ P_7	119.2255	.0442	-.0680	0	0	.2337	.1488	.4064	1.0409	.3508	1	339.87
8.0153	← P_1	196.0016	0	.1307	0	1	.8033	.8711	.6431	0	(.6988)	0	280.48
	P_{10}	115.3140	-.0475	-.0475	1	0	.1286	.0447	.2010	.1208	.1528	-.0006	754.67
	Z-C	1813.4797	.0899	.9093	0	0	1.7009	1.4180	-.6626	.9541	-.8976	0	0
Plan #4													
2.0337	P_7	20.8327	.0442	-.1336	0	-.5020	-.1696	- .2885	.0734	1.0409	0	1	0
7.2121	→ P_6	280.4831	0	.1870	0	1.4310	1.1495	1.2466	.9203	0	1	0	0
	P_{10}	72.4485	-.0107	-.0884	1	-.2187	-.0471	-.1458	.0604	.1208	0	0	0
	Z-C	2065.2396	.0899	1.0770	0	1.2845	2.7327	2.5369	.1635	.9541	0	0	0

In the initial matrix of Table 5 all but the labor coefficients were developed from the information found in Tables 1 and 2. In order to define labor more precisely as a limiting resource, it was necessary to break down labor requirements by months. January and March were found to be the months when labor requirements for cattle were greatest (18, p. 12). In actuality, several months approximate the requirements of these two. Closer examination showed that March labor would not become limiting and that it would therefore be necessary to develop coefficients only for January labor.

Capital coefficients were obtained by dividing the variable cost of production (Table 2) by the number of pounds of beef produced (Table 1). These coefficients indicate the variable cost required to produce one hundred pounds of beef in each case. Range coefficients were calculated by dividing the acres of range by one hundred pounds of beef produced (Table 1). Prices shown in the C row at the top of the matrix are for net returns per hundredweight above variable costs. Fixed costs are not included in the matrix (14, p. 1046) but can be subtracted from returns when the matrix is solved. Column P_o at the extreme left lists the available resources. Capital was arbitrarily chosen at $5,000. Rangeland is 1500 acres. The 240 man hours of labor represents the labor of one man working full time for a month.

Much time can be saved in the computations by pretesting and, where possible, visualizing anticipated results. This has been done in Figure 4, a two dimensional sketch of a cow-feeder (F) and purchasedfeeder (G) enterprise combination. This diagram was first sketched from anticipated results and then redrawn in its present state after the program was solved. Through a diagram of this sort one can quickly see that March labor will not become limiting. The process of condensation or "shortcutting" is discussed by Boles in a recent article in the <u>Journal of Farm Economics</u> (4).

In Figure 4, the production of beef is plotted from Enterprise F, the cow-feeder operation, on the vertical axis, and from Enterprise G, the purchased feeder enterprise, on the horizontal axis. This is the familiar "product-product" diagram also illustrated in Figure 3. The limiting resources are drawn as solid straight lines. Note that neither March labor nor rangeland are limiting for Enterprise G, as is indicated by lines parallel to the G axis. However, range always becomes limiting before March labor for Enterprise F. As the broken iso-revenue curve moves away from the origin, it encounters rangeland as the first limiting factor at Point A. At this point the largest cow-herd possible under stipulated grazing

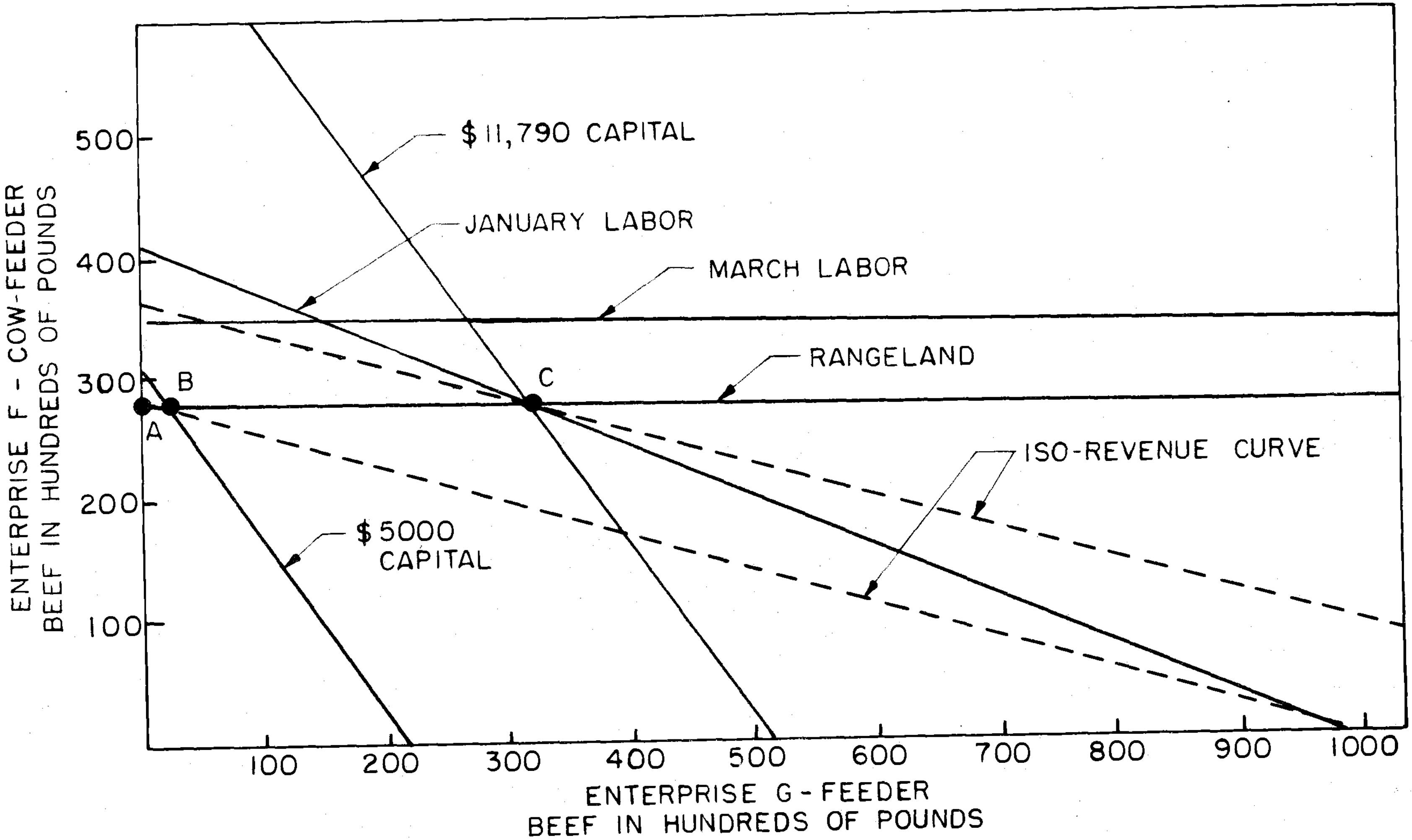

Figure 4. A geometric illustration of linear programming showing the combination of two cattle enterprises with various recourse restrictions for wheat-fallow farms in the Columbia Basin, Oregon, 1956

conditions is being maintained on the 1500 acres of range-land. Now expansion can only occur through an enlarged feeder enterprise where range is not required. The iso-revenue curve slides along the range resource line away from Point A (G is supplementary to F with respect to range) until a $5,000 capital restriction is encountered at Point B. No more capital is available to further increase the size of the purchased feeder enterprise (G). This combination of the two enterprises becomes the most profitable with the resources given. This geometric analysis, while limited in scope, should lend some insight to the discussion which follows.

Once the coefficients have been arranged as in Plan 1 of Table 5, the program is ready to be solved. According to procedure the largest negative number in the Z-C row is selected, for this indicates the enterprise with the highest marginal return. The highest negative number is found in Column P_1, and therefore P_1 will be the column for which R values are computed. To obtain R, the coefficient in each row of Column P_1 is divided into the corresponding number in Column P_0. The quotient (R) in each case represents the amount of beef that can be produced by the particular resource or the quantity of that resource remaining. Hence, the lowest R value (196) computed for P_1 (the cow-calf enterprise) tells us that Row P_9, range, is the most limiting resource. Row P_9, the out-going row in the first plan, is replaced by P_1, the incoming row in Plan 2 (note the arrows). This shift uses up all of the range resource. Selecting again the most negative number in the new Z-C row and the lowest number in the R column, P_8 is removed in Plan 2 and replaced with P_7 (a purchased feeder operation) in Plan 3. This exhausts the remaining $2300 of capital.

However, the negative numbers appearing in the Z-C row of Plan 3 indicate that an optimum plan has not yet been achieved. The procedure dictates that Row P_1 in Plan 3 be replaced with Row P_6. That is to say, the cow-calf enterprise is replaced with a cow-feeder enterprise. Because more capital is required for a cow-feeder operation on the same amount of range, less is available for the purchased feeder enterprise that was introduced in Plan 3. This is reflected by the decrease in quantity of meat that can be produced under P_7 in the P_0 column from 11,923 pounds in Plan 3 to 2,083 pounds in Plan 4. The maximum income solution calls for a combination of Enterprises F and G, cow-feeder and purchased feeder. This is Point B in Figure 4. In terms of livestock numbers, this means adding 2,083 pounds of beef or two steers (1075 pounds per head at market weight in Enterprise G) to the twenty fed out for market under Enterprise F.

The solution is very much the same as that found by budgeting. If $845 of fixed costs are subtracted from the $2,065 of income found in Plan 3 the remainder is $1,220. This figure is $42 above the income realized by Enterprise F in Table 2. The added income is represented by the two added steers which net $2 per hundredweight. Of course, few farmers would want to supplement their herd by as few as two steers. Plan 2 shows the income above variable costs for the cow-calf operation alone. Subtracting $792 of fixed costs from $1,551 gives the $779 net income found under Enterprise A in Table 2.

