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A Method of Estimating Minimum Dairy Farm Sizes for Specific Income Levels

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A METHOD OF ESTIMATING MINIMUM DAIRY FARM SIZES

FOR SPECIFIC INCOME LEVELS

by

K. Dale Russell

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of

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K. Dale Russell

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ABSTRACT

A Method of Estimating Minimum Dairy

Farm Sizes for Specific Income Levels

by

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Utah State University, 1972

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The purpose of this paper is to calculate a method of estimating minimum dairy farm sizes for specific income levels. A survey of a sample of Utah dairy farmers was conducted to obtain data to calculate a long run average cost schedule. Dairy farmers who had just recently built new facilities and with varying sized herds were interviewed. Individual costs were studied to establish their effect on the long run average cost curve. Different average revenue curves for varying prices and production levels were used to establish minimum cow numbers needed to give specified incomes and growth potentials. Marginal analysis was used to establish the most efficient methods of growth, i.e., cow numbers, herd production and blend price.

(71 pages)

INTRODUCTION

The Changing Scope of the Farm Industry

Dairy farms provide a living for many farm families. Today income derived from the family farm is decreasing, and people are either moving away or turning to part-time jobs in order to supplement their income. According to the United States Census of Agriculture for 1964 there are approximately 15,759 farms in Utah; 3,670 of these farms have gross sales above $10,000. A gross return of $10,000 can be expected to give a net income of $3,500 which is the poverty level in Utah for a family of five. In 1970 there were 2,000 dairy farms in Utah with an average of 37 cows per herd. Dairy farmers wanting to keep their farms as a full-time enterprise have had or will have to increase their size through number of cows or intensity of production.

Nikolitch interprets the changing situation as follows:

> If technological advances or economic changes are incompatible with an American agriculture of predominantly family farm enterprises the following changes would not be apparent:
> 1. A decreasing proportion of farmers and markets.
> 2. Self-employed family labor decreasing in proportion to total farm labor.
> 3. Family farm business losing management and control of productive resources.
> 4. Farm production concentrating on a number of decreasing large farming enterprises. (Nikolitch, 1969, p. 533)

These four criteria are happening today and in order to cope with the problem many farmers must:

1. Get larger,
2. Get supplemental income or
3. Get out.

In October of 1971 new sanitary requirements went into effect for Utah dairymen who produce manufacturing milk. Approximately one half of the manufacturing milk producers will have to rebuild their facilities if they wish to continue commercial dairying. The new sanitary requirements have speeded up the trend of larger dairy enterprises, because small producers will not have the necessary gross returns to cover the added expense of improved physical facilities. Of the dairymen who need to rebuild, 31 groups have expressed desires to consolidate in some form (Barnard and Clements, 1971).

The change in sanitary requirements will be particularly felt in the small communities in northern Utah. In one typical community there are currently eight families engaged in dairying. Of these eight families, two will move to urban centers hoping for employment and two will be retrained in other fields and remain in the community. The members of two families are too old to be retrained or acquire jobs elsewhere and will remain in the community on welfare. Only two of the eight families will remain in the community as dairymen (Barnard and Clements, 1971).

The above discussion points out that the changing agricultural sphere has been temporarily speeded up in Utah due to the increased sanitary requirements.

Comparative Advantages of Utah Dairymen

Utah enjoys a bright future in dairying. It has a ready interstate and local market for Grade A and processing milk. Of D.H.I.A. herds reporting in 1966-67, Utah had the third highest production per cow record of the fifty states and Puerto Rico, Utah was only surpassed by California and New York. Its average D.H.I.A. herd size was only 50 cows; this is five cows less than the national average for D.H.I.A. Of the states below Utah in herd sizes, only three dipped below 40 cows into the 30's. Six of the states with herd numbers above Utah were over the 100 cow mark. It appears that herd size in Utah needs some drastic improving if economies of scale for herd size do exist.

The Western Pacific states (particularly California) offer a large and growing market for Utah dairy products. Although feed is limited in Utah, northern counties easily import feed from Idaho, an extensive feed producing state. Most of the dairying is located in northern and central Utah so that feed is readily accessible. Although small dairy farms are being forced out of production, there appears to be substantial room for more large and efficient dairies in Utah.

OBJECTIVES

The purpose of this study was to calculate the minimum size of dairy which is economically feasible under different combinations of specified conditions. The specified conditions to be considered are:

1. Income level,

2. Desired rate of growth.

Size will be considered in relationship to production per cow, base, and number of cows.

REVIEW OF LITERATURE

Growth

George D. Irwin (1964) defines growth as the accumulation of resources resulting from reinvestment of net savings by the farm operator. Johnson (1966) describes firm growth as an increase in the worth of the firm. The term "worth" refers to all of the physical assets of the firm, evaluated at an assumed constant price. He demonstrates his definition by the following equation:

$$A\ (1 + r)^n = B$$

A - worth of firm at beginning of particular growth period

n - period of time

B - worth of firm at the end of a given period of time

r - variable defining average rate of growth

Johnson listed four factors of input which have an influence on firm growth.

1. Initial asset position of the farm firm.
2. Capital or credit use policies of the farm firm.
3. The nature of the variability of crop yields.
4. Consumption policies.

Richardson mentions four input characteristics which relate indirectly to those of Johnson's.

> Given a will to expand, a firm's rate of growth could be limited, it would seem, by one or more of four characteristics: shortage of labor or physical inputs, shortage of finance, lack of investment opportunities, and lack of sufficient managerial capacity. (Richardson, 1964, p. 9)

A condition for growth exists when a firm has unused productive resources. Penrose (1959) considers financial and managerial capacity as the most important unused resource. This condition seems particularly relevant to the agricultural marketing system. Butcher and Whittlesey show that Penrose's conditions do exist in agriculture. Their assertion is as follows:

> There are few restraints on the acquisition of purchased inputs. The tremendous surge in fertilizer use has continued for twenty years without any significant increase in price. Therefore the major problems encountered with growth in farm size are likely to be in the areas of management and finance. At present, diseconomies to large scale enterprises are most often associated with some deficiency in management. (Butcher and Whittlesey, 1966, p. 1514)

Johnson (1966) sums up the conditions for growth by means of cost curves. He says that the existence of constant or decreasing long-run average cost curves is the primary condition for firms to grow.

Efficiency of Size

Internal physical economies

A decreasing long-run average cost line is the result of cost economies of size which exist in the industry. Faris (1961) shows that medium sized farms are as well equipped as large farms to take advantage of cost economies of scale. Once the farm has reached a certain size, any additional machinery is acquired in multiples of the equipment for a medium sized farm; e.g., once a milking parlor of certain size is achieved another parlor is built instead of doubling the size of the original parlor.

Internal market economies

Large farms do receive discounts on physical inputs. Faris (1961) argues that a competent manager of a smaller unit can also get discounts. Cooperative marketing also helps the small producer compete for minimum prices of inputs. Size of operation does affect the amount and interest rate on loans. A small but efficient operator can still receive some credit advantages through production credit associations. Large firms pay about the same for custom and contract work as the small producer, but they do receive preferential treatment because of the relative size of their accounts with the contractor. His summation is that large farms do have advantages but small farms with good management can still be competitive.

Management factor

Swanson (1961) states that most economies of scale in livestock production occur because of specialized management and capital intensification.

Faris (1961) shows that factors such as uncertainty, managerial ability, and the tax structure may be more important in determining whether or not a farm operator should increase the size of his farming operation than economies associated with size. Howell (1961) says that adequate management must be assumed in size analysis. He states that management factors for dairying, such as buying, selling and timing of production, do not pay as important a role as they do in the hog and beef feeding enterprises. In the dairy enterprise the cost analysis leads one to conclude that the present trend of expanding the individual dairy enterprise will continue and the complete disappearance of the small enterprise is not far away.

