Supply response of Grade A milk production in upper Flathead Valley
by Jack R Davidson

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics at Montana State College
Montana State University

Abstract:
This study was devised to estimate supply response of Grade A milk in Flathead County. Examination of previous work indicates that several methods of approach have been utilized. Limitations of time and data restricted it largely to a demonstration of the manner in which the budget technique might be used for this purpose, yet some of the substantive results can be stated briefly.

A representative Grade A milk producing farm for this area was described with a synthetic model based on the use of survey data. The existing organization was related to current price for milk and other relevant farm products. For posited changes in milk price, optimal adjustments were budgeted in selected parts of the farm organization. The results in terms of milk output then serve as estimates of supply response to changes in milk price over a restricted range—but only with respect to the budgeted adjustments Elasticity of supply with respect to milk price is estimated at between .25 and .08 as a possibility of almost immediate response, based on response due to change in feeding level. Over a time period sufficient to permit changes in herd size the elasticity estimate increases. It would increase still further, if other adjustments were taken into account. On the other hand, many of the non-economic factors which influence supply response would doubtlessly reduce the actual elasticity estimates.

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Approved:

Head, Major Department

Chairman, Examining Committee

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The Abstract

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PART I

INTRODUCTION

The Problem

The Concept of Supply

The concept of supply as used by economists indicates the quantities of a product or productive service that will be made available to buyers in a specified market at a specified time, at any of a series of specified prices if such prices were offered. As in the case of demand, actual production of the physical commodity is unnecessary for the existance of supply. Rather supply represents willingness and ability to make the quantity available in response to a price situation. 1/ With supply as a function of price, the quantity of a product made available is a function of price expectations.

Statement of Problem

Questions of the aggregate production functions and supply responses in agriculture are of concern to all individuals, firms and public agencies related to agriculture. 2/ Supply functions are of particular concern to those buying from or selling to operating farmers and to agencies responsible for the development of policy and administration of programs which affect farmers. The farmer's concern with supply response is indirect but important.

1/ Thomsen & Foote, Agricultural Prices, McGraw-Hill Book Company, Inc., 1952, p. 57.

2/ E. O. Heady, Economics of Agricultural Production and Resource Use, Prentice-Hall, Inc., New York, 1952, p. 672.

As an exploration in farm management research methodology the purpose of the following study will be to point to a method for the derivation of meaningful supply curves for the production of Grade A Milk. The objectives of the present investigation will be, (1) to discover the problems met in determining the factors influencing the production-response to a change in milk price, (2) to determine the various alternatives available by which Grade A dairy farms in mountain valleys of western Montana may respond, (3) to point to a method by which the response may be indicated and by which the various alternatives may be tentatively tested, and (4) to test, illustratively, some of the available alternatives to arrive at the expected response.

Review of Literature

Early Work

Studies of supply response, as concerned with agricultural production, are not new. In the past 30 years studies of farmer response to price and other factors have dealt with a wide range of farm products. The problem received considerable attention in the decade between 1930 and 1940 as an important factor in the effort to adjust agricultural production to prospective supply and demand conditions. The individual producer who would adjust his acreage and livestock numbers, with due regard to what other producers are doing, needs to judge in advance the probable total output that will compete with his production when it is ready for market. Similarly, in setting up the over-all production objectives of a national agricultural program, advance judgments must be made not only of the probable effects of the program itself but also of farmers response to price, technological changes, and other factors. For these reasons most of the work prior to 1939 was related to the short run or immediate response. 3/

The Role of Price Expectations

One hypothesis relating to the role of price expectations in determining supply response, the "Cobweb Theorem", was presented by Mordecai Ezekiel in 1938. 4/ This was of particular value in explaining the type of response which might be expected as a result of year to year adjustments. With supply a function of price under conditions of atomistic competition, the price and production of a commodity is determined at the point where the supply and demand curves intersect. Under the static conditions assumed, a disturbance moving price and production from the intersection point sets into motion the forces to return to the original position. 5/

In considering the amount supplied as a function of the price expectations, where this is a considerable lag in the response of production to price change, and elasticity of supply = elasticity of demand, the price and production may not return to the original point but instead may circulate

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3/ R. P. Christensen and R. L. Mighell, Supply Responses in Milk Production in Dodge and Barron Counties, Wisconsin, U.S.D.A. Tech. Bul., 1941, p. 1.

4/ Mordecai Ezekiel, "The Cobweb Theorem", Quarterly Journal of Economics, LII, February, 1938.

5/ G. S. Shepherd, Agricultural Price Analysis, Iowa State College Press, 1947, p. 90.

about it. Under this concept a high price calling forth a large supply intersecting the demand at a low price would in turn call forth a relatively short supply which, in turn, would intersect the demand curve at a high point. This concept would be one of continuous fluctuation around the equilibrium point as illustrated in Part A of Figure 1 below.

When elasticity of supply is greater than the elasticity of demand a situation occurs as shown in part B of Figure 1. This would be a situation of divergent fluctuations. The magnitude of cyclical price and production changes increase over time. Under these conditions the situation might grow increasingly unstable until the elasticity of supply changed or production was abandoned. The reverse situation as shown in part C is that of convergent fluctuations in which price and production approach more and more closely to the equilibrium conditions as outlined in the static concept.

A. Continuous Cycles   B. Divergent Cycles   C. Convergent Cycles

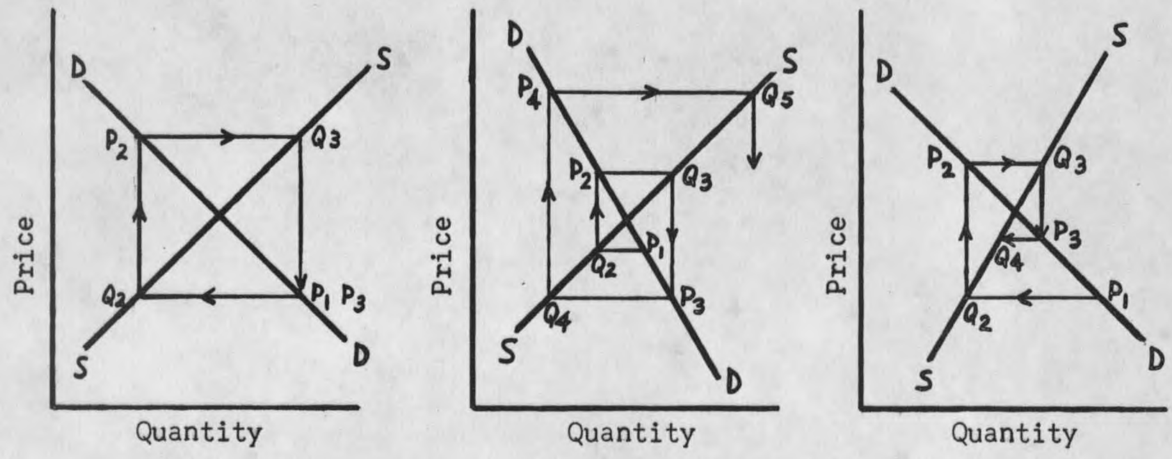

Figure 1. The mechanics of continuous, divergent and convergent cycles in prices and production.

Significance of Earlier Studies

These studies made little more than passing references to the significance of longer-term phases of supply. This situation was not peculiar to studies of production and supply, but was also found in the field of consumption and demand research in that period.

There appear to have been two principle reasons for this situation. The first is related to the rapid development and widespread use by agricultural economists of statistical procedures (including multiple correlation technique) for dealing with time-series data. As such analysis is projected further into the future, the standard error of estimate becomes larger. As the period is lengthened, the number of independent variables become larger and net influence of each is harder to estimate. Data requirements become greater and more difficult to handle. As such these statistical procedures seemed most effectively applied to short-run problems. The second and more important reason for the concern of the public research agencies with short-run problems was that these appeared to be more urgent, and most practical assistance could seemingly be rendered in this way to farmers and to the general public. Although it was recognized that farmers had important long-term decisions to make, it was generally felt that the most useful contribution could be made in developing information to aid in the year-to-year adjustments. 6/

Efforts of research workers in deriving meaningful supply curves by the historical-statistical procedure have not been too fruitful and the

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6/ Christensen and Mighell, op. cit., p. 2.

results are open to question. As indicated by G. S. Shepherd, this can be attributed to the many variables which must be taken into account in supply analysis such as weather, changes in prices of various cost items, changes in technological processes, etc. 7/ However, the value of this work as ground breaking device is very important.

Methods Developed to Determine Supply Response of Milk Production

In an attempt to analyze supply response of milk production, several alternative ways to derive supply curves have been attempted. For example, in 1940 an attempt was made to derive a supply curve for milk in a localized area of Vermont by the familiar budget procedure. 8/ In this case the supply curve represents a much longer-run period as all adjustments which could reasonable take place within ten years were permitted. Estimates were based upon the study of individual records from representative samples of farms. It consisted of working out budget estimates of production for each farm, say, ten years hence, under several different price situations--higher price for the product (say 15 percent higher), constant prices and lower price. These estimates, added up, then provide three points on the long-time curve.

This method presents difficulties of its own, and involves a good deal of estimation. The results of applying this method to a study of milk production in the Cabot-Marshfield area of Vermont are shown in Figure 2. The heavy solid line BAC shows the estimated response of production ten

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7/ Shepherd, op. cit., p. 90.

8/ R. H. Allen, Erling Hole, and R. L. Mighell, Supply Responses in Milk Production in the Cabot-Marshfield Area, Vermont, USDA Tech. Bul. 709, 1940.

years later to milk prices 15 percent higher, constant, and 15 percent lower than they were originally. A short-term (three-month) supply curve for the same area is shown by the curve SS.

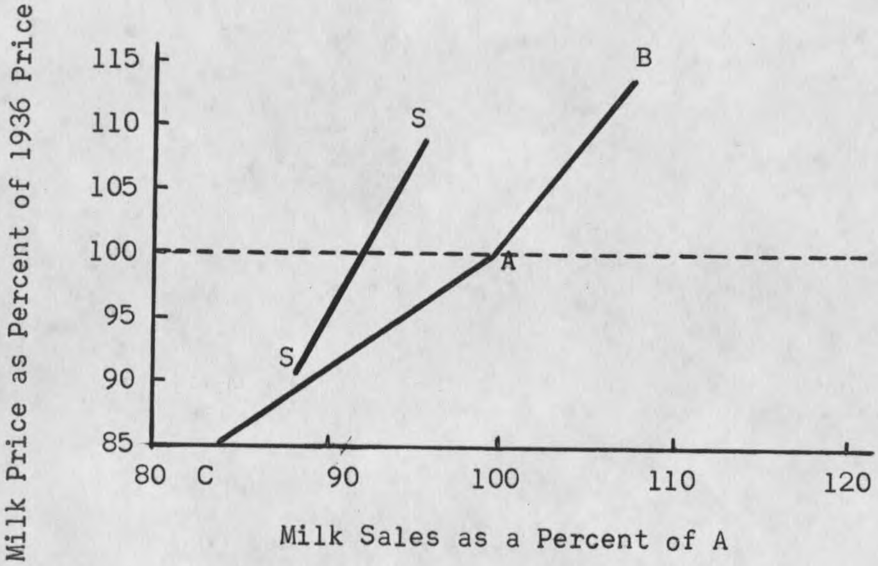

Fig. 2. Long-time and short-time responses of milk production to price changes. (As taken from Allen, Hole, and Mighell by G. S. Shepherd). 9/

Cost Analysis and Supply Curves

In developing a supply curve for an individual firm or an industry, (discussed in a later section) supply is a function of the costs that are variable. Estimations of these costs depend upon productivity estimates for variable resource services. Hence, Einar Jenson endeavored to derive a production function for feeding dairy cattle by experimental techniques.

9/ G. S. Shepherd, Agricultural Price Analysis, Iowa State College Press, 1947, p. 92-93. See also Allen, Hole, and Mighell, op. cit.

This method gives an indication of the possibilities of the experimental technique. Results from such a study can be transformed into the familiar cost curves of traditional economic theory. The portion of the marginal cost curve lying above the minimum point of the average variable cost curve represents the supply curve for the firm in terms of milk. In this case, changes in the amount supplied are assumed as due only to changes in the amount of feed input. Thus, each production function depends on the level at which the other factors are held constant. The supply curve which is derived in this fashion can be used to represent responses which are likely to occur in the short-run and are concerned with the variable feed costs. 10/ Although adaptibility of experimental data to actual situations is questionable, the importance of the method indicated and the nature of the results of such observations should not be overlooked.