The Simplex Solution Allowing Capital to Vary

A broader perspective was achieved in the previous chapter by making certain alternate assumptions regarding decisions in budgeting. Here it was emphasized that there is no one answer for all farmers in the wheat-fallow area. Opportunities may vary from farm to farm. What determines a farmer's production potential is basically the resources which he has at his disposal: land, labor, capital, and management. The latter resource, management, cannot be handled directly in budgeting or programming. Aside from management, the two resources which vary most from farm to farm throughout the wheat-fallow area are capital and rangeland. In this section enterprise selection and combination is studied allowing capital to vary while other

Table 6. A Continuous Capital Solution in Linear Programming for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956

Resources		P_0	ΔP	P_8	P_9	C → P_{10}	8.0153 A Cow-Calf P_1	5.2131 B Cow Yrling. P_2	5.8667 C Cow-Long Yrling. P_3	6.6437 D Cow-Calf Feeder P_4	1.1627 E Calf Feeder P_5	7.2121 F Cow-Yrling. Feeder P_6	2.0337 G Yrling. Feeder P_7	R
Plan #1														
Capital	P_8	0		1	0	0	11.7602	14.7295	13.6089	16.7487	23.5277	16.1462	22.6038	--
Rangeland	← P_9	1500		0	1	0	7.6530	6.1475	6.6667	4.9213	0	5.3476	0	196.00
Jan. Labor	P_{10}	240		0	0	1	.4891	.5779	.5067	.6138	.3725	.5793	.2413	490.7
	Z-C	0	0	0	0	0	-8.0153	-5.2131	-5.8667	-6.6437	-1.1627	-7.2121	-2.0337	
	D						-.6816	-.3539	-.4311	-.3967	-.0494	-.4467	-.0900	
Plan #2														
	P_8	-2305.0500	-2305.05	1	-1.5367	0	0	5.2826	3.3637	9.1861	23.5277	7.9285	22.6038	--
8.0153	⇄ P_1	196.0016		0	.1307	0	1	.8033	.8711	.6431	0	.6988	0	280.5
	P_{10}	144.1500		0	-.0639	1	0	.1851	.0807	.2993	.3725	.2376	.2413	606.7
	Z-C	1571.0116	1571.0116	0	1.0446	0	0	1.2256	1.1154	-1.4891	-1.1627	-1.6110	-2.0337	
	D									-.1621	-.0494	-.2032	-.0900	
Plan #3														
	P_8	-4528.8450	-2223.7958	1	-3.0196		-11.3458	-3.8315	-6.5196	1.8896	23.5277	0	22.6038	--
7.2121	→ P_6	280.4831		0	.1870		1.4310	1.1495	1.2466	.9203	0	1	0	Unlim.
	← P_{10}	77.5095		0	0.1083		-.3400	-.0880	-.2155	.0806	.3725	0	.2413	203.1
	Z-C	2022.8598	451.9825	0	1.3487		2.3053	3.0774	3.1237	-.0065	-1.1627	0	-2.0337	
	D									-.0074	-.0494	0	-.0900	
Plan #4														
	P_8	-11789.5552	-7260.7102	1	-13.1646	-93.6751	20.5037	4.4119	13.6674	-5.6606	-11.3663	0	0	
7.2121	← P_6	280.4831		0	.1870	0	1.4310	1.1495	1.2466	.9203	0	1	0	196.00
2.0377	→ P_7	321.2163		0	-.4488	4.1442	-1.4090	-.3647	-.8931	.3340	1.5434	0	1	--
	Z-C	2677.4023	654.4205		.4342	8.4446	-.5658	2.3343	1.3038	.6741	1.9829	0	0	
	D						-.0276							
Plan #5														
	P_8	-15808.3732	-4081.8180	1	-15.8440	-93.6751	0	-12.0584	-4.1941	-18.8468	-11.3363	-14.3282	0	
80153	→ P_1	196.0050		0	.1307	0	1	.8033	.8711	.6431	0	.6988	0	
2.0377	P_7	597.3872		0	-.4517	4.1442	0	-1.4965	-2.1205	-.5722	1.5437	-.9846	1	
	Z-C	2788.3348	110.9325	0	.5082	8.4446	0	2.7888	1.7967	1.0380	1.9829	.3954	0	

resources and prices are held constant.

Table 6 presents a modified simplex solution for linear programming with variable capital restrictions. Candler (6) has recently written an article discussing this refinement in the linear programming technique. Two simple steps are required to modify the existing matrix (Plan 1, Table 5) so that capital may be varied. First a "decision" or D row must be computed by dividing the Z-C value by the capital coefficients in each column. The quotient in each case is the percentage return for variable capital (see Table 2, Row 21). Activities are now selected on the basis of the most negative number in the D row. The most negative number indicates the activity with the highest return for the use of capital.

The next step necessary before computation can begin is to set the varying resource, capital, in the P_o column at zero. Now the capital requirement for each plan will appear as a negative number in the P_0 column. The row containing the varying resource can never be the outgoing row.

The highest negative number in the D row is found in Column P_1 (-.6816) which becomes the column for which the R values are computed. The R value is the lowest for rangeland, and hence, P_9 becomes the out-going row. Observing the P_0 column in Plan 2, we see that if rangeland is completely exhausted, 19,600 pounds of beef will be produced under a cow-calf system (see beef production under Enterprise A, Table 1) with $2,305 of capital required (see Table 2, Row 11). This means that any operator with less than $2,300 to spend in cattle should not be concerned with feeding out cattle, for when he has this much range, he will obtain highest returns with a cow-calf operation.

Enterprise A is replaced with Enterprise F, a cow-feeder enterprise. While higher returns to capital are attained with a cow-calf enterprise, once capital becomes plentiful in relation to other resources a cow-feeder enterprise will be more profitable. With rangeland fixed, Enterprise F can simply become larger than a cow-calf enterprise by the very fact that it uses more capital for feeding out cattle. The higher capital investment permits Enterprise F to show higher returns. This has already been observed in the budgets. When range is completely utilized, Enterprise F requires $4,529 of capital to produce 28,050 pounds of beef. (Again these figures can be compared with those in Tables 1 and 2.) With between $2,300 and $4,500 capital available an operator can maximize his profits by selecting the cow-feeder enterprise, F.

Once the supply of range has been exhausted capital may be added until labor becomes limiting. Obviously, one of the two enterprises requiring no range will be added to Enterprise F. The most negative D is found in Column P_7, and therefore the yearling purchased feeder enterprise (G) is introduced in Plan 4. Glancing once again at Figure 4 (Page 63), the iso-revenue line now moves along the range limitation line toward Point C where labor will become limiting. Point C is expressed in the program (Table 6 again) by Plan 4. Here a combination of cow-feeder and purchased feeder enterprise (F and G) will utilize all range and labor and $9,120 of capital in the production of 60,200 pounds of beef. This necessitates purchasing thirty head of cattle to supplement the twenty-two head of yearling feeders raised on the farm.

A maximum profit solution has still not been achieved for unlimited capital since a negative number remains in the decision row. Plan 5 reverses the procedure of Plan 3 by replacing Enterprise F with Enterprise A, the cow-calf operation. However, the cow-calf activity is reintroduced in combination with purchased feeder cattle, Enterprise G. What this states is that a farmer should sell weaner calves and then turn around and purchase fifty six yearling steers to feed out. This is not a very practical suggestion, and not one that very many farmers would follow.

The irrational solution, Plan 5, is forced in because of low labor requirements for the cow-calf operation as compared with the cow-feeder enterprise. (This can be observed by comparing the labor coefficients for these two enterprises in the initial matrix of Table 6.) In the cow-calf enterprise January labor is necessary only to maintain the cow herd. But labor for cattle on feed is also included in the cow feeder enterprise. Considering only the January labor restriction, a farmer could market the most beef by purchasing nothing but yearling feeders which have the lowest labor requirements per hundred pounds of beef produced. However, net returns to purchased feeders are so low that this plan would return only $2,023 and therefore does not enter the solution.

Aside from this, the most beef per unit of January labor can be produced by selling weaner calves in the fall and buying feeder cattle. (See Table 7.) Once sufficient

Table 7. A Summary of the Continuous Capital Solution in Linear Programming for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956

Capital Optimum	Capital Needed	Lbs of Beef from Enterprises A	F	G	Income $
Plan 1	0	0	0	0	0
Plan 2	2,305	19,600	0	0	1571
Plan 3	4,529	0	28,050	0	2033
Plan 4	11,790	0	28,050	32,220	2677
Plan 5	15,808	19,600	0	59,740	2788

capital is available the purchased feeder enterprise, even with its low monetary returns, can be greatly expanded in combination with a cow-calf enterprise to more than offset the difference in returns between cow-calf and cow-feeder enterprises. Income from purchased feeders in Plan 5 is increased by $562, which offsets the difference between returns to Enterprise F (P_6) and Enterprise A (P_1) by $110. The advantage gained over Plan 4 is very slight as marginal returns to variable capital are less than 3%.

Table 7 summarizes the optimum solutions obtained from the successive plans of Table 6.