Nikolitch explains the increase in enterprise size with the following:

> The economic survival size of a farm shifts upward as keen competition in agriculture compels farmers to purchase more capital goods to meet the new requirements of expanding technology and as these increasing capital inputs reduce net income per unit of output. The size of farm business tends to become larger also, as demand for family income increases. (Nikolitch, 1969, p. 540)

Growth Models

In discussing firm growth and research techniques, Walker and Martin have described the ultimate model as follows:

> Eventually, a model must be selected which starts where we are, in terms of resources, incomes and goals, and carries the analysis to the point of estimating where they can or should or will go.
>
> The package should contain:
>
> 1. Finance
> 2. Managerial capacity
> 3. Imperfect knowledge

4. Time
5. What may be called metabolism of the farm
6. Significant externalities.

(Walker and Martin, 1966, p. 1534)

Simulation

Of the growth models used so far a simulation technique will probably fit the above criterion for a model the best. Hall (1969) used a simulation model for a growth analysis of Oklahoma Grade A dairy farms. He was able to do a detailed sensitivity analysis on growth rates. He used net worth as the growth criterion. By this technique he found that price of milk marketed and production levels had a significant effect on dairy farm growth. These conclusions coincide with a Utah study by Palmer (1965). Palmer showed that price of milk, level of production per cow, and number of cows had the most statistically significant effect on net income for the dairy firm.

Hall (1969) found that increasing interest and labor rates actually increased growth rates because of the necessity of culling lower producing cows to achieve a minimum requirement of cash flow levels. The results of his analysis, and simulation as a whole, are very quantitative and not easily understood by technically untrained persons. Even so, the model is complex, difficult to explain, specific, costly and capable of harboring researcher's bias.

Linear programming

Boehlje and White (1969, p. 556) used the following two multiperiod linear programming growth models.

$$DI = \sum_{t=1}^{T} \frac{\sum_{j=a}^{d} n_{jt} x_{jt} + \sum_{j=u}^{x} n_{jt} y_{tt} - \sum_{j=e}^{g} D_{jt}}{(1 + p)^{t}}$$

present value of disposible income stream	=	sum of discounted annual disposible income

$$NW = \overline{NW}_k + \sum_{j=h}^{l} \sum_{t=1}^{k} r_j T_{jt} - \sum_{j=m}^{q} \sum_{t=1}^{k} r_j s_{jt} + \sum_{j=m}^{q} \sum_{t=1}^{k} + \sum_{j=r}^{u} T_{jt} = k + \sum_{j=u}^{x} Y_{jt} - \sum_{j=y}^{z} \sum_{t=1}^{k} N_{jt} + \sum_{j=y}^{z} \sum_{t=1}^{k} B_{jt} r_j N_{jt}$$

net worth = adjusted initial net worth = total farm investment - total sales + adjustment of depreciation for sales + income transfer from k to k + 1 + off farm investment - total borrowing + principal repayment

Both the net worth and disposable income objective functions are subject to the following constraints:

Production capacity

Investment capacity

Borrowing capacity

Debt service requirement

Income transfer

Non negativity

Their conclusions were as follows:

> When net worth is maximized a heavy debt load is incurred and the amount of disposable income available to satisfy farm family consumption is restricted. In contrast, the objective of maximizing disposable income results in the generation of substantially less net worth but much less credit is used and more income is available for consumption. Consequently, under the assumptions of this study, it can be concluded that the objective of maximizing net worth will generate a greater value of owned assets, but family consumption must be sacrificed and a more vulnerable debt position is acquired. (Boehlje and White, 1969, p. 562)

Budgeting

Brewster (1969) used a straight budgeting procedure to determine minimum resource requirements for given income levels. In his example he compared two farms A and B. Farm A had 28 acres of soybeans, 35 beef cows and 35 acres of grass. Farm B consisted of 58 beef cows and 63 acres of grass.

His minimum wage levels were set at \$3,500. Farm A was able to achieve the \$3,500 income with 14 percent less investment and 3 cents less total cost per dollar of output. But soybeans are not a widely established crop in the region of the given study. Experience with soybeans in the region was so limited that plan B was followed. The objective of the study was to show the limitation of budgeting and linear programming in doing analyses of this type.

THEORETICAL MODEL

Economies of Scale

In pure competition the demand and marginal revenue curve are shown graphically as the same horizontal line, this is shown in Figure 1. Since an individual farmer cannot influence the price of his products, he achieves the greatest net return per unit by minimizing production costs.

There are basically four types of cost economies or diseconomies involved in agriculture.

1. External market economies refer to an outside conglomerate of influences which influence the resource and product market of a firm.
2. External physical economies refer to the environment which gives particular lenience to an industry in a given region.
3. Internal market economies result from cost advantages of buying or selling in large volumes.
4. Internal physical economies arise from the specialization of labor and machinery, and divisibility of resource because of the internal volume of a firm.

Internal market economies have become minimized because of cooperative buying and selling of products by smaller producers. Also, feed

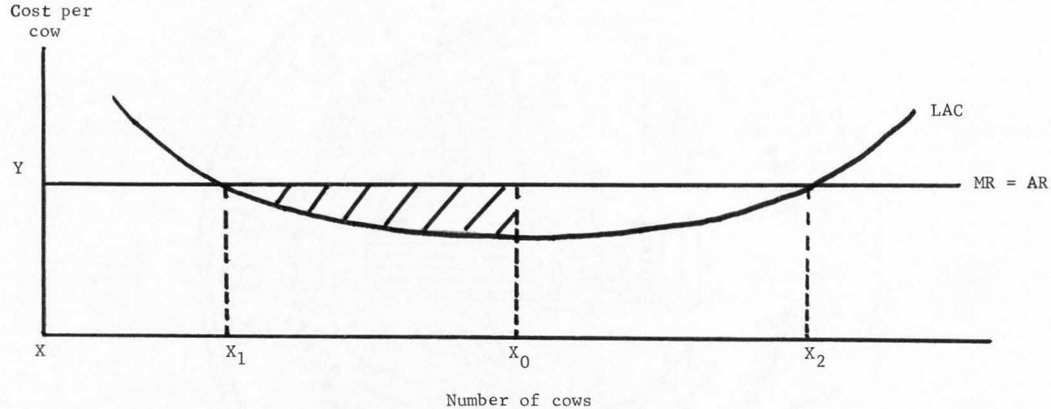

Figure 1. A theoretical long run average cost curve and average revenue curve in a pure competition market for various sized herds of dairy cows.

costs, which represent approximately one half of the production costs, are usually home grown in dairying.

Internal physical economies are the most important factor in determining optimum farm size and growth rates. Returns to scale and proportional adjustments are both a manipulation of internal physical economies. The extent of returns to scale and proportional adjustments are measured by a long run average cost curve.

Long run average cost curve

All resources on a long run average cost curve are variable and it provides a planning model for the future.

The long run average cost curve is made up of short run average cost curves, Figure 2. A short run average cost curve is a schedule representing varying costs per cow as the output, measured by number of cows, are increased for a given sized plant excluding cows. Each short run average cost curve represents an individual combination of fixed factors for a given physical plant. At point A the fixed resources in the physical plant represented by SAC_3 are underemployed. There is not enough cows producing milk to rationally pay for the larger plant. At point A the most efficient physical plant to produce with would be that represented by SAC_2 even though SAC_2 is not at its minimum. If the operator already owned the physical plant represented by SAC_3 he could attain greater efficiency by increasing his output through number of cows.