Inter-Area Analysis

A third alternative has received mention but little widespread recognition. This is the possibility of developing supply curves on the basis of data collected within geographic regions throughout which production conditions are similar, but in which inter-area prices differ. If several different areas can be found with similar conditions of productions but different prices, and if these price differences have persisted long enough for the production of different areas to become adjusted to them, then the

10/ Stanton P. Parry and William McD. Herr, "A Note on the Derivation of Short-run Supply Curves," Journal of Farm Economics, August, 1954.

prices and production per square mile in the different areas can be used as points on a long-time supply curve. 11/ It is necessary to assume that the functional relationship between feed inputs and milk output is similar between the geographic areas within the region. It also must be assumed that each area is homogeneous with respect to resources and their prices but with differing product price situations. Under these assumptions a short-run curve is meaningful only insofar as the rate of feeding is the primary response by farmers to short-run changes. 12/

Determinants of Supply

Supply Curves

At any price the respective competitive firms will attempt to operate at the output where marginal cost equals price. This will maximize returns net of variable cost and hence designate the optimum. If the total outputs of the various firms in a region or industry are added together, the total amount which will be supplied at any given price will appear. With the finding of the quantity which will be supplied at other prices the supply curve for the industry can be constructed. Given the supply and demand curve for the industry, the price at which quantity supplied equals quantity demanded is found as demonstrated in Figure 3.

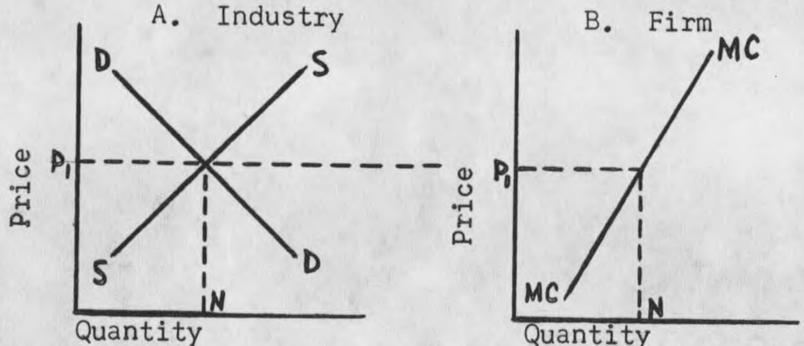

Figure 3. Price Determination of a Firm's Output

11/ Shepherd, op. cit., p. 90.

12/ For further information concerning this type of analysis see Stanton and Herr, op. cit., p. 521.

In determining the amount to be supplied only the relevant portion of the marginal cost curve or that portion lying above average variable costs is shown in Figure 3B.

The Elasticity of Supply

The elasticity of supply is the proportional relationship between prices and quantities. It can be indicated as the percentage change in quantity or output divided by the percentage change in price:

$$E_s = \frac{\Delta q}{q} \div \frac{\Delta p}{p} = \frac{\Delta q}{\Delta p} \cdot \frac{p}{q}$$

The elasticity of the supply curve will normally differ at each point on the curve. The "elasticity of the supply curve", usually relates to the arc (average) elasticity rather than point elasticity. However, the term "elasticity of supply" may refer to either. 13/

Elasticity of supply, due to the number and type of alternatives available, is usually greatly increased over longer periods of time as compared to that of shorter periods (as shown in milk supply curves, page 4). 14/ Under many different supply situations in agriculture, particularly those covering relatively short periods of time, the supply appears to be so inelastic within the normally encountered price range as to justify its designation as "fixed".

Thomsen and Foote, in attempting to analyze the difficulty of separating the effects of price from other influences on production and isolating the precise price-quantity relationships indicated by the law of supply,

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13/ Heady, op. cit., p. 674.

14/ Shepherd, loc. cit., p. 93.

indicate that the apparent exceptions reflect three conditions: (1) the difficulty or impossibility of determining what price producers or sellers expect to receive when they make their plans for production or selling; (2) the interference of weather and other environmental conditions not related to price; (3) frequent shifts in the supply schedule or curve as a whole so that it cannot be determined whether a given change in quantity resulted from a change in prices or from a change in the whole schedule of quantities associated with different prices. 15/

Sources of Supply

The sources of supply or quantity that will be furnished in response to a given price may be derived from (1) the stock of the particular commodity held in storage by the firms or (2) from production. 16/ Supply derived from production in turn must come from resources committed to the production process or resources not committed. The first type of response would necessarily depend a great deal on the storability of the product and the economic feasibility of storage as decided by the second type or length of time required for the potential producers to respond. As the length of time and certainty of price expectations are extended, the role of uncommitted resources becomes progressively more important as a factor in determining supply.

It should be pointed out that only by considering very short periods of time is there found important examples of commodities in "fixed" supply.

15/ Thomsen and Foote, *op. cit.*, p. 70-71.

16/ Thomsen and Foote, *op. cit.*, p. 58-9.

It should be apparent that the length of time necessary to vary the supply would depend upon the size, complexity and degree of specialization of the plants involved as well as the products produced. The reluctance of producers to commit resources in the form of fixed investment items also extends the time period necessary to induce response. When response of production becomes flexible over short periods of time, supply more nearly becomes a function of price. This function in turn is influenced as previously mentioned by prices, quantity, availability of feed stocks and uncertainty of duration of change. This analysis deals with the quantities that farmers should rationally attempt to produce in response to given price expectations to maximize net income not with the quantities actually produced insofar as these are affected by conditions outside of the firm's control. Estimates of the latter sort require the use of probability estimates unavailable for this study.

Price as a Determinant of Supply

Of the many important variables influencing production and the types of uncertainty encountered, the main criterion used in determining what production program will be followed is profitability. Any apparent lack of relationship between price and subsequent supply is largely due to the associated variables and the relative importance of non-economic considerations rather than an absence of a definite price-supply relationship. It must be remembered that despite the influence of these other factors, which tend to partially cover up the operation of the law of supply, the changes in production would have been different in the absence of the changes taking place in the price of the commodity. As discussed previously, the response will be considered the function of price expectations. Therefore the level of price change and certainty of change necessary to cause the producer to act must be considered.

Variability in Price

The individual farmer as entrepreneur of a competitive firm, has no control over prices. Large fluctuations may occur between planting and harvesting. The coefficient of annual milk production variation in Montana for the period 1944-1954 was 28 percent. The range of milk prices in this area often varies 10 percent or more within a lactation period.

Factor prices as a rule show less variability than product prices. This has long been a point of contention to the farmer who must adjust his production to a downward shift in product price while factor prices remain inflexible.

The Hypothesis

For purposes of this study it will be assumed that profitability is the prime determinant of the amount which will be produced. Assuming the farmer is economically motivated, the hypothesis of this study is that the budget method can be adapted to a study of supply response of milk production. This should reveal, within the range of the alternatives tested, the production possible as a response to a change in price expectations.

The Method

Farm Budgeting

The farm budget consists of an operational and organizational statement of a firm either hypothetical or actual over a given period of time. It is, under the "actual" situation, together with an estimate of income and expense related thereto, a plan of future operation. Thus it can be used as an analytical technique for comparing net returns from several alternative organizations of an individual farm firm. 17/

The budget can also be used as a descriptive device in terms of which to synthesize an average or representative situation. The flexibility of the budgeting technique has long made it a useful tool in the application of economic principles to a farm firm.

The synthetic farm model is analogous to such devices as test plots or experimental conditions used in other areas of research in agriculture. In depicting an average or representative farm to serve as a form of classification, the concept entails the construction of the model under very precisely defined conditions. In this way the method has been developed and used in a wide variety of farm management studies.

Using the Synthetic Model

The synthesizing process is used to permit freedom in combining production resources and practices so that a similar degree of managerial ability or efficiency is attained for all farms included as combined in the "average". The synthetic models, analogous to experimental technique, "fix" many of the variables found under actual conditions in order to estimate the influence of the variable factors under study.

17/ E. G. Strand and E. Hole, Supply Responses of Milk Production in Southeastern Minnesota, USDA, Tech. Bul. 789, Nov. 1941, p. 25.

Estimates of the effects of change can and often are based directly on information provided by research in such areas as agronomy, animal nutrition and agricultural engineering. Crop and livestock response information obtained from such sources may be utilized to provide the input-output data basic to the construction of farm models. 18/ Information from sample sources is utilized in determining size, type of farm and as a basis for making classifications. In general the strength of sample information used in the synthesis is in its representation of the universe in which the study is being conducted.

In practice the budgetary technique starts from a given situation. The effect of an adjustment on farm income is then calculated by estimating the additional expenses and receipts that are associated with the change. In this way the impact of alternative production practices on total farm business can be estimated. However it should be noted that this trial and error method is so time-consuming that only a few of the more important variable conditions can be tested. To facilitate this, the greater manipulative power given by linear programming may be attractive in farm management studies requiring analysis of numerous alternatives.

Short Cut Budgets

To increase the number of variables which can be tested, the method of partial budgeting will be used. Starting with the synthetic model representing the complete budget, analysis will be made by partial or "short-cut"

18/ I. E. Fellows, G. E. Frick and S. B. Weeks, Production Efficiency on New England Dairy Farms, Storrs Agr. Expr. Sta., Bull. 285, p. 9.

budgets. This is to estimate costs and returns where changes are related to only that part of the business directly concerned.

The Budget and the Supply Function

As was previously mentioned the budgeting technique provides one of the major tools with which farm management research has applied economic principles to problems in the farm business. Through use of experimental data to obtain physical production functions, the budgetary approach employed in farm management work provides a working alternative to the statistical approach. The standards of performance as derived from secondary sources and applied to the synthetic organization are over-simplified versions of partial production functions. Utilized in describing the farm organization under consideration they represent levels of accomplishment under precisely defined situations when many of the usual variables are held constant. They are, as incorporated in the synthetic stiuation, response observations hypothetically taken from identifiable points on the production surface developed from the interrelationship of several important variables.

The synthetic model representing a particular form of agriculture in a specified area, may, if properly constructed, represent the average of the group under consideration. Likewise the supply schedule or curve of the industry represents the aggregate or total supply of the firms under consideration and the elasticity of the curve should be representative of the average. If the synthetic model is representative of the group as to organization, enterprise combination, resource allocation, etc. it should also be representative.

PART II

METHODOLOGICAL APPROACH AND DERIVATION OF SYNTHETIC MODEL

Area Under Consideration

Description of Area

The area under consideration is that of the Upper Flathead Valley in the northwestern part of Montana, north of the Flathead Lake and immediately west of the Continental Divide. Nearly all of the area lies in Flathead County as is shown in Figure 4. 19/

The area is 14 miles wide and approximately 31 miles long. It comprises approximately 238,000 acres and embraces a major part of the cultivated land in Flathead County. The average elevation is approximately 3,000 feet above sea level.

Climate and Precipitation

The climate of the Upper Flathead Valley area is typical of the intermountain valleys of the Pacific slope. It is characterized by abundant sunshine, low relative humidity, comparatively low rainfall and wide daily and seasonal variations in temperature.

Weather records show that the precipitation is rather evenly distributed throughout the year. Forty-five percent of the average annual precipitation of 15.02 inches falls during the growing season, as indicated

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19/ W. W. Mauritson and H. R. Stucky, Facts About Flathead County Agriculture, Mont. Ext. Service, Circ. No. 264, June 1950, pp. 5-6.