The solution in Table 7 is diagrammed in Figure 5. The practical value of this graphical presentation is at once evident, for the "confusion" of the linear programming process can be set forth in a form that the layman can easily comprehend. In Figure 5 capital is plotted on the horizontal axis and income on the vertical axis. Points 2, 3, 4, and 5 represent Plans 2, 3, 4, and 5 respectively. Points 2 and 4 in Figure 5 correspond to Plans A and C in Figure 4. Furthermore, the progression of plans forms a segmented linear production function similar to that in Figure 1. When a resource is allowed to vary, coefficients designed to predict one point on a curve are allowed to predict an entire curve. It is difficult to know for what range these coefficients are reliable or the degree of

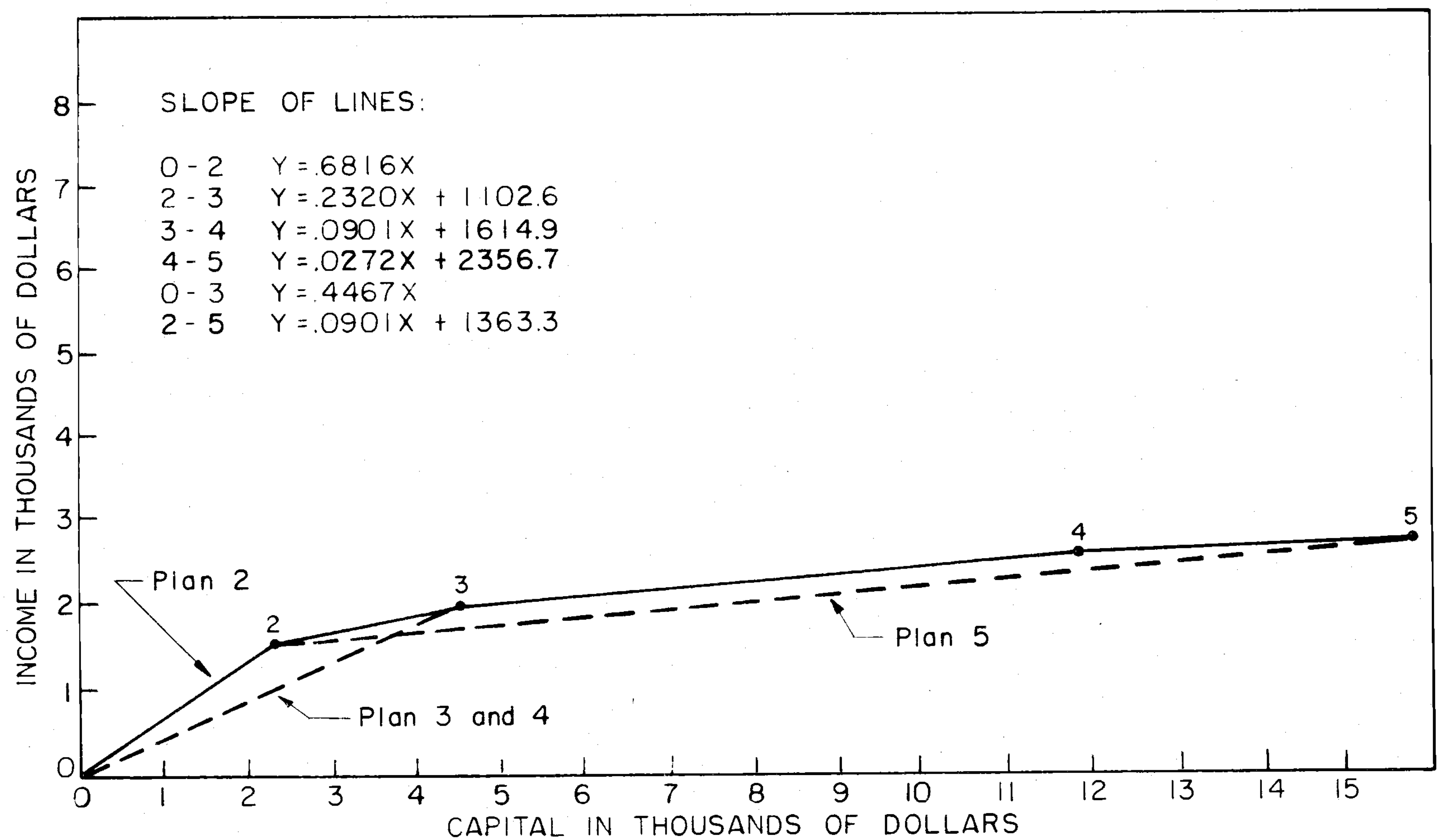

Figure 5. A linear programming solution allowing capital to vary continuously, using the ten year average returns, 1946-1956, for selected beef cattle enterprises on wheat-fallow farms in the Columbia Basin, Oregon

distortion that occurs due to linearity. There are undoubtedly certain efficiencies of scale with respect to capital and labor as herd size is increased. The simplex method of linear programming in its present form is not equipped to handle the scale problem. This is perhaps the most serious limitation of our linear programming analysis.

The dotted lines in the diagram indicate the enterprise combinations which exist in the solution for each plan. Thus, in Plan 3 and 4 the cow-feeder enterprise, indicated by the line 0-3, replaces the cow-calf enterprise (0-2). Plan 5 represents a combination of cow-calf (0-2) and purchased feeder (2-5) enterprise. The man with $10,000 to invest will combine home raised feeders (0-3) with purchased feeders (3-4). Substituting $10,000 for X in Equation 3-4 ($Y = .0901X + 1614.9$), one finds that he will have a return of $2,516. Returns for the use of capital are represented by the slopes of the lines which appear in equation form.

Once a given capital level has been selected, the requirements for the other resources can be obtained and the new plan quickly worked out. In Table 5 capital is fixed at $5,000. This falls somewhere between $4,529 required by the cow-feeder enterprise (F) and $11,790 required by cow-feeder and purchased feeder (F and G) in combination. These are the capital requirements for Plan 3 and Plan 4, in Table 6. The actual change in capital ($11,190-$4,529) is $7,261. However, the desired change in capital ($5,000-$4,529) is $481. The ratio of the wanted capital input to the actual capital input is .0062. Now it is necessary to determine only the actual change in other resources when moving from Plan 3 to Plan 4 and apply the ratio to find the requirements for other resources at the $5,000 capital level. The actual change for the range resource is zero as no change is required when adding feeders. The actual change in January labor is zero minus 77.5. This latter number is determined by subtracting the labor supply remaining in Row P_{10}, Plan 4 from that found in P_{10}, Plan 3. Plan 4 has completely utilized 240 hours of January labor, and therefore the number is zero. Plan3 has used 162.5 hours of the available 240 hours. Hence, -77.5 is multiplied by the ratio .0062 computed for the $5,000 capital level. The results show that the $5,000 plan requires 5.31 hours more than Plan 3 which would leave 72.4 hours of unused January labor. This number agrees with that shown in Row P_{10}, Plan 4, Table 5.

With $10,000 capital, using the same procedure as above, the new ratio of needed to actual capital would be .7534. This figure multiplied by -77.5 tells us that 58.4 hours of labor are used. Only 19.1 hours of January labor remain. The $10,000 plan would call for 1500 acres of

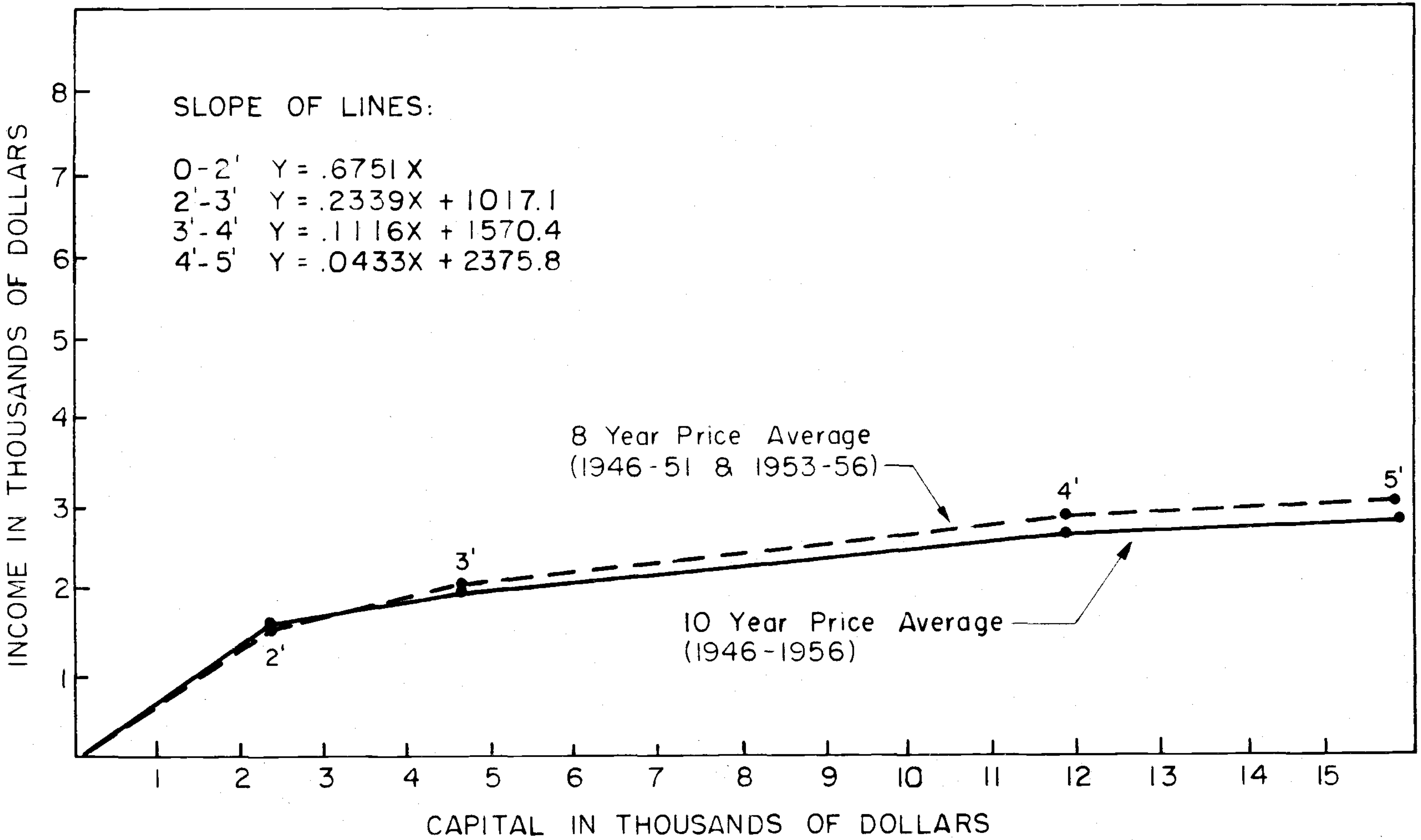

Figure 6. A linear programming solution allowing capital to vary continuously, comparing eight and ten year average returns for selected beef cattle enterprises on wheat-fallow farms in the Columbia Basin, Oregon, 1946-1956