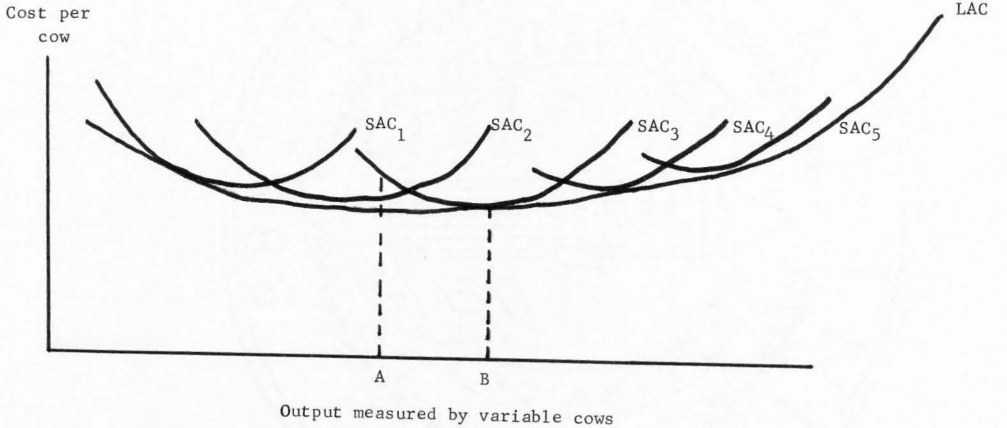

Figure 2. A theoretical long run average cost schedule for various sized herds of dairy cows.

After a series of short run average cost curves have been sketched, a long run average cost curve is drawn tangent to or near the minimum cost points of all the short run average cost curves. At its minimum point the SAC_3 represents the minimum cost per cow of producing milk in the long run. If minimizing costs is the main objective of the operator, SAC_3 at B level of production B would be the most feasible plant to build.

Figure 1 represents the basic relationship of the long run average cost curve and the average revenue curve used in this study. The average revenue curve represents the amount of revenue each individual cow produces. If an operator is producing milk with a herd size less than X_1 cows, his costs per cow will be higher than the revenue per cow. Costs per cow and revenue per cow will be equal at X_1 and X_2 herd sizes. X_0 represents the greatest positive net return per cow.

Net income can be calculated by integrating between the average revenue and long run average cost curves. For example, if a person owned X_0 cows, his net income could be determined by the following formula:

$$\int_0^{X_0} AR - \int_0^{X_0} LAC = \pi$$

AR - numerical formula for the revenue produced by each cow for average revenue schedule represented in Figure 1

LAC - numerical formula for the long run average cost schedule

X_0 - number of cows

π - net revenue

This formula can also be used in reverse. If a farmer stipulated the income that he required, then the equation could be solved for X_0 to find the number of cows he needed to give him the specified net income.

Marginal Analysis

After the firm has been constructed, the long run average cost curve is no longer useful in determining profit maximization for the firm. Marginal cost analysis is used to determine the optimum size and growth decisions for the given physical plant. The problem is to vary the variable resources with market conditions so that:

$$\frac{\text{M.V.P. cows}}{\text{P. cows}} = \frac{\text{M.V.P. labor}}{\text{P. labor}} = \frac{\text{M.V.P. capital}}{\text{P. capital}} = \frac{\text{M.V.P. management}}{\text{P. management}} = 1$$

M.V.P. - the additional receipts incurred from adding one more unit of the resource.

P. - price of the last unit of resource.

PROCEDURE AND BASIC ASSUMPTIONS OF THE STUDY

The Survey

A sample of farmers were interviewed to obtain operating and fixed costs for milk production. Only farmers who had built dairy facilities within the last two years were interviewed. They were chosen arbitrarily by the Utah State Extension Service. The main criteria for choosing them was varying herd sizes and at least average management abilities. Only selected counties with a strong dairy industry were visited. A list of the counties is included in the Appendix in Table 17. Forty-three interviews were conducted, but of those only thirty-three were able to answer all questions. Some dairies were only partly new construction or the person being interviewed was unsure of some of the costs. Budgets were prepared for the complete interviews and incomplete budgets were made up from the others. It was assumed that the physical plant was comprised of standard facilities. Any excessive costs due to elaborate equipment, such as glass lined silos and completely automatic feeding equipment, were reduced to comparable costs for standard equipment. The test for standard equipment was whether or not it was in common usage in Utah.

Feed costs

More than one half of the interviews were indefinite on the feed costs because much or all of the feed was raised on the farm. National averages of physical quantities of feed required for milk production at various cow production levels were used.

National D.H.I.A. feed records were available before the survey was taken. They included the national averages of feed costs and physical quantities of feed required for various production levels of cows. Table 1 shows the D.H.I.A. average for physical quantities of feed required for cows at different levels of production. The feed prices used are an average of Utah prices over the five year period of 1966 to 1970. Feed quantities in the dairy survey were compared to national averages. A summary of the survey feed costs is included in Appendix Table 19. Where there was a response of three or more dairies for one production level, the Utah figures were similar to the national figures. There were six responses at 12,000 pounds of production. Feed costs were estimated, from quantities fed by the farmers, at $293.80 per cow per year, which was $16.20 or 5.8 percent higher than the national average. There were three responses at 14,000 pounds of production and they estimated an average of $302.40 per cow per years. This was $3.50 or 1.1 percent less than the national average. At 15,000 pounds of production there were five responses with an average of $314.90 per cow. This was $1.60 or .5 percent above the national averages. National physical

Table 1. Average estimated feed costs using national D.H.I.A. feed quantities for 1966-1967 and Utah feed prices averaged for 5 year period of 1965 to 1970

Average milk production per cow per year	Pounds concentrate	Cost at $3.30 cwt.	Pounds succulent forage	Cost at $.42 cwt.	Pounds forage	Cost at $1.20 cwt.	Total cost per cow	13 percent extra for dry cows	Total feed cost per cow
pounds	cwt.	$	cwt.	$	cwt.	$	$	$	$
6,000	26	86	49	21	25	30	136	18	154
7,000	31	102	73	31	30	36	169	22	191
8,000	35	116	82	34	32	38.4	188	25	213
9,000	37	122	91	38	35	42	202	26	233
10,000	40	132	97	41	36	43.2	216	28	244
11,000	43	142	104	44	38	45.6	231	30	261
12,000	46	152	109	46	40	48	245	32	278
13,000	49	162	113	48	41	49.2	258	34	292
14,000	52	172	116	48	42	50.4	271	35	306
15,000	54	178	116	49	42	50.4	277	36	313
16,000	58	191	114	48	45	54	293	38	331
17,000	61	201	114	48	45	54	303	39	343
18,000	64	211	108	45	47	56.4	313	41	354
19,000	67	221	103	43	52	62.4	327	43	369

feed figures were used in the study because a complete, discrete function from 6,000 to 19,000 pounds of milk production was available.

Taxes

Taxes and mill rates were calculated from an average of the mill rates used in the counties from which farmer interviews were obtained. The mill rates are included in the Appendix.

Assumptions

The operator's time was limited in the study to 3,000 hours. Any time beyond 3,000 hours was considered as hired labor and was included in the operating costs at $2.00 per hour. The questionnaire used in the study included questions relative to labor requirements. The average dairy from 35 to 60 cows required little or no labor above the 3,000 hours provided by the operator. One man can handle up to 60 cows with occasional help, given average management. If the operator had up to 1,000 man hours per year part-time help, he could handle up to 100 cows, given average management.

Manure was not valued. It was not included in the analysis because of the varying distances and types of equipment involved in hauling the manure to the land. A cement apron or simple liquid tank was assumed for the manure handling facilities at the dairy. The cost of hauling the manure was not charged to the dairy enterprise.

Interest rates were set at: 6 percent for land, 8 percent for any equipment and buildings with a life expectancy or amortization rate of more than 5 years, and 10 percent interest was charged for cows and any other asset with a life expectancy or amortization rate between 1 and 5 years. No interest was charged for monthly or yearly operating expenses because dairying is a cash return enterprise with receipts distributed throughout the year.

Costs were calculated for two differenct capital assumptions. One assumption was that capital was unlimited and that all fixed investments with a life of one year or more were borrowed and paid back at the above interest rates over the amortization period. The other capital assumption was that capital was unlimited but the cows and the breeding bulls were owned by the operator, and the interest accumulating to them was included in the disposable income. The amortization rates for the fixed investments are the same as used by the Utah State Extension Service and are given in the Appendix in Table 18. A budget of average costs excluding feed costs and operator's labor for milk production for a typical 80 cow dairy herd is included in Table 2.