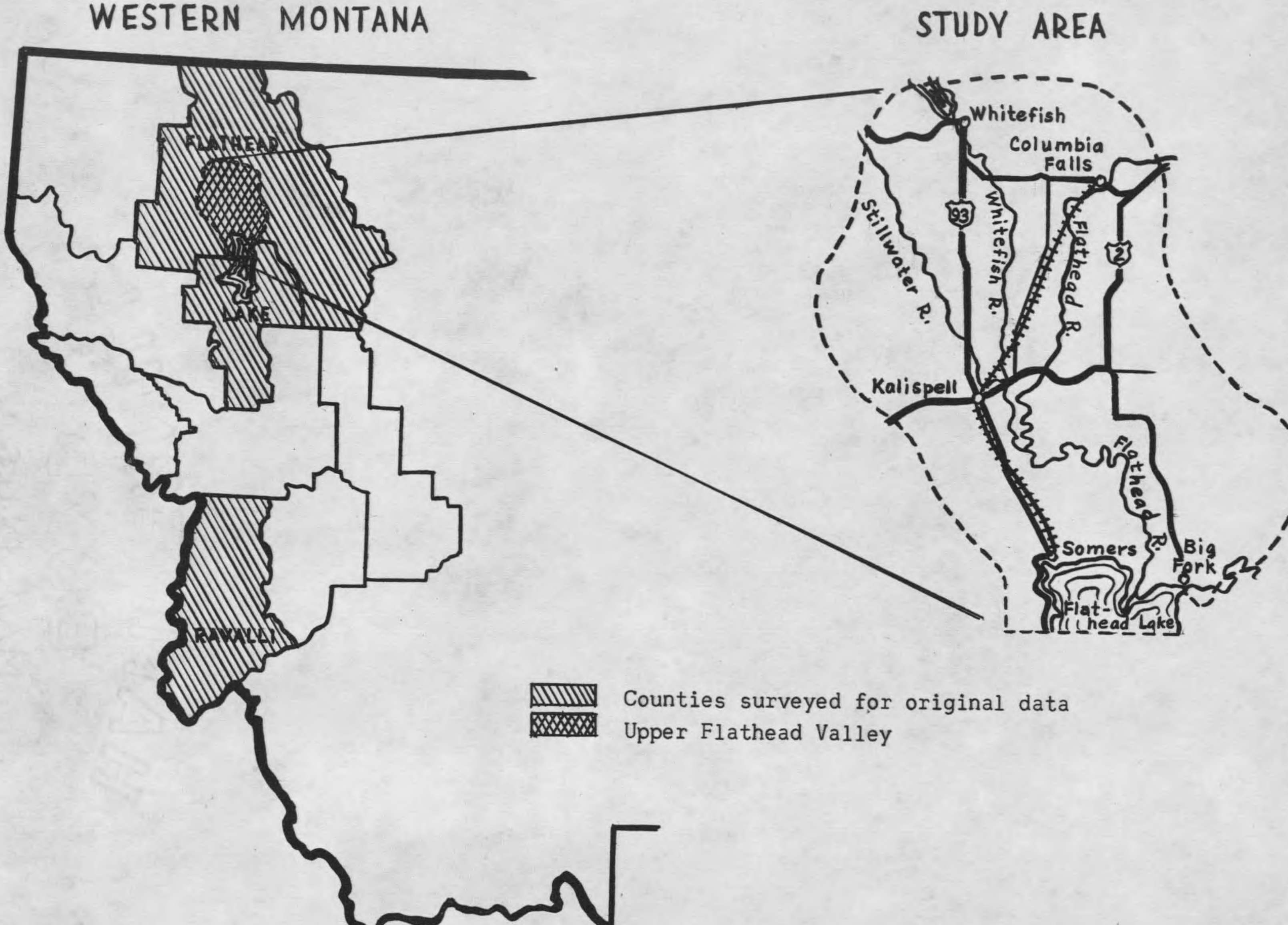

Figure 4. Study Area

by the Kalispell records. 20/ The frost-free season varies considerably over the area and ranges from 99 days bordering the mountains to 150 days at the valley center.

Agriculture of the Area

Field crops provide the principal source of farm income. In order of their importance the principle crops are wheat, barley, hay, oats, potatoes and peas. 21/ Winter wheat is produced in preference to spring wheat, particularly in the drier areas. In maturing earlier, it tends to partially escape drought, insect and disease hazards.

Alfalfa is the principal hay crop and is utilized primarily for local consumption. With the exception of wheat most of the crops are used as feed for livestock, especially on those farms combining crop and livestock enterprises.

The main livestock enterprise is dairying, with hogs and poultry production as minor enterprises on most farms. Beef cattle and sheep are raised on relatively few farms of the area.

Early Agriculture

Stockmen were the first agriculturalists of the area. Few crops were produced and the small amount of farming that existed was directed largely to the production of native hays. The advent of the railway in 1892

20/ F. K. Nunns, Upper Flathead Valley Area, Unpublished Manuscript, Dept. of Agronomy, Agr. Exp. Sta., Montana State College, Jan. 1947, pp. 2-3.

21/ Mauritson and Stucky, op. cit., pp. 8-9.

induced greater emphasis on cash crops but most of the production was geared to the needs of the lumbering industry that developed when the railway provided a means of marketing lumber. Horses, oats and hay and foodstuffs were major products that the lumbering industry readily absorbed within the area. 22/

Wheat became a major crop during the high prices of the World War I period. The mechanization of farming and lumbering, beginning during the "twenties", reduced the need for horses, horsefeed, and pasture. Wheat more than ever was the major crop.

Trends in Milk Production

As early as 1932 publications appeared proclaiming Western Montana as an important dairy region. As a butter and cheese area, the physical advantages were declared equal or superior to that of some of the major dairying states of the Great Lakes region. However, even at that time the market was limited by distance and interregion competition. 23/ Dairying as a whole expanded rapidly during World War II. Grade A milk production grew rapidly. Wartime demand for butter remained high through the early postwar years.

Increased local business activity in the form of an early postwar boom caused a still further expansion of the fluid milk industry. Early

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22/ Nunns, *op. cit.*, pp. 10-11.

23/ S. E. Johnson, J. O. Tretsven, M. Ezekiel and O. V. Wells, *Organization, Feeding Methods and Other Practices Affecting Returns on Irrigated Dairy Farms in Western Montana*, Bul. 264, Montana State College Ag. Exp. Sta., Bozeman, Montana, June 1932, p. 61.

adoption of modern milk handling techniques by the local co-operative creamery extended the market far into the eastern part of the state. However, by 1949 and early 1950, the demand for butter had dropped off and production of manufacturing cream on a commercial basis became a thing of the past although it has remained in the form of a supplementary enterprise on many crop farms. Grade A milk production was gradually restricted to a more localized market through interregional competition and gradual leveling out of business activity.

At the present time the milk cow numbers shown in Figure 5 below have adjusted closely to the local demand. Recent restrictions on wheat acreage however have thrown increased emphasis on dairying as a means of keeping farm income high. Lack of adjustment on the part of the farmers to

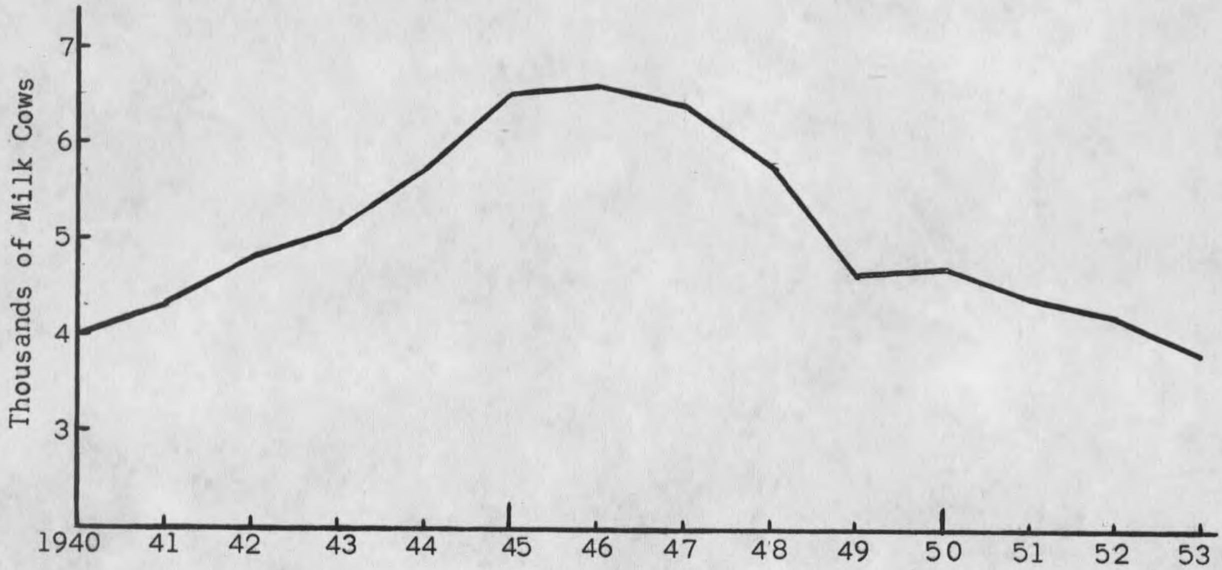

Figure 5. Milk cow numbers, Flathead County, 1940-1953, as taken from Montana Agricultural Statistics, as compiled by U.S.D.A., co-operating with Montana Department of Agriculture, Helena.

the seasonal nature of demand has created a surplus problem causing wide variation in seasonal prices as an effort on the part of distributors to match the flow of milk with local consumption.

Market Outlets and Transportation

The main line of the Great Northern Railway traverses the northern part of the area in an east-west direction, and a branch line connects Kalispell to the main line at Columbia Falls. This railway provides facilities for the shipment of livestock and crops to outside markets, such as Spokane, Seattle, Great Falls and St. Paul. Missoula, Great Falls, and Butte are the chief within-state markets for these products. State and Federal highways traverse the central and eastern portion of the area in a north-south direction, and the northern portion in an east-west direction. 24/

Most of the hays and feed grains produced are, as was previously mentioned, consumed by livestock on the farms. The wheat is marketed locally through cooperative and privately owned elevators. Most of the livestock not used for local slaughter is marketed in Missoula, Spokane and Pacific Coast cities.

There are three creameries at Kalispell and one at Whitefish. These plants handle the market milk and cream produced in the valley. Their principal outlet for dairy products consists of the year-around local trade and in the summer they supply the camps and hotels of Glacier Park. 25/ Local trade is sharply increased during the summer months due to tourist trade

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24/ Nunns, op. cit., pp. 11-12.

25/ Mauritson and Stucky, op. cit., pp. 7-10.

and use of local resort facilities.

The Methodological Approach

The Budget Analysis

With the previous portions of the study in mind it will be recalled that the primary purpose of the study is to develop a method whereby the production response of wholesale milk may be estimated under defined price changes.

The Primary Data

Primary data serving as a basis for the budget analysis is derived from a random sample of Grade A milk producers of Flathead County. The sample was conducted for the purpose of discovering production alternatives on dairy farms in Western Montana. 26/ The original sample was of 60 Grade A milk producers. Of the 60 farm records obtained, 55 were considered as adequate and complete enough for the study at hand. The sample was drawn from producer lists supplied by the local distributors which represent virtually all producers of commercial milk in Flathead County.

Data obtained from these schedules is utilized primarily to determine the nature of the universe within which the operation is carried out. Descriptive information regarding size of operations, number of acres found in different crops, average porduction rates per cow, etc., as derived from the sample data serves as the organizational and production base of the synthetic model.

26/ Unpublished Experimental Station Data, MSC, Agr. Expt. Sta., Bozeman, Montana.

Limitations of Sample Data

The sample data relating to the 1953 production periods has several important limitations: (1) The time period covered by the sample was too short to provide information regarding production trends, past price response, etc. (2) The information was gathered in the late summer and fall of 1954 rather than directly following the production year involved. Thus making qualitative analysis, completeness, accuracy, and memory bias become factors limiting the usefulness of the information. (3) In general the information is not related specifically to the supply problem, not being secured specifically for this purpose.

Secondary Data

As was previously mentioned, the synthesizing process as presented relies on information provided by the various fields of agricultural research. Crop and livestock response information derived under conditions resembling those of this study as closely as possible has been utilized to provide the input-output data. Various rates of machinery use, costs, etc., are derived in a similar manner. The major sources of such data will be indicated in the model.

With the descriptive material derived chiefly from sample data of the 1953 period, the price and production base used relates to that period. The standards set up regarding input-output relationships, standards of performance, etc., will be used consistantly throughout.

The alternative method to using price and production data of a single year would have been to use data "averaged" from several years. This would, as is pointed out by M. E. Quenemoen, not bring the problem any nearer to actuality and nothing would be gained in the final analysis. 27/

The Farm

Of the 55 sample farms, 37, or 67 percent, combined a wheat and Grade A dairy operation. The remaining 33 percent were primarily dairy farms with their own produced feed resources. Of the first group, 24 farms, or 65 percent had between 20 and 60 percent of their total crop acreage in wheat. Of the 37 farms found producing dryland wheat and Grade A milk in combination, the average sized farm was found to consist of 212 acres. Land use of all sampled farms is listed below.

Table I. Land Use of Sample Farms

Item	Amount
Total Acres	7851
No. of Farms	37
Mean of sample	212 Acres
Use	%
Wheat	21
Fallow	21
Hay	16
Oats	9
Barley	10
Pasture and Waste	23
TOTAL	100%

Based on the information given above, a 212 acre wheat and dairy farm is chosen as representative of the group. On this basis the following budget is presented.

27/ M. E. Quenemoen, Economic Aspects of Water Spreader Developments on Southeastern Montana Ranches, Montana Agr. Exp. Sta., Circ. 62, Dec. 1952, p. 25.

The Crop Organization

The land use organization and crop production plan is given in Table II, based on the percentages given above, the farm has 45 acres in wheat, 34 in hay, 19 in oats and 21 in barley. The 45 acres of wheat is raised specifically for cash sales but only surplus over livestock requirements of other crops is sold. Yield figures are based on county averages for the year 1953. 28/

Table II. Land Use and Crop Production System

Crops and Land Use	Acres	Yield	Prod.	Disposition			Cash Income	
				Feed	Seed a/	Sold	Price b/	Total
Winter Wheat	45	30 Bu.	1350		45	1305	$ 2.00	$ 2610
Summer Fallow	45							
Barley	21	28	588	480	32	76	1.00	76
Oats	19	30	5570	523	38			
Alfalfa	34	2 T.	68	62		6 T.	20.00	120
Cleared Pasture	15							
Timber Pasture	25							
Farmstead & Waste	8							
TOTAL	212							$ 2806

a/ All seed is assumed as home grown.
b/ Price corresponds to 1953 level. See Price Received by Montana Farmers and Ranchers, 1910, Bul. 503, Montana State College Ag. Exp. Sta., Bozeman, Montana.

