A methodology for analysis of the technological and organizational alternatives available for drylot dairy operations

A METHODOLOGY FOR ANALYSIS OF THE TECHNOLOGICAL AND ORGANIZATIONAL ALTERNATIVES AVAILABLE FOR DRYLOT DAIRY OPERATIONS

by

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23 January 1981
Date

PREFACE

Most dairy farms are family farms. As the families grow dairymen are faced with a need for increased income from increased milk production in order to maintain or improve the family lifestyle. This can be achieved by increasing per cow production or by increasing herd size, or both. A dairyman considering growth through expansion of his dairy operation has to decide which of the organizational and technological alternatives best fit his situation. The purpose of this study is to develop a method for a dairyman to use in analyzing the alternatives and planning the expansion of his dairy operation.

I wish to acknowledge the support of the faculty of the Department of Agricultural Economics in this project. I particularly wish to thank Roger A. Selley, Professor of Agricultural Economics, and Dennis V. Armstrong, Arizona Extension Dairy Specialist, for their advice and counsel on this research.

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ABSTRACT

The demand for milk and dairy products in Arizona is expected to increase due to an increasing population. Arizona dairymen can meet this increasing demand with higher production per cow and/or with more cows. Herd expansion is typically limited by the equity and borrowed capital available for investment in land, cattle and facilities. This thesis discusses the technological and organizational alternatives available for herd expansion and develops a method for a dairyman, with a capital constraint, to evaluate the alternatives and decide on a combination that is best for his situation.

The technological alternatives are the various types and sizes of milking parlors available for group handling of cows in large herds, and the mechanization that can be incorporated to reduce milking labor. The organizational alternatives are herd replacement strategies (raised, purchased or leased cows), milking frequency and milking parlor usage. A methodology for evaluating these alternatives involves comparison of the graphic display of the financial factors for each mix of alternatives.

The example of a typical expansion situation shows the organizational alternatives of purchased cows and three times a day milking to be the most profitable. The example illustrates the complexity of manual manipulation of the pertinent financial factors. An exhaustive analysis of all alternatives with various cost/price ratios would necessitate a computer program.

CHAPTER 1

INTRODUCTION

The dairy industry is an important sector of the Arizona economy. In 1978 the cash receipts from farm marketings of Arizona dairy products was $101.2 million (USDA/ESCS, 1979a). This was 12% of the total receipts for livestock and livestock products and 7% of the total receipts for all agricultural commodities (Arizona Crop and Livestock Reporting Service 1979). The Arizona dairy industry is composed of four important components: the producer, the processor, the consumer and the milk price stabilization program.

Milk Production

In recent years the nationwide trend in milk production has been relatively stable with milk cow numbers declining and the average milk production per cow steadily increasing (Figure 1). Arizona milk production per cow has also been increasing. However, in contrast to national trends, total milk production and milk cow numbers have been increasing in Arizona (Figure 2).

Arizona producers consistently achieve high annual production per cow in spite of the adverse effects of summer heat. Since 1967, production per cow in Arizona has been 17-19% above the national average. In 1978 Arizona had an average production of 13,176 lbs per cow. Many Arizona herds achieve much higher production levels however,

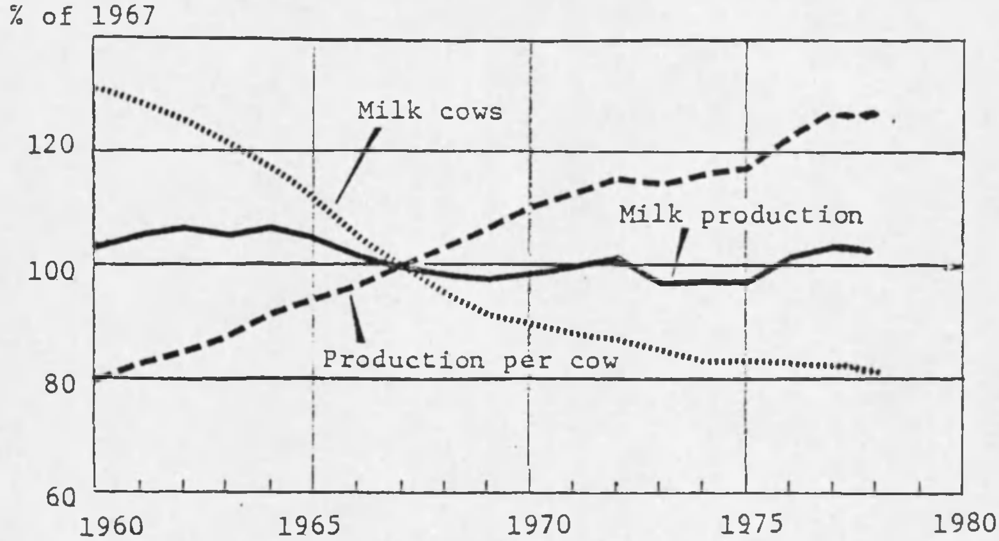


Figure 1. U.S. milk production, number of cows and milk per cow.

Source: USDA Handbook of Agricultural Charts, 1978a.

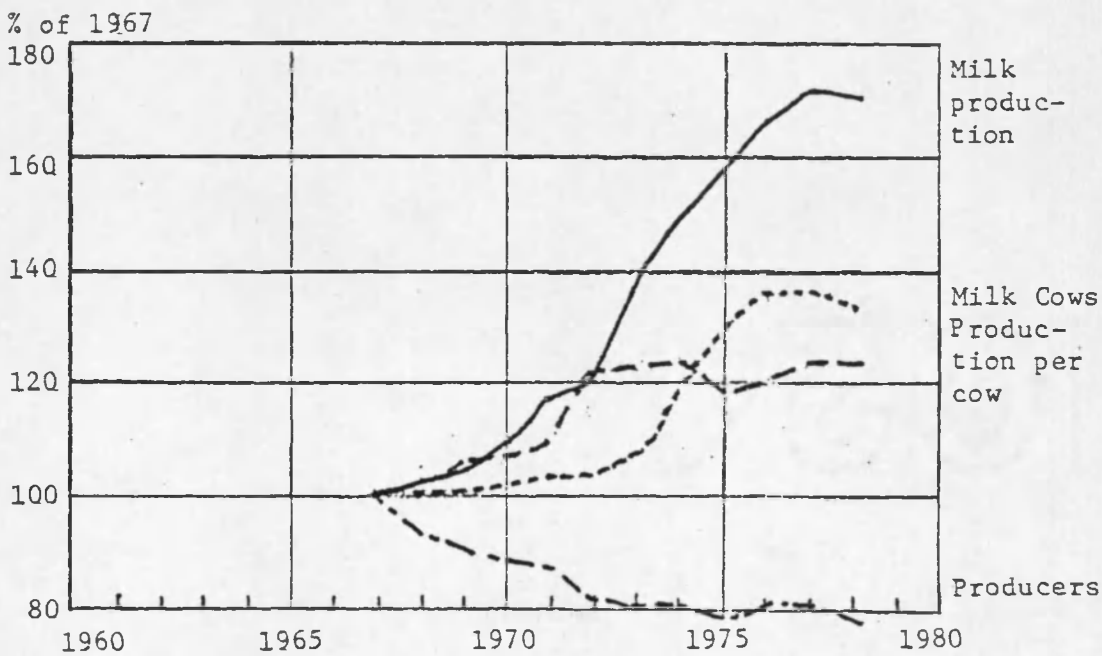


Figure 2. Arizona milk production, number of cows, milk per cow and number of producers.

Source: USDA Agricultural Statistics 1967-1978, 1978b.

as is demonstrated by the Arizona DHIA average of 15,500 lbs per cow in 1978 (Arizona Dairy Herd Improvement Annual Summary 1978).

The number of cows, production per cow and total production in Arizona declined slightly in 1978 (Table 1); however, the Arizona Crop and Livestock Reporting Service reported 70,000 milk cows in Arizona in 1979. This increase in milk cows suggests a resumption of the long term upward trend in the number of cows and the amount of milk produced.

There has been a national trend towards large scale operations which is much more pronounced in the arid southwest. Drylot operations purchase most inputs and employ group handling of cows, with production line milking and feeding methods, to a greater extent than do diversified dairy farms elsewhere. The typical herd size in Arizona is 600 cows (Korzan et al., 1979), compared to a national average of 50-60 cows. Capital intensive large sized dairy herds have achieved internal economies of size that have enabled Arizona dairymen to remain competitive with diversified farms in temperate areas where feed is less expensive (USDA/ESCS, 1979b). The attrition of producers, however, has been high in Arizona. From 1950 to the present the number of producers declined from 848 to 156, an 81% attrition (USDA/AMS, 1979). Figure 2 illustrates the decline in number of producers since 1967.

Over 90% of Arizona milk is marketed by the United Dairymen of Arizona (UDA), a bargaining and supply cooperative. The UDA has a milk base/quota price system that provides a price incentive to keep the production of milk aligned with the demand in the Central Arizona Marketing Order. Nearly 70% of the milk produced in Arizona is utilized as fresh milk or Class I milk (UDA, 1979).

Table 1. Arizona milk production 1967-1978.

Year	Milk Cows (No.)	Production Per Cow (lb)	Total Production (million lb)
1967	51,000	10,570	524
1968	51,000	10,840	539
1969	51,000	11,235	559
1970	52,000	11,250	572
1971	53,000	11,700	608
1972	53,000	12,800	629
1973	55,000	12,930	737
1974	62,000	13,065	810
1975	67,000	12,537	840
1976	69,000	12,783	882
1977	69,000	13,246	914
1978	68,000	13,176	896

Source: USDA Agricultural Statistics 1967-1978, 1978b.

The Outlook for Milk Production in the Future

It is assumed that the per capita consumption of dairy products in Arizona follows the nationwide trend (Figure 3). This trend has shown a slight increase during the past two years and is expected to stabilize during the next ten years (Manchester, 1978).

There has been a continually increasing aggregate demand however, for milk and dairy products in Arizona. This increase is primarily a result of the increasing population. Arizona's population increased 48% from 1967 to 1978. It is expected to further increase 20% by 1985 and 35% by 1990 (Valley National Bank, 1978). Thus Arizona dairymen can expect the aggregate demand for their product to increase from 2 to 3 percent each year during the immediate future. Historical trends would indicate that 3 or 4 dairymen will discontinue production each year. If this trend continues, a decreasing number of producers will be faced with a challenge to increase milk production to meet the increasing demand.

Increasing the annual milk production will necessarily entail expansion of individual herds and facilities. Such expansion will involve substantial capital investments and these investments must be planned to assure a return on the investment that is competitive with alternative uses of capital; and, provide adequate cash flow for family living, income tax payments and debt service.

Objective of this Study

The objective of this study was to develop a method for evaluating the technological and organizational alternatives available for large size drylot dairy operations. Achieving this objective entailed analysis

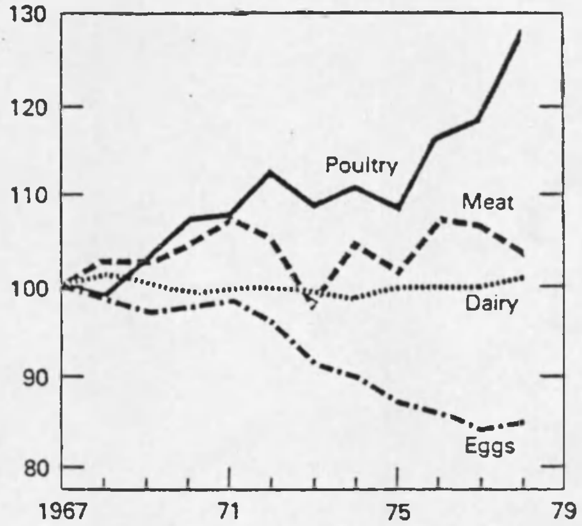


Figure 3. U.S. per capita consumption of selected livestock products.

Source: USDA Handbook of Agricultural Charts, 1978a.

of the costs and capabilities of milking parlors and labor saving devices for group handling of cows and production line milking. It required review of conventional economic cost theory and the application of this theory in the evaluation of the various mixes of milking parlor technology, replacement cow strategies and milking frequencies that are available to the producer who is initiating an expansion investment.

Chapter 2 reviews the theoretical framework regarding size of business and the previous work accomplished pertaining to costs and returns for various sizes of dairy operations. Chapter 3 discusses the investment and organizational alternatives available for increasing milk production. Chapter 4 describes the development of a methodology for evaluating these alternatives. Chapter 5 presents an analysis of a typical investment situation. Chapter 6 analyzes milking frequencies with equal investment, two times per day milking (2X/day) versus three times per day (3X/day). Chapter 7 summarizes the results of the study and offers conclusions regarding the initiation of an expansion investment to increase milk production.

CHAPTER 2

REVIEW OF PREVIOUS WORK

Previous work includes the development of economic theory regarding costs and economies of size, data collection and the development of cost/return and cost/size relationships using synthetic budgets, descriptive studies of facilities and technology, analysis of efficiencies in large size dairy operations, and an analysis of 3X/day milking frequency.

Theoretical Framework for Evaluation: Economies of Size

The theory of cost and production provides a general explanation of cost-output relationships regarding various size firms. Excellent treatises on the economies of scale and size are presented by Viner (1952) and Boulding (1955).

In the analysis of the firm, or a dairy in this case, the time period for analysis may be usefully classified as short-run or long-run. Short-run analysis is characterized by production costs that vary with herd size or milk production where costs related to milking facility, corrals, machinery, wells, etc., do not vary with changes in output. Long-run analysis is when all costs are variable.

Conventional Economic Theory Applied to Dairy Operations

Figure 4 illustrates conventional economic theory as applied to dairy operations. Figure 4a has hypothetical cost curves for four large scale dairy operations to show the use of cost theory in the development of a long range planning curve expressed in terms of output. Figure 4b has average value product curves and marginal value product curves for the same four dairy operations to show the use of production theory in the development of a long run planning curve in terms of the level of investment.

Figure 4a has the short run average cost (SRAC) curves for four sizes of dairy operations. The long run average cost (LRAC) curve is traced out as the envelope of the SRAC curves having the lowest cost at each level of output. Theoretically an average cost curve is U-shaped to show decreasing costs in the region of increasing returns to size, and increasing costs in the region of decreasing returns to size. In the case of the large size dairy operations depicted in Figure 4, the maximum outputs at the technical capacities of the milking parlors (Q_1, Q_2, Q_3 and Q_4) are reached prior to encountering decreasing returns to size. Accordingly the LRAC curve is discontinuous at the technical capacity of each dairy operation.

Conventional theory indicates that the profit maximizing level of production is where marginal cost (MC) equals marginal revenue (MR) at a point above average cost. It is assumed here that marginal revenue (MR) and average revenue (AR) are equal. In Figure 4a profit maximization would be where the MR line intersects the long run marginal

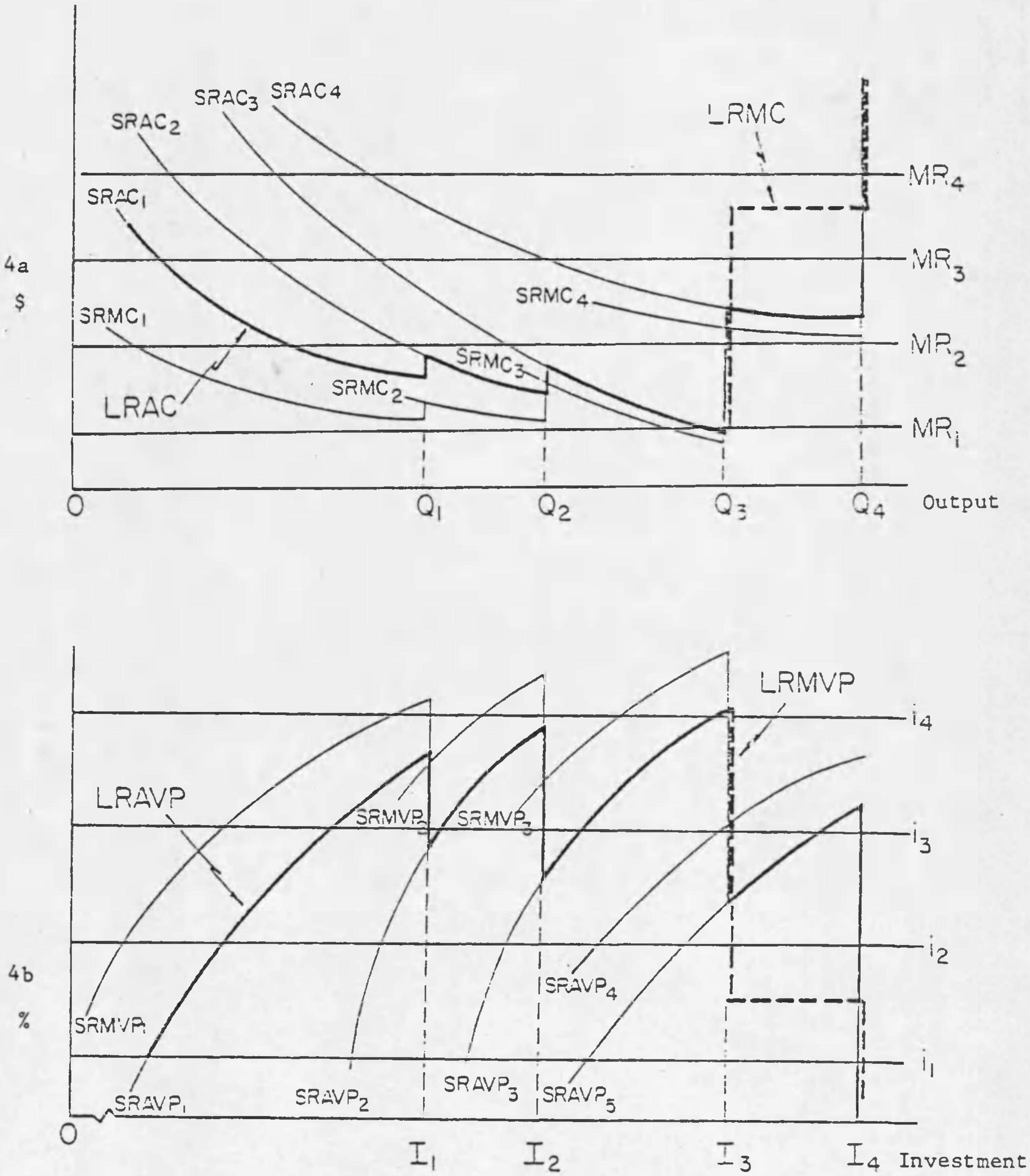


Figure 4. Cost and production theory applied to dairy operations, without constraint.

cost (LRMC) curve. With this theory we can determine the size dairy operation for maximum profits using Figure 4a. At the lowest marginal revenue shown, MR_1, dairy operation 3 is selected for output Q_3. It is the only operation where MR_1 is greater than average cost. At MR_2 dairy operations 1, 2 and 3 are profitable with maximum profits from dairy operation 3 at output Q_3. At MR_3 all four dairy operations are profitable; however, the profits of 3 and 4 have to be calculated to determine which is the most profitable. As shown, dairy operation 3 is the most profitable at output Q_3. At MR_4 all four dairy operations are profitable with maximum profits from dairy operation 4 at output Q_4.