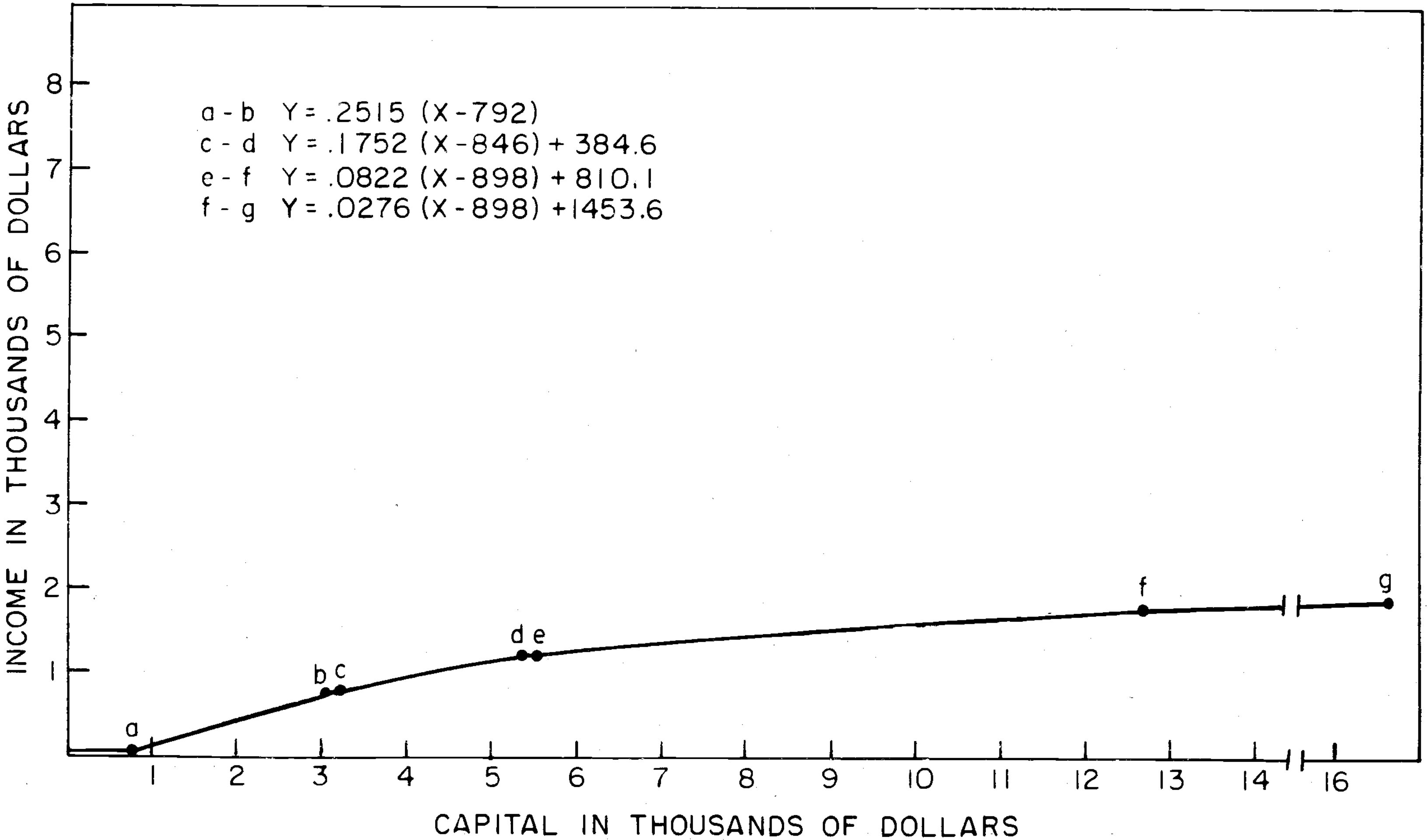

Figure 7. A linear programming solution allowing capital to vary continuously using ten year average returns, 1946-1956, and considering fixed costs for selected beef cattle enterprises on wheat-fallow farms in the Columbia Basin, Oregon

rangeland and 220.9 hours of January labor.

In Figure 6 the dotted lines represent the linear segments when the ten year average of incomes is replaced by the eight year average, excluding the 1951-52 and 1952-53 seasons as shown in Table 4 (page 49). These results are summarized in Table 8. The matrixes appear in the

Table 8. A Summary of the Continuous Capital Solution in Linear Programming, using Eight Year Average Prices omitting 1951-52 and 1952-53, for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956

Capital Optimum	Capital Needed	Lbs of Beef from Enterprises A	F	G	Income $
Plan 1	0	0	0	0	0
Plan 2	2,305	19,600	0	0	1,556
Plan 3	4,529	0	28,050	0	2,076
Plan 4	11,790	0	28,050	32,220	2,886
Plan 5	15,808	19,600	0	59,740	3,062

Appendix, Table 15. Contrasted with the ten year average, the eight year average attributes higher incomes to the feeder operations. This effect is seen in comparing the shape of the two curves.

Figure 7 introduces fixed costs and a fixed cost charge. The results considering fixed costs are summarized in Table 9. Fixed costs are indicated by the horizontal

Table 9. A Summary of the Continuous Capital Solution in Linear Programming Considering Fixed Costs for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956

Capital Optimum	Fixed Costs	Variable Costs	Total Costs	10 yr. Incomes	8 yr. Incomes
Plan 1	0	0	0	0	0
Plan 2	792	2,305	3,097	779	668
Plan 3	845	4,529	5,374	1,178	1,231
Plan 4	898	11,790	12,688	1,779	1,988
Plan 5	898	15,808	16,706	1,890	2,165

lines o-a, b-c, and d-e in Figure 7. The line o-a represents \$792 of fixed costs; b-c represents \$53 (\$845-\$792) of fixed costs; d-e represents \$53 (\$898-\$845) of fixed costs. Incomes are, of course, considerably reduced when fixed costs enter the picture. Plans 2, 3, 4, and 5 are indicated by Points b, d, f, and g respectively. The net returns for Plans 2 and 3 are identical to those found for Enterprises A and F in the budgets.

The Simplex Solution Allowing Range to Vary

Aside from capital, which we have just discussed, and management which cannot be handled by linear programming, land is the most variable resource from farm to farm throughout the wheat-fallow area. Some farmers have far more rangeland than cropland. Other farmers have no range at all. It is obvious that the man without grazing land has only the alternative of buying feeder cattle or staying out of the cattle business. However, when different levels of range are combined with other resources, the optimum plan will vary. A summary of a linear programming solution allowing rangeland to vary continuously is shown in Table 10. The solution is computed in the identical manner as

Table 10. A Summary of the Linear Programming Solution allowing Rangeland to vary Continuously for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956

Range Optimum	Range Needed	Lbs of Beef from Enterprises A	F	G	Income $
Plan 1	0	0	0	0	0
Plan 2	1,469	29,850	0	0	1,983
Plan 3	1,656	0	30,960	0	2,233
Plan 4	3,254	0	0	42,520	3,408

those for continuous capital. The resources held constant are $5,000 of capital and 240 hours of labor. The complete solution appears in the Appendix, Table 16. Range inputs are plotted against monetary returns for the optimum plans in Figure 8.

The results obtained are according to expectations. It is logical that, when rangeland is extremely limited in

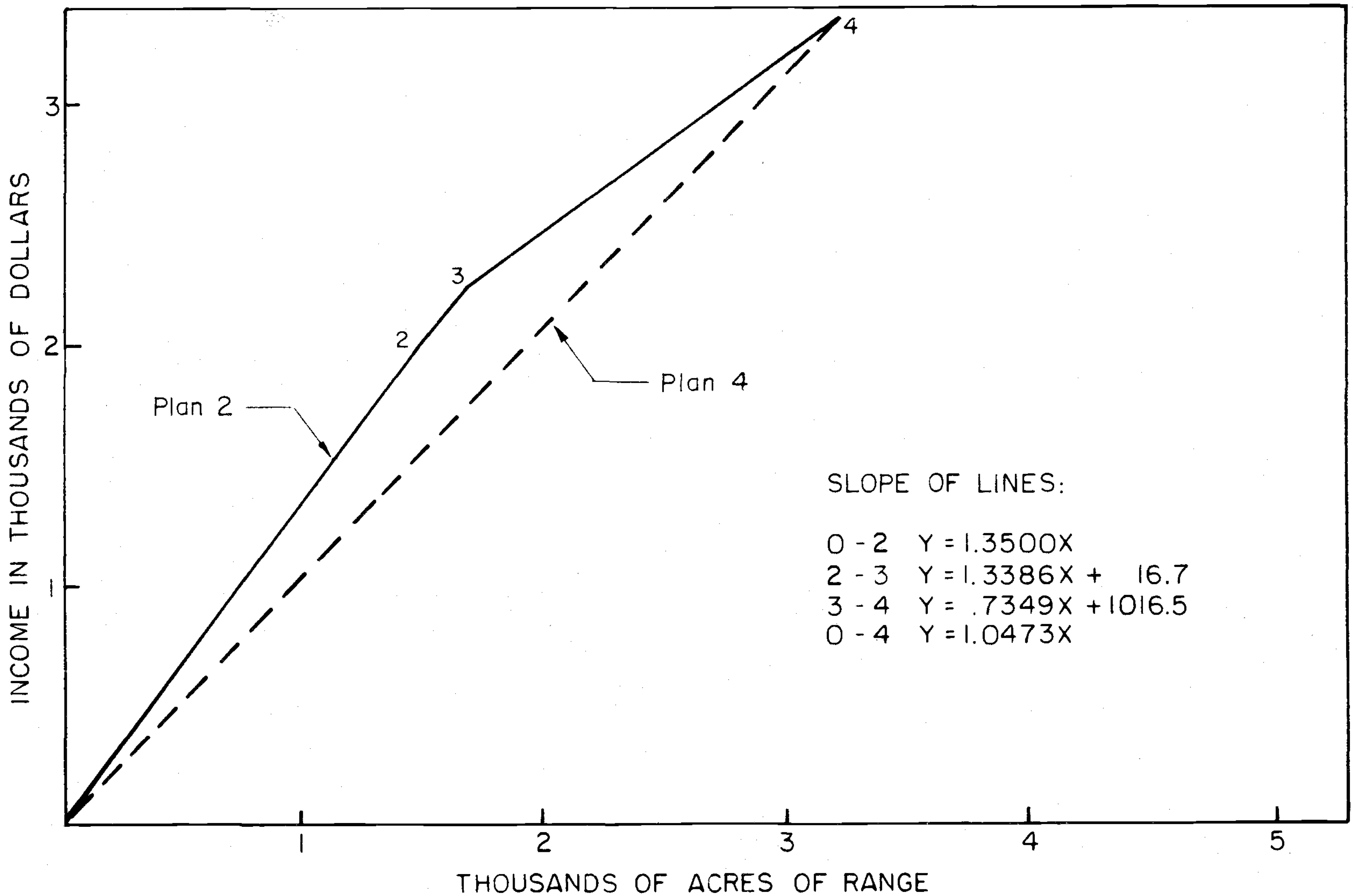

Figure 8. A linear programming solution allowing rangeland to vary continuously for selected beef cattle enterprises on wheat-fallow farms in the Columbia Basin, Oregon, 1946-1956