Table III shows the machine operations involved in crop production and the number of acres involved in each operation. Information derived from the sample indicates that the common major rotation on these farms is three years in length: winter wheat, feed grain, and fallow. Summer

28/ Montana Agricultural Statistics, Montana Dept. of Agric., Labor, and Industry, cooperating with the U.S.D.A., Bureau of Agric. Econ., Helena, Montana, Vol. V, Dec. 1954.

fallowing is an important weed control measure in this area. 29/

Table III. Crop Requirements

Operation	Acres Wheat	Acres Barley	Acres Oats	Acres Summer Fallow	Acres Alfalfa	Total Acres
Plowing		21	19	45		85
Disking	45	21	19			85
Springtoothing	45	21	19	45		130
Harrowing	90	42	38	135		305
Drilling	45	21	19			85
Weeding	45			135		180
Combining	45	21	19			85
Mowing					68	68
Raking					68	68

Using the above data table IV is developed to show the direct costs of crop production. Hours per acre and cost per hour figures are derived from the research studies listed below and are adapted to the area under consideration. 30/

Total variable costs orginarily vary with the amount of use of the machine. However, following the suggestion of the New England efficiency study, a charge for wear depreciation is not made because of the relatively few hours of annual use of the items involved. Three hundred hours was considered the minimum number at which to charge use depreciation for

29/ For information concerning alternative means of weed elimination on Montana wheat farms, see the work of Carl Infanger, Unpublished Manuscript, Montana State College, Agr. Exp. Sta.

30/ Sources of performance rates used include Leo E. Choate and Scott A. Walker, Guide in Answering Basic Questions on Farm Machinery Costs, Idaho Agr. Exp. Sta. Bul. 224, Univ. of Idaho, Moscow, 1954; A.D. Reed, Machinery Costs and Related Data, Univ. of Calif., Agr. Ext. Ser. Circ., Davis, Calif., Nov., 1954; and G. E. Frick, S. B. Weeks and I. F. Fellows, Production Efficiency on New England Dairy Farms, N. H. Agr. Exp. Sta., Univ. of New Hampshire, Durham, N. H., Bul. 407, May, 1954.

simple machinery items. Similar charge for power or high capacity machine items begins at 500 hours under the recommendations of this study. 31/

Table IV. Direct Costs of Power and Machine Operation

Operation	Acres	Acres Per Hour	Total Hours	Cost Per Hour	Total Variable Costs
Plowing	85	1.00	85	$0.12	$ 10.20
Disking	85	2.4	35.4	.18	6.37
Springtoothing	130	7.0	18.6	.24	4.46
Harrowing	305	8.5	35.8	.04	1.43
Drilling	85	3.0	28.3	.69	19.53
Weeding (rod weeder)	180	3.3	54.5	.13	7.09
Combining	85				340.00
Mowing	68	2.5	27.2	.58	15.78
Raking	68	2.5	27.2	.18	4.90
Hauling or Elevating	67	4.0	16	.04	.64
Custom Baling a/					340.00
Custom Spraying					56.25
Tractor Hours			328	.70	229.60
TOTAL					$1036.25 b/

a/ Custom Baling is charged at the rate of $5 per ton or $10 per acre.
b/ The variable cost value shown above includes such items as gas, oil, grease and repairs. It does not include a charge for labor, as the family labor is assumed as more than adequate. The labor problem of the area seems to be one of making a more complete use of that available rather than obtaining more. Labor is not considered a limiting factor in this study.

The total variable costs of crop production are $804.05. Further break down of these cost items will be made in the following section of the study to determine the direct costs involved in the production of the different crops.

The Livestock Organization

The livestock budget as suggested by the average of the sample data and

31/ G. E. Frick, S. B. Weeks, and I. F. Fellows, *op. cit.*, pp. 5-10.

consistant with the type of crop organization listed above is shown in Table V.

Table V. Livestock Organization

Beginning Number	Kind	Born	Died	Home Use	Sales			Ending Number
					No.	Price	Value	
14	Milk Cows				3	110.	$ 330	14
3	2 yr. old heifers							4
4	1 yr. old heifers							4
	Calves	14	2	2	6	7.	42	
1	Sows			1				1
	Pigs	7	1	1	4	14.	56	
100	Hens		2	25	25	1.25	31	100
	Chicks	60	8					
	TOTAL						$ 459	

The herd is predominantly holstein and the average weight per head is 1100 pounds. Each cow produces an average of 6775 pounds of 4.0 milk. Table VI shows disposition of livestock produce.

Table VI. Livestock Produce Disposition and Use

Product	No. of Head	Prod. Rate	Total Prod.	Value of Home use	Sold Amt.	Price	Cash Income
4% milk	14	6775	94,850	$ 177.	90,865	$4.50 a/	$ 4089
Veal	2	200#	400#	60.			
Eggs	100	12 doz.	1200 doz	45.	1050 doz.		315
Pork	2	200#	400#	60.			
Poultry	25			31.			
TOTAL				373.			$ 4404

a/ Milk sold and used on the farm is credited at its net value at the farm. Based on a local distributor price of 4.90, 40 cents per cwt. was deducted for hauling.

Herd life for dairy stock averages 6 production years. The replacement rate varies. All replacements are normally provided from home raised stock. Stock shown over the required replacements are ordinarily sold if not needed. Bull calves and those heifers not intended for replacement purposes or home consumption are normally sold as day-old calves under the present budget.

The hog and poultry enterprises are of a supplemental nature and are used primarily for home consumption. Extra pigs are sold as weaners.

Roughage consumption of dairy cattle is based on a 105 day pasture period. Pasture is considered as good native dry land supplying approximately 1200 pounds of total digestable nutrients per animal per season. Grain is fed on the basis of the relative prices of milk and grain for the 1953 period. The concentrate ration for the milking stock, composed of 2/3 barley to 1/3 oats is fed at a yearly rate of 2000 pounds per cow. This is equal to approximately 75% total digestable nutrients. Disposition of feed resources is budgeted in Table VII.

Table VII. Annual Feed Disposition

Livestock	No.	Hay Tons	Barley pounds	Oats pounds	Total Grain Pounds Fed Per Year
Milk Cows	14	51.42	18,667	9,333	28,000
2 yr. old	3	3.75	1,000	1,000	2,000
1 yr. old	4	4.0	1,500	1,500	3,000
Calves	6	4		2,800	2,800
Hogs	3		1,698	898	2,569
Poultry	100		200	165	365

The annual direct expenses of the livestock system are shown in Table VIII. Both obsolescence and use depreciation of buildings is charged as a direct expense to enterprises making exclusive use of building and equipment.

Indirect and Fixed Expense Items

The machinery used to operate the farm is listed in Table IX. The total annual cost of ownership of the machine is expressed as a percentage

Table VIII. Direct Expenses of Livestock Enterprise

Enterprise	Type	Cost Per Head a/	Total Enterprise
Dairy Cows	Building	$ 12	$ 168
	Equipment Use	8	112
	Artificial Insemination	8	112
	Veterinary	2	28
	Electricity	3.50	49
	Spray and disinfectant	2.50	35
	Washing powder (Soap, etc.)	3.00	42
	Miscellaneous Expenses	2.00	28
Hogs b/	Veterinary		25
	Building Depreciation		5
Poultry	Mash 4000 pounds @ 2.75 cwt.		110
	Building Depreciation		37
TOTAL			$ 751

a/ Cost items for dairy enterprise, are synthesized from K. T. Wright and T. L. Hodges bulletin, Dairy for Profit in Southeastern Michigan, Michigan State College, Agr. Exp. Sta., East Lansing, Michigan, Special Bulletin 373, August 1951, and adjusted to sample data.

b/ Hog and poultry items are derived from J. P. Doll's, Economic Application of Soil Survey Data in Irrigated Areas, Mimeo, Cir. 87, Agr. Exp. Sta., Montana State College, Bozeman, Montana, June 1955, p. 27.

Table IX. Fixed Costs of Power and Machine Items

Machine	Size of Machine	New Cost	Expected Life Yrs.	Annual Ownership Cost	
				Total	Percent of original cost
Tractor	20 hp	$ 2,000	10 yrs.	$280.00	14
Plow	2-16"	230	16	24.38	10.6
Combine					
Grain Drill	10'	540	18	54.00	10
Disk (offset)	8'	600	6	150.00	25
Rod Weeder	12'	225	7	51.30	22.8
Springtooth	20'	410	12	51.25	12.5
Harrow Spike	30'	300	20	28.00	9.5
Mower	7'	330	18	33.00	10
Side Deliv. Rake	8'	395	16	41.87	10.6
Manure Spreader	70 bu.	175	18	17.50	10
Wagon	2 Ton	250	14	28.50	11.4
Hydraulic Farmhand		1,075	14	122.55	11.4
Misc. tools		350	5	98.00	28
Truck	$1\frac{1}{2}$ T.	2,000	12	337.50a/	12.5
Auto (Farm Share)		1,000	10	250.00	14.0
Total				$1,567.80a/	

a/ Auto and truck include fuel, oil and repairs.

of the original cost. These total percentages include obsolescence depreciation, interest, taxes, insurance, and housing. The straight-line method with a 10 percent trade-in value was used to determine depreciation. The total life of each machine used to determine the depreciation is given in the third column. 32/

Table X includes costs, life span, annual depreciation and repairs of buildings and structural items not assigned as direct costs to the specific enterprises.

Table X. Fixed and Non-allocable Expense of Buildings and Other Depreciable Real Property

Item	Cost a/	Life	Annual Depreciation	Repairs	Total
Dairy Housing	$4000	33	$-- b/	$--	$ --
Granary	1200	"	36	24	60
Hog House & Equip.	85	"	--	--	--
Poultry House & Equipment	740	"	--	--	--
Fence	2034		31	20	51
Total			$67	$44	$111

a/ Cost items adjusted from J. P. Doll, op. cit., p. 32, see also Farm Budget Standards for Irrigated Farming, U. S. Dept. of Interior, Bureau of Reclamation, Region 6, Billings, Montana, October 1948, p. 5.
b/ Assigned as a direct expense to enterprise involved.

Other expense items include taxes, and an annual overhead expense added to cover general farm expenses chargeable to the whole farm. Such items as general upkeep of the farm, farm organization dues, farm papers,

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32/ Percentages were derived from F. C. Fenton, and G. E. Fairbanks, The Cost of Using Farm Machinery, Kansas State College, Engineering Exp. Sta., Bul. 74, Sept. 1954, see Table III and IV, pp. 12 to 34, also 13 to 23.

and telephone, make up this charge. It was estimated as five percent of the total of other non-specific costs. 33/

Table XI. Other Non-allocable Expense Items

Item	Amount
Taxes	$ 215
Overhead Expense	130
Total	$ 345

The indirect and fixed expenses for the farm are summarized in Table XII. Indirect expenses include machinery depreciation and repairs listed in Table IX and overhead expense from Table XI. Fixed expenses include taxes, depreciation of buildings and structures, interest, etc. not listed as "direct", or as shown in Table X.

Table XII. Summary of Indirect and Non-allocable Fixed Expenses

Indirect Expenses	Amount
Annual Ownership Costs	$ 1568
Overhead Expense	130
Total Indirect Expenses	$ 1698
Fixed Expenses	Amount
Building Depreciation and Repairs	$ 111
Taxes	215
Total Fixed Expenses	$ 326

Summary of the Budget

Table XIII. Budget Summary

Receipts	Amount
Crop	$ 2806
Livestock	4863
Home Consumption	373
Total Receipts	$ 8042

Expenses	Amount
Direct	
Crop	$ 1036
Livestock	751
Indirect	1698
Fixed	326
Total Expenses	3811
Net Farm Income	$ 4231

33/ Wright and Hodge, op. cit., p. 52.

Net farm income is calculated by subtracting the total expense from the total income. Thus it represents the return to the farmer for use of resources he owns: his labor, and management, together with interest on his equity in investment. 34/

This model is presented to represent the most predominant type of farm of the region on which Grade A Milk is produced. It will be used to test the possibilities of production response to milk price changes. The next step is to develop and test the alternatives by which the farmer may respond.

34/ J. P. Doll, *op. cit.*, p. 33.

PART III

EMPERICAL INVESTIGATION

Combinations to Meet Price Variation

The length of time necessary to vary (1) production from a given size of herd, (2) size of herd, (3) scale of operation, etc., may be only a few weeks or may extend into periods of years. It depends on the existing resource commitments (e.g., degree of specialization) and limitational factors. A drylot dairy operation with purchased resources will respond, in general, more readily than will a farm which combines crop enterprises and livestock. With limited amounts of capital and other resources available, competition arises in the allocation of available "bundles" of resources.