The farmers interviewed were using artificial insemination or natural breeding methods or both. This study assumed a bull for up to 100 cows depending on the size of the herd. This would mean using artificial insemination except for heifers and hard to settle cows.

Table 2. Breakdown of average costs less feed costs for a typical 80 cow herd in Utah in 1971

Individual cow costs per cow per year:			
Replacements		$84.50	
Breeding			
artificial insemination	$ 7.80		
supplemental bull services	3.30		
total		11.10	
Veterinary and medicine		9.00	
Organization fees		10.00	
Taxes on cows		2.60	
Bedding		4.50	
Total			$121.70
Overhead costs per cow per year:			
Utilities		11.50	
Machinery			
truck	9.30		
tractor	16.30		
total		25.60	
Accounting and legal fees		1.90	
Small tools		.90	
Barn supplies		7.50	
Miscellaneous and general repairs		1.90	
Total			49.30
Physical plant costs per cow per year:			
Taxes and insurance on physical plant		3.00	
Milk parlor		22.50	
Cow barn and corrals (freestall)		20.80	
Feeding equipment		22.50	
Feed storage		4.10	
Land costs (5 acres)		5.50	
interest	4.30		
land taxes	.20		
total		4.50	
Total			82.90
Hired labor costs per cow per year above the operator's 3,000 hours:			22.00
Total			$275.90

Land values in the survey varied from \$20 per acre to \$3,000 per acre. State tax commission used \$500 as a base value for land used as a dairy facility. The same value was used in this study to calculate interest and tax costs on the land.

Each cow in the milking herd was assigned a \$50.00 credit per year for a calf. This allows for a probability of 50 percent for either sex and a 2 percent death loss by the age of 3 days. It was assumed for the growth models that the physical plant was initially established to facilitate growth in number of cows. If the plant was built with an expansion potential, the costs per cow for expanding should not vary significantly from those already incurred.

The average costs used in the study do not include the purchase of base, hauling charges and any cooperative fees which are based on the volume of milk sold. The dairyman could make allowances for base costs in the analysis by the following formula:

$$\frac{\text{(Total Purchase Price of Base) (.149)}}{\text{(Hundredweight of Milk Sold per Year)}}$$

The formula will calculate the base cost per hundredweight of milk sold if the base cost is amortized for a ten-year period. The formula will give the amount to be deducted from the selling price of milk over a ten-year period to account for base costs. As more base is acquired it is amortized over a ten-year period separately from the present base. Hauling and co-op fees can be deducted directly from the milk price.

Method of Analysis

Average costs per cow were calculated for each dairy farm in the survey. Regression analysis was used on the average costs per cow to obtain a long run average cost curve.

Average revenue was calculated for various combinations of price and production levels. Prices in the study were assumed to vary from $4.00 per hundredweight to $6.50 per hundredweight and production per cow varied from 6,000 pounds of milk per year to 18,000 pounds.

A simulation model was used to calculate the number of cows needed for specified disposal income levels at various levels of production, income and operator owned capital. Another model was used to measure the growth potential of varying herd sizes at specified net income per cow levels. A flow chart of both models is included in the Appendix in Figures 6 and 7.

Marginal cost was used to compare different methods of growth. Growth was incurred by buying more cows of the same production level or by replacing present cows with higher producing animals.

ANALYSIS

Regression of Average Costs Without Feed

From the 43 dairy farmers interviewed, 32 complete budgets were obtained. Figure 3 demonstrates the different average costs of milk production at various herd sizes. The average costs, other than feed costs and operator's labor are illustrated in the figure. Feed costs per cow vary with production levels because as a cow produces more milk, she requires more feed. Feed cost per cow does not vary with herd size because most feed is home grown or can be purchased through co-operatives. If the feed is home grown, the cost of feed would be levied against the dairy enterprise at the current average feed price. If the feed is purchased through co-operatives, the farmer with a small herd will receive feed at the same price a larger dairy will.

A simple linear regression was applied to the average cost less feed and operator's labor costs and herd sizes to obtain the following equation: Average cost less feed cost = 275.8 - (.012) (number of cows). Herd sizes used to obtain the equation varied from 35 to 670 cows. A second simple linear regression was applied to the costs, less feed and operator's labor costs, for the herd sizes limited between 35 and 240 cows. This computation formulated the following equation: 272.3 + .009 (number of cows) = average cost. The first equation, which included the

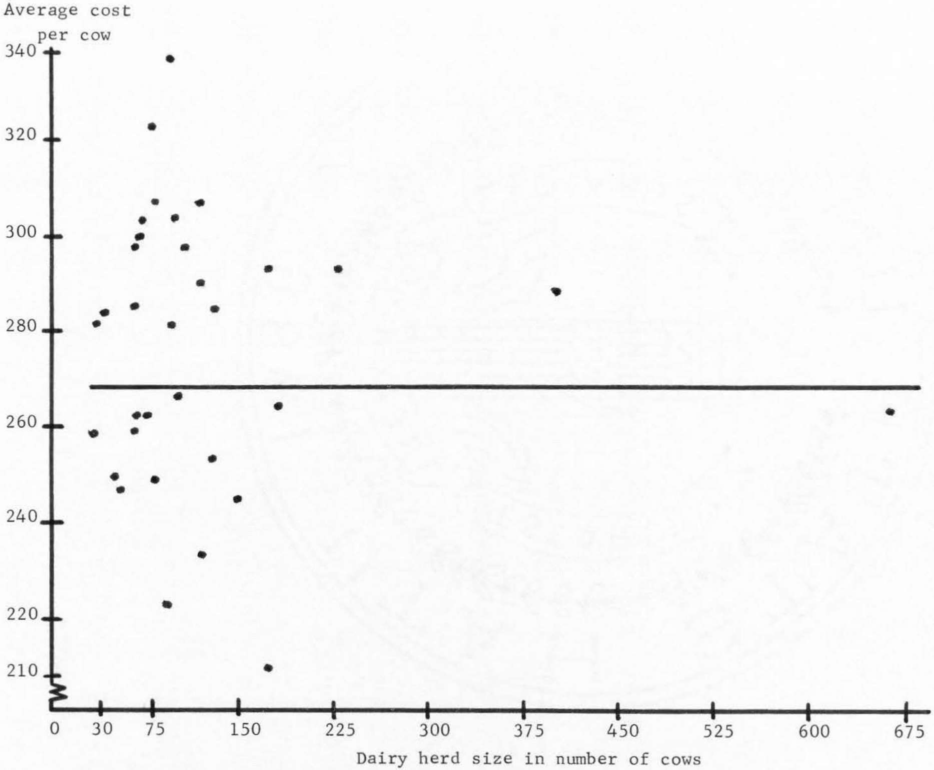

Figure 3. Linear regression of average costs of herds in survey to obtain a long run average cost curve less feed and operator labor cost.

two larger herds, was assumed to be the best model of the long run average cost curve because of a slight downward slope. The equation: Average cost, less feed cost = 275.8 - (.012) (number of cows) will be used throughout the rest of the study to represent the long run average cost curve.

At 35 cows the equation predicted an average cost, less feed and operator's labor costs, of $275.40 per cow. This was $1.10 more per cow than the average cost for all herds of $274.30. At 670 cows the equation predicted an average cost per cow less feed, of $267.80 which was $6.50 less than the average costs per cow, less feed. The equation represents a decrease in average costs of $7.60 or a decrease of 2.8 percent from a 35 to a 670 cow herd. This would represent a 1.4 percent decrease in total cost per cow, including feed cost but excluding operator's labor costs, for a herd producing 12,000 pounds of milk per cow per year.

Feed costs will not change the slope of the regression equation but should be added to the vertical intercept to obtain the following equation: Average cost = 275.8 + feed cost - (.012) (number of cows). This equation represents the total cost, less operator's labor, hauling and base costs, a cow will incur in a year.