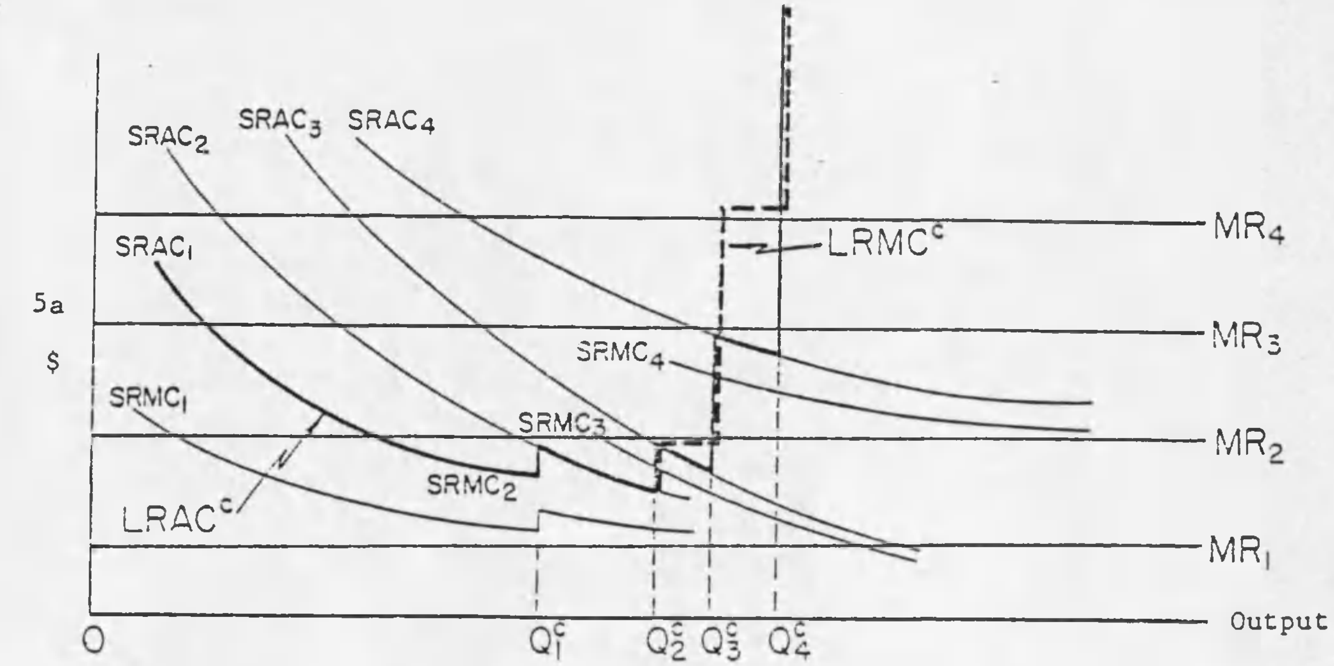
Conventional theory also indicates that profit maximization is achieved when the marginal value product of an input equals the price of the input ($MVP_x = P_x$). Figure 4b relates this conventional theory to the same four large scale dairy operations used in developing Figure 4a. The short run average value product (SRAVP) curve for each dairy operation is the loci of the points of rate of return on investment at each level of investment possible (cows, corrals and milking facilities). The long run average value product (LRAVP) curve is traced out as the envelope of the four SRAVP curves having the highest rates of return at each level of investment. The SRAVP curves terminate at the technical capacities of the milking parlors, and the LRAVP curve is discontinuous similar to the LRAC curve in Figure 4a.

The relevant segment of the long run marginal value product (LRMVP) curve is drawn to determine the profit maximizing level of investment. Since the marginal value product is the marginal percentage rate of return, the appropriate marginal factor cost is the percentage interest rate paid on borrowed capital and/or the percentage opportunity cost on equity capital. Four levels of interest cost are shown in Figure 4b and the profit maximizing levels of investment are the same as the profit maximizing levels of output shown in Figure 4a. At a high interest rate (i_4) only dairy operation 3 is profitable. At a low interest rate (i_1) all dairy operations are profitable with maximum profits available from dairy operation 4 at investment level I_4. At interest rate i_2 all dairy operations are profitable but calculations indicate profits with dairy operation 3 at investment level I_3 exceed profits with dairy operation 4 at investment level I_4.

Figure 4 illustrates the point that either marginal cost theory or marginal production theory can be used to evaluate returns to size of dairy operations and thereby select the most profitable investment level and output.

Conventional Economic Theory Applied to Dairy Operations When a Capital Constraint Limits Investment

Figure 5 illustrates conventional economic theory when a capital constraint limits the investment in a dairy operation at something less than the technical capacity of each operation. The typical equity input required by lenders differs for each investment component. Figure 5 depicts this situation with a limit on output and investment with dairy operations 2, 3 and 4, and shows the maximum sizes of these dairy operations that are possible with a given equity.



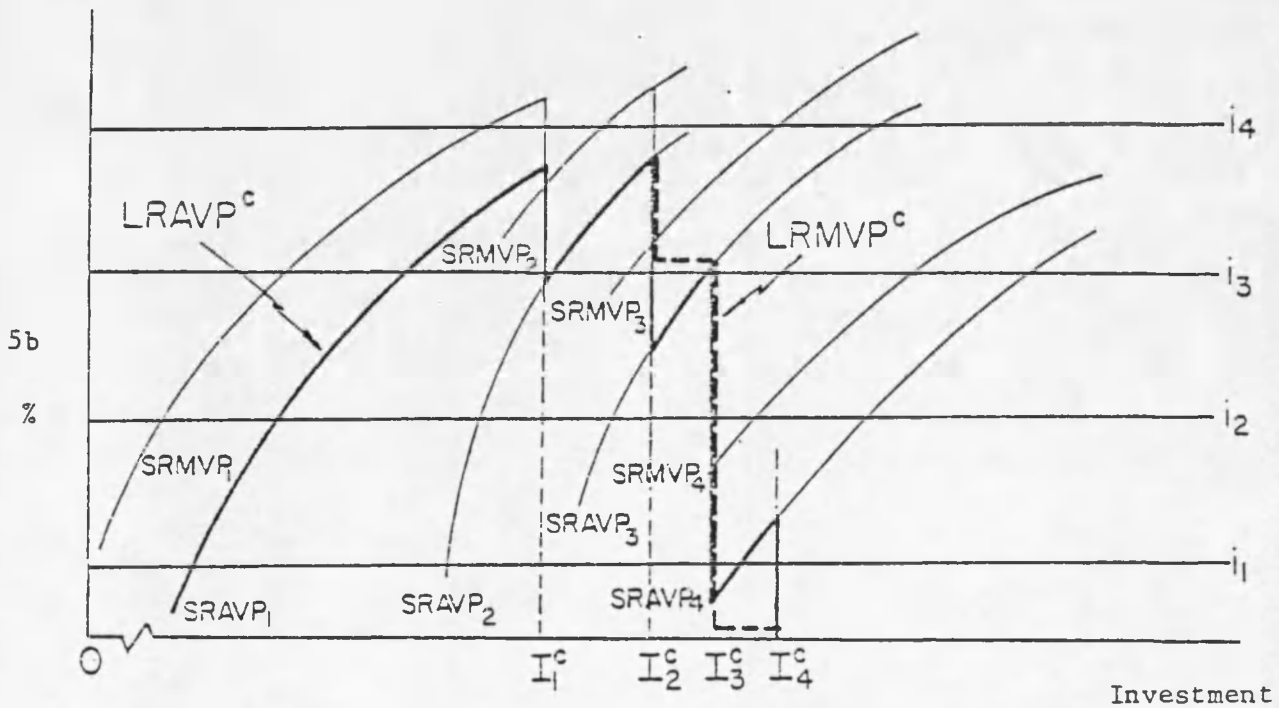


Figure 5. Cost and production theory applied to dairy operations with capital constraint.

The SRAC curves in Figure 5a are the same as those seen earlier in Figure 4a. The constrained long run average cost ($LRAC^c$) curve is modified as necessitated by the output limits Q_2^c, Q_3^c and Q_4^c. The profit maximizing level of output is where the marginal revenue line intersects the constrained long run marginal cost ($LRMC^c$) curve (only the relevant segment of the $LRMC^c$ is shown). At MR_1 no dairy operation is profitable since all have average costs that exceed MR_1 (and average revenue) at all levels of output. At MR_2 dairy operations 1, 2 and 3 are profitable with dairy operation 3 the most profitable at output Q_c^c. At MR_3 and MR_4 all dairy operations are profitable but in each case calculations show greater profits from dairy operation 3, at output Q_3^c, than from dairy operation 4, at output Q_4^c.

In Figure 5b the SRAVP curves for the four dairy operations are the same as those seen in Figure 4b. The constrained long run average value product ($LRAVP^c$) curve is modified as required by the investment constraint. The profit maximizing level of investment indicated here at various interest rates corresponds to the profit maximizing level of output as shown in Figure 5a by equating marginal revenue to marginal cost. At the high interest rate no large scale dairy operation is profitable. At other interest rates dairy operation 3 is the most profitable at investment level I_3^c.

This review of the use of conventional economic theory has shown how a long run planning curve can be derived to select a profitable dairy operation in either a constrained or an unconstrained situation.

Dairymen planning expansion normally have a capital constraint that precludes initial investment in the dairy operation that would maximize unconstrained profits. Nevertheless, their initial investment should be at a profitable level with sufficient cash flow for family living, debt service and income taxes. This study builds upon the conventional economic theory to develop a methodology to evaluate expansion alternatives.

Analysis of Dairy Production Costs

Moran and Greene (1960) conducted a study of Arizona dairy costs in an historical framework using empirical data. They developed the average costs of a given group of dairies in a given period of time to provide dairymen and agri-businessmen with data for evaluating costs. Martin and Hill (1962) examined the cost/size relationships of Central Arizona dairies to determine how costs vary under different typical input situations and to identify the most efficient size of operation. They concluded that with the technologies and managerial skills available at that time, the majority of Arizona dairies would stabilize herd size at around 150 head. They found that as herd size increased beyond 150 to 250 cows, unit costs increased primarily because of management difficulties.

Economies of size in Minnesota dairy farming was examined by Buxton and Jensen (1968). The diversified farming operations used in their study had combined crop and dairy enterprises with the dairy enterprise accounting for 60% of gross income. Their conclusions were similar to Martin and Hill (1962) in that the lowest unit costs were achieved with group handling of cows and that diseconomies of size occur because of limitations in technology and managerial skills.

Subsequent to the analytical work completed in the early 60s, the limitations in technology and management have been reduced and the transformation towards large scale drylot dairy operations has accelerated. Milking parlor designs, equipment and mechanization have been developed for more efficient production line milking. Managerial services have become available to assist dairymen with ration formulation, genetic improvement, production testing, etc., to facilitate management of large scale dairies. Wright and Angus (1973) developed synthetic budgets for typical 350 cow herds and for 700 cow herds. These budgets were updated in 1975 to reflect price changes. Their budgets showed increasing profitability of the larger sized herds largely due to their lower average fixed costs.

The efficiencies of large-scale dairying were analyzed recently by Matulich (1978). He determined that significant economies of size were evident for up to 750 cows. He identified three major characteristics that distinguish industrialized dairying in California, Arizona and Florida from small multi-enterprise dairying in other dairy areas. First, the presence of a well developed feed market and distribution system. Second, year round availability of quality labor. Third, highly specialized managerial and operational expertise.

Selley et al. (1979) utilized computer generated drylot dairy budgets to compare investment costs as well as operating costs for 350 cow and 700 cow herds. These budgets showed that at current costs of facilities, livestock and equipment, the economies of size realized by

700 cows were necessary to attain a rate of return on investment comparable with alternative uses of capital.

Milking Facility Technology

Current technology for production line milking in large size dairies includes milking parlors of various sizes and shapes, as well as labor saving devices for milking and cow movement. This technology has been described in several undated Arizona Cooperative Extension Service Publications (Table 2). The descriptions include investment costs, annual operating costs and through-put for milking parlors with various mixes of labor saving devices. Through-put is the number of cows milked per unit time and is the basis for cow milking costs. Through-put data in the descriptions is from time observations of commercial dairy operations. The publications in Table 2 are the basis for the descriptions of the expansion investment alternatives considered in Chapter 3.

Increased Production with 3X/day Milking

A method for increasing milk production without increasing herd size and without capital investment in facilities is to increase the milking frequency from 2X/day to 3X/day. Logan, Armstrong and Selley (1978) reviewed research on 3X/day milking and found that a 6 to 20 percent increase in milk production had been achieved by changing to 3X/day milking frequency. They concluded that a milk production increase of 8 to 10 percent was necessary to cover the increased costs associated with the change. The breakeven percentages with various feed costs and wages are shown in Tables 3 and 4.

Table 2. Arizona Cooperative Extension Service publications describing milking facility technology.

Publication Number		
Q 340	Armstrong, Speicher and Bickert	Comparisons of Equipment for Mechanizing the Milking of Cows
Q 24	Armstrong	Milking Machine Detachers: Effect on Production and Udder health
Q 342	Bickert, Armstrong	Rotary Milking Parlors
Q 43	Armstrong, Bickert	Herringbone and Side-Opening Milking Parlors
Q 42	Armstrong, Bickert	Polygon Milking Parlors
WREP 27	Armstrong	Trigon Milking Parlors

Table 3. Estimated breakeven points for percentage increase in production from 3X/day milking under various feed and labor costs. Milk sold at fat adjusted price of $8.53/cwt.a/

Feed Cost/Ton		Milker wage per annum $8,000	$10,000	$12,000	$14,000	$16,000
1	$110	9.2%	9.6%	9.9%	10.3%	10.7%
2	115	9.4	9.7	10.1	10.5	10.9
3	120	9.5	9.9	10.3	10.7	11.0
4	125	9.7	10.1	10.5	10.9	11.2
5	130	9.9	10.3	10.7	11.1	11.5
6	135	10.1	10.5	10.9	11.3	11.7
7	140	10.3	10.7	11.1	11.5	11.9
8	145	10.5	10.9	11.3	11.7	12.1
9	150	10.7	11.1	11.5	11.9	12.4
Increased costs (excluding milker labor & feed)		$24,845	$24,845	$24,845	$24,845	$24,845
Milker labor		9,140	11,430	13,714	16,000	18,290
TOTAL INCREASED NON-FEED COSTS		$33,985	$36,275	$38,559	$40,845	$43,135

a/ UDA overquota milk price (1977)

Table 4. Estimated breakeven points for percentage increase in production from 3X/day milking under various feed and labor costs. Milk sold at fat adjusted price of $10.33/cwt.[a/][b/]

		Milker wage per annum				
Feed Cost/Ton		$8,000	$10,000	$12,000	$14,000	$16,000
1	$110	7.4%	7.7%	8.0%	8.3%	8.6%
2	115	7.5	7.8	8.1	8.4	8.7
3	120	7.5	8.0	8.3	8.6	8.9
4	125	7.8	8.1	8.4	8.7	9.0
5	130	7.9	8.2	8.5	8.8	9.1
6	135	8.0	8.3	8.6	8.9	9.3
7	140	8.1	8.4	8.8	9.1	9.4
8	145	8.2	8.6	8.9	9.2	9.6
9	150	8.4	8.7	9.0	9.4	9.7
Increased costs (excluding milker labor, feed and interest on additional base)		$24,845	$24,845	$24,845	$24,845	$24,845
Milker labor		9,140	11,430	13,714	16,000	18,290
TOTAL INCREASED NON-FEED COSTS (excluding interest on additional base)		$33,985	$36,275	$38,599	$40,845	$43,135

a/ Assumes 8.5% interest per cwt. on added milk base produced at $20/cwt.

b/ UDA quota milk price (1977).

Summary of Previous Work

Early work indicated that there were potential economies of size in large dairy operations but size was constrained due to limitations in technology and managerial skills. The prediction was that the majority of Arizona dairies would stabilize at around 150 cows since they could compete with the larger dairies of above-average managers. Since this early work, technology and managerial services have become available to reduce and effectively eliminate these constraints to large size drylot dairy operations. Current constraints to herd size are the limitations of milking parlor facilities.

Where the milking parlor capability exists, a dairyman may be able to profitably expand production without capital investment by changing to 3X/day milking frequency. When the parlor capability is constraining and capital investment is necessary for expansion, a dairyman should consider parlor size, parlor equipment, parlor mechanization, milking frequency and herd replacement alternatives.

Previous work does not develop a methodology for a dairyman to completely evaluate the investment alternatives when initiating a new dairy operation; however, this work does describe a method for this evaluation.

CHAPTER 3

INVESTMENT ALTERNATIVES FOR LARGE SIZE DAIRY OPERATIONS

A dairyman planning capital investment to increase milk production and profits has several technological and organizational alternatives to consider. These investment alternatives are:

1. Various milking parlor designs and sizes.
2. Various levels of mechanization to be included in the parlor and number of milkers to be used per shift.
3. Leasing, purchasing or raising heifers/cows to meet herd expansion and replacement needs.
4. Milking two or three times a day in two or three shifts with or without sufficient milk base to cover all production.

Figure 6 shows the possible combinations of alternatives with each milking parlor design and size.

Milking Parlors

Milking parlor designs currently available are Side-Opening, Herringbone, Rotary, Polygon, and Trigon parlors. Information and schematics of these parlors are taken from the descriptive work listed in Table 2.