As enterprises are added, say feed production, to the single enterprise dairy operation a whole new series of input-output relationships and substitution relationships must be considered. The question of optima must now include not only optimum level of feeding for livestock but also must adjust the feed base to the livestock and vice versa. In terms of the budget construction a crop system must be added to a livestock system, adding an array of direct and indirect expenses. In the realm of management, as crop enterprises are added to livestock, the number of alternatives to meet price variability are increased. The possibility of adding supplemental enterprises becomes important as crop enterprises are added, whereas with highly specialized dairy units the alternatives are largely of a financial nature. When a system combining both crop and livestock enterprises (such as the theoretical model used) is presented, the budget becomes increasingly awkward in testing the number of alternatives available. Although a diversified type of operation is generally accredited as being more flexible, to meet price variability, competition in the use of land, labor, capital and management resources available necessarily limit the range of choice. As more and more resources are committed the resulting restraints tend to reduce flexibility.

Time Period Involved

In this study, only two time periods will be considered. The first, often referred to as the intra-year or post planting period, will consider only those adjustments which are possible during the year after production plans are made. The second period will be concerned with year to year adjustments. During this period all enterprises are considered variable or subject to change within certain limits, as will be specified later.

Major Alternatives of the Intra-year Period

The first analysis will be made to indicate the possibilities of a within year response. The period under construction is so short as to include possibilities of shifting crop acres and as data are not available in this area to permit the construction of realistic post-planting production function for crops. As such the crop functions will be assumed as given within the scope of this analysis. The possibility, however, exists that given data necessary to conduct a study of this type and with a sufficient magnitude of price change, important indications of farmer response might be shown.

In constructing a production function for livestock, an immediate or intra-year response is possible, due largely to the emphasis on direct or variable resources made possible by the elastic response of milk output to changes in feed composition, rate of feeding, etc. Possibilities of an almost immediate response of milk production to price changes exists whereas in the case of crops with the crop already in the ground there is little or no chance to increase the product within the production period.

Intra-year Adjustments of Milk Production

Milk production, as a function of feed input, can vary over a fairly wide range during a given lactation period. Optima include, (1) the optimum combination of feed components to produce a given product to minimize cost and (2) the different levels of output made possible by successive applications of the feed input (of given composition) and the most profitable level at which to produce.

In the first instance, research studies indicate that a considerable range of substitution exists not only between two grains but between hay and grain, and grain and pasture. 35/ In this case the optimum or point of cost minimization occurs where the marginal rate of substitution of one feed component for another, as determined by the ratio of the marginal products is equated to the inverse price ratio of the two feeds:

$$MPP_{x1}/MPP_{x2} = P_{x2}/P_{x1}$$

35/ E. O. Heady, op. cit., chapters 5 and 9. For specific reference to pasture and grain substitution possibilities as dairy feed see also S. Stangeland, Input-Output Relationships in (continued on next page)

This relationship is of importance in studying response to variation in relative prices of the feed components. However, assuming a given ration in this study, the price of the feed aggregate only is considered. With this assumption, the principal alternative appears to be the level of grain which should be fed to determine the optimum level of production under possible price changes.

Input-Output Relationships in Milk Production

In this analysis milk output is regarded as a direct result of grain input with other variables of production held constant under an assumed level of management. The derived product curve will vary depending on what level other variables are assumed fixed. Most of the studies of recent years show animal production functions subject to diminishing marginal physical productivity, as animals are fed to heavier levels. In the study of E. Jensen previously indicated, it is clearly shown that the law of diminishing physical output applies to milk production. In this study milk production increased with every increase in grain allowance, but at a decreasing rate. 36/ A functional relationship of the type $Y = f(X_1/X_2 \ldots X_n)$ appears with each level of output, Y representing the expected response to the given level of application of the variable factor X_1.

By adapting the average productivity per cow of the area under consideration (as derived from the sample data) to the previously mentioned study,

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(footnote from preceding page: concluded) Livestock Production, Agr. Exp. Sta., South Dakota State College and Bureau of Reclamation, U.S. Dept. of Interior cooperating. Ag. Econ. Pamphlet 38, Jan., 1952, pp. 7-14.

36/ Jensen, op. cit., p. 86.

the method used to derive the input-output relationships shown in Table XIV was to employ the Spillman production function of the type $Y = m - ar^x$. The equation as suggested by the Jensen study is indicative of the type of response expected on alfalfa hay fed freely during the off pasture season. Since the coefficients of the equation were not given by Jensen, the "r"

Table XIV. Input-output Relationships of Milk Production

X 1-30 Levels of feeding	Total lbs. grain fed	r^x (r = .945)	ar^x (a = 2575 lbs)	(m = 7505.69 lbs)	(lbs. of milk added per added pound of grain MPP_x)
0	0	0		4855.60	
1	100	.9450	2433.38	5172.31	
2	200	.8930	2299.48	5306.21	1.3390
3	300	.8439	2173.04	5432.65	1.2644
4	400	.7975	2053.56	5552.13	1.1948
5	500	.7536	1940.52	5665.17	1.1304
6	600	.7122	1833.92	5771.77	1.0660
7	700	.6730	1732.98	5872.71	1.0094
8	800	.6360	1637.70	5967.99	.9528
9	900	.6010	1547.58	6058.11	.9012
10	1000	.5679	1462.35	6143.34	.8523
11	1100	.5367	1382.00	6223.69	.8035
12	1200	.5072	1306.04	6299.65	.7596
13	1300	.4793	1234.20	6371.49	.7184
14	1400	.4529	1166.22	6439.47	.6798
15	1500	.4280	1102.10	6503.59	.6412
16	1600	.4045	1041.59	6564.10	.6051
17	1700	.3823	984.42	6621.27	.5717
18	1800	.3613	930.35	6675.34	.5407
19	1900	.3414	879.11	6726.58	.5124
20	2000	.3226	830.69	6775.00	.4842
21	2100	.3049	785.12	6820.57	.4557
22	2200	.2881	741.86	6863.83	.4326
23	2300	.2723	701.17	6904.52	.4069
24	2400	.2573	662.55	6943.14	.3862
25	2500	.2431	625.98	6979.71	.3657
26	2600	.2297	591.48	7014.21	.3450
27	2700	.2171	559.03	7046.66	.3245
28	2800	.2052	528.39	7077.30	.3064
29	2900	.1939	499.29	7106.40	.2910
30	3000	.1832	471.74	7133.95	.2755

value of .945 (representing a constant ratio of the marginal products) was computed from Table 21 of Jensen's study. 37/

The coefficient "m", equal to 7506 pounds, represents the maximum output to be obtained from the fixed technical unit (one cow). The sample average of 6775 pounds indicates a low capacity dairy animal as defined by Jensen. 38/ The "a" value, equal to 2575 pounds of milk, indicates the maximum output to be added by an increment of the particular variable factor under consideration. This represents the type of response expected assuming free feeding of high quality alfalfa hay. Table XIV, shows the computations used in deriving an estimation of the expected total and marginal response per 100 pounds of grain fed. "X" values of 1 to 30 represent 30 levels of feeding.

The milk production function derived from the above chart is shown in Figure 6. The corresponding marginal productivity curve is shown directly below the total product curve.

Major criticisms of the use of this type of function are: (1) initial increasing returns are not shown, and (2) by nature of the upper limit of production assumed, a decreasing total product cannot be shown. For this study, these segments of the TPP curve are not of concern since in the analysis the economically relevant area falls between maximum average physical product and maximum total physical product. It is true that when price variation is introduced, as the price of the variable factor approaches zero,

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37/ Jensen, op. cit., p. 68.

38/ Jensen, op. cit., Fig. 4, p. 42.

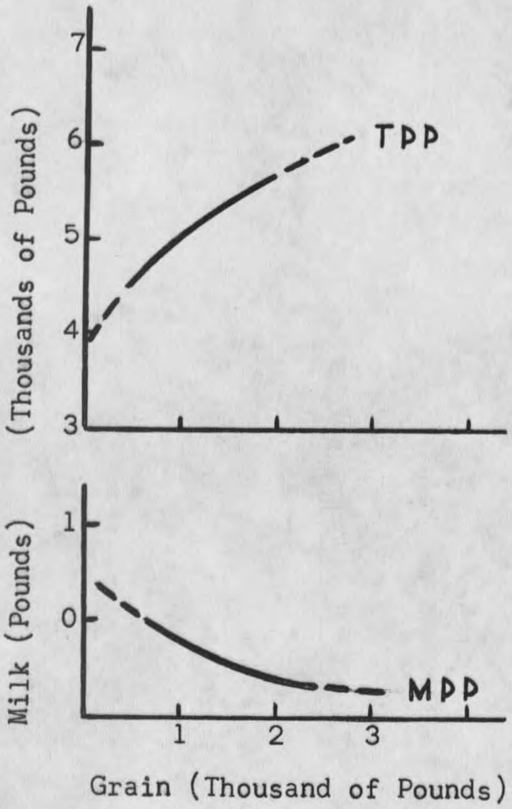

Figure 6. Total and Marginal Product Curves.

the tendency is toward maximiaztion of the TPP, and as the price of the fixed factor approaches zero, the tendency is to maximize APP. However, such extremes in price variation will not be approached in this analysis. Only that portion of the total product curve designated by the heavy solid line is considered relevant.

Given the input-output relationships shown above, the next question is one of choosing the amount of the variable factor to be used to maximize income net of grain feed cost.

To determine grain feeding levels value relationships must again be introduced. Assuming a price for milk, these optima are derived by conversion of the physical function into value terms by multiplication of the marginal physical product at different levels of feeding by the milk price and equating this value of marginal product with the price of the grain input. Graphically this is equivalent to finding a tangent to the slope of the total product curve equal to the ratio of feed price to milk price. Following this method, the value of marginal product is shown in Table XV for each level of feeding at selected milk prices ranging from 33.3 percent higher to 44.4 percent lower than the 1953 level assumed in the synthetic model.

Table XV. Value of Marginal Product with Milk Prices at $2.00 to $6.00 per cwt.