comparison with other resources, higher returns will be achieved by feeding out the cattle that come off the range. The budgets indicate that this is true even with 1,500 acres of rangeland available, for in the budgets returns were higher for the cow-feeder enterprises (D and F) than for the cow-calf enterprise (A). The difference between D and F is small. However, when more than 1,656 acres of range is available weaner calves begin to substitute for fed cattle. If the farmer selects either one enterprise or the other, he should choose the cow-calf enterprise if he has more than 2,132 acres of range. With 2,132 acres of range Enterprise A and F show equal returns. This is determined by setting Y (income) equal to $2,233 in the equation for Line 0-4 (Y = 1.0473X) and solving for X (rangeland). Line 0-4 represents the returns to rangeland for Enterprise A. With 3,254 acres of rangeland found under Plan 4, a herd of 80 cows would be maintained with 69 calves sold as weaners annually.

The contrast here is between extensive and intensive farming. When a small amount of range (less than 1,656 acres) is combined with the other given resources, the intensive cow-feeder operations (D and F) are optimum. But for large amounts of rangeland, an extensive cow-calf operation is optimum. If the level of capital inputs was to be increased, one could expect to find cow-feeder operations most profitable for an increasingly higher level of range, at least to the point where labor becomes limiting. At the 3,254 acre range level, capital is fully utilized, but 32 hours of January labor remain idle.

An additional refinement in linear programming could have been employed, that of variable pricing. It is often advantageous to know the degree of change in price required to bring in another activity or enterprise. This, however, is not as important in a situation where all enterprises are producing beef. Generally beef prices will move up and down together although occasional relative changes occur between slaughter and feeder grades. Nevertheless, it can be observed that returns for the cow-feeder enterprises (D and F) and for the purchased feeder enterprises (E and G) are very close together, and that approximately a dollar rise in price of the younger, lighter weight, slaughter cattle would cause Enterprises D and E to substitute for F and G in the matrixes.

We have shown in this chapter that for capital limitations below $2,300 a cow-calf enterprise is preferable to a cow-feeder enterprise. When there are no restrictions on capital, the optimum plan is achieved by supplementing home raised cattle with purchased feeders, although it should be noted that returns to investment are considerably lower for purchased feeder cattle. Just as severe capital restrictions will encourage farmers to become extensive, severe range restrictions will encourage them to adopt a more intensive feeding operation if maximum profits are to be attained. At the $5,000 capital level highest incomes are achieved by feeding calves to slaughter weights when range is below 1,656 acres. These results emphasize that the program which an individual farmer selects will depend on the resources, including management, available to him.

Chapter VI

UNCERTAINTY AND INCOME VARIABILITY

Conditions of Uncertainty

Discussion has been, to this point, largely concerned with profit maximization, primarily because it is a paramount and measurable objective of farmers. In this chapter analysis is made of the various enterprises and enterprise combinations with respect to uncertainty. It is important that this should be done because the adoption of an enterprise that promises higher level of income often necessitates the acceptance of greater uncertainty in income. In the classical concept uncertainty is associated with a large range and variance in income (16, p. 720). However, farmers also attach a measure of uncertainty to the frequency of loss.

It is impossible to tell to what degree farmers will be willing to sacrifice financial security for the prospect of a higher income. Nevertheless, the impact of an enterprise or enterprise combinations on income uncertainty can be analyzed and this information presented to farmers. Knowledge of potential return and potential uncertainty offered by various enterprises and enterprise combinations improves the farmer's decision making framework. His choice of enterprise may then to a large degree reflect his "indifference curve" or preference for greater income as compared with greater certainty of returns. Higher income is often associated with higher uncertainty, but this is not always true.

While farmers may have a definite notion about the degree of uncertainty associated with individual enterprises, as expressed by variability of returns and frequency of loss, they do not all view uncertainty with the same attitude. They do not all possess the same preference for risk, and there are very good reasons for this.

First, and most obviously, individuals differ in their psychological makeup. Some are born gamblers: others possess a high degree of "risk aversion". The individual who is willing to take no chance at all would perhaps be happier in some business other than farming. Farming characteristically involves a sizeable measure of uncertainty. Because farmers must often accept the whims of nature, they are faced with more uncertainty than most other businesses. Within agriculture itself, however, the degree of uncertainty varies tremendously. Dairy farming is a relatively stable occupation contrasted with wheat farming. Milk checks come in once a month, prices do not fluctuate rapidly, and the problem of crop failure is not acute. Feeding out purchased cattle normally presents greater uncertainty than marketing cattle from a cow herd.

The man who buys and feeds cattle stands to loose heavily with a drop in the cattle market or a rise in the feed grain market, or to make great profits when the reverse takes place. Thus, the beef-barley ratio has the same significance for Oregon cattle feeders that the familiar corn-hog ratio has for mid-western hog producers.

The fact that a farmer's psychological makeup is subject to change, especially with the passage of time, is often overlooked. Young farmers are usually the ones who will gamble with new ideas. In the older farmer the aversion to change may be more important than the aversion to risk although, undoubtedly, both are closely linked.

The influence which certain events may have on an individual's thinking is closely associated with this concept of a changing psychological makeup. The "old-timers" in the wheat-fallow area still like to recall how things were back in the thirties when, as one operator said, "I didn't know from one day to the next whether the hired man or I owned the place." In contrast, those who began farming since 1940 have lived in an inflationary age. They are not hampered in thought or in actions by reminiscences of the thirties.

Other factors help to mold the farmer's attitude toward uncertainty. His capital position is of extreme importance. Naturally the individual with sufficient capital backing need not concern himself greatly with the consequences of failure. On the other hand, the farmer with severe capital restrictions must always keep in mind the survival of the firm. For this farmer the statistical probability of success or failure has considerable consequence. Regardless of the probable variability and range of returns, he will choose that enterprise that offers the least chance for loss. He may have no chance to try again after the first bad year.

The family-firm complex offers a third cause for variation in farmer attitude toward uncertainty. A farmer is a consumer as well as a producer. The young farmer with a growing family has high demands placed upon him for consumption capital. This will indeed affect his willingness to adopt enterprises with high variable returns, although many enterprises with rapid rate of turnover, such as livestock feeding operations, embody a high degree of uncertainty.

Thus, there are probably no two farmers who view the problem of uncertainty in exactly the same manner. Forces are present which shape the individual's outlook. Even should two farmers possess the same degree of risk aversion, they may differ greatly in level of knowledge. This will cause them to have different expectations of outcome. A farmer may have a very clear notion of returns forthcoming

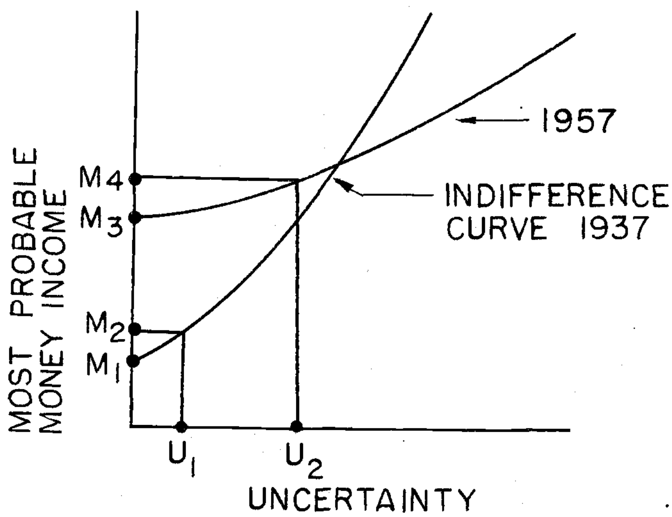

Figure 9. Two indifference curves showing the hypothetical relationship between income and willingness to accept uncertainty for wheat-fallow farmers in the Columbia Basin, Oregon

from a certain course of action. He is said to have a high degree of "subjective certainty". The well informed farmer pushes back the boundaries of uncertainty with his superior knowledge.

With this brief discussion of uncertainty, we can speculate as to the nature of the indifference curves for farmers in the wheat-fallow area. Figure 9 shows two hypothetical indifference curves. The indifference curves measure the farmer's willingness to accept a greater risk in order to obtain a higher income. The most probable return is plotted on the vertical axis, the degree of uncertainty on the horizontal axis. The indifference curve of a

1936 wheat farmer is compared with that of a 1956 wheat farmer. In 1936 the country was still in the midst of a depression. Wheat farmer incomes were low. Many farmers faced the possibility of foreclosure. As the curve indicates, farmers would probably have been willing to accept greater uncertainty only if there was good prospect of a considerably higher income. The 1956 wheat farmer had just witnessed a decade of post-war prosperity. Improved capital position and the gradual weakening of "depression psychosis" would cause a shift in the slope of the curve. The contention is that the 1956 farmer would be willing to accept higher uncertainty than his 1936 predecessor with prospects of the same increase in return. This is shown by Figure 9 where M_1-M_2 is equal to M_3-M_4.

Further than this we will not go, for in the final analysis the slope of the indifference curve will vary for each individual. The next step is to select some measure of the magnitude of uncertainty.