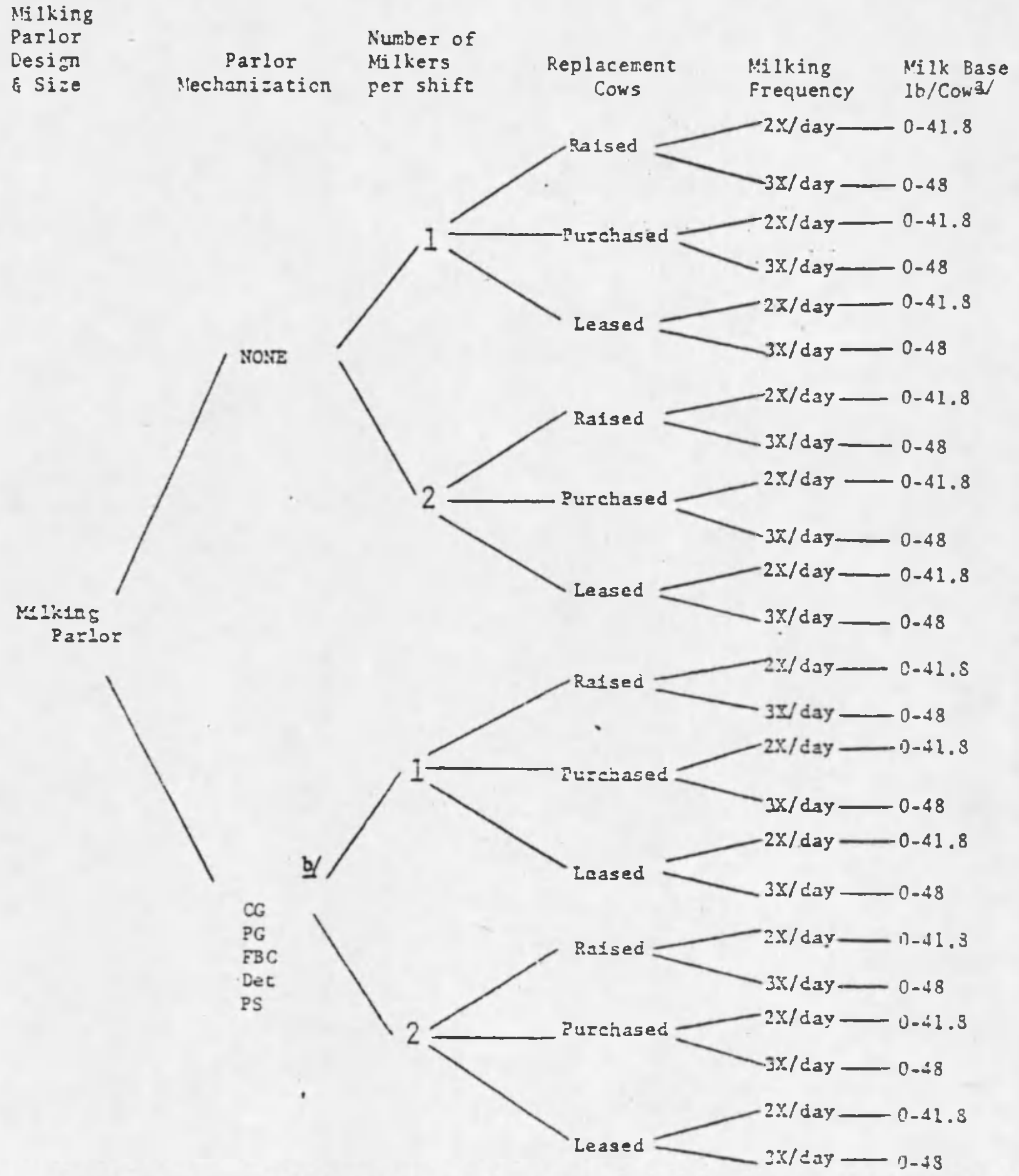


Figure 6. Expansion alternatives.

a/ A pound of milk base is the authorization to market one pound of milk per day at the higher "quota" price. Milk base possessed can range from 0 to the amount of production per cow per day. With 2X/day milking and typical production of 50 lb/cow/day, milk base required would be (50 lb/cow) (305 days) ÷ 365 days = 41.8 lbs. With 3X/day milking, and a 15% increase in production, milk base required would be 1.15 (50 lb/cow) (305 days) ÷ 365 days = 48 lbs.

b/ CG - Crowd gate, PG - Power entry/exit gates, FBC - Feed bowl covers, Det - Automatic milking machine detachers, PS - Preparation stalls (Side-opening milk parlors only).

Side-Opening Parlors

The side-opening parlors are either single or double with the double side-opening as shown in Figure 7 the more popular because there is less walking for the milker. Sizes range from two to four milking stalls on each side of the milker's pit. Cows move individually to the stalls, entering and exiting through gates on one side of the stall.

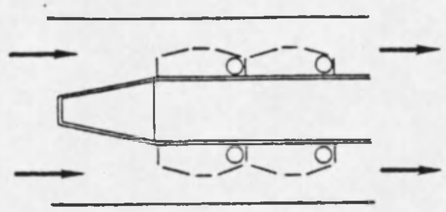


Figure 7. Double-2 side-opening parlor.

Herringbone Parlors

The herringbone parlors are normally double herringbone design as shown in Figure 8 with sizes ranging from double-4 to double-12. Cows are handled in groups with a group moving into one side, being milked and moving out together. This is a disadvantage in the large herringbones since a slow milking cow holds up the group. This disadvantage is offset to some extent in that cows move better in groups and the milker's walking is reduced due to the herringbone design. Distance between udders is 36-48 inches as compared to 8-10 feet in the side opening parlors.

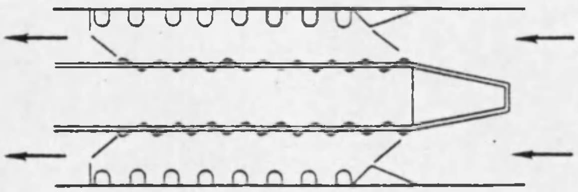


Figure 8. Double-8 herringbone parlor.

Rotary Parlors

There are three types of rotary parlors in use; the rotary tandem, the rotary turnstile and the rotary herringbone which is shown in Figure 9. The rotary concept is for the cows to be on a moving platform with the milking operation completed during a revolution of the platform. Sizes range from 5 to 22 stalls with some larger rotary parlors in use in New Zealand. The rotary parlor is losing popularity because of high investment costs, high operating costs and problems encountered in trying to achieve expected throughput. The rotary milking parlor is not considered further in the study.

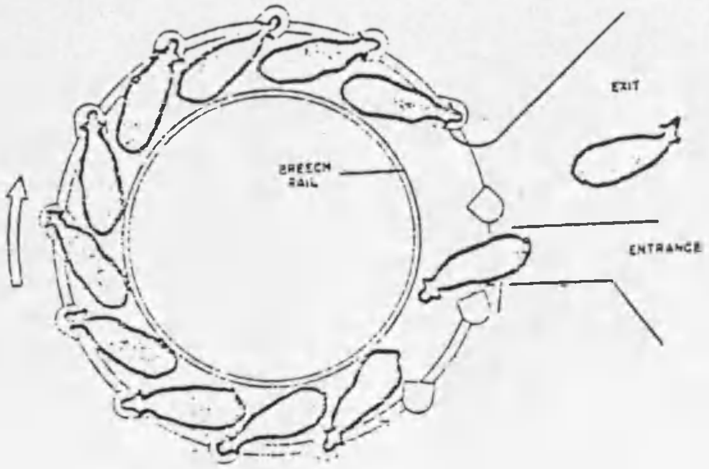


Figure 9. Rotary Herringbone Parlor.

Polygon Parlors

The polygon milking parlor is a four sided parlor utilizing herringbone stalls (Figure 10). Sizes range from a Polygon 16 with four stalls per side to the Polygon 32 with eight stalls per side. The polygon is larger and more expensive than the side-opening and double herringbone designs and is more efficient in that higher rates of throughput are typical. The polygon has higher annual costs per cow in smaller herds; however it can accommodate a herd expansion up to 2100 cows with the Polygon 32.

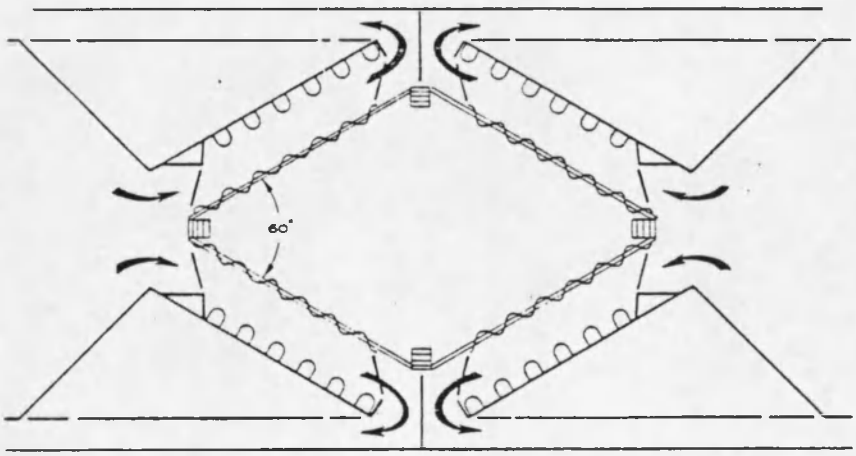


Figure 10. Polygon 24 parlor.

Trigon Parlors

The trigon parlors are a recent innovation to achieve improved performance on a per stall basis over the double herringbone parlor of the same size. This design utilizes herringbone stalls on three sides of the milker's pit (Figure 11). Sizes currently in use are 12, 16 and 18 stall parlors with larger sizes being considered. Improved performance results with the trigon design because a slow milking cow does not delay as many cows as with the double herringbone. This enables higher throughput and lower annual cost per cow than the double herringbone parlor with the same number of stalls.

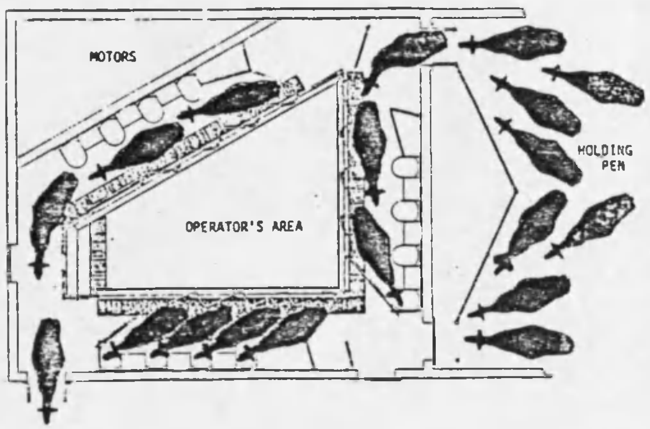


Figure 11. Trigon 12 parlor.

Milking Parlor Mechanization

Labor saving devices currently available for installation in each parlor are listed below:

1. A crowd gate that moves cows forward in holding pen. It stops when it touches a cow, then restarts after a preset time delay.
2. Power gates that are pneumatically or electrically operated entry and exit gates and doors. Multiple controls are located at strategic points around the milker's pit to reduce walking.
3. Feed bowl covers that facilitate cow movement out of the milking stalls by preventing access to feed when exit gates are opened.

4. Automatic detaching units, loosely coupled to the claw, that detect cessation of milk flow and shut off the vacuum to cause the teat cups to detach.
5. Preparation stalls that are located in front of side-opening parlor stalls and provide cold water wash or warm water spray to stimulate milk let down, or both.

Complete mechanization would entail the use of all the labor saving devices, as appropriate, i.e., preparation stalls apply to the side-opening parlors only. Partial mechanization is when one or more of the labor saving devices are used. The items included are specified.

Table 5 and Table 6 list the technical capacities of milking parlors with and without mechanization. Technical capacity is the number of cows that can be accommodated by the parlor in 24 hours. This is calculated using the steady state throughputs, or number of cows milked per hour, reported by Armstrong et al. in the publications listed in Table 2.

The number of cows milked at technical capacity are calculated as follows:

$$CM/24\ Hrs. = [\frac{24}{MF} - (ST + CT + MT)]\ SST$$

where

CM = number milk cows

MF = milking frequency (number of times each cow is milked per day)

ST = setup time prior to milking

CT = cleanup time after milking

[a] Typical production is 50 lb/day for 305 days lactation or 15,250 lb annual production.

[b] Production with 3X/day milking is 15% higher than with 2X/day milking or 17,537.5 lb annual production.

[c] Cows per hour exclusive of set up, clean up and cow movement.

[d] With 3X/day milking the production at each milking is less and throughput increases 10-15% above 2X/day milking.

[e] $$CM/24\ Hrs = \frac{24}{MT} - (ST + CT + MT)\ SST$$

where CM = milk cows
MF = milking frequency
ST = set up time
CT = clean up time
MT = cow movement time
SST = steady state throughput

[f] $$TC = \frac{365}{305}\ CM$$

where CM = milk cows
TC = total cows or herd size

[g] Crowd Gates, Power Gates, Prep. Stalls and Detachers.

[h] Crowd Gates, Power Gates, Feed Bowl Covers and Detachers.

[i] Crowd Gates, Power Gates, and Feed Bowl Covers. (Note that this configuration without detachers has same steady state throughput yet technical capacity is lessened due to parlor shut down for cow movement).

Table 5. Technical capacity of milking parlors with typical production.

Parlor Type	Mechanization	Number Milkers	2X/day [a] Steady State Throughput [c]	2X/day Milk Cows [e]	2X/day Total Cows [f]	3X/day [b] Steady State Throughput [d]	3X/day Milk Cows [e]	3X/day Total Cows [f]
Side Opening								
6 stall	None	1	49	480	574	55	339	406
	Partial[g]	1	60	573	686	67	402	481
8 stall	None	2	56	540	646	63	381	456
	Partial[g]	1	65	615	736	73	432	517
10 stall	None	2	65	615	736	73	432	517
	Partial[g]	1	75	695	832	84	486	582
Herringbone								
Double 4	None	1	37	372	445	42	266	318
	Partial[h]	1	47	463	554	53	328	392
Double 6	None	2	60	573	686	68	406	486
	Partial[h]	1	67	631	755	75	442	529
Double 8	None	2	74	687	822	83	481	575
	Partial[h]	1	82	748	895	92	524	627
Double 10	None	2	86	778	931	97	546	653
	Partial[h]	1	89	800	957	100	560	670
Trigon								
12 stall	None	2	80	733	877	90	514	615
	Partial[h]	1	82	748	895	92	524	627
16 stall	None	2	88	793	949	99	556	665
	Partial[h]	1	90	808	967	101	565	676
18 stall	None	2	96	851	1018	108	595	712
	Partial[h]	1	98	866	1035	110	604	723
22 stall	None	2	102	894	1070	115	625	748
	Partial[h]	1	104	908	1086	117	634	759
Polygon								
16 stall	None	2	87	786	940	98	551	659
	Partial[h]	1	97	859	1028	109	600	718
24 stall	Partial[h]	1	112	918	1098	126	622	745
	Partial[h]	2	138	1518	1816	155	1085	1298
	Partial[i]	2	138	1294	1548	155	909	1088
32 stall	Partial[h]	2	161	1771	2120	181	1267	1516

Footnotes on facing page.

[a] High production is 60 lb/day for 305 days lactation or 18,300 lbs annual production.

[b] Production with 3X/day milking is 15% higher than with 2X/day milking or 21,045 lb annual production.

[c] Cows per hour exclusive of set up, clean up and cow movement. (Note that steady state throughput is lesser with high producing cows.)

[d] With 3X/day milking the production at each milking is less and throughput increases 10-15% above 2X/day milking.

[e] $$MC/24\ Hrs = \frac{24}{MF} - (ST + CT + MT)\ SST$$

where CM = milk cows
MF = milking frequency
ST = set up time
CT = clean up time
MT = cow movement time
SST = steady state throughput

[f] $$TC = \frac{365}{305}\ CM$$

where CM = milk cows
TC = total cows or herd size

[g] Crowd Gates, Power Gates, Prep. Stalls and Detachers.

[h] Crowd Gates, Power Gates, Feed Bowl Covers and Detachers.

[i] Crowd Gates, Power Gates and Feed Bowl Covers. (Note that this configuration without detachers has same steady state throughput yet technical capacity is lessened due to parlor shut down for cow movement).

Table 6. Technical capacity of milking parlors with high production.

Parlor Type	Mechanization	Number Milkers	2X/day[a] Steady State Throughput[c]	2X/day[a] Milk Cows[e]	2X/day[a] Total Cows[f]	3X/day[b] Steady State Throughput[d]	3X/day[b] Milk Cows[e]	3X/day[b] Total Cows[f]
Side Opening								
6 stall	None	1	47	463	554	53	328	392
	Partial[g]	1	58	557	666	65	391	468
8 stall	None	2	56	540	646	63	381	456
	Partial[g]	1	65	615	736	73	432	517
10 stall	None	2	65	615	736	73	432	517
	Partial[g]	1	75	695	832	84	486	582
Herringbone								
Double 4	None	1	37	372	445	42	266	318
	Partial[h]	1	41	309	490	46	289	346
Double 6	None	2	60	573	686	67	402	481
	Partial[h]	1	60	573	686	67	402	481
Double 8	None	2	72	671	803	81	472	565
	Partial[h]	1	70	655	784	79	462	553
Double 10	None	2	82	748	895	92	524	627
	Partial[h]	1	76	703	841	86	495	592
Trigon								
12 stall	None	2	70	655	784	79	462	553
	Partial[h]	1	70	655	784	79	462	553
16 stall	None	2	80	733	877	90	514	615
	Partial[h]	1	80	733	877	90	514	615
18 stall	None	2	88	793	949	99	556	665
	Partial[h]	1	88	793	949	99	556	665
22 stall	None	2	94	837	1002	105	582	696
	Partial[h]	1	94	837	1002	105	582	696
Polygon								
16 stall	None	2	85	771	923	96	542	649
	Partial[h]	1	95	840	1005	107	591	707
24 stall	Partial[h]	1	100	840	1005	112	568	680
	Partial[h]	2	126	1386	1659	142	994	1190
	Partial[i]	2	126	1197	1433	142	844	1010
32 stall	Partial[h]	2	149	1639	1961	168	1176	1407

Footnotes on facing page.

MT = cow movement time: 15 minutes per 100 cows = $(\frac{15}{60})$ $(\frac{CM}{100})$

SST = steady state throughput.

Total cows or herd sizes at technical capacity are milk cows plus dry cows. Typical annual lactations are 305 days and thus milk cows are $\frac{305}{365}$ of the herd size or

$$TC = \frac{365}{305} CM$$

where CM = milk cows

TC = total cows or herd size

A number of observations are apparent from the data in Table 5 and Table 6. When partial mechanization is added to any milking parlor the number of milkers per shift is reduced and the steady state throughput is increased. The steady state throughputs are mostly based on observations and are extrapolated where observed data was not available. High producing cows take longer to milk and so the throughputs in Table 6 are lower than those in Table 5. Cows milked 3X/day give less milk per milking and so they move through the parlor faster. Thus throughputs are consistently higher with 3X/day milking. This increase in throughput ranges from 10-15%.