Parlor costs

Figure 4 demonstrates that parlor and equipment costs represent the theoretical downward sloping cost curves. Total costs of various sized

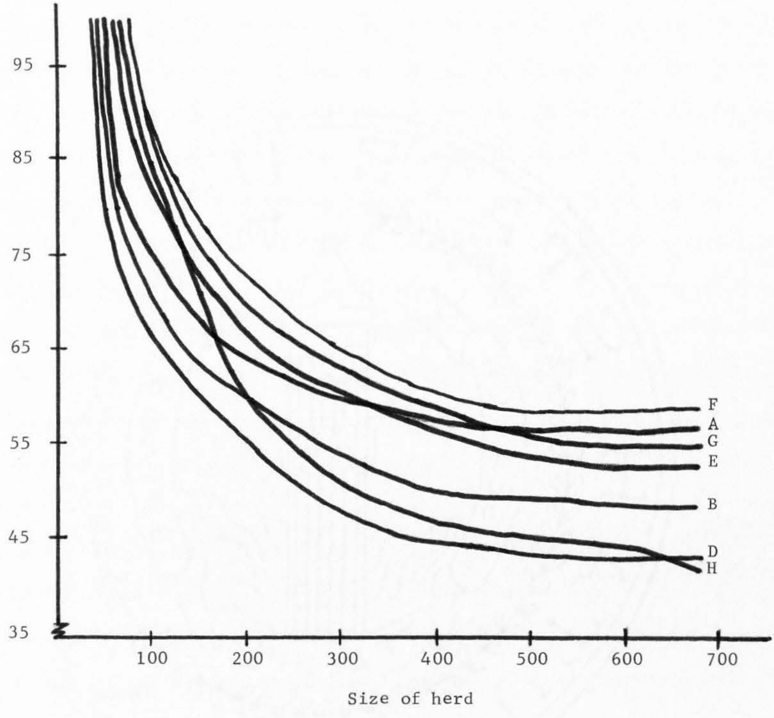

Figure 4. Parlor costs for various sized herds with labor calculated at $2 per hour.

A - Double 3 with 3 milkers and 1 man milking
B - Double 3 with 6 milkers and 1 man milking
D - Double 4 with 4 milkers and 1 man milking
E - Double 4 with 8 milkers and 2 men milking
F - Double 6 with 6 milkers and 2 men milking
G - Double 6 with 12 milkers and 2 men milking
H - Double 8 with 8 milkers and 2 men milking

parlors and equipment, obtained from the survey, were averaged to obtain total costs for each sized parlor. The total cost for each sized parlor was amortized over a ten-year period at eight percent interest to obtain a yearly parlor cost.

Cows milked per hour in the different sized parlors were also obtained from the interviews. Labor charged against the parlor included milking only because clean-up and preparation for milking does not vary with parlor size. All labor for milking was charged with a rate of $2.00 per hour. There was no "free" operator's labor assumed in the actual milking. Average costs were calculated by dividing the number of cows into the yearly total cost of the parlor and equipment plus the hours spent milking per cow per year. Each sized parlor had a different amount of milking labor per cow. The milking hours per cow did not vary with herd size. Schedule D which represents a double four parlor, has the lowest costs per cow until approximately a 670 cow herd is obtained. If the barn was used for milking for 20 hours, this would leave four hours per day for clean-up and repairs, the maximum herd size physically possible to milk would be 400 head per day. Beyond 400 head a double eight parlor represented by line H would be the minimum cost combination. Its limit in a 20 hour day would be 850 cows. At a 400 cow herd level the double four parlor with four milkers and one man average cost per cow per year will be $15.00 less than the average cost per cow for a double six parlor with six milkers and two men milking. The individual parlor costs are averaged for an estimated average cost throughout the rest of the study.

Significance of other costs

Labor, less actual milking time, which is measured by hours per cow, declines almost as quickly as parlor costs. The survey showed a 50 percent decline in labor per cow from 35 cows to 670 cows. Utilities, truck, tractor, cow barn, and corral costs represent 10 percent of the total cost per cow. They showed no significant decrease over the herd sizes.

Parlor costs and labor costs are a large enough portion of total costs per cow to have a significant effect on the costs per size of herd. But, the study assumed that 3,000 hours would be deducted from the labor costs so the labor returns for the operator could be included in his desired income. It was also assumed that one man could handle a 60 cow herd and one man with part-time help could handle up to 100 cows. Therefore, there was no labor charge for herds less than 60 cows and only a slight charge for herds from 60 to 100 cows. This "free" labor has done away with the visible diseconomies that should theoretically exist with small herds. The "free" labor also exists in large herds but after the same number of hours is divided into more cows the "free" labor per cow decreased. The study showed an increase in labor cost per cow, less operator's labor cost, from $0 to $68.

Break-Even Production Levels

Even though feed costs increase for higher producing cows the extra production is advantageous because of the extra receipts received for the cow's production. Table 3 shows the average revenue per cow at various production and milk price, less hauling and base costs, levels. Break even levels of production can be obtained by equating the average revenue to total average cost figures for the corresponding levels of production. The average cost figures are obtained from the formula: Average cost - 275.8 + (feed cost) - (.012) (number of cows). Table 4 lists levels of production per cow needed to break even at various prices per hundredweight for milk and various herd sizes. Any combination of herd size, price per hundredweight, or production per cow less than these will produce a negative income.

Minimum Resource Requirements

Because of the nature of the production and marketing system in this study, once a break-even point is determined, the herd may be expanded up to 700 head and still be profitable. Because of lack of data no predictions have been made beyond 700 head.

Figure 5 demonstrates the shape of the average cost and average revenue curves obtained from the data for this study. Two average revenue schedules are used in the diagram. AR_B represents an average revenue at which production is feasible from 35 cows to 675 cows. The

Table 3. Average revenue per cow per year calculated at various production levels and milk prices, less hauling and base costs, based on estimated Utah calf prices for 1970

Level of	Price of milk per cwt.					
Production	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
Pounds	$	$	$	$	$	$
6,000	290	320	350	380	410	440
8,000	370	410	450	490	530	570
10,000	450	500	550	600	650	700
12,000	530	590	650	710	770	830
14,000	610	680	750	820	890	960
16,000	690	770	850	930	1010	1090
18,000	770	860	950	1040	1130	1220

Table 4. Production levels needed to break-even at varying milk prices, less base and hauling costs, and herd sizes using costs obtained from the Utah survey 1970

Herd size	Price of milk per cwt. $4.00	$4.50	$5.00	$5.50	$6.00
	#	#	#	#	#
35	12,500	10,500	9,000	8,000	6,500
75	12,500	10,500	9,000	8,000	6,500
100	12,500	10,500	9,000	8,000	6,500
500	12,000	10,500	9,000	8,000	6,500
670	12,000	10,500	9,000	7,500	6,500

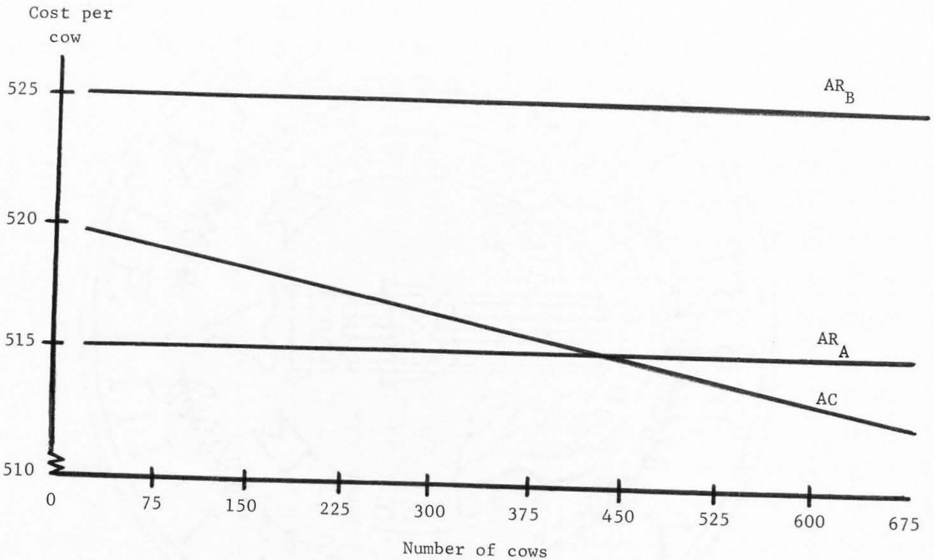

Figure 5. Demonstrates the shape of the average cost and average revenue curves of a herd producing 10,000 pounds of milk in Utah for 1970.

price of milk, less hauling and base costs, at AR_B is \$4.75 per cwt. If an operator's average revenue schedule is AR_A, he will only produce at herd sizes of 420 to 675 head. The distance between the average revenue and average cost lines represents the net revenue per cow. If both the average revenue and average cost curves are multiplied by the number of cows in the milking herd, total cost and total revenue curves will be obtained. The distance between the total revenue and total cost curves represents the total profit. Figure 6 demonstrates the total cost and total revenue functions at various prices for a herd averaging 10,000 pounds of milk per cow per year.