Statistical Methods Employed

Uncertainty is indicated both by variance of returns and by frequency of loss of income. This latter measure of uncertainty can be examined by establishing a frequency distribution table for the net incomes of the various enterprises. Comparing variability, however, is a more difficult task. The common statistical measures of variability are "variance", "standard deviation", and "coefficient of variation". The first two (the standard deviation being the square root of the variance) will indicate the absolute variability of returns for a given enterprise, but where enterprises differ in scale, these measures are of little value for comparing variability. Some enterprises may show low absolute variability, but income variation may be great relative to the size of the income itself. The concept of relative variability, which can be measured by the coefficient of variation, is the more useful one in decision making (16, p. 665). It is for this reason that coefficient of variation (defined as the standard deviation divided by the mean) was chosen for comparing uncertainty among enterprises and enterprise combinations.

The coefficient of variation, as a measure of variability, is useful in indicating the degree of uncertainty attached to various enterprises. However, it has certain limitations which must be mentioned (16, p. 719-721). Difficulty occurs in comparisons when the mean and variance of one enterprise are both larger than those of a second enterprise. In our case, the mean and variance of net incomes for cow-feeder enterprises are larger than those of the cow-calf enterprise as Table 12 indicates. In this situation, for example, although the coefficients of variation might be equal, the enterprise with the smaller mean and variance may show less uncertainty in the classical sense in that range and variance are small, while the other may show less uncertainty in the sense that frequency of loss is less. Which enterprise a farmer should choose would depend upon his capital position. This analysis is further complicated when the frequency distributions overlap.

Additional difficulty is encountered when the frequency distributions are nonsymmetrical. If the frequency distribution of incomes differs between enterprises, the coefficients of variation are not comparable since the direction and amount of skewness may differ (16, p. 721). Table 11 shows that frequency distribution of net incomes, especially for the brief ten year period, is far from symmetrical.

Two further observations can be made with respect to the use of coefficient of variation for drawing uncertainty comparisons between enterprises with the net income data at hand. First, the two feeder enterprises have negative means for the twenty five year period (see Table 12). Coefficient of variation cannot be used to give a cardinal measure of uncertainty when means are negative because for a given variance, as average returns or means become more negative the coefficient of variation becomes smaller.

Secondly, market prices were used for cattle feed which makes up over half of the cost of producing beef. Differences in correlation between feed prices and cattle prices could cause serious disturbance in the variances of enterprises. Those enterprises showing a higher positive correlation of feed prices with cattle prices would tend to show lower variability of income and visa versa. In order to analyse this problem three enterprises were selected and hay and barley prices correlated with cattle prices. The highest positive correlation coefficient, .52, was for the cow-calf enterprise (A). Next followed the cow-feeder enterprise (F) with a coefficient of .36. The lowest correlation coefficient was . 24 for the cow-yearling enterprise (B). Thus, considerable variation does exist among the enterprises in the correlation coefficients for feed and cattle prices.

Four points have been discussed which could seriously affect the interpretation of coefficient of variation for the net income data available. The evidence dictates that coefficient of variation should not be calculated for the net incomes. However, coefficients of variation were computed for gross incomes. With gross incomes the problems created by negative means and by the use of market prices for feeds do not occur. Frequency distribution difficulties are present but are not as severe as in the case of net incomes because many of the comparisons are made between combinations for which means, variances, and distributions are very close (see Table 14).

Variability arising from enterprise combinations is of major interest. Whether or not the addition of an enterprise will reduce income variability is determined by the variance of income for each enterprise and the correlation between the enterprise returns.

The primary enterprises in the wheat-fallow area are grain and cattle. Until recently the grain raised has been almost entirely wheat, but since 1951 wheat acreage restrictions have caused the diversion of approximately 35% of the cropland to the production of barley. In combining one of the seven cattle enterprises with the grain enterprise, a formula is needed for computing combined variance and subsequently coefficient of variation. Two formulas are available. The decision as to which formula to apply is based upon resource availability. There might be sufficient resources on hand so that a cattle enterprise could be added without reducing the quantity of resources employed in existing enterprises. On the other hand, it might be necessary to transfer resources out of an established enterprise if a new enterprise is to be added.

The first of these situations conforms more closely to conditions existing in the wheat-fallow region of Oregon, for the cattle enterprise is in large part supplementary to the grain enterprise in that it makes use of resources, rangeland and winter labor, that would otherwise lie idle. However, all resources must be examined on this count. Competition could exist for capital, for example, in a situation where a farmer reduces fertilizer application in order to increase the size of his beef enterprise. Competition could also exist for labor. Labor is required both for grain and cattle in the spring and possibly at other times in the year. Also, competition could exist for cropland. While wheat cannot be grown on most rangeland, cattle can be raised on land that normally produces wheat. Of these individual resources, competition is most apt to occur for capital. However, when all resources are considered together, supplementarity more accurately describes the relationship between the grain and the cattle enterprises in the wheat-fallow area. The assumption in this study is that the two enterprises are supplementary, or that resources need not be transferred out of grain production on the decision to adopt a cattle enterprise. Consequently the following formula is applicable (13, p. 512 and 8, p. 65-66):

$$V_t = V_x + V_y + 2rs_xs_y \qquad (1)$$

where V = variance of gross incomes

X = existing enterprise (grain)

Y = added enterprise (cattle)

r = correlation coefficient between enterprises

s = standard deviation.

Whether or not adding an enterprise will reduce absolute variability of gross income (*i.e.*, V_t will be less than V_x) will depend upon the variance of the added enterprise (V_y) and the size of the correlation coefficient (r).

From this equation a second formula can be drived for calculating the combined coefficient of variation.

$$\frac{\sqrt{V_t}}{I_t} = \frac{\sqrt{V_x + V_y + 2rs_xs_y}}{I_x + I_y} \qquad (2)$$

This is nothing more than the standard deviation divided by the mean or average gross return for the enterprise combination. With this equation coefficient of variation can be computed for enterprise combinations. Relative variability of gross incomes can then be compared for the grain enterprise and the grain in combination with the various cattle enterprises.

Empirical Analysis of Income Uncertainty

Net income variability

Farmers are interested in knowing the frequency and magnitude of loss associated with various enterprises.

Table 11. Frequency Distribution of Net Income for Selected Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956 and 1931-1956

Enterprises	Percentage of Years with Net Incomes of								
	-$1000 or less	-$500 to -1000	-$1 to -500	$0 to 499	$500 to 999	$1000 to 1499	$1500 to 1999	$2000 to 2499	$2500 & over
				(1946-1956)					
A Cow-calf	0	10	20	10	10	30	0	20	0
B Cow-yearling	20	0	10	10	30	20	0	0	10
C Cow-long yearling	20	0	10	30	20	10	10	10	0
D Cow-calf feeder	0	20	0	20	0	20	20	10	10
E Calf feeder	30	0	10	10	20	0	20	0	10
F Cow-yearling feeder	0	10	10	10	10	20	20	10	10
G Yearling feeder	10	30	0	10	10	30	10	0	0
				(1931-1956)					
A Cow-calf	0	4	36	40	4	12	0	8	0
B Cow-yearling	8	8	28	32	12	8	0	0	4
C Cow-long yearling	4	12	24	32	16	4	4	4	0
D Cow-calf feeder	0	20	24	20	12	8	8	4	4
E Calf feeder	20	20	28	8	12	0	8	0	4
F Cow-yearling feeder	0	20	20	24	8	12	8	4	4
G Yearling feeder	16	36	8	8	12	16	4	0	0

Table 11 shows the percentage frequency distribution of net incomes for the seven cattle enterprises for each year of both the ten and twenty five year period. The frequency and size of loss in the feeder enterprises, even during the relatively favorable cattle years since the war, would rule out straight feeding for a great many farmers. The calf feeder enterprise (E) shows profits of over $1,000 in three of the last ten years and losses of over $1,000 for an equal number of years. In the yearling feeder enterprise (G) losses of over $1,000 occurred in only one of the last ten years. However, again in this chapter just as with the budgets, caution must be used in interpreting figures. Remember that "net returns" include some non-cash expenses that are not always included in a net income figure.

Table 12 shows the average returns and the standard deviations. Incomes are higher for the post-war period but variability of incomes are also greater. In the budgets for the individual years, for most enterprises losses were greater in the 1952-53 and 1955-56 seasons than they were during any of the depression years. For the twenty five year period cattle incomes were highest in the years 1947-1951.

The net income data does not lend itself to a more thorough analysis of variability. Net incomes are not available for the grain enterprise. Therefore, it is

Table 12. Average Returns and Standard Deviation of Net Incomes for Selected Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1931-1956 and 1946-1956

Enterprise	Average Net Return 1931-56	Standard Deviation 1931-56	Average Net Return 1946-56	Standard Deviation 1946-56
A. Cow-calf	325	726	779	934
B. Cow-yearling	138	825	480	1170
C. Cow-yearling	197	820	520	1152
D. Cow-feeder	470	1106	1180	1397
E. Feeder	-237	1239	130	1850
F. Cow-feeder	406	1050	1178	1193
G. Feeder	-62	993	360	1100

necessary to turn to gross income figures to compare variability of the grain enterprise with that of the various grain and cattle combinations. It is this comparison that is most important in our variability analysis. The farmer is concerned more with the year to year fluctuation of his entire income than with the variability of returns forthcoming from any given enterprise.

<u>Gross income variability</u>

Variability in livestock returns is largely due to price variation as yield fluctuations can be kept to a minimum with sound management practices. However, fluctuation in income from grain is due as much to yield as to price variability. For the forty-four year period, 1911-1954, coefficient of variation for Oregon wheat price received by farmers was approximately 46%. The average coefficient of variation in yields for a number of varieties of wheat grown and harvested at the Moro Experiment Station for the same time period was 31% (19, 9.45). One can appreciate the influence of weather throughout this region by comparing this figure with a 21% average coefficient of variation for the yield of a number of varieties raised at the Pendleton Station, where rainfall is higher and less variable.

Table 13. Coefficient of Variation for Gross Incomes for the Grain Enterprise and Selected Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956 and 1931-1956

Enterprise	Coefficient of Variation 1946-1956	1931-1956
Grain 1/	11.0	57.8
A. Cow-calf	29.5	62.8
B. Cow-yearling	27.4	57.7
C. Cow-long yearling	25.7	60.7
D. Cow-calf feeder	22.9	56.9
E. Calf feeder	22.7	56.1
F. Cow-yearling feeder	21.8	60.5
G. Cow-yearling feeder	24.8	67.1

1/ Gross incomes for wheat include 35% of wheat acreage diverted to barley since 1951.