Tables 5 and 6 facilitate the comparison of technical capacities for various parlors. For example, the Double 8 Herringbone, the Trigon 16 and the Polygon 16 each have the same number of milk stalls, yet the technical capacity of each parlor is different. With typical production and 2X/day milking the technical capacities are 895, 967 and 1,028, respectively.

Milking Parlor Investment Costs

Milking parlor construction and equipment costs are given in Table 7. The cost figures were obtained from contractors and dairymen in western U.S. who built parlors during 1979.

Milk Cow Replacement

Three options are available to acquire cows for herd expansion and for replacement purposes. These are leasing cows, purchasing cows or raising replacement heifers.

Leased Cows

Leasing cows allows the dairyman to acquire cows without investment in cows, youngstock or youngstock facilities and without committing equity as security for borrowed money for cow purchases. Lease costs are high but they are a direct deduction from ordinary income. Leasing is not common practice in Arizona; however, it is available from the Dairy Farm Leasing Company located in Minneapolis, Minnesota.

Purchased Cows

Purchasing initial herd and replacement heifers entails a significant annual cash requirement; however there is no investment required for youngstock or youngstock facilities. Additionally there is no annual cost for youngstock feed, facilities and labor. There are tax benefits in that some cows would qualify for investment credit and all purchased animals can be depreciated.

Table 7. 1979-80 milking parlor costs.

Parlor Type	Building[a]	Equipment[b]	Mechanization[c]	Total
Side-opening 6 stall	60,560	64,000	12,500	137,060
Side-opening 8 stall	74,700	77,900	14,400	167,000
Side-opening 10 stall	79,740	87,400	16,300	183,440
Herringbone Double 4	39,996	36,400	17,120	93,516
Herringbone Double 6	52,320	47,400	21,480	121,200
Herringbone Double 8	65,330	56,800	25,840	147,970
Herringbone Double 10	75,960	65,700	30,200	171,860
Trigon 12 stall	58,704	47,400	21.880	127,984
Trigon 16 stall	69,530	56,800	26,240	152,570
Trigon 18 stall	79,740	63,200	28,420	171,360
Trigon 22 stall	87,876	67,700	32,780	188,356
Polygon 16 stall	90,260	57,300	28,240	175,800
Polygon 24 stall	134,088	80,600	37,960	252,643
Polygon 32 stall	164,850	93,800	46,680	305,330

Source: Armstrong 1979b.

[a] Includes electricity, plumbing, hot water and holding pen for approximately 1 hr of milking. Office, milk house and storage \$25/sq.ft., milking parlor \$21/sq.ft. and holding pen \$15/sq.ft.

[b] Equipment includes refrigeration, milk storage, milking equipment, stalls and feed sugars.

[c] Mechanization includes power gates, crowd gates, feed bowl covers and detachers.

Raised Replacements

Purchasing initial herd and raising replacements involves the highest investment for a given herd size due to investment in calves, heifers and facilities. Annual costs for feed, facilities and labor are also higher. There are tax benefits in that revenue from cull cows that were raised is capital gain rather than ordinary income. Farmers who raise their replacement heifers contend that they are also better able to control the genetic improvement of their herds.

Milking Frequency

The milking frequency alternatives considered here are to milk 2X/day or 3X/day. As shown in Tables 5 and 6 the technical capacity of each milking parlor is higher with 2X/day milking. Accordingly the total investment at technical capacity is higher with 2X/day milking due to a larger investment in cows and corrals. Milking frequency must be determined from the projection of net cash flows and profitability as indicated by rates of returns. The milking frequency that will provide the highest net cash flows and highest profits should be selected.

Milk Base

The United Dairymen of Arizona (UDA) is a bargaining and supply cooperative whose members market over 90% of the milk in Arizona. The UDA awards "milk base" to members according to their production in base earning periods. A pound of "milk base" is the authorization to market a pound of milk every day through the UDA for the "quota" milk price. Milk marketed in excess of milk base owned is sold at the "over-quota" price. Milk base was being transferred between UDA members at \$20-\$25 per pound during 1979. This is an additional investment alternative.

CHAPTER 4

METHODOLOGY FOR EVALUATION OF ALTERNATIVES

The methodology developed is for determining the investment in a milking facility, cows and corrals that achieves adequate cash flow for debt service, family living and income taxes without exceeding any borrowing constraint. Debt service includes principal and interest payments. Alternatives that achieve adequate cash flow can then be evaluated to determine the maximum profit alternative. The methodology developed to evaluate cash flow and profits for the various mixes of alternatives and herd sizes uses graphic analysis. Financial factors are calculated for each milking parlor and mix of alternatives over a range of herd sizes up to the technical capacity of the parlor. The graphs provide approximations that suffice for comparison of the various alternatives. Once the best combination is determined graphically, precise budget development can follow.

Calculations

The financial factors that are calculated and plotted on the graphs are 1) total investment, 2) maximum borrowed capital, 3) equity capital, 4) annual net cash flow, 5) before tax annual net returns, and 6) before tax rates of returns. These factors are the decision criteria for selecting a dairy operation.

Total Investment, Borrowed Capital and Equity

The total investment is the sum of the dollar value of land, buildings, corrals, livestock, equipment and machinery for each dairy operation over the range of possible herd sizes. Equity is the increment of the total investment that is committed from the net worth of the entrepreneur or dairyman in this case. The remainder of the total investment is borrowed funds. This borrowed capital consists of long term loans on real estate and intermediate term loans on the personal property in the dairy operation. Lenders typically require security on these loans in the form of equity in varying amounts. The maximum borrowed capital is contingent on the equity available.

(1) $I = E + L$

where I = total investment

E = equity or net worth and

L = borrowed capital or liabilities

Annual Net Cash Flow

The annual net cash flow is the sum of annual cash inflow minus the sum of annual cash outflow. Calculations herein include debt payments but exclude family withdrawals and income tax payments.

Before Tax Annual Net Returns

The before tax annual net returns are the average annual cash and noncash revenues minus the cash and non-cash costs. Cash revenues are cash sales of milk and livestock. Cash costs are the cash operating costs. A common non-cash item in a dairy operation is an annual change in inventory. An increase in inventory is a non-cash revenue and a decrease is a non-cash cost. Another non-cash cost is depreciation. Depreciation is included here. Changes in inventory are assumed to be zero.

There are two types of average annual net returns calculated. The net return to management and total investment does not include interest payments on borrowed capital as a cost. The net return to management and equity does include these interest paymens as a cost.

(2) $R_I = TR - TC$

where: R_I = return to management and total investment

TR = total revenue

TC = total costs

(3) $R_E = R_I - i(I-E)$

where: R_E = return to management and equity

i = average interest rate on borrowed capital

Rates of Returns

The rates of returns facilitate comparison of the profitability of the alternative dairy operations. The rate of return on total investment is the return on management and total investment divided by the total investment. The rate of return on equity is the return on management and equity divided by the equity. These rates of returns are calculated and plotted.

(4) $r_I = \frac{R_I}{I}$

where: r_I = rate of return on total investment

(5) $$r_E = \frac{R_I - i(I - E)}{E}$$

where: r_E = rate of return on equity

$i(I - E)$ = interest paid on borrowed capital

Maximum Profits

The return on management and investment is the profit on the investment and is considered herein to be a function of the total investment. The return on management and equity is the profit for the dairyman.

(6) $$\pi_I = R_I = F[I]$$

where: π_I = profit on investment

(7) $$\pi_E = R_E = F[I] - i(I-E)$$

where: π_E = profit on equity

To maximize profits it is necessary to satisfy the condition:

(8) $$\frac{d\pi_E}{dI} = F' - i = 0$$

Substituting equation (7) into equation (5) results in the following expression for the rate of return on equity:

(9) $$r_E = \frac{F[I] - i(I-E)}{E}$$

To maximize the rate of return on equity it is necessary to satisfy the condition:

(10) $$\frac{dr_E}{dI} - \frac{F'}{E} - \frac{i}{E} = 0$$

After simplifying equation (10) we find that the condition for maximum profits and for maximum rate of return on equity are:

(11) $F' - i = 0$

Therefore maximizing the rate of return on a given equity contribution results in maximum profits.

Maximum Borrowing Capability

Lenders advise that the amount of money a farmer can borrow depends on the "Four C's of Credit" which are: 1) Character, 2) Collateral, 3) Capability and 4) Cash Flow.

Character includes personal honesty, integrity and trustworthiness. Collateral is the amount of security or equity a borrower can pledge to the lender. Capability refers to the management skills demonstrated in operating the business. Cash flow is the projected returns available for debt service.

Discussions with loan officers of lending institutions regularly doing business with Arizona dairymen provided an estimate of the maximum borrowing capability for investment in dairy operations. The concensus is that an individual with suitable character and capability could borrow up to 75% for long term investment in real property, up to 50% for intermediate term investment in personal property and up to 100% for short term loans for operating capital, providing the projected cash flow is adequate to cover debt service. Long term loans are typically 20-30 year mortgages on land, buildings, corrals and wells. Intermediate term loans are typically 5-7 year loans for machinery, cattle and equipment. Short term loans, three to twelve months, are for feed purchases and are not considered here as investment borrowing. Lending institutions prefer not to accept milk base as collateral and so the UDA milk base necessary for selling milk at the higher "quota" price must be earned during the annual "base earning period" or purchased with equity capital.

Graph Construction

Figure 12 is an illustration of a typical series of graphs for a specific investment alternative. The horizontal axis for each graph is the size of the dairy operation in number of cows. The vertical axes for the investment graph and cash flow graph are dollars. The vertical axis for rates of return is in percent.

The series of graphs are constructed so that the various financial factors related to each size of dairy operation are portrayed. Construction of the graphs entails calculating the financial factors for the range of herd sizes and plotting the points. The loci of the points are the curves of the variables considered. Once constructed, the series of graphs can be entered at any one of the variables; herd size or financial factors, and the other variables can be read off the graph.

In the sample situation depicted in Figure 12, the rate of return on investment is greater than the rate of return on equity. The average interest rate paid on borrowed capital determines which rate of return is higher. If the rate of return on the investment is greater than the average interest rate, the rate of return on equity is greater than the rate of return on investment. Conversely, if the rate of return on investment is less than the average interest rate, the rate of

12a
12b
12c

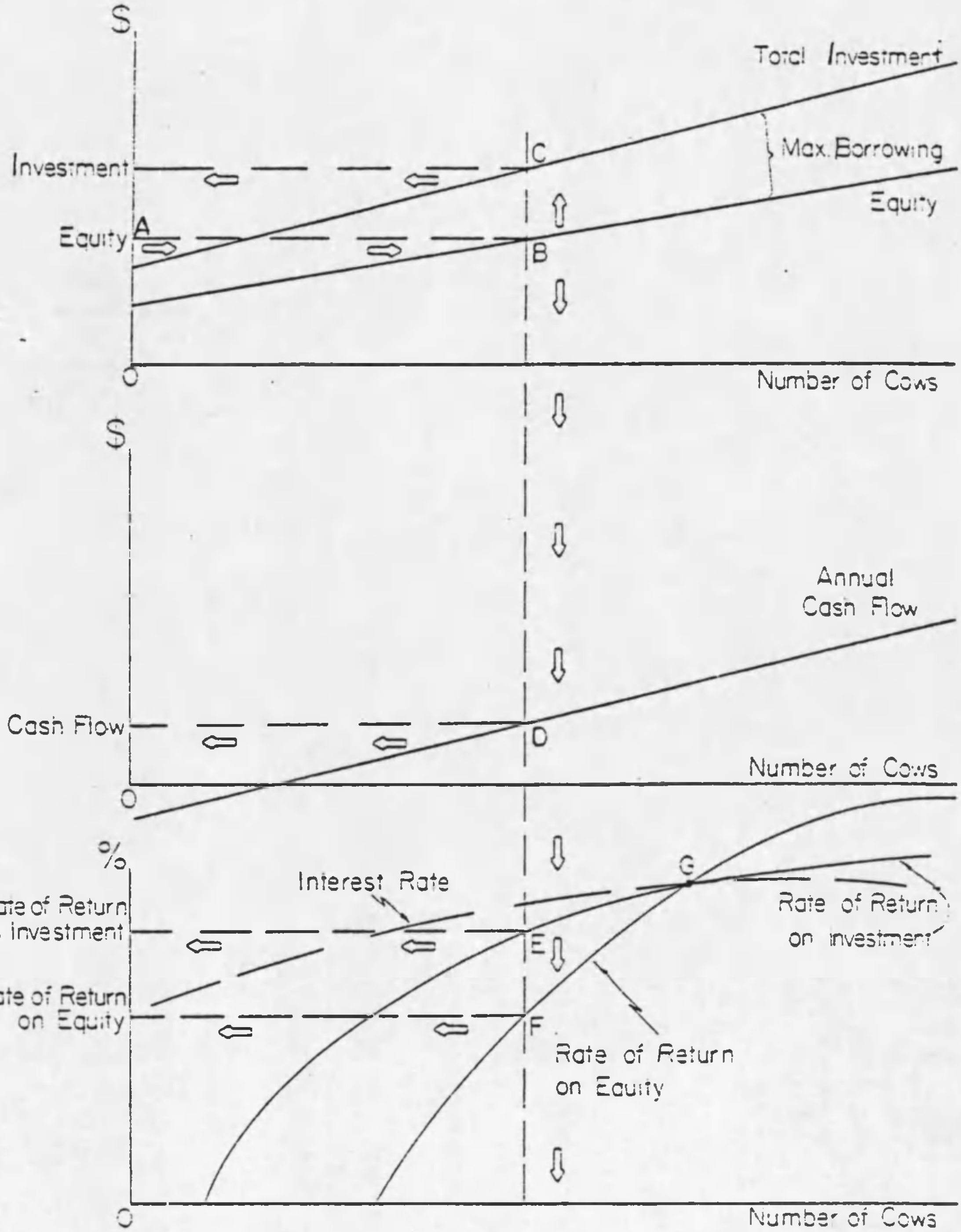


Figure 12. Sample graph for evaluation of dairy operations.

return on equity is less than the rate of return on investment. This is proven as follows:

Subtracting r_I from both sides of equation (5) yields

$$(10)\quad r_E - r_I = \frac{R_I - i(I - E)}{E} - r_I$$

This equation is simplified to

$$(11)\quad r_E - r_I = (r_I - i)\ (\frac{I}{E} - 1)$$

Since $I > E$ then $(\frac{I}{E} - 1) > 0$. Therefore

if $(r_I - i) > 0$ then $(r_E - r_I) > 0$; or,

if $r_I > i$ then $r_E > r_I$. Conversely

if $(r_I - i) < 0$ then $(r_E - r_I) < 0$;

or, if $r_I < i$ then $r_E < r_I$.

Evaluation of Alternatives

The limiting factor for a dairyman considering an expansion investment is the net worth constraint. To evaluate the investment alternatives he would enter the series of graphs at his equity (point A) and proceed horizontally until intersecting the minimum equity line at point B. This intersection establishes the size dairy operation and the related financial factors; total investment at point C, annual cash flow at point D, rate of return on investment at point E, and rate of return on equity at point F. To compare and evaluate the investment alternatives requires construction of a separate series of graphs for each expansion alternative shown in Figure 6 that is to be considered.

The feasible alternatives are those with a herd size that provides a positive annual net cash flow adequate for family living and income taxes. The graphs of the feasible dairy operations are compared to select the most profitable, as indicated by rates of returns; and, the operation with the highest cash flow possible with an equity constraint. Another consideration not dealt with here is the most profitable operation when expanded over time to the technical capacity of the milking parlor.

The dairy operation selected will depend on the individual's situation. Some will decide on the alternative that provides the highest profits immediately. Others will opt for the operation with potential for growth to the largest size dairy herd.

CHAPTER 5

EVALUATION OF ALTERNATIVES: A TYPICAL EXAMPLE

The methodology developed in Chapter 4 is used here to evaluate the alternatives in a typical situation facing an Arizona dairyman. The situation is a dairyman selling his farm to capitalize on urban expansion who estimates a net worth of $2 million in cash, land, cattle, equipment and milk base. He intends to initiate a dairy operation at a new location in a mechanized Polygon 24 milking parlor. The technical capacity of this parlor with 2 milkers ranges from 1,660 - 1,800 cows with 2X/day milking and from 1,190 - 1,300 cows with 3X/day milking (Tables 5 and 6). He has to decide whether to initiate the dairy operation with raised, purchased or leased cows; with 2X/day or 3X/day milking, and the amount of milk base to purchase.

Graphic Analysis

The financial factors (Investment, Maximum Borrowing, Equity, Net Return, Annual Cash Flow and Rates of Returns) are calculated for each alternative in 200 cow increments up to the technical capacity of the Polygon 24. The data used as a basis for calculation of the financial factors is extrapolated from budgets generated by the University of Arizona Dairy Budget Generator Program using 1979 cost/price information.

Investment

The investment in a dairy operation with a Polygon 24 milking facility and various herd sizes is shown in Table 8. There are three types of investment costs considered here; fixed investment costs, lumpty investment costs and per cow investment costs.

Fixed Investment Costs. These costs are the polygon 24 milking parlor with milk house, office, holding pen, plumbing and electrical hook0up; the equipment including stalls, milking system, milk storage, milk cooling and parlor feed system; and the mechanization including crowd gate, power entry/exit gates, feed bowl covers and automatic detachers. They are fixed regardless of herd size; raised, purchased or leased cows; 2X/day or 3X/day milking; and, milk base acquisition.

Lumpy Investment Costs. These costs are for the wells/water storage system, parlor waste disposal system, machinery for moving feed, livestock and supplies. They are fixed in the smaller herd sizes and increase in lumpy increments as the numbers of livestock increase.

Per Cow Investment Costs. Costs that increase on a per cow basis include cows, corrals, milk base, cool shades, land, youngstock and calf/heifer facilities. The youngstock and youngstock facilities investment costs only apply to the raised replacement alternatives. The per cow costs typically account for over 90% of the investment costs and so the total investment lines on the graphs are approximately straight lines.

Equity

The minimum equity requirement for the herd sizes of each alternative is the difference between the maximum borrowing capability and

Table 8. Polygon 24 investment costs.