Specified Disposable Income Levels

The cost budgets were set up with the assumption that 3,000 man hours per year, for the operator's time, was not to be used as a cost. It was expected that all net revenue would accrue to the operator as labor, management, and interest on milking stock for disposable income. If he owns any equipment or part of the physical plant, the interest derived from it will be extra income. Interest and amortization rates are included in the Appendix Table 18. Costs were calculated at two levels. One set of costs assumed all resources with a life expectancy of over one year accrued interest charges. A set of costs were also calculated assuming that the operator owned all of his own milking and breeding stock and that the interest accrued to them was to be applied to

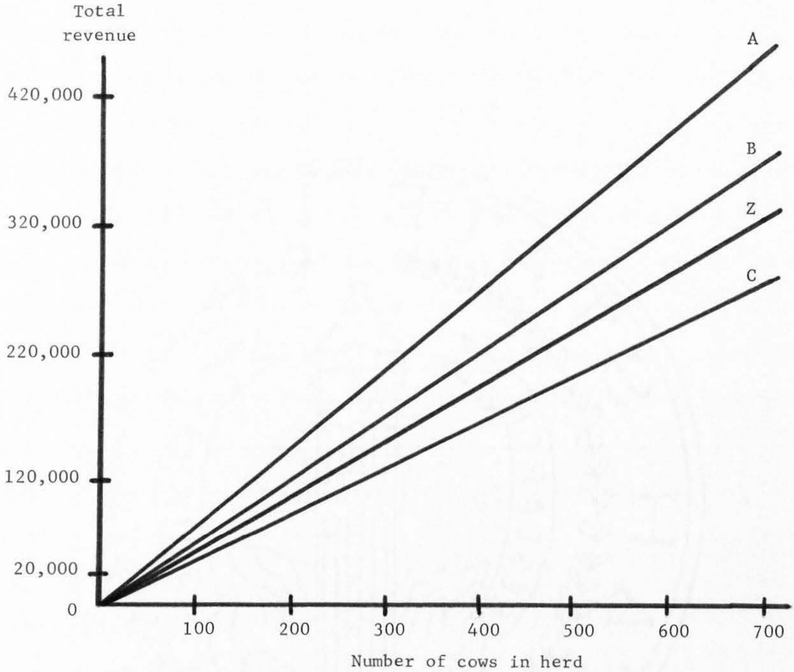

Figure 6. Total revenue and total cost curves for various sized herds at 10,000 pounds of production.

A - Total revenue at $6.00 per hundred weight
B - Total revenue at $5.00 per hundred weight
C - Total revenue at $4.00 per hundred weight
Z - Total cost at 10,000 pounds of milk production

Base and hauling costs must be deducted from price disposable income or growth potential. All profits are assumed to be used as disposable income or reinvested for growth potential.

By using the formula for determining total profits, the number of cows that will be needed for specific income levels can be calculated. The revised formula is as follows: (AR - AC) X # cows = D.I. If a farmer has a given price for his milk, and his cows produce at a given level, he can calculate the number of cows that he will need for a specified disposable income.

The total revenue function is:

$$\left(\frac{\text{cows yearly production}}{100}\right) \text{(price of milk per hundredweight less hauling and base costs) (number of cows)} + (50)\text{ (number of cows)}.$$

The total cost function is as follows:

$$\text{(feed cost} + 275.8)\ (\#\text{ cows}) - (.012)\ (\#\text{ cows})^2.$$

If a particular farmer who does not own his own cows, is producing 12,000 pounds of milk and receives \$5.00 per hundredweight after hauling and base costs are deducted, and he wants an income of \$7,000 per year, the following equation will determine the number of cows that he needs:

$$(120)\ (5.)\ (C) + 50C - (277.6 + 275.8)C + (.012)C^2 = \$7{,}000$$

C = number of cows

The equation yields a value of C = 71. The farmer producing under the above conditions with average management practices, needs 71 cows to produce his desired disposable income level. The series of tables 5-11

Table 5. Minimum herd size needed to achieve a disposable income level of $3,000 with and without interest costs on milking stock

Production per cow	$4.00*	$4.50	$5.00	$5.50	$6.00	$6.50
pounds	Number of cows needed to achieve specified income level**					
$3,000 income level with interest:						
6,000	11679	9185	6695	4217	1797	232
8,000	9908	6587	3292	445	71	36
10,000	5851	1781	95	37	22	16
12,000	2070	79	30	19	13	10
14,000	101	30	17	12	9	7
16,000	35	18	12	9	7	6
18,000	21	13	9	7	5	5
$3,000 income level without interest:						
6,000	7873	5388	2927	699	110	53
8,000	6107	2821	283	62	34	23
10,000	2110	109	39	23	17	13
12,000	125	36	21	14	11	9
14,000	40	20	14	10	8	7
16,000	23	14	10	8	6	5
18,000	16	10	8	6	5	4

*Deduct hauling and base costs from price of milk.

**Cow numbers between lines drawn on chart represent herd sizes within the limits of this study.

Table 6. Minimum herd size needed to achieve a disposable income level of $5,000 with and without interest costs on milking stock

Production per cow	$4.00*	$4.50	$5.00	$5.50	$6.00	$6.50
pounds	Number of cows needed to achieve specified income level**					
$5,000 income level with interest:						
6,000	11693	9203	6720	4256	1879	349
8,000	9925	6612	3341	589	116	60
10,000	5879	1865	155	61	38	27
12,000	2144	130	51	31	23	18
14,000	165	50	29	20	16	13
16,000	59	30	20	15	12	10
18,000	35	21	15	12	9	8
$5,000 income level without interest:						
6,000	7894	5418	2981	838	178	87
8,000	6134	2878	411	103	56	39
10,000	2182	177	65	39	28	22
12,000	201	60	35	24	19	15
14,000	66	34	23	17	14	11
16,000	38	23	17	13	11	9
18,000	26	18	13	10	9	7

*Deduct hauling and base costs from price of milk.

**Cow numbers between lines drawn on chart represent herd sizes within the limits of this study.

Table 7. Minimum herd size needed to achieve a disposable income level of $7,000 with and without interest costs on milking stock

Production per cow	$4.00*	$4.50	$5.00	$5.50	$6.00	$6.50
pounds	Number of cows needed to achieve specified income level**					
$7,000 income level with interest:						
6,000	11708	9221	6744	4294	1956	451
8,000	9941	6637	3388	707	161	84
10,000	5907	1942	213	86	53	38
12,000	2213	180	71	44	32	25
14,000	225	70	41	29	22	18
16,000	83	42	28	21	17	14
18,000	49	30	21	17	13	11
$7,000 income level without interest:						
6,000	7915	5448	3033	953	242	122
8,000	6161	2932	520	143	79	54
10,000	2250	241	90	55	39	30
12,000	272	83	48	34	26	21
14,000	93	48	32	24	19	16
16,000	54	33	24	18	15	13
18,000	37	25	19	15	12	10

*Deduct hauling and base costs from price of milk.