Government programs may have had considerable influence on the variability of income for wheat farmers. Table 13 compares the coefficients of variation for gross income for both cattle and grain in the two time periods. The point of interest in this comparison is the relative stability in the gross income of grain over the past ten years, part of which can be attributed to yields, part to prices. How much of this reflects the influence of government support programs is hard to say. However, for the entire ten year period wheat prices have never fluctuated more than twenty-three cents from the $2.00 per bushel price which is becoming well engrained in the thinking of most wheat men. The range in returns per bushel of forty-two cents, contrasts with a range in returns per hundredweight of $13.20 for cattle that have averaged close to $20.00 for the same ten year post-war period. Thus, the range for cattle prices is more than three times that of wheat.

Indeed, the knowledge that returns from cattle would show greater relative variability than returns from grain might cause many farmers to shy away from a cattle enterprise. However, when adding one enterprise to another, the variability of gross income for the combination will depend on the variance of the individual enterprises and on the correlation coefficient between enterprises. Because grain is the larger enterprise, it has a much greater absolute variability than cattle. For the ten year period the correlation coefficient for grain and cattle gross incomes is practically zero. Table 14 shows that, even though cattle

Table 14. Variability of Gross Incomes for Selected Enterprise Combinations on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956 and 1931-1956

Enterprise Combination	Average Gross Returns	Standard Deviation	Coefficient of Variation
		(1946-1956)	
Grain 1/	33,109	3,641	11.0
Cow-calf A	3,876	1,142	29.5
Cow-feeder F	6,552	1,432	21.8
Feeder G 2/	4,700	1,166	24.8
Grain - cow-calf	36,984	3,957	10.7
Grain - cow-feeder	39,662	3,935	9.9
Grain - feeder	37,809	3,804	10.1
		(1931-1956)	
Grain	20,791	11,574	55.7
Cow-calf A	2,384	1,497	62.8
Cow-feeder F	4,026	2,438	60.5
Feeder G	2,882	1,934	67.1
Grain - cow-calf	23,175	12,624	54.5
Grain - cow-feeder	24,817	13,833	55.7
Grain - feeder	23,673	13,256	56.0

1/ Gross income for grain includes 35% of wheat acreage diverted to barley since 1951.
2/ Initial cost of feeders has been subtracted.

enterprises are relatively more variable, the coefficient of variation of gross incomes for the combination of cattle and wheat is actually smaller than for grain alone. For the twenty-five year period, gross incomes for grain and cattle have a high positive correlation of .85 or greater. Coefficient of variation for the enterprise combinations is approximately the same as that for grain alone.

Certainly it would have been more desirable to have used net income data for these comparisons, had adequate information been available. Relative variance in gross incomes for the seven cattle enterprises does not differ greatly. Hence, it was considered sufficient to set forth in Table 14 only those cattle enterprises selected by linear programming in the optimum solutions.

In this chapter we have dealt with income uncertainty. It would seem that many wheat farmers are in a position where they would be willing to accept a fair amount of risk to achieve a higher return as Figure 9 (page 89) hypothesizes. However, high frequency of loss in feeding might discourage many farmers. This does not negate the fact that individual operators, especially those highly skilled in feeding, may have a very low frequency of loss when purchasing and feeding out cattle. Unfortunately we must deal with averages, and averages can be misleading. A number of difficulties prevented the comparison of net income variabilities between enterprises. Nevertheless, analysis of gross income variability gives evidence that generally farmers need not be concerned with increasing the relative variability of income through the addition of a cattle enterprise. Were the incomes for grain and cattle to fluctuate more closely together than at present, or were farmers to make the cattle enterprise a larger portion of their total operation, this might not hold true.

Chapter VII

SUMMARY AND CONCLUSIONS

Surplus wheat production coupled with the current "cost-price" squeeze in agriculture is causing wheat-fallow farmers in the Columbia Basin of Oregon to view the future with considerable doubt and unrest. Wheat farmers are beginning to look for ways in which to organize and utilize more efficiently their available resources. With the surplus of wheat and the prospect of a continued increase in the demand for beef, a beef cattle enterprise may offer just such an opportunity.

Therefore, the primary objective of this study was to analyze the economic alternatives of beef enterprises on Oregon wheat-fallow farms. The hypothesis states that over the long run these farmers will find more profit in feeding out cattle to slaughter weight than in selling calves or yearlings as feeders. As a corollary, information presented on profits and fluctuations in returns for the various enterprises and enterprise combinations will assist farmers in decisions concerning the combination of a beef enterprise with wheat.

In order to test this hypothesis, it was necessary to gather information on cattle operations for wheat-fallow farms in the Columbia Basin. A survey of nearly fifty farms provided the basic data from which several representative cattle enterprises were developed. These synthesized enterprises were based on some of the most common practices being carried on in the wheat-fallow area: selling calves as weaners, carrying calves through the winter for sale in the spring as yearling feeders, feeding out either purchased or home raised cattle to slaughter weight.

Once the basic resources were selected, budgets were constructed for a period of twenty five years, from 1931 to 1956, using market prices for both inputs and outputs. The budgeted results show that the cow-feeder enterprises, where home raised cattle are fed out to slaughter weight, will return more profit than calves or yearlings sold as feeders. However, a sharp difference exists between returns for home raised and purchased cattle feeding operations. Purchasing feeders and feeding them out to slaughter weights proved to be the least profitable alternative. This was true in large measure because cow herds were able to make best use of a "free" resource, rangeland; "free" in the sense that rangeland was considered to have no opportunity cost or alternative use. In other words, the results indicate that farmers, in adopting a cattle enterprise, should plan to make use of available rangeland.

Which beef enterprise is selected to utilize this range will depend principally on two factors: the amount of rangeland available, and the amount of capital available. Situations of severe capital limitation will call for an extensive operation, either a cow-calf or a cow-yearling enterprise. However, when more than sufficient funds are available to stock the range adequately, cow-feeder operations will bring higher returns. This is made manifest by the linear programming findings.

Through linear programming it is possible to allow one resource to be varied while others are held constant. This procedure introduces a different optimum plan for different input levels of the varied resource. Consequently, when capital was varied continuously, with rangeland held at 1,500 acres and January labor at 240 hours, the cow-calf enterprise proved optimum for lower levels of capital input. However, after $2,300 of capital was spent for variable costs, resources could be employed to greater advantage by a cow-feeder operation. The $2,300 level was the critical level at which the range became adequately stocked. Because no more cows could be grazed, higher profits were forthcoming only when calves produced on range were fed out to slaughter weight. A transition period existed between $2,300 and $4,500 capital input in which some combination of the two enterprises was most profitable.

When rangeland was allowed to vary continuously, capital was held constant at $5,000 and January labor at 240 hours. The cow-feeder enterprises showed higher returns when rangeland was in short supply. However, with more than 1,650 acres of rangeland available, resources could be more profitably transferred to a cow-calf enterprise. A transition period existed between 1,650 and 3,250 acres of rangeland for which some combination of the cow-feeder and cow-calf enterprise was most profitable.

However, rangeland is generally the resource which first becomes limiting for beef production on wheat-fallow farms. This means that for wheat farmers the cow-feeder operation is the more appropriate in the majority of cases. Rangeland is in shorter supply in the wheat-fallow region than in any other section of eastern Oregon, and the needed feed grain, barley, is grown right on the farm. It is, therefore, particularly important that wheat farmers in the Columbia Basin be made aware of the advantages of carrying over cattle and feeding them out to slaughter weight when rangeland is scarce.

Nevertheless, it is important to observe that for maximizing profits the same recommendations will not apply to all farmers within a given area, but will depend on the resources available on each individual farm. Suggestions as to course of action for two farmers located side by side may be quite different, yet quite rational, even where profit is the primary goal of each.

Although the budgets showed low returns and high frequency of loss for purchased feeder operations, buying and feeding out cattle to slaughter weight is not ruled out as an alternative. As the linear programming results indicate, this works best in combination with a cow feeder operation where fixed costs (such as fencing and cattle equipment) can be spread over a large number of cattle. Many farmers, if they are to achieve sufficient volume in cattle operations, must supplement their cow-feeder enterprise in this manner. However, emphasis must be placed on the high managerial requirements of feeding, and, therefore, on the personal or individual nature of any recommendations regarding cattle feeding. Cow-calf and cow-yearling operations require a minimum of skill, cow-feeder enterprises require considerable ability in feeding, and purchased feeder operations require high ability in both feeding and marketing. While low average returns over time and frequent large losses stand as a warning signal to many farmers, purchased feeders have a definite place on a limited number of wheat-fallow farms.

This observation emphasizes the role that education can play. A "short course" in beef buying, feeding, and handling might provide the necessary information and inspiration to raise considerably the quality of the managerial input of many farmers. If the wheat-fallow area is to produce a sizeable amount of slaughter grade beef in the future, wheat men must be educated to the ways of beef cattle fattening.

Of course, some wheat farmers will have neither the managerial ability nor the desire to feed out cattle to slaughter weights. These farmers may be interested in knowing whether it is more profitable to sell weaner calves or to carry them through the winter and sell them as yearlings in the early spring or as long-yearlings off pasture in mid-summer. While in any given year advantage might be gained from following one or the other course of action, there appears to be no monetary advantage in the long run in carrying calves through the winter. Some farmers, however, prefer to winter calves to make fuller use of hired labor.

The analysis of uncertainty and income variability gives evidence that the addition of a beef enterprise in any form will not greatly increase risk. The cattle enterprise is supplementary to the wheat enterprise in that it makes use of resources, rangeland and winter labor that would otherwise lie idle. Gross incomes from cattle enterprises proved more variable than those from grain during the period 1946-1956. For the twenty five year period, 1931-1956, gross income variability for cattle and grain was much the same. In the post-war years gross income from cattle and grain had a correlation of close to zero, but for the period, 1931-1956, the gross incomes for these two enterprises showed a high positive correlation. Principally because grain is the major enterprise, the relative variability of gross income for the grain-cattle enterprise combinations in all cases was approximately the same as that for the grain enterprise alone. Thus, wheat farmers should find that risk and uncertainty does not constitute an obstacle to the adoption of cattle enterprises.