	Herd Size								
	200	400	600	800	1,000	1,200	1,400	1,600	1,800
A. Parlor	134,088	134,088	134,088	134,088	134,088	134,088	134,088	134,088	134,088
B. Milk Stalls	35,260	35,260	35,260	35,260	35,260	35,260	35,260	35,260	35,260
C. Parlor Equip.	106,100	106,100	106,100	106,100	106,100	106,100	106,100	106,100	106,100
D. Calf Facilities[a] ($60/cow)	12,000	24,000	36,000	48,000	60,000	72,000	84,000	96,000	108,000
$E._1$ Corrals[a] ($360/cow)	72,000	144,000	216,000	288,000	360,000	432,000	504,000	576,000	648,000
$E._2$ Corrals[b] ($197/cow)	39,400	78,800	118,200	157,600	197,000	236,400	275,800	315,200	354,600
F. Cool Shades ($154/cow)	30,800	61,600	92,400	123,200	154,000	184,800	215,600	246,400	277,200
G. Wells/Waste	60,400	60,400	60,400	60,400	73,600	73,600	73,600	106,800	106,800
H. Machinery	76,000	76,000	112,400	112,400	130,750	130,750	165,000	165,000	185,000
$I._1$ Cattle[a] ($1,860/cow)	372,000	744,000	1,116,000	1,488,000	1,860,000	2,232,000	2,604,000	2,976,000	3,348,000
$I._2$ Cows[c] ($1,200/cow)	240,000	480,000	720,000	960,000	1,200,000	1,440,000	1,680,000	1,920,000	2,160,000
J. Land (40,000 + $160/cow)	72,000	104,000	136,000	168,000	200,000	232,000	264,000	296,000	328,000
K. Milk Base $23/lb									
15,250.0 ave. 41.78 lb/cow	192,192	384,384	576,576	768,768	960,960	1,153,152	1,345,344	1,537.536	1,729,728
16,012.5 ave. 43.87 lb/cow	201,802	403,604	605,406	807,208	1,009,010	1,210,812	1,412,614	1,614,416	1,816,218
16,675.0 ave. 45.68 lb/cow	211,412	422,824	634,236	845,648	1,057,060	1,268,472	1,479,884	1,691,296	1,902,708
17,537.5 ave. 48.05 lb/cow	221,022	442,044	663,066	684,088	1,105,110	1,326,132	1,547,154	1,768,176	1,989,198
18,300.0 ave. 50.14 lb/cow	230,632	461,264	691,896	922,528	1,153,160	1,383,792	1,614,424	1,845,056	2,075,088

a. Items D_1, E_1, I_1 applicable with raised replacements only.

b. Item E_2 applicable with leased and purchased cows only.

C. Item I_2 applicable with purchased cows only.

the total investment. The maximum borrowing capability is calculated using the guidelines discussed earlier, that is, 75% of real property amortized over 25 years plus 50% of personal property amortized over seven years. The interest rate used for long term mortgages was 10.1% and for intermediate term loans is 12%. The annual debt payments for the real estate mortgages and the personal property loans were calculated and interest payments were used as a cost in calculating the annual net return to the owner's management and equity.

Cash Flow with Polygon 24

The before tax annual net cash flow is the cash inflow minus the cash outflow. This is the cash received from milk and livestock sales minus cash paid for operating costs and debt service. Any family cash withdrawals or income tax payments are not included.

Net Returns with Polygon 24

The before tax annual net return to the owner's management and equity is revenue from milk and livestock sales minus operating costs, depreciation and interest on borrowed investment capital. The before tax annual net return to management and investment is revenue from milk and livestock sales minus operating costs and depreciation only.

Rates of Returns with Polygon 24

The rate of return on equity is the return on management and equity divided by the equity. The rate of return on investment is the return on management and investment divided by the total investment.

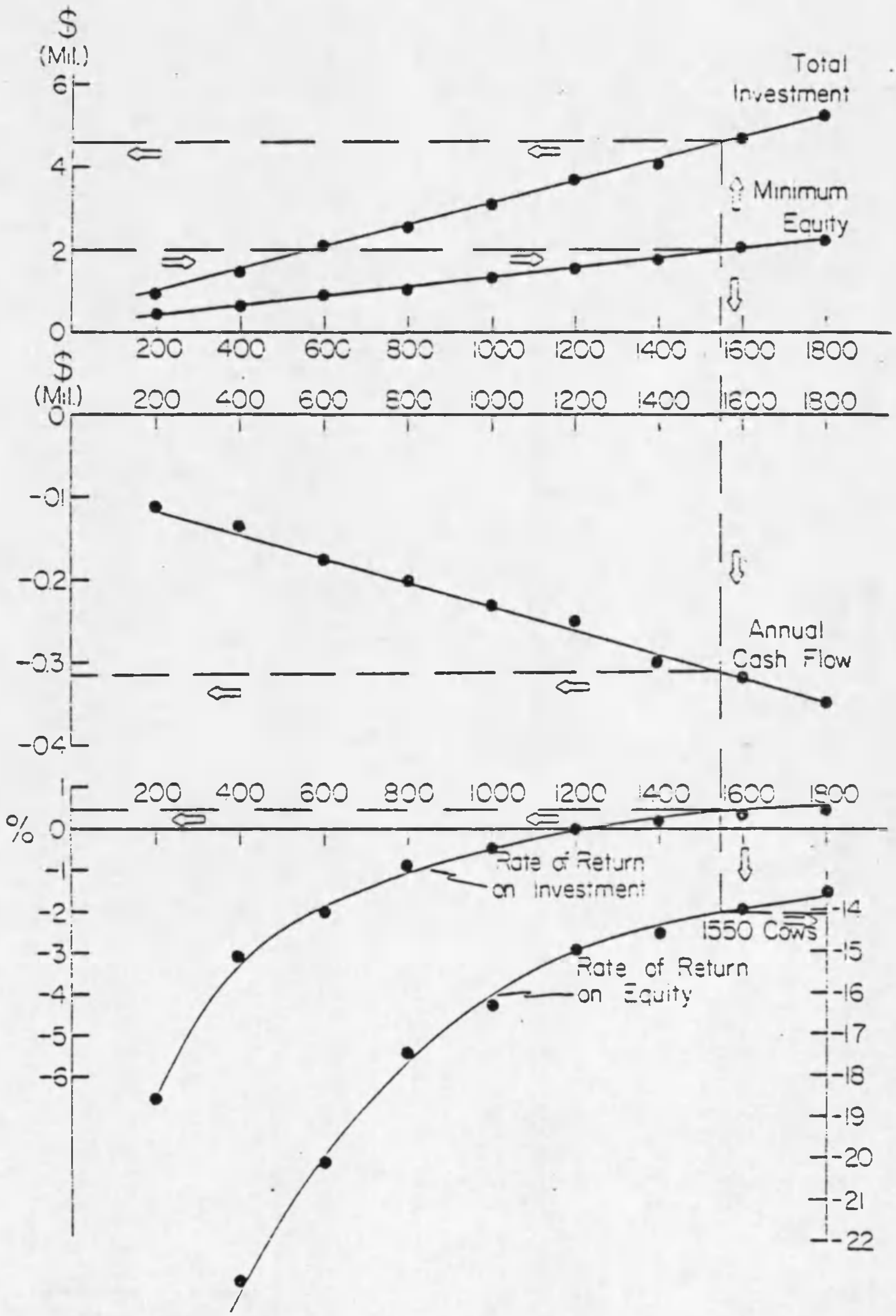


Figure 13. Evaluation of raised replacements, 2X/day milking, no milk base.

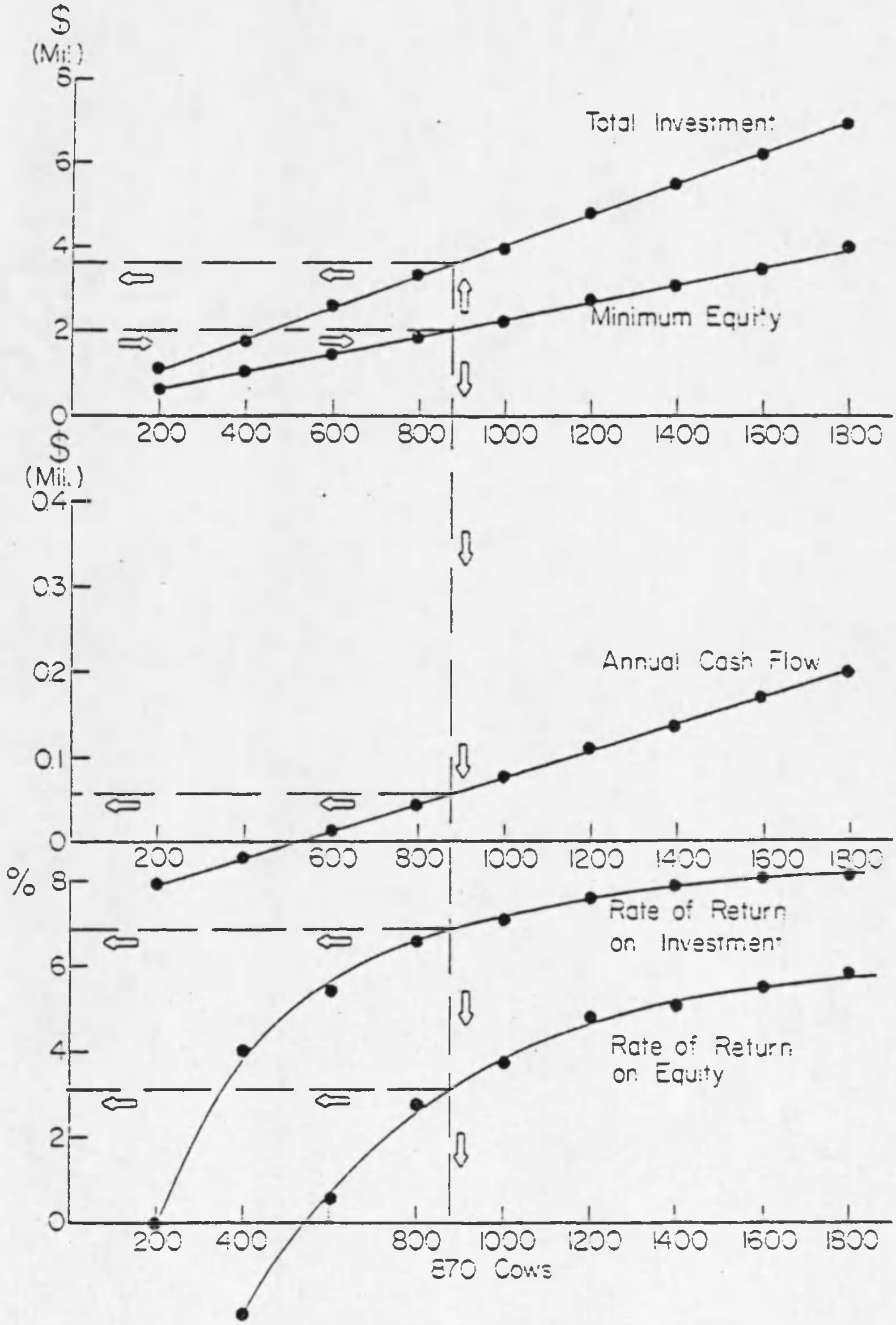


Figure 14. Evaluation of raised replacements, 2X/day milking, sufficient milk base.

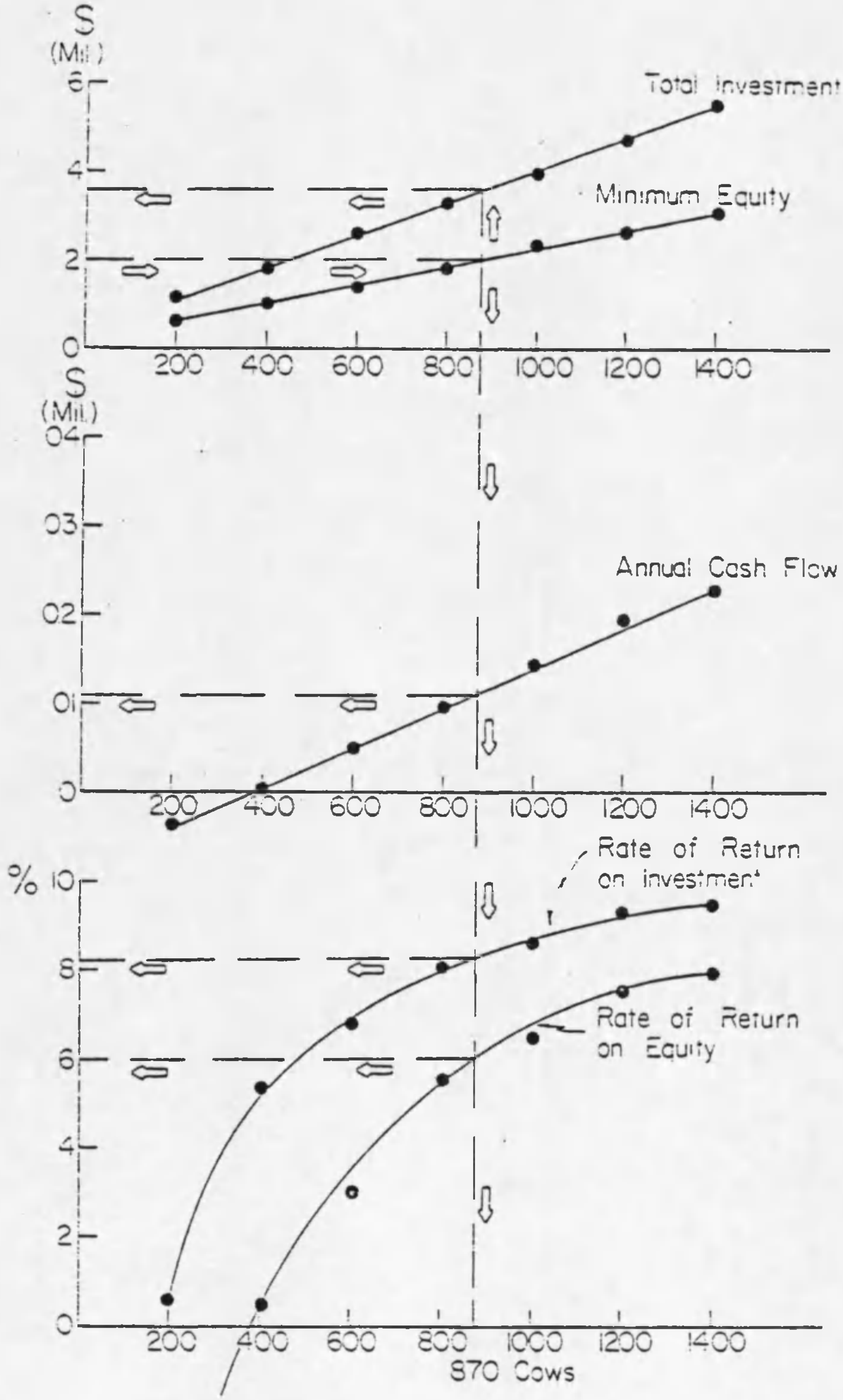


Figure 15. Evaluation of raised replacements, 3X/day milking, no additional milk base for production increase.

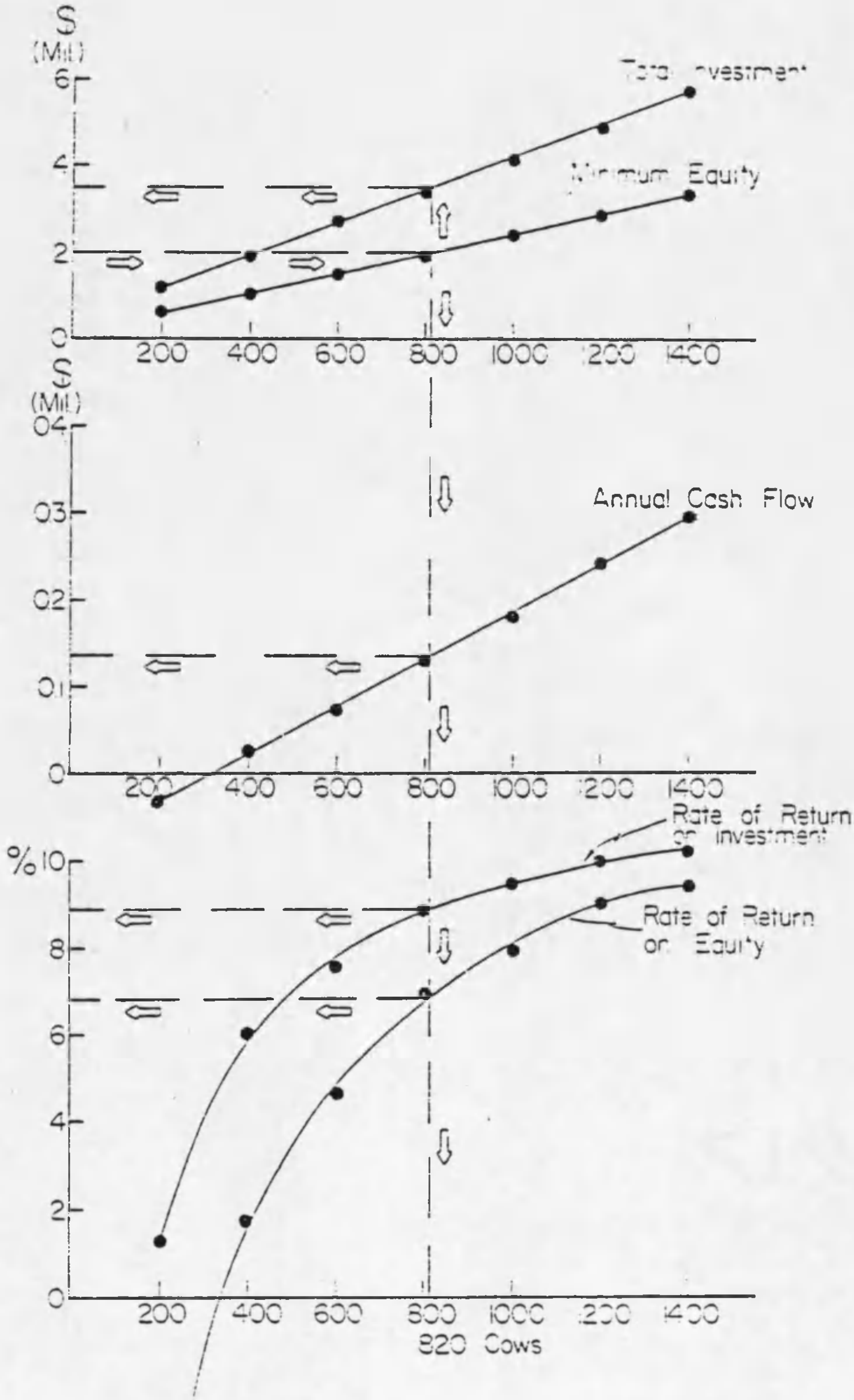


Figure 16. Evaluation of raised replacements, 3X/day milking, sufficient milk base.