cwt of grain	MPPx	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
2	1.3390	2.68	3.01	3.34	3.68	4.02	4.35	4.60	5.02	5.36	5.69	6.03	6.36	6.70	7.03	7.36	7.70	8.03
3	1.2644	2.53	2.84	3.16	3.48	3.79	4.11	4.43	4.74	5.06	5.37	5.69	6.01	6.32	6.64	6.95	7.27	7.59
4	1.1948	2.39	2.69	2.99	3.29	3.58	3.88	4.18	4.48	4.78	5.08	5.38	5.68	5.97	6.27	6.57	6.87	7.17
5	1.1304	2.26	2.54	2.83	3.11	3.39	3.67	3.96	4.24	4.52	4.80	5.09	5.37	5.65	5.93	6.22	6.50	6.78
6	1.0660	2.13	2.40	2.67	2.93	3.20	3.46	3.73	4.00	4.26	4.53	4.80	5.06	5.33	5.60	5.86	6.13	6.40
7	1.0094	2.02	2.27	2.52	2.77	3.03	3.28	3.53	3.79	4.04	4.29	4.54	4.79	5.05	5.30	5.55	5.80	6.06
8	.9528	1.91	2.14	2.38	2.62	2.86	3.10	3.33	3.57	3.81	4.05	4.28	4.53	4.76	5.00	5.24	5.48	5.72
9	.9012	1.80	2.02	2.25	2.47	2.70	2.93	3.15	3.38	3.60	3.83	4.06	4.28	4.51	4.73	4.96	5.18	5.41
10	.8523	1.70	1.92	2.13	2.34	2.55	2.76	2.98	3.20	3.41	3.62	3.84	4.05	4.26	4.47	4.69	4.90	5.11
11	.8035	1.61	1.81	2.01	2.21	2.41	2.61	2.81	3.01	3.21	3.41	3.62	3.82	4.02	4.22	4.42	4.62	4.82
12	.7596	1.52	1.71	1.90	2.09	2.28	2.47	2.66	2.85	3.04	3.23	3.42	3.61	3.80	3.99	4.18	4.37	4.56
13	.7184	1.44	1.62	1.80	1.98	2.16	2.33	2.51	2.69	2.87	3.05	3.23	3.41	3.59	3.77	3.95	4.13	4.31
14	.6798	1.36	1.53	1.70	1.87	2.04	2.21	2.38	2.55	2.72	2.89	3.06	3.23	3.40	3.57	3.74	3.91	4.08
15	.6412	1.28	1.44	1.60	1.76	1.92	2.08	2.24	2.40	2.56	2.73	2.89	3.05	3.21	3.37	3.53	3.69	3.85
16	.6051	1.21	1.36	1.51	1.66	1.82	1.97	2.12	2.27	2.42	2.57	2.72	2.87	3.03	3.18	3.33	3.48	3.63
17	.5717	1.14	1.29	1.43	1.57	1.71	1.86	2.00	2.14	2.29	2.43	2.57	2.72	2.86	3.00	3.14	3.29	3.43
18	.5407	1.08	1.22	1.35	1.49	1.62	1.75	1.89	2.03	2.16	2.30	2.43	2.57	2.70	2.84	2.97	3.11	3.24
19	.5124	1.02	1.15	1.28	1.41	1.54	1.66	1.79	1.92	2.05	2.18	2.31	2.43	2.56	2.69	2.82	2.95	3.07
20	.4842	.97	1.09	1.21	1.33	1.45	1.59	1.71	1.83	1.95	2.06	2.18	2.32	2.44	2.56	2.69	2.78	2.91
21	.4557	.91	1.03	1.14	1.25	1.37	1.48	1.59	1.71	1.82	1.93	2.05	2.16	2.27	2.39	2.50	2.61	2.73
22	.4326	.87	.97	1.08	1.19	1.30	1.41	1.51	1.62	1.73	1.84	1.95	2.05	2.16	2.27	2.38	2.49	2.60
23	.4069	.81	.92	1.02	1.12	1.22	1.32	1.42	1.53	1.62	1.73	1.83	1.93	2.03	2.14	2.24	2.34	2.44
24	.3862	.77	.87	.97	1.06	1.16	1.26	1.35	1.45	1.54	1.64	1.74	1.83	1.93	2.03	2.12	2.20	2.32
25	.3657	.73	.82	.91	1.01	1.10	1.19	1.28	1.37	1.46	1.55	1.65	1.74	1.83	1.92	2.01	2.10	2.19
26	.3450	.69	.78	.86	.95	1.04	1.12	1.21	1.29	1.38	1.47	1.55	1.64	1.73	1.81	1.90	1.98	2.07
27	.3245	.65	.73	.81	.89	.97	1.05	1.14	1.22	1.30	1.38	1.46	1.54	1.67	1.76	1.84	1.92	1.95
28	.3064	.61	.69	.77	.84	.92	1.00	1.07	1.15	1.23	1.30	1.38	1.46	1.53	1.61	1.68	1.76	1.84
29	.2910	.58	.65	.73	.80	.87	.95	1.02	1.09	1.16	1.24	1.31	1.38	1.46	1.53	1.60	1.67	1.74
30	.2755	.55	.62	.69	.76	.83	.90	.96	1.03	1.10	1.17	1.24	1.31	1.38	1.45	1.52	1.58	1.65

Table XVI. Optimum Feeding Level of the given grain ration in pounds of grain per cow per year.

Price Milk cwt.	Price Grain ($/cwt) 1.68	1.89	2.10	2.31	2.52
200	1000	800	600	400	300
225	1200	1000	800	600	500
250	1400	1200	1100	800	700
275	1500	1300	1200	1000	800
300	1700	1500	1300	1100	1000
325	1800	1600	1400	1300	1100
350	2000	1800	1600	1400	1200
375	2100	1900	1700	1500	1400
400	2200	2000	1800	1600	1500
425	2300	2100	1900	1700	1600
450	2400	2200	2000	1900	1700
475	2500	2300	2100	2000	1800
500	2600	2400	2200	2000	1900
525	2700	2500	2300	2100	2000
550	2800	2600	2400	2200	2000
575	2800	2700	2500	2300	2100
600	2900	2700	2500	2400	2200

To determine the level at which to feed grain at any one of the milk prices shown in Table XV, the optimum as previously mentioned is to equate the value of the marginal product to the price of the price of the grain ration. Table XVI illustrates the derived optimum level of feeding with milk prices between $2.00 to $6.00 per hundred weight and feed prices 10 and 20 percent lower and higher than the 1953 composite price of the assumed ration.

Supply Estimates With Input-Output Data

With grain as the only variable input under the assumptions made, the supply response of milk production to price changes can be derived. Figure 7 illustrates graphically the nature of this supply curve. Grain prices are held constant at $2.10. Milk prices vary from $2.00 to $6.00 per hundred weight.

SS' represents the production or supply response permissible with respect to the given grain ration. However, it should be pointed out again that this is not necessarily the way the farmer would respond to price changes of this magnitude based on the assumed input-output relationships. Rather it shows the possibility of response which might be produced.

Over a finite range of the supply function, let the average elasticity, E_s, be given by

$$E_s = \frac{q_2 - q_1}{q_2 + q_1} = \frac{p_2 + p_1}{p_2 - p_1}$$

where q_i = milk, measured in pounds per cow per year, p_i = price per hundred weight of milk. Then, between selected milk prices, the average elasticities are shown in Table XVII.

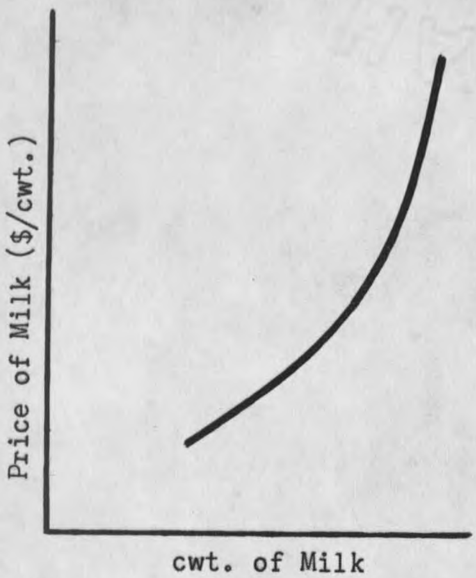

Figure 7. Optimum milk price supply response with respect to a given grain ration.

Table XVII. Estimates of Average Elasticities Between Selected Price Levels

Price 1	Price 2	Quantity 1	Quantity 2	Elasticity of Supply
$ 2.00	$ 3.00	5772	6371	E_{1s} = .25
3.00	4.00	6371	6675	E_{2s} = .16
4.00	5.00	6675	6864	E_{3s} = .13
5.00	6.00	6864	6980	E_{4s} = .08

Expected Farmer Response to the Feeding Alternative

Given the range of price changes shown in Table XV, milk output may be varied optimally over a range of 1208 pounds. As a point of departure the budget makes use of the level of feeding indicated as most profitable under grain at $2.10 cwt. From the milk output thus yielded, output may be varied 1003 pounds to meet the maximum assumed price decrease or raised 205 pounds to meet the maximum assumed price increase. To use these relationships to estimate actual farmer response it would be necessary to assume that the operator is aware of the existing relationships.

Considering the post-planting period or within year price changes, the problem of how the farmer is likely to respond (as well as how he can respond) should be considered. 39/ Given a price change of sufficient magnitude to interest the farmer in the possibility of increasing his output in spite of the uncertainty of the duration of the change, the following questions should be answered: (1) how much does it pay the farmer to feed the given herd at the indicated optimum to meet the price change, and (2) is this sufficient inducement to call forth the extra labor and management required to meet the change? To determine the possible income per cow, assuming additional grain, above and below budget requirements, is bought and sold at $2.10 per hundred weight and attributed to the technical unit under consideration, Table XVIII is presented. 40/

Table XIX is presented to determine the profitability of adjusting optimally to changes in milk price. The optimum income from milk and feed expected at the various milk prices is shown in Table XVIII. Income (from milk alone, since no feed is bought or sold) at the assumed feeding level of pounds of grain per cow per year is shown, for various milk prices, in column 3 of Table XIX. This assumes, then, no adjustment whatever, in feeding level, in response to a change in milk price. Column 4 shows the difference, per cow, of optimum income and the income resulting from failure to adjust optimally. The last column shows the same thing on a herd basis.

39/ The previously mentioned studies by Jensen, et al; Allen, Hole and Mighell; and Johnson, Tretsven, Ezekiel and Wells; all indicate this as a major alternative of short term response. However, assuming different environmental conditions as well as different input-output relationships, a test should be made.

40/ The term technical unit refers to a single, fixed unit in production for which output and returns may be calculated, (e.g., one cow, one acre).

Table XVIII. Income Per Cow ± Value of Additional Feed Required

Price of milk	Total Grain Per Cow	Feed Sold	Feed Bought	Value of Additional Feed	Value of Milk Prod.	Milk Income ± value of feed sold or bought
$2.00	600	1400		+ 29.40	115.44	144.84
2.50	1100	900		+ 18.90	155.60	174.50
3.00	1300	700		+ 14.70	191.13	205.83
3.50	1600	400		+ 8.40	229.74	238.14
4.00	1800	200		+ 4.20	267.00	271.20
4.50	2000	0	0	0	304.50	304.88
5.00	2200		200	- 4.20	343.20	339.00
5.50	2400		400	- 8.40	381.87	373.47
6.00	2500		500	- 10.50	418.80	408.30

Table XIX. Additional herd income at optimum feeding levels.

Price of Milk	Net Income of Table XVIII	Income with feed at 2000 pounds	Additional Income per Cow at optimum	Additional Income 14-cow herd
$2.00	$ 144.84	$ 135.50	$ 9.34	$ 130.76
2.50	174.50	169.38	5.12	71.68
3.00	205.83	203.25	2.58	36.12
3.50	238.14	237.12	1.02	12.28
4.00	271.20	271.00	.20	2.80
4.50	304.88	304.88	.00	.00
5.00	339.00	337.75	1.25	17.50
5.50	373.47	371.52	1.95	27.30
6.00	408.30	406.50	1.80	25.20

With a price increase of $1.00 per hundred pounds of milk, a possible increase in income of $1.95 per year per cow would provide little inducement to shift factors of production to meet the change. This may be an important factor in explaining the failure shown by farmers of the area to respond readily to the price changes applied for the purpose of controlling milk output. However, it should be pointed out that if the farmer were not faced with the alternative of buying or selling additional grain but could readjust his supply on hand, this type of response would perhaps be more significant. 41/

It should be pointed out, however, that the basic analysis of the study is derived from a synthetic model. This model is derived with the aid of sample data to represent a predominant type of farm in a certain geographic area. As such the farm represents not only the average producers of the area but the high and low producers also. With this in mind it can be pointed out that even a small possibility for response would be seized upon by some of the producers in the area, while others would remain almost inactive under any reasonable price changes. Also the expected response of the milk production to levels of feeding would vary widely as the capacity of cows increased, improved managerial techniques were introduced, etc. It should be kept in mind that the assumptions of a milk production function and a capacity rating of cows are based upon experimental results adjusted to the sample data. The possibility exists that, due to a lack of information, the seemingly low capacity per cow may be due to a lack of managerial ability and initiative on the part of the farmers rather than the inherent qualities of the animals.

Other Alternatives of the Intra-year Period 42/

Looking back to the original budget, another short term alternative of increasing production to meet a price rise appears. This is an increase

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41/ This might be attributed to (1) the perfect market assumed may not exist thus bring error into the pricing of the variable input, and (2) with price changes of the nature discussed, the relative profitability of alternative enterprises would fluctuate giving a possibility of shifting feed resources in and out of the supplemental hog, poultry, calf and heifer enterprises. This would (continued on next page)

in herd size. Given a price change large enough to motivate, a change in output could readily take place within a short period of time by the addition of more animals. The possibility of increasing herd size in face of short-term price certainty would be to increase the given herd by buying a additional animals or changing the existing culling practice to increase herd size over short periods of time. Buying of stock in face of short-term certainty is decidedly risky and only the alternative of a change in culling rate will be analyzed in this section.

Under the present setup the average production of three cows of the given 14, is divided between three freshening heifers and three cull cows. With cows being replaced as heifers are freshened, the herd is maintained at approximately 14 cows throughout the year. In this way, one-half of this production is attributed to each source.

In view of the price change discussed above the farmer could hold the cull cows until their lactation period is terminated. In this way it is assumed that an additional 10,163 pounds of milk could be obtained. Cost and expense items are shown in Table XX. The total milk income net of the direct expenses (as shown in Table VIII of the synthetic model) is shown both at the present level of production at the increased price and at the new level considering an increase in herd size. This is shown in short-cut budgets 1 and 2 respectively.

(footnote from preceding page: concluded) pose important alternatives and would facilitate shifts in milk output.

42/ Other short-run alternatives would include improved managerial practices to regulate production to meet seasonal price shifts, improved practices to increase production and eliminate waste.

Table XX. Returns Per Herd Net of Direct Expenses

Budget 1		Budget 2	
Cow Numbers (average)	14	Cow Numbers (average)	15.5
Total Production (pounds)	94,850	Total Production (lbs.)	105,013
Value of Product ($5.50 cwt.)	$5217	Value ($5.50 cwt.)	$5,776
Direct Expenses ($41 per head)	574	Direct Exp. ($41 per head)	636
Income net of D. Exp.	$4643	Additional Feed a/	183
		Income Net of D. Exp.	$4,957

a/ Cows are fed at the present budget level of 2000 lbs. per cow per year.