**Cow numbers between lines drawn on chart represent herd sizes within the limits of this study.

Table 8. Minimum herd size needed to achieve a disposable income level of $9,000 with and without interest costs on milking stock

Production per cow	$4.00*	$4.50	$5.00	$5.50	$6.00	$6.50
pounds	Number of cows needed to achieve specified income level**					
$9,000 income level with interest:						
6,000	11722	9239	6769	4331	2028	542
8,000	9958	6662	3434	809	205	108
10,000	5934	2014	268	110	68	49
12,000	2279	228	92	57	41	32
14,000	283	90	53	37	29	23
16,000	106	55	36	27	22	18
18,000	63	38	28	21	17	15
$9,000 income level without interest:						
6,000	7936	5478	3084	1053	304	155
8,000	6187	2984	616	182	101	70
10,000	2315	302	116	70	50	39
12,000	339	107	62	44	34	27
14,000	119	62	41	31	25	21
16,000	69	43	31	24	20	17
18,000	48	32	24	19	16	14

*Deduct hauling and base costs from price of milk.

**Cow numbers between lines drawn on chart represent herd sizes within the limits of this study.

Table 9. Minimum herd size needed to achieve a disposable income level of $11,000 with and without interest costs on milking stock

Production per cow	$4.00*	$4.50	$5.00	$5.50	$6.00	$6.50
$11,000 income level with interest:						
pounds	Number of cows needed to achieve specified income level**					
6,000	11736	9257	6793	4368	2095	624
8,000	9975	6687	3480	900	247	132
10,000	5962	2081	321	134	83	60
12,000	2341	275	112	69	50	39
14,000	339	110	65	46	35	29
16,000	130	67	45	34	27	22
18,000	77	47	34	26	21	18
$11,000 income level without interest:						
6,000	7956	5508	3134	1143	363	189
8,000	6214	3035	703	220	124	85
10,000	2377	361	141	86	62	48
12,000	403	130	76	54	41	34
14,000	145	75	51	38	31	25
16,000	84	52	38	29	24	20
18,000	58	39	29	24	20	17

*Deduct hauling and base costs from price of milk.

**Cow numbers between lines drawn on chart represent herd sizes within the limits of this study.

Table 10. Minimum herd size needed to achieve a disposable income level of $13,000 with and without interest costs on milking stock

Production per cow	$4.00*	$4.50	$5.00	$5.50	$6.00	$6.50
pounds	Number of cows needed to achieve specified income levels**					
$13,000 income level with interest:						
6,000	11750	9275	6817	4404	2159	701
8,000	9991	6711	3524	984	289	156
10,000	5989	2146	373	158	98	71
12,000	2401	321	132	82	59	46
14,000	393	130	76	54	42	34
16,000	153	79	53	40	32	26
18,000	91	56	40	31	25	22
$13,000 income level without interest:						
6,000	7977	5537	3182	1225	420	221
8,000	6240	3084	783	258	146	101
10,000	2436	417	166	102	73	57
12,000	464	154	90	63	49	40
14,000	170	89	60	45	36	30
16,000	100	62	44	35	28	24
18,000	69	46	35	28	23	20

*Deduct hauling and base costs from price of milk.

**Cow numbers between lines drawn on chart represent herd sizes within the limits of this study.

Table 11. Minimum herd size needed to achieve a disposable income level of $15,000 without and with interest costs on milking stock

Production per cow	$4.00*	$4.50	$5.00	$5.50	$6.00	$6.50
pounds	Number of cows needed to achieve specified income levels**					
$15,000 income level with interest:						
6,000	11764	9292	6841	4439	2221	773
8,000	10008	6735	3567	1061	330	179
10,000	6016	2207	423	181	113	82
12,000	2458	365	152	95	68	54
14,000	445	149	88	62	48	39
16,000	176	91	61	46	37	31
18,000	105	64	46	36	29	25
$15,000 income level without interest:						
6,000	7997	5566	3228	1301	474	254
8,000	6266	3132	857	295	168	116
10,000	2493	472	191	117	84	66
12,000	523	177	104	73	57	46
14,000	196	103	69	52	42	35
16,000	115	71	51	40	33	28
18,000	80	54	40	32	27	23

*Deduct hauling and base costs from price of milk.

**Cow numbers between lines drawn on chart represent herd sizes within the limits of this study.

shows the results of the above calculations for different income, production, price and cost levels.

The interest returns on investment for milking cows and breeding stock have been deleted from the cost function for those tables labeled "Without Interest." It is assumed that the interest will accrue to the operator as disposable income or as reinvestment potential.

Growth Potential

Growth potential with borrowed capital

If an operator wants to grow to a higher income level than he has now, he will need more cows than the tables show. If the capital for buying extra cows is borrowed, then the only restriction will be capital. Growth rate can be calculated by looking on the "Herd Size to Achieve A Desired Return" tables with interest. If an operator is now at a $5,000 income level with a herd average of 12,000 pounds production and receives $5.00 per hundredweight for his milk, he has 51 cows. If a $9,000 income within five years is desired, the tables will give the number of cows required. If the same production level is maintained, an operator will need a total of 92 cows in five years or an increase in 41 cows. These can be added at a gradual rate of eight cows per year or can be added in the fifth year depending on capital restrictions.

If herd size cannot be increased without losing production per cow, the number of cows needed for a \$9,000 income can be obtained from a lower production level on the same chart.

Growth potential for operator owned livestock

If a farmer owns his own stock and wants to increase his production, he has two avenues to follow. Extra cows can be bought from savings or the farmer can drop back to a lower disposable income level to give more cows for a growth potential. For example, a farmer was currently receiving a disposable income of \$5,000 at 12,000 pounds of production, \$5.00 per hundredweight selling price, less base and hauling costs, and 35 cows. He wants to be able to grow to a \$9,000 disposable income within ten years. At a \$9,000 income for the same resource base, 62 cows would be needed. This is an increase of 27 cows in ten years. All of the profits are being turned into the \$5,000 disposable income. More cows will be needed either through purchase of additional cows or a cut-back in disposable income. Additional cows needed can be determined by calculating profit per cow and then accumulating the profits per cow on the purchase of new cows until the desired increase is brought about. The profit per cow will be 5,000 ÷ 35 = \$143 per cow. If the farmer has three additional cows and reinvests the profits back into more cows, he can accumulate 27 cows and \$114 in ten years. It was assumed that the purchase price was \$425 per head for them. Thirty-eight cows would be needed to give a \$5,000 per year income and a growth potential of \$9,000 in ten years. If the extra money for the initial three cows was not available, three cows could be cutback from the original herd for a growth factor. This will give 3 x 143 = $429 less disposable income per year for the next ten years and 30 cows will have to be accumulated instead of 27 to achieve a $9,000 disposable income level.

Table 12 lists the number of cows that can be accumulated in five years if the profits are reinvested in cows. Table 13 lists the cows accumulated in ten years.

Marginal Analysis

Marginal analysis is a decision tool used for short run decisions. Typically profit and/or expansion rates are maximized by its use.

In this study marginal revenue for milk has been constant for each price level of milk. The marginal revenue curve follows the same schedule as average revenue. Average cost slightly decreases if output is increased by increasing the number of cows in a herd. Over the same schedule the marginal cost schedule is below that of the average cost and decreases at a faster rate. Within the limits of the cow numbers used in this study, there is no point at which a firm should cease to increase the cow numbers once a positive profit is being made.

Even though there is no shutdown point for increasing production, marginal cost analysis can be used to find the most efficient growth combinations.