Raised Replacements

Figures 13 to 16 are the graphs developed to evaluate the mechanized Polygon 24 milking parlor with raised replacements, different milking frequencies and different levels of milk base. The net returns, cash flows, and rates of returns are based on revenues and costs pertinent to a dairy operation that is raising calves and heifers for replacement stock. All heifer calves are raised and those springer heifers not needed to replace the 30% annual cull and 3% mortality in the milking herd are sold. Revenues and costs are as indicated in Tables 9 and 10.

Figure 13 is the series of three graphs developed to evaluate a dairy operation with raised replacements that is milking 2X/day with typical annual milk production of 15,250 lbs of 3.5% milk per cow, with no milk base. Most Arizona dairymen market their milk through the UDA and those who haven't earned or purchased milk base must accept the lower "over-quota" price for milk sales. As indicated in Figure 13 the lower milk price makes an option without milk base infeasible. With a $2 million equity and no investment in milk base the herd size is 1,550 cows. Regardless of herd size, the operation would be infeasible because the annual cash flow is negative at all herd sizes and is decreasing with size.

Figure 14 is the series of three graphs developed to evaluate the same dairy operation as in Figure 13 with sufficient milk base possessed so that the 15,250 lbs. annual milk production per cow is marketed at the higher "quota" price. In this case there is investment in milk base and so the herd size with a $2 million equity is reduced to 870 cows. This option is feasible since there is a projected positive $50,000 net annual cash flow for family living and income taxes. The rates of returns are low at the initial

Table 9. Revenues.

Milk Sales per Cow per Year

Production Situation	Dollars/Cow[a]
2X/day milking 15,250 lb. annual production No Milk base possessed Over quota price ($10.50/cwt)	1,601.25
2X/day milking 15,250 lb. annual production Sufficient milk base possessed Quota price ($12.50/cwt)	1,906.25
3X/day milking 17,537.5 lb. annual production[b] No additional milk base[c] 152.5 cwt @ quota price ($12.24)[d] 22.875 cwt @ over quota price ($10.24)[d]	2,100.84
3X/day milking 17,537.5 lb. annual production[b] Sufficient milk base Quota price ($12.24)[d]	2,146.59

Livestock Sales per Cow per Year

	Raised Replacements	Purchased Cows	Leased Cows
Calf Sales[e]			
Heifer[f] @ $100		47.5	47.5
Bull[f] @ $ 50	23.75	23.75	23.75
Heifer Sales[g]			
Springer @ $1200	88.33		
Cull Sales			
Heifer[h] @ $.50/lb.	7.63		
Cows[i] @ $.50/lb.	195.00	195.00	
Dead Sales[i]			
Heifer @ $25	.33		
Cows @ $25	.75	.75	.75
Total	315.79	267.00	72.00

[a]Raised, purchased and leased cows.

[b]15% increase in production with 3X/day milking.

[c]No milk base acquired for 15% increase in production.

[d]Milk prices adjusted - $.26 for decrease in butterfat associated with 15% increase in production.

[e]50% heifer and 50% bull calves born.

[f]5% calves born dead or deformed

[g]Mortality Rates: calves 0-12 mo. 8%; yearlings 13-24 mo. 3%; cows 24 mo. + 3%.

[h]Sterility rate 4%.

[i]Cull rate 30%.

Table 10. Operating costs.

	Herd Size[a]					
	0-500	500-900	900-1,300	1,300-1,500	1,500-1,700	1,700-1,900
Polygon 24 Parlor Equipment and Mechanization[b]						
Depreciation	18,135	18,135	18,135	18,135	18,135	18,135
Taxes	3,663	3,663	3,663	3,663	3,663	3,663
Insurance	1,610	1,610	1,610	1,610	1,610	1,610
Repairs & Main.	13,955	13,955	13,955	13,955	13,955	13,955
Wells, Water Storage Waste Disposal & Machinery						
Depreciation	15,426	20,826	24,518	29,656	31,870	34,870
Taxes	1,652	2,120	2,509	2,954	3,318	3,578
Insurance	1,299	1,839	2,147	2,662	2,734	3,034
Repairs & Maint.	15,784	21,544	25,336	30,816	32,808	36,008

Table 10--Continued.

Per Cow Costs that Do Not Vary with Milk Production

	Raised Replacements	Purchased Cows	Leased Cows
Depreciation[c]	48.85	34.00	34.00
Taxes[d]	16.25	13.60	5.80
Insurance[e]	11.32	7.60	7.60
Repairs and Maint.[f]	22.70	16.50	16.50
Fuel	25.00	22.00	22.00
Utilities	26.00	20.00	20.00
Labor	140.00	100.00	100.00
Breeding	15.00	15.00	15.00
Veterinary	7.50	7.50	7.50
Forage and Youngstock Feed	841.00	530.00	530.00
Cow Purchase		400.00	
Cow Lease			576.00
Mortality Replacement			36.00
Total	1,153.62	1,166.20	1,370.40

Per Cow Costs that Vary with Milk Production

2X/day milking 15,250 lb. annual production	Dollars/cow[g]
Feed concentrate	482.60
Milk hauling	36.60
Coop. fees	36.60
Supplies	43.00
Production testing	10.20
Milking[j]	59.00 - 99.00

Table 10--Continued.

3X/day milking 17,537.5 lb. annual production[h]	Dollars/cow[g]
Feed concentrate[i]	548.40
Milk hauling	42.09
Coop. fees	42.09
Supplies	64.00
Production	11.52
Additional Utilities	10.00
Milking labor[j]	83.00-138.00

[a]Same costs for raised, purchased and leased cows.

[b]Same costs regardless of herd size.

[c]Calf pens, corrals, cool shades.

[d]Calf pens, corrals, cool shades, cattle, land.

[e]Calf pens, cool shades, feed inventory.

[f]Calf pens, corrals, cool shades.

[g]Same costs for raised, purchased and leased cows.

[h]15% increase with 3X/day milking.

[i]One pound additional concentrate per 2.5 pounds additional milk production.

[j]Milking labor costs vary with herd size:

$$MLC = WR \times NM \times LH \times 365$$

where: WR = hourly wage rate
NM = number of milkers
LH = labor hours per day

and: $$LH = MF \left[\frac{CM}{SST} + CT + ST + \frac{CM}{100} (MT) \right]$$

MF = milking frequency
CM = number milk cows
SST = steady state troughput
CT = clean up time
ST = set up time
MT = movement time of 100 cows

870 cow herd size but are acceptable at the technical capacity of the milking parlor.

Figure 15 is the series of three graphs developed to evaluate the $2 million equity investment in a dairy operation with raised replacements that is milking 3X/day with a 15% increase in milk production to 17,537.5 lb. per cow. With this production increase the quality of milk is lessened to 3.3% butterfat and the milk price is adjusted accordingly. No additional milk base is added so 15,250 lb. of milk is marketed at the higher "quota price" and the 15% increase (2,287.5 lb.) resulting from 3X/day milking is marketed at the lower "over-quota price". Since there is no additional investment for milk base with this option the herd size is 870 cows, the same as the previous option. This dairy operation is feasible with approximately $113,000 net annual cash flow for family living and income taxes. The rates of returns are acceptable at the initial 870 cow herd size and would be even better at the technical capacity of the parlor.

Figure 16 is the series of three graphs developed to evaluate a dairy operation with raised replacements that is milking 3X/day with a 15% increase in production and sufficient milk base possessed so that all milk is sold at the higher "quota price". The additional investment in milk base reduces the initial herd size to 820 cows. This option is the best possible with raised replacements.

Table 11 summarizes the results determined from the series of graphs. Three X/day milking of 820 cows projects the highest annual net cash flow and the highest rates of returns. Additionally, this option projects the most profitable operation at the technical capacity of the Polygon 24 milking parlor with raised replacements. The rate of return.

Table 11. Raised replacements: Characteristics with $2 million equity investment.

Dairy Operation	Herd Size	Net Cash Flow	% Return on Investment[a]	% Equity	% Return on Equity[a]
	No.	$	%	%	%
3X/day Milking and Sufficient Milk Base	820	135,000	8.9	57	7.0
3X/day Milking Without Added Milk Base for Increased Production	870	113,000	8.3	56	5.9
2X/day Milking Sufficient Milk Base	870	50,000	6.9	56	3.1
2X/day Milking No Milk Base	1,550	-315,000	0.3	43	-14.1

[a] Average annual interest rate on borrowed capital ranges from 11.4% to 11.6%. This is greater than the rate of return on investment, therefore this rate of return on investment is greater than the rate of return on equity. ($r_I < i \therefore r_E < r_I$)

on investment because the rate of return on investment is less than the average interest rate paid on borrowed money ($r_I < i$ therefore $r_E < r_I$).

Purchased Replacements

Figures 17 to 20 are the graphs developed to evaluate the mechanized Polygon 24 milking parlor with purchased replacements, different milking frequencies and different levels of milk base possessed. The net returns, cash flows, and rates of returns are based on revenues and costs pertinent to a dairy operation that is not raising any heifers, but instead is selling all calves and purchasing all replacement cows. One third of the milking herd is purchased annually to replace the 30% cull and 3% mortality. Revenues and costs are as indicated in Tables 9 and 10.

Figure 17 is the series of three graphs developed to evaluate a dairy operation with purchased replacements that is milking 2X/day with typical annual milk production of 15,250 lbs. of 3.5% bf milk per cow and no milk base. With no investment in milk base, there is unused equity at the technical capacity of the Polygon 24 milking parlor. This is not a feasible option because the net annual cash flow and the rates of returns at all herd sizes is negative.

Figure 18 is the series of three graphs developed to evaluate the same operation as Figure 16 with sufficient milk base possessed so that the milk is sold at the higher "quota price". With investment in milk base, but no investment in youngstock or youngstock facilities, the herd size is 1,025 cows. This operation is feasible with $90,000 projected net annual cash flow available for family living and income

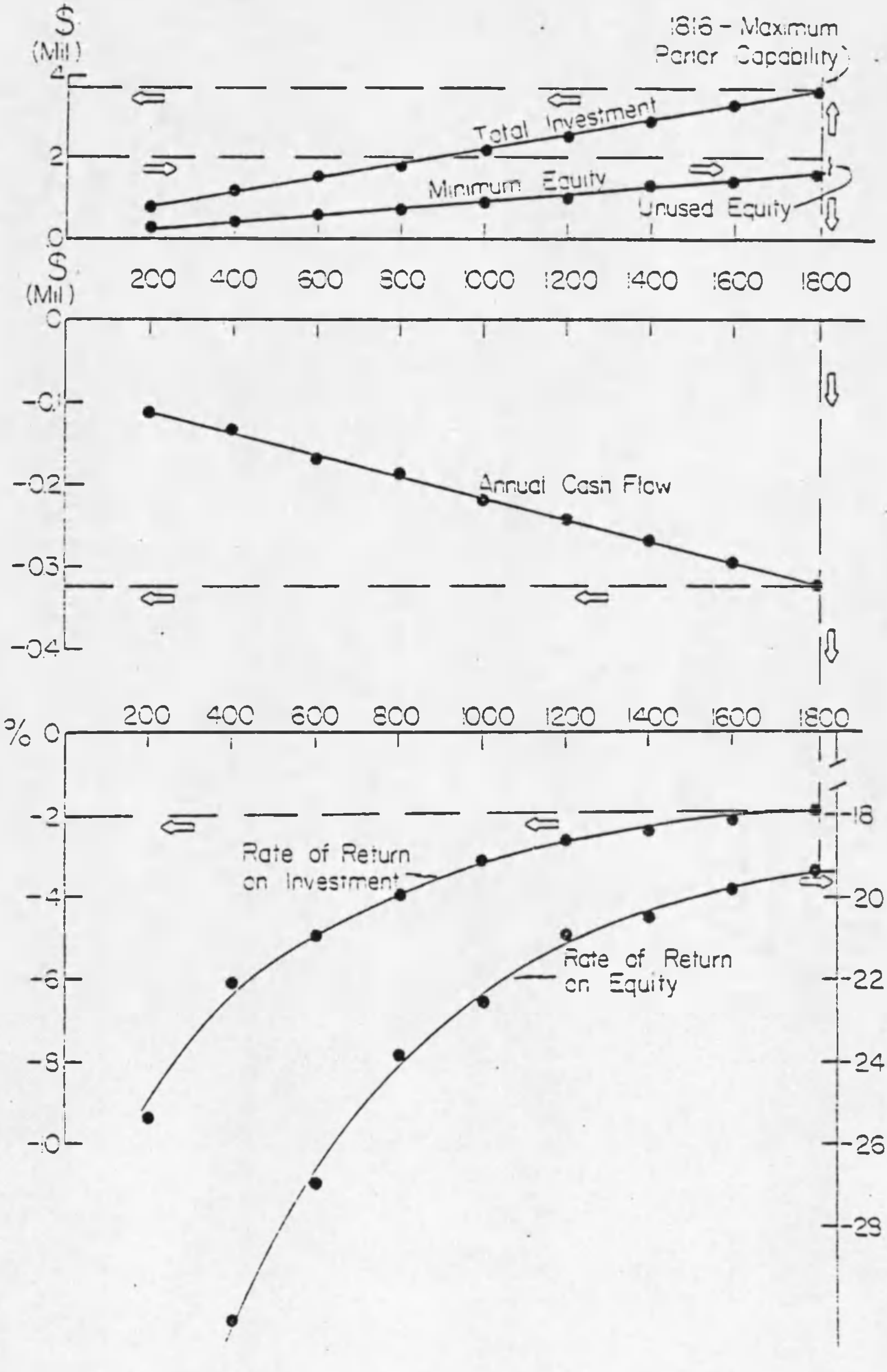


Figure 17. Evaluation of purchased replacements 2X/day milking, no base.

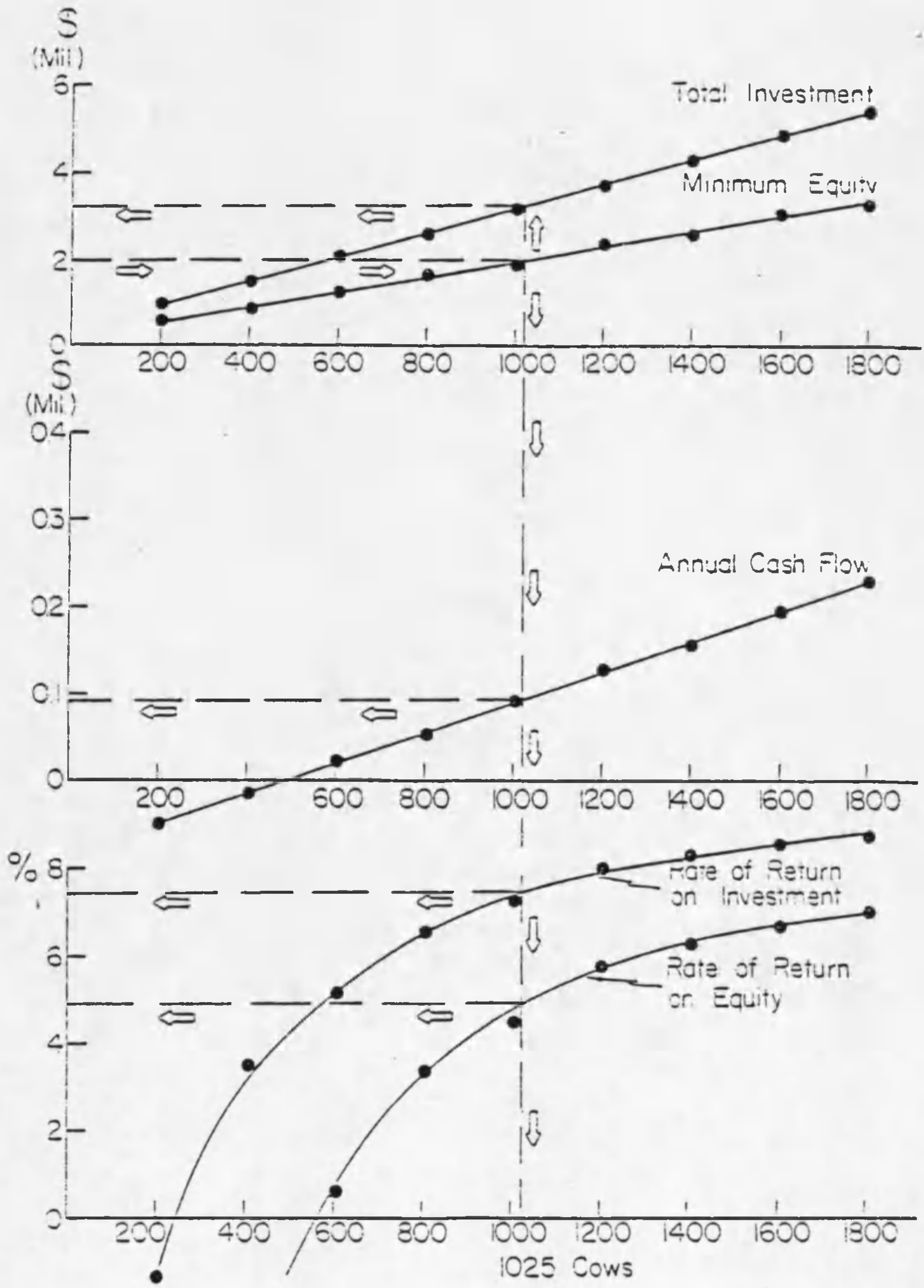


Figure 18. Evaluation of purchased replacements 2X/day milking, sufficient milk base.