There is considerable opportunity in the wheat-fallow area for increased feeding operations. For the many farmers who are now selling calves and yearlings as feeders and who have limited range greater profits can be realized in feeding out cattle to slaughter weights. Opportunity exists for skilled farmers to purchase and fatten cattle. Whether or not the wheat-fallow area of eastern Oregon will become an important cattle feeding area in the future will be determined principally by the price of cattle as determined by the demand for beef, the beef-grain price ratio, which has the same significance for Oregon cattle feeders as the corn-hog price ratio for mid-western hog raisers, and the government influence on gross returns for wheat through both price and production controls. Wheat-fallow farmers who desire to make the most efficient use of resources and receive the highest returns must keep a close watch on these factors.

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APPENDIX I

The Cattle Feeding Program

Cow herd

The cows are turned out on range from mid-March to the first of April. After harvest they have access to the stubble fields. They have access to straw and chaff dumps during the fall and winter. Some herds are wintered on chaff alone, but this is generally reflected in poor weaning weights and a poor calf crop percentage. Many operators improve the cow herd ration during calving time. For the purpose of this study, the cows receive 20 pounds of hay per day for a 60 day period during calving. Annually they consume 1200 pounds of hay and a ton of chaff. Those culled are marketed at 1,000 pounds.

Calves

Calves are dropped from January through April in the wheat-fallow region and are weaned in October and November. They are weaned at from 7 to 9 months at a weight of 300 to 500 pounds. The assumptions for the cow-calf enterprise (A) are shown in Table 15.

Yearlings

Calves weaned in October and November are often carried through the winter on hay, straw, and chaff occasionally fed with molasses and up to three pounds of barley. Calves gain from one half a pound to a pound a day during the winter months. Yearlings are normally sold in March and April at from 500 to 700 pounds. The spread in weights depends as much on the weaning weights as on the ration fed during the winter. The assumptions for the cow-yearling enterprise (B) are shown in Table 15.

Long yearlings

Some farmers carry yearlings through the winter and then turn them out on pasture before sending them to market. They gain better than a pound a day on the spring grass and are usually marketed when the grass begins to dry up in mid-summer. In this study long-yearlings (Enterprise C) are carried through the winter on exactly the same ration as the yearlings (as Table 15 indicates) and then turned out to pasture for three months. They gain at the rate of 1.4 pounds per day on pasture.

Calf feeders

Calves that are fed out are placed in the feed lot shortly after weaning and fed a ration of hay, grain, and concentrate. It is usually a month before they are on full feed. They are marketed in the spring at from 650 to 800 pounds. During the feeding period average daily gains run

Table 15. Rations and Feeding Program for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon

Rations and Feed Program	Cattle Maintained				
	Calf	Year-ling	Long-yearling	Calf-feeder	Yearling feeder
Daily Lbs.					
Hay		13.3	13.3	8.0	7.0
Chaff		3.3	3.3		
Barley		2.0	2.0	12.0	18.0
SOM 1/				.5	1.5
Annual Lbs.					
Hay		2000	2000	1360	840
Chaff		500	500		
Barley		300	300	1860	1890
SOM				155	158
Days fed	0	150	150	170	120
Daily gain Lbs.		1.0	1.0	2.0	2.5
Wgt. sold Lbs.	425	575	700	765	1075
Date sold	Nov. 1	Apr. 1	Jul. 1	Apr. 20	Feb. 15
Grade	Good	Good-medium	Good-medium	Good-choice	Good-choice

1/ Soybean oil meal

from 1.5 to 2 pounds or better. The assumptions for the calf-feeder enterprises (D and E) are shown in Table 15.

Yearling feeders

Many operators hold their cattle until the second winter or purchase yearling feeders in the fall, feeding them out at weights from 800 pounds up. These heavier cattle can consume a greater quantity of feed in a day and will show average daily gains as high as 2.75 pounds with individual animals topping this. The length of feeding period is normally considerably shorter than for the calves. The assumptions for the yearling feeder enterprises (F and G) are shown in Table 15.

APPENDIX II

Table 16. A Continuous Capital Solution in Linear Programming Using an Eight Year Average of Prices for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956 1/

						C →	7.9388	5.9959	7.0667	7.1096	2.2601	7.4011	2.5230
						Enterprise →	A	B	C	D	E	F	G
Resources		P_0	ΔP_0	P_8	P_9	P_{10}	P_1	P_2	P_3	P_4	P_5	P_6	P_7
Plan #1													
Capital	P_8	0		1	0	0	11.7602	14.7295	13.6089	16.7487	23.5277	16.1462	22.6438
Rangeland	← P_9	1500		0	1	0	7.6530	6.1475	6.6667	4.9213	0	5.3476	0
Jan. Labor	P_{10}	240		0	0	1	.4891	.5779	.5067	.6138	.3725	.5793	.2413
	Z-C	0		0	0	0	-7.9388	-5.9959	-7.0667	-7.1096	-2.2601	-7.4011	-2.5230
	D						-.6751	-.4071	-.5193	-.4245	-.0961	-.4584	-.1116
Plan #2													
	P_8	-2305.0500	-2305.05	1	-1.5367	0	0	5.2026	3.3637	9.1861	23.5277	7.9285	22.6038
7.9388	⇆ P_1	196.0016		0	.1307	0	1	.8033	.8711	.6431	0	.6988	0
	P_{10}	144.1500		0	-.0639	1	0	.1851	.0807	.2993	.3725	.2376	.2413
	Z-C	1556.0175	1556.0175	0	1.0376	0	0	.3813	-.1512	-2.0042	-2.2601	-1.8535	-2.5230
	D								-.0450	-.2182	-.0961	-.2339	-1.1162
Plan #3													
	P_8	-4528.8450	-2223.7950	1	-3.0196	0	-11.3458	-3.8315	-6.5196	1.8896	23.5277	0	22.6038
7.4011	→ P_6	280.4831		0	.1870	0	1.4310	1.1495	1.2466	.9203	0	1	0
	← P_{10}	77.5095		0	-.1083	1	-.3400	-.0880	-.2155	.0806	.3725	0	.2413
	Z-C	2075.8835	519.8660	0	1.3840	0	2.6524	2.5119	2.1594	1.6344	-2.2601	0	-2.5230
	D										-.0961		-.1116
Plan #4													
	P_8	-11,789.5552	-7260.7102	1	-13.1646	-93.6751	20.5037	4.4119	-13.6674	-5.6606	-11.3663	0	0
7.4011	← P_6	280.4831		0	.1810	0	1.4310	1.1495	1.2466	.9230	0	1	0
2.5230	→ P_7	321.2163		0	-.4488	4.1442	-1.4090	-.3647	-.8931	.3340	1.5437	0	1
	Z-C	2886.3122	810.4287		.2517	10.4558	-.9025	1.5918	-.2373	2.4771	1.6119	0	0
	D						-.0440		-.0174				
Plan #5													
	P_8	-15,808.3732	-4081.8180	1	-15.8440	-93.6751	0	-12.0584	-4.1041	-18.8468	-11.3363	-14.3282	0
7.9388	→ P_1	196.0004		0	.1307	0	1	.8033	.8711	.6431	0	.6988	0
2.2530	P_7	597.3872		0	-.4517	4.1442	0	-1.4965	-2.1205	-.5722	1.5437	-.9846	1
	Z-C	3063.2026	176.8904	0	.1180	10.4558	0	2.3168	.5489	3.0575	1.6119	.6307	0

1/ In computing the eight year average of prices for cattle the years 1951-52 and 1952-53 were omitted.

Table 17. A Linear Programing Solution Allowing Rangeland to Vary Continously for Selected Beef Cattle Enterprises on Wheat-Fallow Farms in the Columbia Basin, Oregon, 1946-1956.

Resources		P_o	ΔP_o	P_8	P_9	P_{10}	P_1	P_2	P_3	P_4	P_6	R
						C →	8.0153	5.2131	5.8667	6.6437	7.2121	
						Enterprise →	A	B	C	D	F	
Plan #1 Capital	← P_8	5000		1	0	0	11.7602	14.7295	13.6089	16.7487	16.1462	298.5306
Rangeland	P_9	0		0	1	0	7.6530	6.1475	6.6667	4.9213	5.3476	
Jan. Labor	P_{10}	240		0	0	1	.4891	.5779	.5067	.6138	.5793	391.--
	Z-C			0	0	0	-8.0153	-5.2131	-5.8667	-6.6437	-7.2121	
	D						-1.0473	-.8480	-.8800	-1.3509	-1.3487	
Plan #2 6.6437	⇄ P_4	298.5306		.0597	0	0	.7022	.8794	.8125	1	.9640	309.6790
	P_9	-1469.1600	-1469.16	-.2938	1	0	4.1975	1.8195	2.6680	0	.6033	--
	P_{10}	56.7600		-.0366	0	1	.0581	.0381	.0086	0	-.0124	--
	Z-C	1983.3477	1983.3477	.3966			-3.3501	.6294	-.4687	0	-1.3386	
	D											
Plan #3 7.2121	⇄ P_6	309.6790		.0619	0	0	.7284	.9122	.8428	1.0373	1	425.15
	P_9	-1655.9894	-186.9894	-.3416	1	0	3.7580	1.2690	2.1595	-.6258	0	--
	P_{10}	60.6000		-.0268	0	1	.0671	.0498	.0191	.0129	0	903.13
	Z-C	2233.4359	250.0882	.4466	0	0	-2.7618	1.3361	.2119	.8377	0	
	D						-.7349					
Plan #4 8.0153	→ P_6	425.1500		.0850	0	0	1	1.2523	1.1571	1.4241	1.3721	
	P_9	-3253.7017	-1597.7123	-.6610	1	0	1	-3.4373	- 2.1887	- 5.9775	-5.1593	
	P	32.0724		-.0325	0	1	0	-.0342	-.0585	-.0327	-.0921	
	Z-C	3407.7048	1174.2689	.6813			0	4.7947	3.4076	4.7708	3.7895	