Comparison of the two budgets shows a positive net return of $314 for the alternative budget. This analysis assumes that the cull cows are capable of finishing the lactation period. This is definitely a short-run alternative. Continued use of the cull cows would tend to lower the quality of the herd and increase risk of death loss suffered as a result of this practice would eliminate the salvage value of the cow (assumed at $110) and substantially lower the resulting returns. However, regulation of culling practices to meet expected prices would appear to offer a feasible alternative to increase milk production and hence returns.

Summary of Intra-year Response

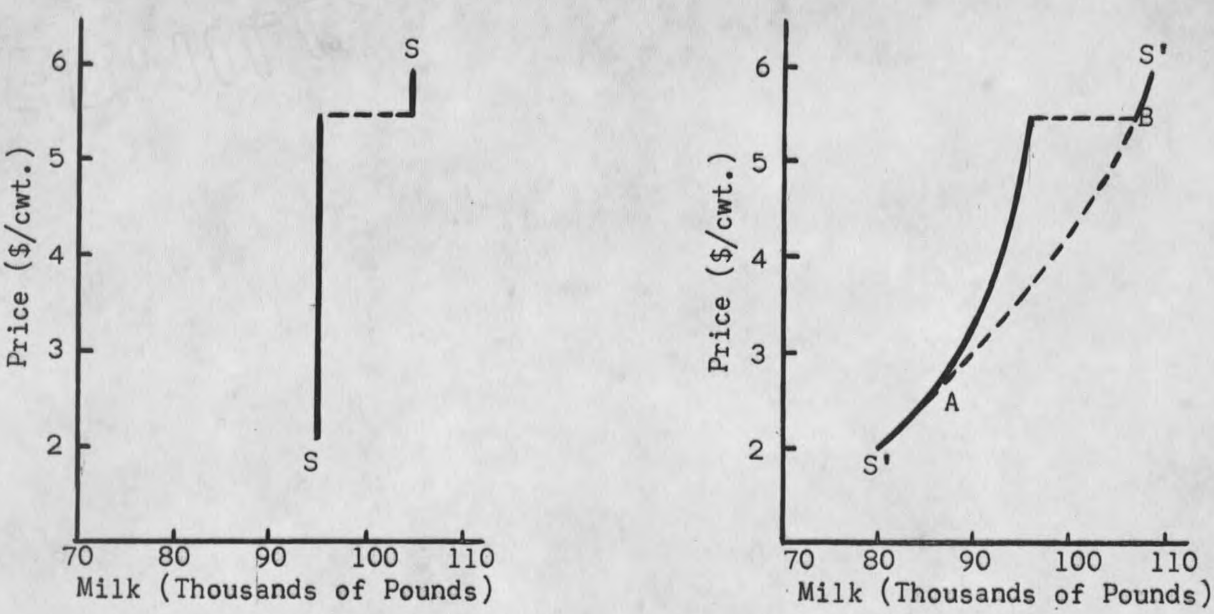
Comparison and summation of the results of the alternatives of the intra-year period which have been examined are shown in supply curves of Figure 8.

In Figure 8, the dotted line between points A and B is presented to indicate that some producers might respond at any of the price levels shown.

Further Analysis With an Expanded Time Period

The Inter-year Period

Previously feed has been considered bought and sold freely; however,



A. Response to Culling Alternative, No Change in Feeding Level.

B. Response to Culling Alternative, @ Optima Feeding.

Figure 8. Supply Response of Alternatives Examined for Intra-year Period.

in the subsequent analysis this assumption is not made. Now the analysis will be concerned with the inter-year production period when the farmer can adjust crop acres to provide additional feed if needed. This analysis is made assuming the farmer is faced with relative certainty of price expectations of a period in excess of one year. This would allow reasonable adjustments in crop acres, as well as in the size of the dairy enterprise. For this investigation the $5.50 per hundred weight milk price which was used in the previous section is again applied. This represents a $1.00 increase over the current milk price and is assumed as sufficient to stimulate farmer reaction.

Direct Expenses of Crop Production

Faced with some certainty over a period of time sufficient to make acreage adjustments, the question arises as to how profitable the shifting of crop acres to supply feed increments for an expanding dairy herd might be. To compare the enterprise alternatives the following table is presented to show the direct costs attributable to the specific crop enterprises.

Table XXI. Direct Expenses Per Crop Acre

1. Wheat (45 crop acres)				
Operation	Acres Worked	Acres Per Hour	Total Hours	Direct Expenses a/
Disking	45	2.4	18.75	$ 3.38
Springtoothing	45	7.0	6.43	1.54
Harrowing	90	8.5	10.54	.42
Drilling	45	3.0	15.00	10.35
Weeding	45	3.3	13.64	1.77
Combining	45			180.00
Spraying	45			56.25
Tractor			64.41	45.09
Total Cost				298.90
Cost Per Acre				6.64
2. Barley & Oats				
Operation	Acres worked	Acres per hour	Total hours	Direct Expenses a/
Plowing	40	1.0	40.00	$ 4.80
Disking	40	2.4	16.67	3.00
Springtoothing	40	7.0	5.71	1.37
Harrowing	80	8.5	9.41	.38
Drilling	40	3.0	13.33	9.20
Combining	40			160.00
Tractor			85.20	59.64
Total Cost				238.38
Cost per acre				5.96
3. Alfalfa (34 acres)				
Operation	Acres worked	Acres per hour	Total hours	Direct Expenses a/
Mowing	68	2.5	27.2	$ 15.78
Raking	68	2.5	27.2	4.90
Hauling			16.0	.64
Baling				340.00
Tractor			70.4	49.28
Total Cost				411.60
Cost per acre				12.11

a/ Direct expense items are a break down of those shown in Table IV as they apply to specific crops.

Acreage Requirement for Dairy Production

With the direct costs per acre as given in Table XXI, the next step is to determine the number of acres required to supply necessary feed required per milking cow. At the present milk production level and crop yields, the estimates are shown in part one of Table XXII. Part two is concerned with the optimum level of feeding at the price assumed.

Table XXII. Dairy Grain and Hay Requirements in Acres Per Milking Cow

1. Budget Feeding Level or Optimum @ $4.50 cwt. milk				
Item	Feed	Amount	Unit	Acres
Cow	oats	667	lbs.	.74
	barley	1333	lbs.	1.05
	hay	3.7	tons	1.84
Replacement Requirements Per Cow a/	oats	240	lbs.	.28
	barley	175	lbs.	.14
	hay	.34	tons	.17
Total hay acres Per Dairy Cow				2.01
Total Grain Acres Per Dairy Cow				2.21
2. Optimum feeding level @ $5.50 cwt. milk				
Item	Feed	Amount	Unit	Acres
Cow	oats	800	lbs.	.89
	barley	1600	lbs.	1.26
	hay	3.32	tons	1.60 b/
Replacement Requirements Per Cow	oats	240	lbs.	.28
	barley	175	lbs.	.14
	hay	.34	tons	.17
Total Grain Acres Per Milk Cow				2.57
Total Hay Acres Per Milk Cow				1.77

a/ Replacement requirements are based on a 6-year productive life per head for milking cows, or 1/6 of the feed requirements needed to raise a replacement heifer to 3 years of age.

b/ This figure represents the adjustment made in hay consumption as grain intake is increased 400 lbs. per year. It represents a 11.5 percent in hay consumption. For further information see Jensen, op. cit., pp. 80-90.

At the present level of production, considering the pasture available as non-allocable to crop enterprises, 4.22 (2.01 in hay and 2.21 in grain) acres are required to supply the dairy feed required per head of milking stock. If additional dairy animals are added, a greater pasture increment must be obtained. Two possibilities exist: (1) additional crop acres may be shifted to pasture production or (2) existing pasture may be improved to meet increased needs. 43/

Direct costs from establishing and maintaining pasture shifted from wheat production will be assumed at $7.50/acre. 44/ This figure includes seed, fertilizer, and power and equipment costs. Initial cost items are allocated over a five year period. Assuming an output of 1800 pounds of TDN production available per pasture season, .67 acres additional pasture would be needed for each additional cow added to the dairy enterprise. By use of this information, the analysis presented in Table XII can be completed and a total number of acres per head can be obtained.

Referring to Table XXIII, if animals are to be fed to the optimum grain feeding level for a milk price of $5.50 per cwt., .12 (5.01 - 4.89) of an additional acre will be needed per milking cow added to the original herd. At the feeding level indicated in part one a total of 4.89 acres are

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43/ Little information is available concerning costs and expected increments of yield for pasture improvement in this area. As a result quantitative analysis is not feasible. However, if the nature of the functions could be determined, it would contribute toward a determinant solution as to the feasibility of shifting acreage.

44/ This expense item was taken from Clarence Jensen's, The Economics of Pasture Integration on Irrigated Farms, Agr. Exp. Sta., Montana State College, Mimeo. Circ. 67, p. 56.

required per cow added. At the level of feeding shown in part two (optimum feeding) 5.01 acres are required per cow added because of additional grain acreage required.

Table XXIII. Feed Acres Required Per Additional Milk Cow

1. Budget feeding level or optimum @ $4.50 cwt. Milk		2. Optimum feeding level @ $5.50 per cwt. Milk	
Hay acres per cow	2.01	Hay acres per cow	1.77
Grain acres per cow	2.21	Grain acres per cow	2.57
Additional pasture acres/cow	.67	Additional pasture acres/cow	.67
Total acres/additional cow	4.89	Total acres/additional cow	5.01

Table XXIV is constructed as a basis for examination of possible acreage shifts between feed (for the dairy enterprise) and wheat. Using the acreage requirements derived above, returns per acre are shown for wheat and for four different combinations for dairy production below.

Comparison of columns 1 and 2 reveals that the present crop acreage utilized in milk production shows a positive net return of $2.29 per acre ($53.65 - 51.36) over an alternative use in wheat, at a milk price of $4.50 cwt. If a price of $5.50 per hundred weight of milk is considered, comparison of columns 1 and 4 reveals that at this price a positive return of $7.15 (58.50 - 51.36) per acre may be expected.

Further analysis, considering columns 4 and 5, ($59.17 - 58.51) show an increase of only $ .66 per acre when animals are fed at the optimum level as compared with the original level of feeding (2000 pounds per cow per year). Due to the lack of more distinction between the optimum and fixed level, for the sake of simplicity, the original level of feeding will be used to complete the analysis.

Table XXIV. Returns Per Acre Net Direct Expenses for Changes in Herd Size and Milk Prices

Income and Expense	Wheat	14-dairy herd		Increase in Herd Size milk @ $5.50	
		milk @ $4.50	milk @ $5.50		
	(1) Acre	(2) Non-optimal Feeding 4.22 acres required	(3) Non-optimal Feeding 4.22 acres required	(4) Non-optimal Feeding 4.89 acres required	(5) Optimal Feeding 5.01 acres required
Gross Returns	$58.00	$304.88	$372.62	$372.62	$381.87
Direct Expense Non-variable		a/ 41.00	41.00	41.00	41.00
Grain b/		13.17	13.17	13.17	15.32
Hay c/		24.32	24.32	27.33	24.07
Pasture (added)				5.03	5.03
Total Direct Exp.	6.64				
Returns Net of Direct Expenses Per Cow		226.39	294.13	286.09	296.45
Returns per acre Net of Direct Expense d/	51.36	53.65	69.70	58.50	59.17

a/ Non-variable direct expense items are per head figures taken from direct expenses attributed to the dairy enterprise shown in Table VIII. This expense item probably is non-linear; however, variation would probably be slight and, lacking the necessary information to synthesize a non-linear function, a linear coefficient is assumed.

b/ Seed requirements per acre are subtracted from the expected yield per acre.

c/ Cost for preparation and seeding of new hay ground is assumed at $1.50 per acre, or a total additional hay cost of $13.60 per acre.

d/ However, while the acreage already in dairy production is more profitable than the alternative use in wheat, analysis indicated that to add a cow (requiring 4.89 acres) at this price level ($4.50 per cwt.) for milk, this would result in a negative return of $6.71 per acre added when compared to the expected wheat return.

Holding production per cow at 6775 pounds and with the direct expenses as given, Table XXV shows the return net of direct expense per acre which might be expected from an increase of milk prices at the given level of feeding.

Table XXV. Dairy Income and Expense Per Acre for Milk Prices of $4.50 to $5.50 cwt.

Milk Prices	Gross Income Per Acre	Direct Expenses Per Acre	Net Income Per Acre
$ 4.50	$ 62.35	$ 17.70	$ 44.65
4.75	65.81	17.70	48.11
5.00	69.27	17.70	51.57
5.25	72.74	17.70	55.04
5.50	76.20	17.70	58.50

The above table seems to indicate that the break even price between wheat and milk lies at approximately $5.00 when the net income column is compared with the derived net income for wheat of $51.36. If response is assumed as forthcoming at this level, the farmer would tend to shift wheat acreage into dairy production only as price of milk approached $5.00 at $2.00 per bushel of wheat.