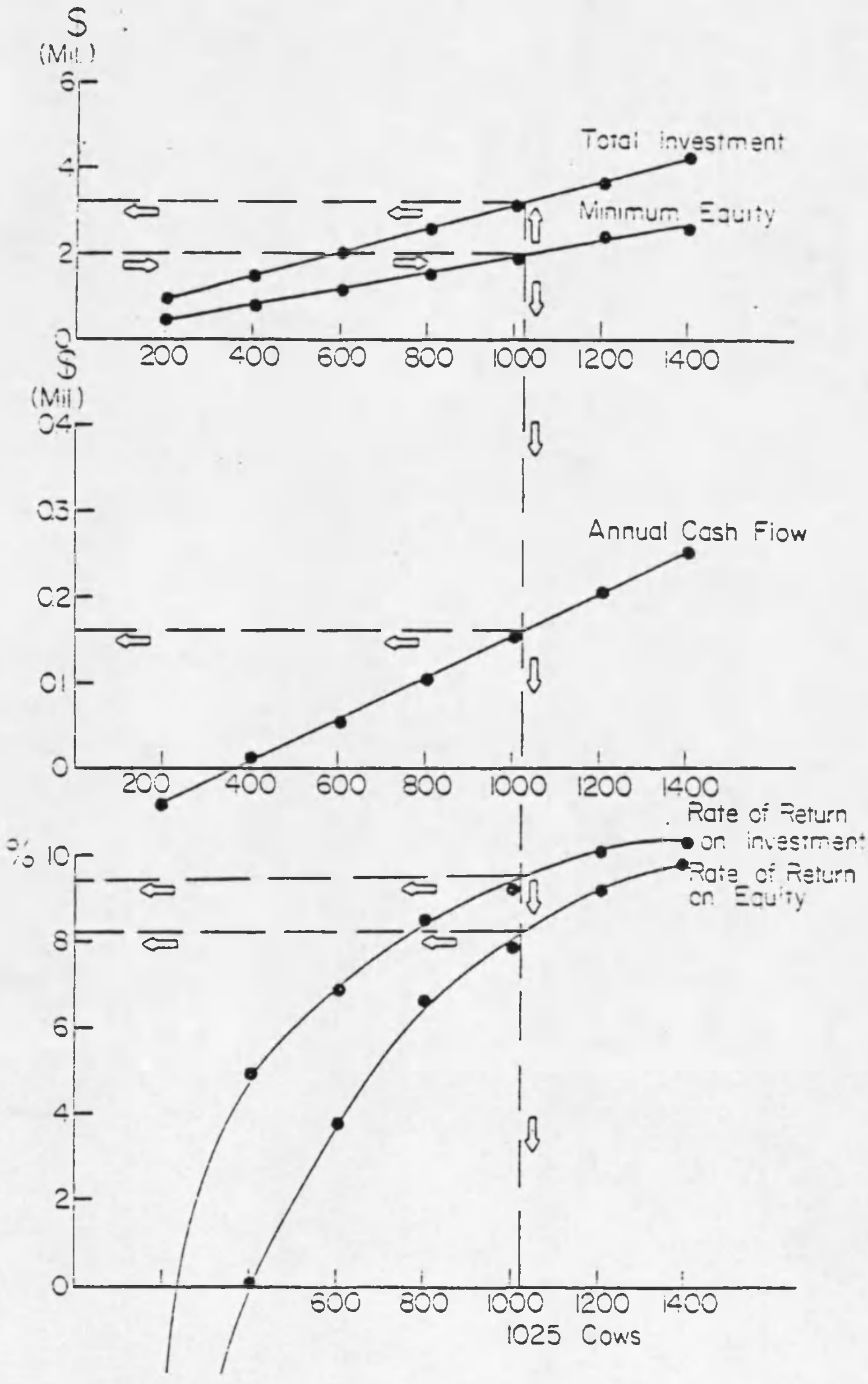


Figure 19. Evaluation of purchased replacements, 3X/day milking, no additional milk base for production increase.

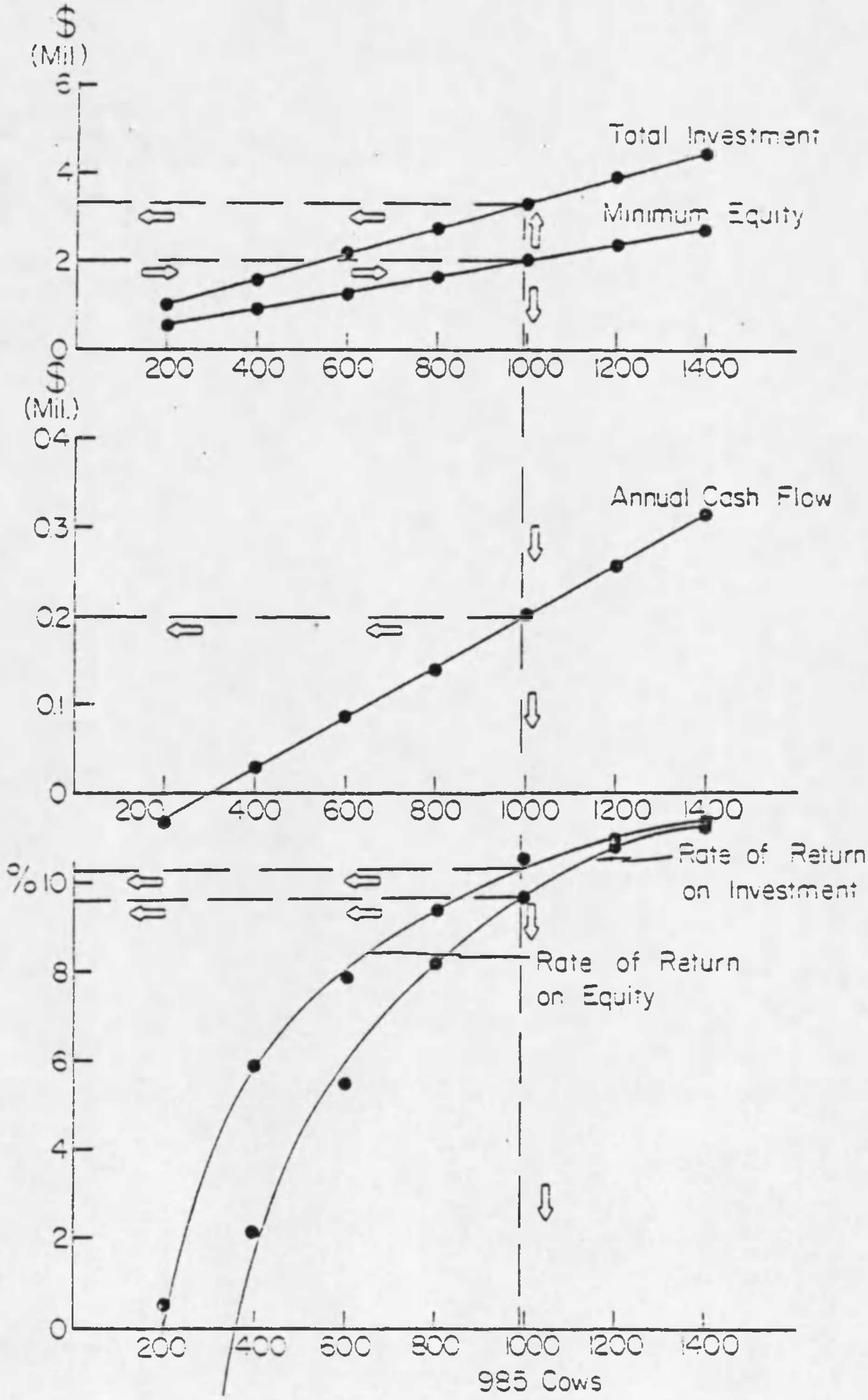


Figure 20. Evaluation of purchased replacements, 3X/day milking, sufficient milk base.

tax. The initial rate of returns are low but the projection is for acceptable rates of returns at the technical capacity of the Polygon 24.

Figure 19 is the series of three graphs developed to evaluate the $2 million equity investment in a dairy operation with purchased replacements that is milking 3X/day with a 15% increase in milk production to 17,537.5 lb. per cow. With this increase in production the quality of milk is changed to 3.3% butterfat and the price is adjusted accordingly. A total of 15,250 lbs./cow is marketed annually at the "quota" price and the 15% increase (2,287.5 lbs.) resulting from 3X/day milking, is marketed at the "over quota" price. Since there is no additional investment for milk base with this option, the herd size is 1,025 cows, the same as the previous operation with 2X/day milking. This dairy operation is feasible with $160,000 net annual cash flow available for family living and income tax. The rates of returns are good at this initial herd size and the projection is for very good rates of return at technical capacity of the milking parlor.

Figure 20 is the series of graphs developed to evaluate a dairy operation with purchased replacements that is milking 3X/day with a 15% increase in production with sufficient milk base possessed so that all milk is sold at the higher "quota" price. The additional investment in milk base reduces the initial herd size to 985 cows. This option is the best possible with purchased replacements.

Table 12 compares the options with purchased replacements. 3X/day milking of 985 cows projects the highest net annual cash flow and the highest rates of returns. Additionally, this option projects the

Table 12. Purchased replacements: Characteristics with $2 million equity investment.

Dairy Operation	Herd Size	Net Cash Flow	% Return on Investment[a]	% Equity	% Return on Equity[a]
	No.	$	%	%	%
3X/day Milking and Sufficient Milk Base	985	200,000	10.4	60	9.5
3X/day Milking Without Added Milk Base for Increased Production	1,025	160,000	9.4	61	8.2
2X/day Milking Sufficient Milk Base	1,025	90,000	7.4	61	4.8
2X/day Milking No Milk Base	1,816	-320,000	-1.9	44	-19.4

[a]Average annual interest rate on borrowed capital ranges from 11.4% to 11.6%. This is greater than the rate of return on investment, therefore this rate of return on investment is greater than the rate of return on equity ($r_I < i \therefore r_E < r_I$).

most profitable operation when herd expansion is completed to the technical capacity of the Polygon 24 milking parlor.

Leased Cows

Figures 21 and 22 are developed to evaluate the mechanized Polygon 24 milking facility with leased cows milked 2X/day and 3X/day. The net returns, cash flows and rates of returns are based on revenues and costs pertinent to a dairy operation that is leasing cows. The lease costs used here are those offereed in 1979 by the Dairy Farm Leasing Company in Minneapolis, Minnesota. The rates are $4.00 per month per $100 cost of cow on a 36 month lease. At the end of the 36 months the cows are returned to the lessor or may be purchased at fair market value. Offspring belong to the lessee. The revenues and costs are as indicated in Tables 9 and 10.

Figure 21 is the series of three graphs developed to evaluate a dairy operation with leased cows that is milking 2X/day with typical milk production of 15,250 lbs. of 3.5% of butterfat milk per cow. Milk base is possessed so that all milk is marketed at the higher "quota" price. A $2 million equity investment would accommodate a 1,550 cow herd; however, this option is not feasible since the annual net cash flow is negative and decreasing at all herd sizes.

Figure 22 is the series of three graphs developed to evaluate a dairy operation with leased cows that is milking 3X/day with a 15% increase in production to 17,537.5 lbs. per cow and sufficient milk base possessed so that all milk is sold at the "quota" price as adjusted for the decrease in butterfat. The additional investment in milk base

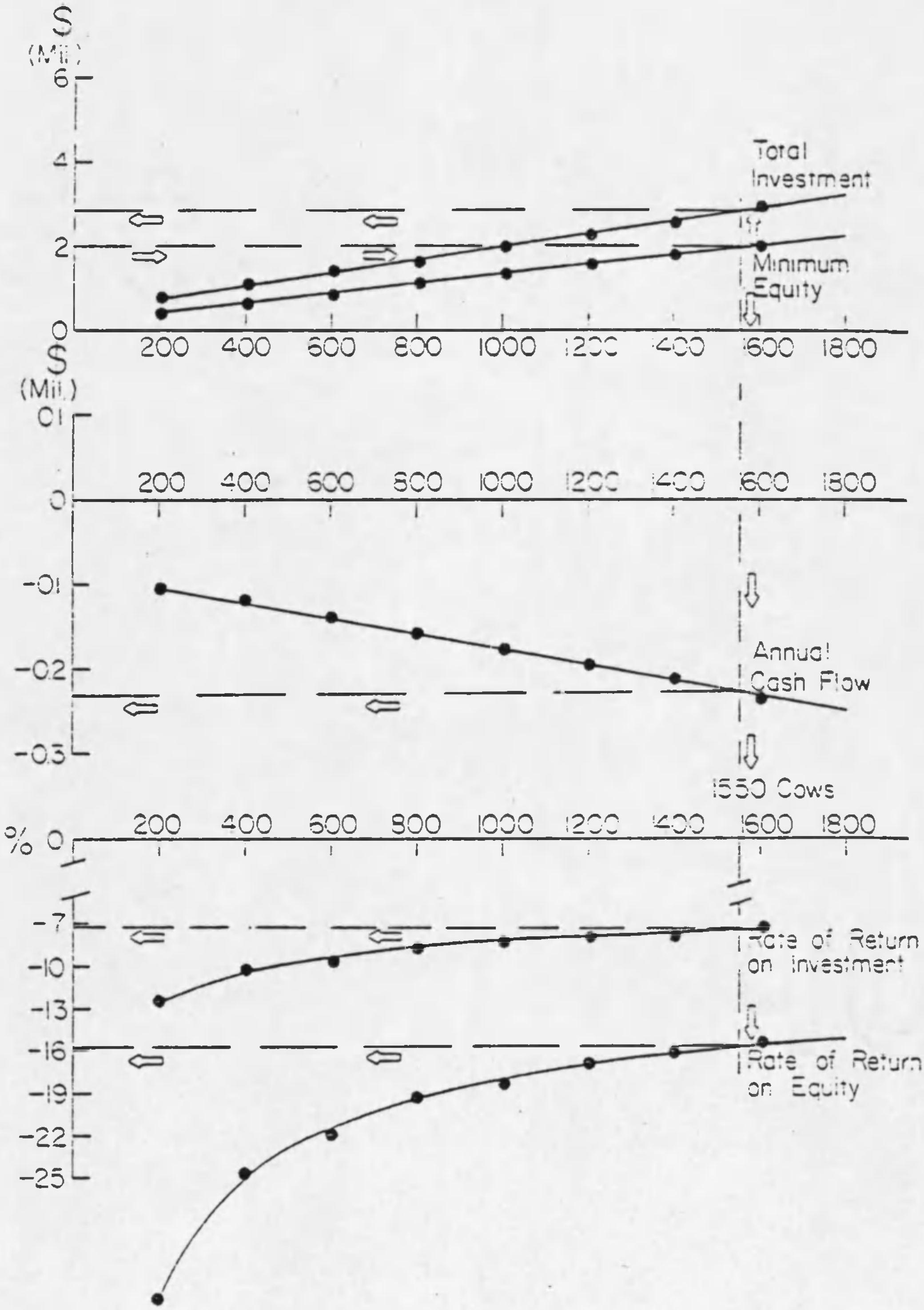


Figure 21. Evaluation of leased cows 2X/day milking, sufficient milk base.

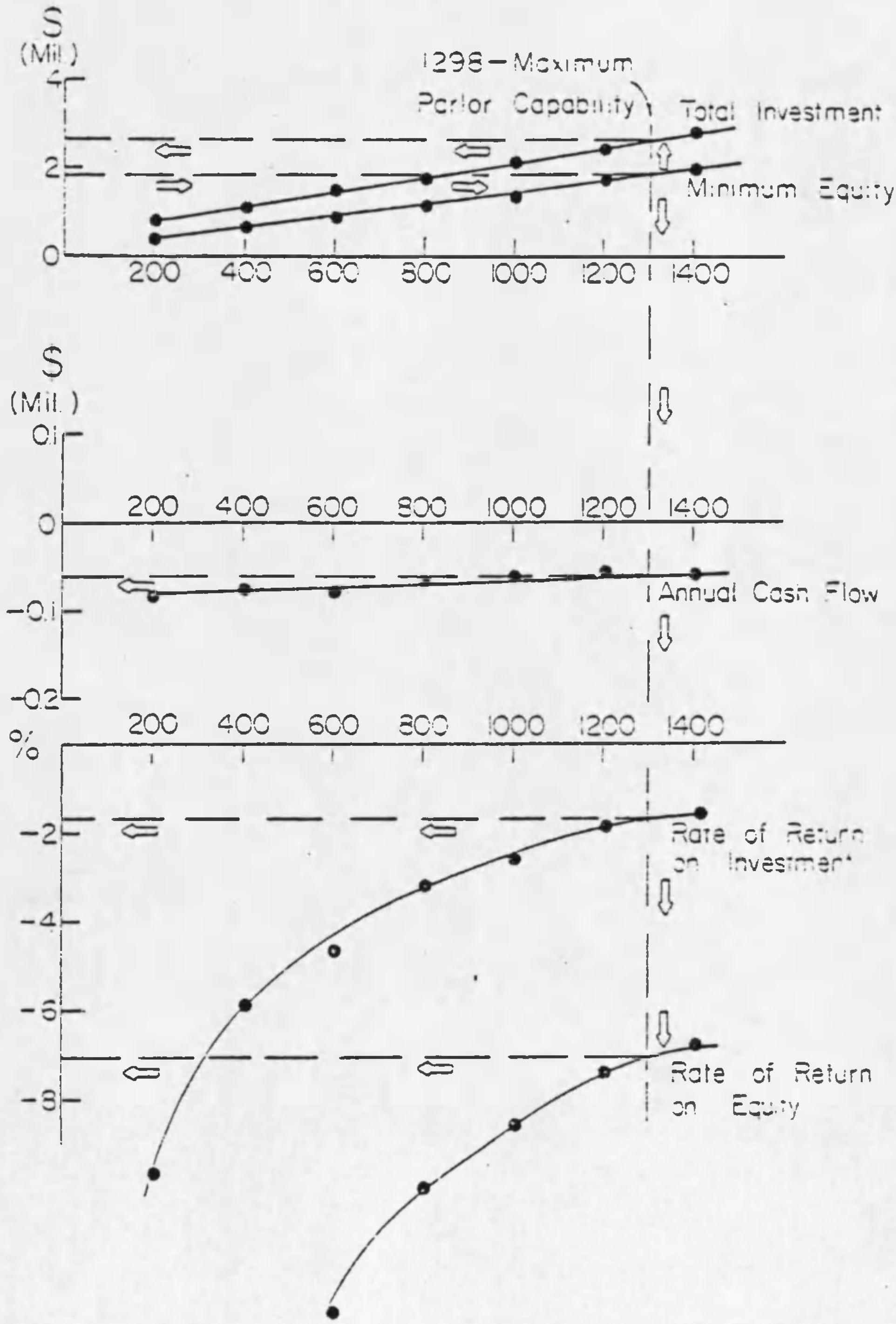


Figure 22. Evaluation of leased cows 3X/day milking, sufficient milk base.

reduces initial herd size to 1,420 cows; however, this option is not feasible at any herd size since the annual net cash flow is negative at all herd sizes.

Several options with leased cows and various production levels were examined. The option depicted in Figure 22 was the best of the attainable production levels. Since none of the leased cow options are feasible, these options are discarded.

Dairymen are leasing cows in small numbers to fill out their herds and avoid unused facilities. It is illogical that they would lease unless the return per cow was more than enough to cover all costs including the high lease costs. Nevertheless, information here indicates that leasing entire herds at attainable production levels is not feasible because of high lease costs.

Purchased Versus Raised Replacements

The evaluations of raised, purchased or leased cows, each with 2X/day and 3X/day milking; and, each of these with two levels of milk base, revealed six feasible dairy operations at the initial herd size as constrained by the $2 million net worth. The characteristics of these six feasible operations are summarized in Table 13. The 3X/day milking frequency provides higher rates of return on investment and on equity than similar operations with 2X/day milking frequency.