Table 12. Growth potential of cows at given profits for five years

Profit per cow	Number cows started with 10	20	30	40	50	60	70	80	90	100
					Number of cows in five years					
25	12	25	38	52	65	78	91	105	118	131
50	16	33	51	67	85	103	121	138	154	172
75	20	43	66	89	110	132	156	179	200	224
100	27	55	85	112	141	170	199	227	257	285
125	33	70	105	142	179	216	251	287	324	361
150	42	89	133	179	223	270	314	360	404	450
175	53	109	165	221	277	332	388	444	503	559
200	65	134	203	270	339	410	476	547	616	685
225	81	163	245	332	414	495	582	666	748	830
250	93	197	298	398	501	603	703	804	903	1003

Table 13. Growth potential of cows at given profits for ten years

Profit per cow	Number cows started with									
	10	20	30	40	50	60	70	80	90	100
	Number of cows in ten years									
25	15	32	49	67	86	105	121	139	156	174
50	26	57	88	117	148	177	208	238	268	298
75	43	96	146	200	248	297	348	401	450	502
100	76	156	241	320	405	488	569	651	739	817
125	118	254	384	514	646	782	912	1039	1175	1309
150	191	400	599	812	1011	1219	1420	1632	1830	2038
175	293	606	924	1237	1554	1860	2177	2492	2816	3133
200	447	923	1392	1861	2331	2817	3272	3758	4236	4708
225	673	1361	2049	2774	3462	4139	4867	5565	6261	6950
250	937	1993	3008	4018	5057	6093	7105	8118	9121	10135

The survey average cost of owning a cow is $45.00 per year. If interest is paid on the cow, it costs $85.00 per year. If growth is incurred through increasing the number of cows producing 10,000 pounds of milk at a 100 cow herd level, it costs $4.79 for each 100 pounds of milk if the cow is owned and $5.19 if the money is borrowed.

Table 14 shows the marginal costs per 100 pounds of milk of expanding milk output by adding cows to a herd. The costs are less an opportunity cost per 100 pounds of milk for the extra calves sold. A 100 cow herd was used as a basis for the costs because there was little difference in marginal costs for various sized herds, given the average cost curve on page 13. The marginal cost of 6,000 pounds production and a 50 cow herd is $6.33, and at a 600 cow herd is $6.22. The marginal cost at 18,000 pounds production and a 50 cow herd is $3.21, and at a 600 cow herd is $3.18.

If a dairyman wants to increase his herd by higher production per cow, it was assumed that his only increased costs will be feed and initial cow costs. Table 15 shows the marginal cost of 100 pounds of milk for increasing production at different levels of production. It also shows the savings accrued at both cost levels if all cows are purchased for $428.00.

The savings in Table 15 represent the savings per cow per year of increasing output by replacing present cows with 1,000 pounds higher producing cows at survey average of $428.00 per cow over increasing milk

Table 14. Marginal cost of 100 pounds of milk by adding cows to herd based on 100 cow herd

Pounds of production	With interest	Without interest
6,000	$6.27	$5.65
8,000	$5.46	$4.96
10,000	$4.69	$4.29
12,000	$4.18	$3.85
14,000	$3.79	$3.50
16,000	$3.48	$3.23
18,000	$3.21	$2.99

Table 15. Marginal cost of feed and savings for extra 100 pounds of milk by buying a better cow

Production per cow	Marginal feed cost per 1,000# of milk	Savings per year per cow over increasing size by number of cows	
		without int.	with int.
6,000 #	$3.69	$1.96	$2.58
8,000 #	$1.98	$2.98	$3.48
10,000 #	$1.73	$2.56	$2.96
12,000 #	$1.44	$2.41	$2.74
14,000 #	$1.31	$2.19	$2.48
16,000 #	$1.13	$2.10	$2.35
18,000 #	$1.54	$1.45	$1.67

output 1,000 pounds by buying more cows. The total savings per cow can be found by multiplying the cow's years in the herd by the savings per cow per year. A farmer can pay extra for a cow up to the total savings per cow level. A farmer's most efficient method of expansion will be by buying better cows as long as he can pay less than the amount shown in Table 16.

Table 16 also shows the price that can be paid for higher producing cows if interest is included in cow costs. The feasible price for cows with interest is obtained by multiplying the savings per cow per year less 10 percent for interest charges by the years of lactation. The years of lactation were figured at the survey average of 3.5 years.

Marginal analysis and parlor costs

Figure 4 showed the most efficient parlor setups. A double four parlor was chosen as the most efficient parlor up to its maximum of 400 cows. If a farmer felt that he would not be operating efficiently with this size of parlor because of external management factors, he could justify a less efficient but larger parlor by marginal cost analysis. If the farmer needed to spend too much time supervising a 20-hour milking day, to the extent that his other enterprises suffered, he could figure the opportunity cost of the extra time spent milking for the different sized parlors. If the extra costs were added to their respective cost curves for the different parlors, it could shift the curves so that a larger parlor would be more efficient for the individual operator.

Table 16. Amount that could be paid extra for a 1,000 pound higher producing cow, given the present price for a cow is $428 and present herd production is at the various indicated levels

Production per cow	Without interest	With interest
Pounds of milk		
6,000	$ 68.60	$ 81.20
8,000	104.30	110.00
10,000	89.60	93.10
12,000	84.40	86.50
14,000	76.70	78.10
16,000	73.50	73.90
18,000	50.80	52.20

Base

Base was not accounted for in the analysis. This was done to make the study applicable to both Grade A and manufacturing milk producers. The following equation was given on page 24 to account for base which has been purchased:

$$\text{Cost per cwt.} = \frac{(\text{T.C.})\ (.149)\ (100)}{\text{pounds milk sold per year}}$$

The cost per hundredweight should be deducted from the price received for milk. Base is another method of growth, as growth is defined as an increase in disposable income.

The only cost of expanding disposable income is the purchase of additional base. Base can be rationally purchased until the cost per hundredweight per year equals the increase in blend price per hundredweight.

SUMMARY AND CONCLUSIONS

A survey of a sample of Utah dairy farmers was conducted to obtain data to calculate a long run average cost schedule. Dairy farmers who had just recently built new facilities and with varying sized herds were interviewed. Budgets were calculated for the complete surveys to establish an average cost per cow for different sized herds. A simple linear regression analysis was used on the individual average costs to fit a long run cost curve.

Individual costs were studied to establish their effect on the long run average cost curve. Costs were studied at two different levels. One set of costs assumed that all capital invested for more than a one year period was not owned by the operator and the costs allowed for repayment of principal and interest at the rates given in the Appendix were applied to long run average cost. The other set of cost data assumed that the operator owned his own milking herd and breeding stock. This lowered the costs per cow by approximately $40.00. It was assumed that all interest accumulating to the owned stock was used as disposable income or growth potential.

Different average revenue curves for varying prices and production levels were used to establish minimum cow numbers needed to give specified incomes and growth potentials. Two simple simulation techniques were programmed to establish the income levels and growth potential.

Marginal analysis was used to establish the most efficient methods of growth. The types of growth considered were: cow numbers, herd production and blend price.

The marginal analysis indicated that production per cow was the most efficient method of expansion. The data used to analyze the growth alternatives assumed the price of springer heifers to be constant. The most common method of expanding cow numbers and replacing unwanted cows is through springer heifers. The heifers are either raised on the dairy farm or purchased. A more thorough analysis of the costs of increasing production per cow through a breeding program would be needed before an analysis of herd expansion applicable to Utah could be determined.

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APPENDIX

Table 17. Counties visited in survey and their mill rate

County	Mill rate
Cache	.06429
Beaver	.06479
Box Elder	.06170
Millard	.0688
Salt Lake	.07823
Sanpete	.0655
Sevier	.0730
Utah	.08188
Weber	.07415
Average mill rate	.0704

Table 18. Amortization periods and interest rates

	Time	Interest
Granary	20 years	8%
Well	20 years	8%
Silo		
upright	20 years	8%
cement	15 years	8%
dirt	10 years	8%
Manure pit		
apron	15 years	8%
tank	10 years	8%
Parlor	10 years	8%
Parlor equipment	10 years	8%
Yards and stalls	10 years	8%
Water pump	5 years	10%
Insemination tank	5 years	10%