The Possibility of Acreage Shifts

In an actual situation the point at which the producer would shift resources would depend upon non-economic factors as well as economic inducements. Some producer might remain inactive under almost any price situation. Others would, depending upon the amount of knowledge available, shift as soon as it becomes economically feasible. The price level at which the shifts would occur would depend, to a large degree, upon the relative certainty of price expectations. The price increase sufficient to call forth the reallocation of the physical resources of the firm would necessarily depend upon the uncertainty accompanying the change. The greater the uncertainty the larger must be the change in expectation.

Under the synthetic model constructed, referring to partial budgets 1 and 2 in Table XXIV, dairy would show a greater net return per acre than wheat. This is at herd level for which pasture is available and not suitable for crop production. This land does not have an alternative use under the present set-up. Hence, there is no opportunity to consider it for shifts to wheat production. At the $4.50 milk price, shifts from wheat to dairy production would not be economically sound. This would come about as a result of the increased acreage and cost necessary to provide extra pasture.

Given an increase in the price of milk, the price of wheat and other factors remaining at the given level, a point would be reached at approximately $5.00 per hundred weight of milk, where continued wheat production would not be economically feasible. The foregoing is assuming a linear production possibility curve and a constant rate of substitution of dairy and wheat production resources. At this point, under a purely economic situation, the producer would shift from wheat to dairy to the limits of his physical production facilities, or as far as the production function remained linear.

Analysis of an Alternative Shift in Acreage

This investigation is devised to show the increase in milk production and the additional returns which might be expected from a shift of crop acreage from wheat to dairy under a price rise of $1.00 per hundred weight of milk. Such a price increase is assumed to be sufficient to bring about the response outlined below. Allowing for sufficient time to adjust, an average number of 20 milking cows is considered the upper limits of the linear cost function. Beyond this number additional capital investment would be necessary to provide adequate building facilities, cooling and milking equipment, etc. With new cost situations, more time would be needed and a greater certainty of price expectation than is to be considered here.

Of the 119 crop acres available, 5 acres are arbitrarily fixed in the production of feed for minor enterprises. Of the remaining 114 acres for a 20 cow dairy, 88.5 acres (14 x 4.22) + (6 x 4.89) would be needed for production. Comparing this situation with one with a 14 cow dairy herd on the same farm, the possible returns are shown in Table XXVI.

Table XXVI. Returns Net of Direct Expenses for Alternative Herd Sizes

Budget 1. 14 cows @ 4.22 acres per cow			
Item	Acres	Return Per Acre Net of D. E.	Total Return Net of D. E.
Dairy	59 a/	$ 69.70	$ 4112.30
Wheat	55	51.36	2824.80
Total	114		$ 6937.10
Budget 2. 14 cows @ 4.22 acres per cow and 6 cows @ 4.89 acres per cow			
Item	Acres	Return Per Acre Net of D. E.	Total Return Net of D. E.
Dairy	59	$ 69.70	$ 4112.30
	28.5	58.50	1667.25
Wheat	26.5	51.36	1361.04
Total	114		$ 7140.59

a/ Permanent pasture available up to 14 cows and replacements.

Comparison of the returns shown above indicates an increase of $203.19 (7140.59 - 6937.10). If the indicated response were to take place the expected increase in milk production would be 40,605 pounds (6775 x 20) - (6675 x 14).

Summary of the Analysis

The above analysis seems to indicate that given a milk price increase, the farmer has a good deal of opportunity to increase milk production by the use of a single production alternative if the price level used were sufficient inducement to bring about the shifts. However, due to the expanded time for adjustment, it is possible that several more opportunities of equal or greater importance may exist. Some of the more obvious of these include pasture improvement, land clearing to bring additional land into pasture production and introduction of sprinkler irrigation to provide a great pasture productivity and longer season of use. Introduction of such alternatives would necessarily change the production program and introduce different feed substitutions and production relationships generally. These, as feasible alternatives, would depend upon existing price relationships, certainty of expectations, farmer inertia to change, etc.

The use of land resources demonstrated in Table XXVI, represents the minimum number of acres which would be required for the respective enterprises. This analysis indicates a greater efficiency of land use than is demonstrated in the original budget. However, the increased efficiency might represent a type of managerial response to be expected from a substantial increase in milk prices.

Under a strictly economic situation the response shown would be expected to take place, that is, if output varied directly with price as indicated by the concept of supply. However, if an estimate is to be made of the production which will actually take place, other factors must come under scrutiny.

The conclusion might easily be drawn that as the time period is lengthened and more alternatives become available and with rising price expectations, elasticity of farmer response may increase. However, in applying this conclusion to the shifts in acreage between wheat and dairy enterprises, several limiting factors should be pointed out. First, wheat at the present time is under strict acreage controls and price supports. Shifts in the direction of additional wheat acreage would be impossible under the existing program. Second, wheat prices are fixed and stable; milk prices lack any such certainty. This would tend to hinder shifts even in price situations where dairy porduction has a distinct economic advantage over wheat for a period of time. Thirdly, the producers would be reluctant to shift acreage from wheat for fear of loss of allotments. Fourth, the short season of labor required for wheat production compared with the exacting year around daily requirements of dairy operation makes wheat an attractive alternative.

However, the purpose of this study has been to demonstrate and tentatively test the usability of the budgeting technique in determination of supply response. Rather than to say the farmer will or will not respond, the analysis has been to point to ways in which he may respond. In doing this, some consideration has been made to indicate a level at which response might take place.

PART IV

CONCLUSIONS AND IMPLICATIONS

Conclusions

Recent developments in Montana have focused considerable attention upon problems relating to the fluid milk industry. Attempts made at various levels to control production through manipulation of the pricing mechanism have indicated the necessity of research in supply response problems. Previously conducted studies have given little, in the way of productive results. There is little literature available to serve as a basis for estimating response or investigating the problems encountered in estimating the supply that might be forthcoming from changes of price expectations in the area under consideration.

Summary of Analysis

The attempt herein has been to estimate Grade A milk supply response within the limited range of alternatives which represent adjustments to price changes. A synthetic model constructed to represent a predominant type of producer of the area provides the basis for analysis.

The various alternatives which are readily discernable are budgeted. The resulting estimates form the basis for constructing supply curves which indicate several possibilities of response. These include changes in feeding level, herd size and culling rate to change herd size. Analysis involving inter-year choices show that although many new alternatives arise, limiting factors make the choices more difficult. This is evident particularly where such choices involve commitment of resources previously uncommitted to the dairy enterprise. As resources are committed in the form of fixed costs downward shifts of milk production are no longer feasible.

Limitations of the Study

The present study is limited by (1) the quantity and quality of the information available, (2) the numerous assumptions necessary to the analysis, (3) the number of alternatives which can be tested in any given situation, (4) the influence of the non-economic factors which influence the reaction of the producers and are not subject to estimation on economic ground.

References were made to price changes sufficient to stimulate producer-adjustments. These were attempts to recognize the many factors which affect the producer's choice. To say that producers will or will not respond to a certain change is not the purpose of this study. To do so would require an account of not only the amount of knowledge available concerning price certainty but evaluation of non-economic factors as well. Some of these factors would include the amount of leisure important to the individual under consideration, importance of year around income as compared to seasonal income, personal preferences, tenure status, capital available, etc. These items, non-measurable in economic terms, cannot be entirely overlooked if a realistic estimation of production response is to be made. They are partially resolved by use of a synthetic model to represent the area. In any given price situation a variety of reactions might be expected. Some alternatives offering small possibilities of improvement might, in the aggregate, be of considerable importance to the individual as economic conditions vary from the average.

Evaluation of the Budget Method

The value of the budgeting technique necessarily depends upon the particular situation under analysis. As a descriptive device to illustrate the type of agriculture under consideration and as a tool to provide the basic framework for analysis, the budget is useful. In a study of supply response, if the important alternatives for response can be isolated and the model used considered representative, the results would be a representative supply curve over a range of price changes. The value of the synthetic model in representing the aggregate necessarily depends upon the amount of quantitative information available and the particular type of agriculture under consideration. In an area with a predominance of single enterprise firms with purchased resources, the budgeting technique and subsequent analysis would have considerable advantage over a situation in which several combinations exist. This would be due to the relatively few alternatives which must be taken into consideration in such a situation as contrasted to the evaluation of the numerous alternatives which must be made in a more diversified type of operation.

To test alternatives available to farmers, the budget is adequate only insofar as the total effect of the alternative can be followed through various enterprises. Given a situation in which numerous alternatives are available and the net effect of any one cannot be restricted to a specific enterprise, the budget becomes an increasingly awkward and clumsy device to use. The hit and miss nature of testing the alternatives may impose considerable limitations on the amount which can be accomplished in any one budgeting study.

Several of the alternatives by which the producer may be expected to respond to a given price change have been examined in the body of this study. Many more would need to be tested in order that a reasonable estimate of the response of all the producers in terms of all reasonable alternatives might be calculated. Some of the most important may yet remain uncovered due to the lack of information and the time and space necessary to conduct a more complete analysis. By use of the partial budgeting technique, more ground is covered than might be expected through the use of more complete budgets. More alternatives and the estimated net effect of these alternatives can be summarized. However, to use partial budgeting, numerous assumptions must be made to limit analysis to the specific items under consideration. Even with the use of short-cut or partial budgeting techniques the number of alternatives which can be tested by any one budgeting study is necessarily limited by the time and space available.

Specific Implications

Individual farmers could use the data given only inasmuch as they can relate their organization and alternatives to those of the average farmer represented by the study. This imposes serious limitations. Most farmers depart from the average. Moreover, the extent and even direction of departure are often difficult to estimate. Hence little can be said for the general adaptability of the estimates developed here to individual situations. Even if the relationships as developed held true for the individual farmer other limitations (e.g., capital, labor, etc.) might prohibit the producer from making adjustments.

The study does suggest a method by which the competent farmer having a more complete knowledge of production relationships specific to his farm may construct a budget and analyze his available alternatives. For the concern of those engaged in making price decisions to regulate output, the study would give an indication of the way in which the producer of the area might be expected to respond.

As a basis for research, this study should be of some value as a starting point to a more comprehensive analysis of supply problems. This suggestion will be discussed more completely in the section of "Suggestions for Further Research".

General Implications

Due to the restricted size of local market, distance to other outlets, and competition limiting expansion of the market, the place of dairy production in this valley may be in the nature of a supplemental enterprise to utilize acreage resources not allocable to wheat due to the present control system. The analysis suggests the possibility that dairy production, as a competitor for land use, may be advantageous only insofar as pasture resources exist which are unavailable to other crops even in the absence of wheat acreage controls. In this light, due to the large amounts of uncleared and partially cleared land available in the area, dairy production might turn out to be a transitional phase of the agricultural development of the area. This would have important policy implications.

Suggestions for Further Research

The results and limitational factors revealed in this anaylsis should provide a basis for further research into supply response problems. Several information deficiencies revealed in this study and resolved by assumptions, indicate need for further farm management research. These include particularly production response estimates of grain feeding, grain and pasture substitution, and the costs and returns which may be expected from pasture improvement and land clearing measures. Information concerning these factors could aid substantially in estimating the results of adjustments by means of a representative model. Valuable information on these aspects could well be accumulated through cooperation of the Creston Branch of the Montana Agricultural Experiment Station. The fact that data deficiencies a appeared in this study suggest that they are deficiencies also for farmers in the area.

With additional estimates of production response and costs incurred under various enterprise setups, a study of supply response might be expected to show more significant results. Also, to facilitate a study of this type, research into the other factors obviously influencing response would be needed. In this study, no real estimates of those dynamic factors such as flexibility, risk and uncertainty, and capital limitations were attempted.

With such additional information, a more comprehensive study of supply response would need to adopt a method or tool to facilitate the selection of alternatives most likely to be used. Selection of optimum alternatives is hampered by the hit and miss nature of the budget technique. Realistic analysis of these problems would be both costly and extremely time consuming. If, however, the most important alternative facing the producer could be isolated, it is reasonable to expect that by use of a modified budgeting technique the possible supply response of a given area might be estimated.

As a tool to isolate the alternatives available and to tentatively test them, the linear programming technique shows distinct possibilities. By use of a synthetic model or models based on the more adequate information suggested to provide the basic restraints necessary to this technique, it seems likely that a large number of alternatives might be tested. By programming under a series of price relationships, it seems likely that a reasonable estimate of the expected supply might be obtained. If further research were desirable in order to more precisely estimate the effects of certain changes, the isolating of more relevant alternatives by a technique such as this would likely prove extremely valuable.

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