The necessity of milk base was clearly indicated in the evaluations. Those options without milk base were not feasible. Acquisition of milk base can be a problem. Milk base requirements range from 36,350 lbs. for the 870 cow herd with raised replacements to 47,237 lbs. for

Table 13. Evaluation of feasible dairy operations with Polygon 24 parlor.

Projected Decision Factors	Raised Replacements: 2X/day milking 15,250 lb 50 lb base	Raised Replacements: 3X/day milking + 15% 50 lb base	Raised Replacements: 3X/day milking + 15% 57.5 lb base	Purchased Replacements: 2X/day milking 15,250 lb 50 lb base	Purchased Replacements: 3X/day milking + 15% 50 lb base	Purchased Replacements: 3X/day milking + 15% 57.5 lb base
At initiation of expansion						
Herd size	870	870	820	1,025	1,025	985
Net cash flow	$50,000	$113,000	$135,000	$90,000	$160,000	$200,000
Rate of Return to Investment	6.9%	8.3%	8.9%	7.4%	9.4%	10.4%
Rate of Return to Equity	3.1%	5.9%	7.0%	4.8%	8.2%	9.5%
At completion of expansion						
Herd size[a]	1,800	1,300	1,300	1,800	1,300	1,300
Net cash flow	$200,000	$208,000	$265,000	$230,000	$225,000	$285,000
Rate of Return to Investment	8.2%	9.4%	10.2%	8.8%	10.3%	11.2%
Rate of Return to Equity	5.8%	7.8%	9.2%	7.1%	9.5%	11.1%

[a]Technical capacity of milking parlor

the best dairy operation with purchased cows milked 3X/day. In 1979, the maximum base that could be earned during the base earning period was 65% of average milk produced per day; or, 65% of the daily production of the average UDA producer (9,784 lbs.), whichever is less. So milk base would have to be purchased from a UDA member going out of business. An increase in milk base possessed at or near the same rate as herd expansion is crucial to the profitability of the expansion.

The projection that a dairy operation using purchased cows is more profitable than one raising replacements is at variance with the current situation where most Arizona dairymen raise replacements. The budgets generated as a basis for the net returns and cash flows used replacement cow prices of $1,200.00 which is the average spring 1979 price for a young cow or springer heifer capable of producing 15,250 lbs. in 305 days. This is a high price that seemed to be inflated during spring 1979, because of high beef prices. Nevertheless, even with high cow prices and one third of the herd replaced annually, the purchased cow option is more profitable, with all other alternatives unchanged.

CHAPTER 6

ANALYSIS OF MILKING FREQUENCY

Logan et al. (1978) determined the break even production increase at 8% to 12% when changing to 3X/day milking frequency without additional investment in cows or facilities (Table 3 and Table 4). The evaluation of alternatives with a polygon 24 milking parlor, discussed in Chapter 5, showed that with a fixed level of equity contribution, the 3X/day milking frequency increased annual net cash flow and rates of returns when 3X/day milking results in a 15% milk production increase. The analysis by Logan et al. and in Chapter 5 both assumed no change in milking parlor. This chapter will extend the analysis to determine the optimum milking frequency when initiating investment, i.e., "is it better to invest in a smaller milking parlor and more cows, planning 2X/day milking; or, to invest in a larger parlor and fewer cows, planning 3X/day milking?". An early decision on this alternative is necessary since less land, cows and corrals are needed with the 3X/day milking frequency.

The analysis that follows entails three different comparisons of dairy operations. First is the comparison of two dairy operations, similar to that of Logan et al., with the same milking parlors and the same number of cows. One is a 16-hour operation milking 2X/day and the other is a 24-hour operation milking 3X/day. The second comparison is of four dairy operations, all are 24-hour operations with two milking

2X/day and two milking 3X/day. Each 2X/day operation is compared with the 3X/day operation of approximately equal investment. These comparisons are similar to those in Chapter 5, except different milking parlors are compared here, and equal investment is assumed rather than equal equity. The third comparison is of two dairy operations with the same milking parlors operating 24 hours daily. One is milking 2X/day and the other is milking fewer cows 3X/day, so that the 2X/day operation involves a greater total investment.

Synthetic budgets were used to evaluate and compare the different dairy operations. These budgets were developed using the Drylot Dairy Budget Generator in the University of Arizona DEC 10 Computer. Assumptions for these budgets are:

1. 1979 cost/price ratios,
2. 15,250 lb/cow herd average with 15% increase achieved via 3X/day milking frequency,
3. Milk price adjusted to compensate for butter fat decrease from 3.5% for 2X/day milking to 3.3% with 3X/day milking frequency,
4. Additional concentrate for cows on 3X/day milking at the rate of 1 lb concentrate per 2.5 lb milk increase, and
5. Raised replacements.

Comparison of Dairy Operations Having the Same Total Investments, Herd Sizes, Facilities and Milking Parlors; But, Different Milking Frequencies and Parlor Usage

The dairy operations in this comparison each have a 718 cow herd of typical production (Table 5), and a Trigon 18 milking parlor. One milks cows 2X/day in 16 hours and the other milks 3X/day in a 24-hour period. Table 14 shows the total investment for each operation. Additional investment in milk base is required for the 3X/day operation if the increase in milk production is sold at the UDA "quota" price.

Table 15 is the summary of returns and costs for each dairy operation. The returns for milk sales are based on the "quota" price with a price adjustment for the 3X/day operation as necessary for the anticipated 0.2% decrease in butterfat. As shown the 3X/day operation has an increased net return of $71,300 or approximately $100 per cow with milk base possessed so as to receive the "quota" price. If the additional milk base was not possessed and the lower "over-quota" price was received for the milk production increase, the milk sales and net return for the 3X/day operation would be reduced by $32,847. The net return for the 3X/day operation, without additional milk base, would be $195,670. This is an increase of only $38,460 over the 2X/day operation or an increase of approximately $54 per cow.

Table 14 shows that the additional milk base for the 15% milk production increase with 3X/day is valued at $103,500. If 12% interest cost was added to the 3X/day operation for this additional investment the net return would be decreased $12,420 (.12 X $103,500). This decrease would give the 3X/day operation a net return of $216,096 or $58,886 higher than the 2X/day operation. Table 16 summarizes the returns possible with these options.

This comparison clearly indicates that 3X/day milking is more profitable if a 15% increase in production is achieved. It is important to know the percentage increase in production that is necessary with 3X/day milking to break even.

Table 14. Investment: Trigon 18 parlor, 718 cow herd.

Investment Item	Dollar Value
Parlor	$79,740
Equipment	63,200
Mechanization	28,420
Cooling/Standby Equipment	23,020
Calf Facilities	38,200
Corrals	258,900
Cool Shades	108,000
Wells-Waste	60,400
Machinery	103,802
Cattle	1,335,350
Land/Excavation	330,200
Total Investment Without Milk Base	2,429,232
Milk Base Investments:	
2X/day	690,000
$\left[\frac{(50\ \text{lb/cow})(305\ \text{days})}{365} \times \$23/\text{lb} \times 718\ \text{cows}\right]$	
3X/day	793,500
$\left[1.15 \times \frac{(50\ \text{lb/cow})(305\ \text{days})}{365} \times \$23/\text{lb} \times 718\ \text{cows}\right]$	

Table 15. Summary of returns and costs with 718 cow herd, 2X/day and 3X/day milking.

	718 Cows, 2X/day		718 Cows, 3X/day	
	Amounts	Per Cow	Amounts	Per Cow
Returns				
Milk Sales[a]	1,368,688	1,906	1,541,250	2,146
Livestock Sales	22,675	31	22,675	31
Non Cash Revenue (Replacement Heifers)	349,200	486	349,200	486
Costs				
Herd Replacement	173,595	242	173,595	242
Depreciation	71,510	100	71,510	100
Property Taxes	16,311	23	16,311	23
Insurance	11,715	16	11,715	16
Repairs & Maintenance	48,977	68	48,977	68
Fuel & Oil	21,952	30	21,952	30
Op. Capital Interest	9,000	12	9,000	12
Feed	949,914	1,323	998,284	1,390
Wages & Salaries	155,806	217	176,599	246
Hauling	25,848	36	30,220	42
Co-op Fees	25,848	36	30,220	42
Utilities	18,668	26	25,848	36
Supplies	30,874	43	45,952	64
Breeding	10,770	15	10,770	15
Production Testing	7,180	10	8,271	11
Veterinary	5,385	7	5,385	7
Pretax Returns				
Total Returns	1,740,563	2,424	1,913,125	2,664
Total Costs	1,583,353	2,205	1,684,609	2,346
Net Returns	157,210	219	228,516	318

[a]Milk sold at "quota" price.

Table 16. Summary of net returns with 718 cow herd; 2X/day and 3X/day milking.

Trigon 18 718 Cows	Net Returns Total	 Per Cow
Milk base possessed, Milk sold @ "quota" price	$	$
2X/day	157,210	219
3X/day	228,516	318
difference	+ 71,306	+ 99
No additional milk base Increased milk production sold @ "over quota" price		
2X/day	157,210	219
3X/day	195,670	273
difference	+ 38,460	+ 54
Additional milk base purchased, 12% interest cost added Milk sold @ "quota" price		
2X/day	157,210	219
3X/day	216,096	301
difference	+ 58,886	+ 82

Break Even Calculations

The partial budgeting methodology and worksheet developed by Logan et al. is used to calculate the break even percent milk production increase necessary with a change to 3X/day milking of a 718 cow herd in a Trigon 18 milking parlor.

Worksheet I. Change in revenue due to 3X/day milking

A. Net milk price/cwt:

	Current average	3X/day @ quota price
Milk price/cwt.	$12.50	$12.50
Less fat adjustment/cwt.	- .00	- .26
Less hauling fees/cwt.	- .24	- .24
Less co-op fees/cwt.	- .24	- .24
Equals net milk price/cwt.	$12.02	$11.76

B. Revenue from added production:

Current annual milk production		109,495 cwt.
Times proportional increase due to 3X milking	X	.15
Equals increased production	=	16,424 cwt.
Times price/cwt. for added production (See section A above)	X	11.76
Equals revenue from added production	=	$193,146

C. Reduced revenue from current production: (See prices in section A above)

Current average net milk price/cwt.		$12.02
Less 3X/day milking net price for current production	-	11.76
Equals price reduction for current production due to fat reduction	=	.26
Times current production	X	109,495 cwt.
Equals reduced revenue from current production	=	$28,469

D. Change in revenue:

Revenue from added production		$193,146
Less reduced revenue from current production	-	28,469
Equals change in revenue	=	$164,677

Worksheet II. Increase in expenses from 3X/day milking

A. Increased parlor costs:

Item	Current annual costs		Proportional increase	Cost increase
Milking labor	$45,030	X	0.50	$22,515
Utilities	18,668	X	0.30	5,600
Parlor supplies	30,874	X	0.48	15,078
Parlor depreciation	9,742	X	0.43	4,179
Total				$47,372

B. Increased production testing costs:

$0.11 per cow per mo. X 12 mo. X 718 cows	=	$948

C. Increased feed and interest costs:

1. Feed				
Feed price per cwt.		$6.85		
Divided by cwt. milk per cwt. feed	÷	2.5		
Equals feed costs per cwt. milk	=			$2.74
2. Interest				
Cost of base per cwt.		$2,300		
Divided by 365 cwt. that can be delivered in year	÷	365		
Equals investment per cwt. milk	=	6.30		
Times interest rate	X	0.12		
Equals interest on milk base investment per cwt. milk	=			$0.76
Total feed and interest costs per cwt. milk	=			$3.50
Times increased production from 3X/day milking (see Worksheet 1B)			X	16,424 cwt
Equals increased feed and interest costs			=	$57,484

D. Total increased expenses:

Increased parlor costs	$47,372
Increased production testing costs	+ 948
Increased feed and interest costs	+57,484
Total	$105,804

Worksheet III. Additional income from 3X/day milking and the breakeven point production level

A. Additional Income:

Change in revenue (Worksheet I-D)		$164,677
Less increased costs (Worksheet II-D)	-	105,804
Equals Additional Income	=	$ 58,873

B. Breakeven analysis

1.	Net revenue/cwt. (Worksheet 1-A)		$11.76	
2.	Less feed and interest costs/cwt. added production (Worksheet II-C)	-	3.50	
3.	Net revenues less feed and interest costs/cwt. added production		8.26	
4.	Increased parlor costs (Worksheet II-A)		47,372	
5.	Plus increased production testing costs (Worksheet II-B)	+	948	
6.	Plus reduced revenue from current production due to fat reduction (Worksheet I-C)	+	28,469	
7.	Equals total (lines 4 + 5 + 6)	=	76,789	
8.	Divided by net revenue less feed and interest costs/cwt. added production (see line 3 above)	÷	8.26	
9.	Equals breakeven increased annual herd production	=	9,296	cwt.
10.	Divided by current annual herd production	÷	109,495	cwt.
11.	Equals breakeven proportional increase in annual herd production	=	.0849	

This shows that with 1979 cost/price ratio on 8.5% increase in milk production is necessary to break even with the change to 3X/day milking frequency.

Comparison of Dairy Operations Having the Same Total Investments and Milking Parlor Usage; But, Different Herd Sizes, Facilities, Milking Parlors and Milking Frequencies

This comparison is to evaluate the investment and net returns of dairy operations with equal investments, one milking 2X/day and the other milking fewer cows 3X/day. Two comparisons are evaluated. First is a Double 6 Herringbone using 2X/day milking compared with a Trigon 18 using 3X/day milking. Second is a Trigon 18 using 2X/day milking compared with a Polygon 24 using 3X/day milking.

Double 6 Herringbone/Trigon 18

The investment in a dairy operation using a mechanized Double 6 Herringbone Parlor to milk 631 cows 2X/day is approximately equal to the investment in a dairy operation using a mechanized 18 stall Trigon Parlor to milk 600 cows 3X/day (Table 17). These milk cows plus dry cows comprise dairy herds of 755 cows and 718 cows respectively. The substantive difference in the investment in land, cattle and corrals while the 718 cow, 3X/day milking operation has the larger investment in milking facility, and milk base.

The summary of returns and costs are shown in Table 18. The pretax net return per cow with the 718 cow, 3X/day milking operation, is $318 or 45% greater than the $219 per cow with the 755 cow, 2X/day milking operation. Dividing the total net return for each dairy operation by the total new investment gives the projected rates of return on total investment of 5.1% on the larger herd milking 2X/day and 7% on the smaller herd milking 3X/day (Table 19).

Table 17. Investment: Double 6 Herringbone and Trigon 18 parlors.

	755 Cows, 2X milking Double 6 Herringbone	718 Cows, 3X milking Trigon 18 Stall
Parlor	52,320	79,740
Equipment	47,400	63,200
Mechanization	21,480	28,420
Cooling/Standby Equipment	20,400	23,020
Calf Facilities	41,200	38,200
Corrals	267,750	258,900
Cool Shades	108,000	108,000
Wells/Waste	60,400	60,400
Machinery	103,802	103,802
Cattle	1,403,500	1,335,350
Milk Base	725,535	793,500
Land/Excavation	370,200	330,200
TOTAL	3,221,987	3,222,732

Table 18. Summary of returns and costs: Double 6 Herringbone vs Trigon 18 parlors.

	755 Cows, 2X/day Double 6 Herringbone		718 Cows, 3X/day Trigon 18 Stall	
	Amount	Per Cow	Amount	Per Cow
Returns				
Milk Sales	1,439,213	1,906	1,541,250	2,146
Livestock Sales	24,000	31	22,675	31
Non Cash Revenue (Replacement Heifers)	367,200	486	349,200	486
Costs				
Herd Replacement	183,095	242	173,595	242
Depreciation	68,570	90	71,510	100
Property Taxes	16,266	21	16,311	23
Insurance	11,457	15	11,715	16
Repairs & Maintenance	46,668	61	48,977	68
Fuel & Oil	21,952	29	21,952	30
Op. Capital Interest	9,000	11	9,000	12
Feed	999,020	1,323	998,284	1,390
Wages & Salaries	176,599	233	176,599	246
Hauling	27,633	36	30,220	42
Co-op Fees	27,634	36	30,220	42
Utilities	19,630	26	25,848	36
Supplies	32,465	43	45,952	64
Breeding	11,325	15	10,770	15
Production Testing	7,701	10	8,271	11
Veterinary	5,663	7	5,385	7
Pretax Returns				
Total Returns	1,830,413	2,424	1,913,125	2,664
Total Costs	1,664,678	2,205	1,684,609	2,346
Net Returns	165,734	219	228,516	318

Table 19. Rate of return on investment: D-6 Herringbone vs Trigon 18 parlors.

	755 Cows, 2X/day Double 6 Herringbone	718 Cows, 3X/day 18 Stall Trigon
Net Return	165,734	228,516
÷ Total Investment	3,221,987	3,222,732
= Average Rate of Return on Investment	5.1%	7%

This comparison indicates that the 3X/day milking frequency, with a 15% milk production increase, is the better strategy. The 3X/day milking results in approximately $160 of added milk sales per cow net of the added feed, hauling and coop fees. The difference in net returns of these two herds is $62,782 or about $85 per cow. If the milk production increase from 3X/day milking was only 6.8%, the difference would be erased. Investment in milk base would also be reduced.

Trigon 18/Polygon 24

The investment in a dairy operation using a mechanized 18 stall Trigon parlor, milking the 857 milking cows in a 1,026 herd 2X/day is approximately equal to the investment in a dairy operation using a partially mechanized 24 stall Polygon parlor for 3X/day milking of the 823 milking cows in a 985 cow herd (Table 20). The Polygon 24 in this comparison is without automatic detachers to facilitate equalizing investment. Additionally, the technical capacity of the parlor is not attained because of the requirement for equalized investment. For these reasons labor efficiency and the minimum annual parlor cost per cow is sacrificed in the smaller herd using 3X/day milking frequency. The substantive differences in investment are that the 1,026 cow, 2X/day milking operation has a larger investment in land, cattle and corrals while the 985 cow, 3X/day milking operation has a larger investment in milking facility and milk base.

The summary of returns and costs are shown in Table 21. The pretax net return per cow with 3X/day milking was $323 or 29% greater than the $250 per cow net return with 2X/day milking. Dividing the calculated

Table 20. Investment: Trigon 18 and Polygon 24 parlors.

	1,026 Cows, 2x Trigon 18	985 Cows, 3x Polygon 24
Parlor	79,740	134,088
Equipment	63,200	80,600
Mechanization	28,420	15,160[a]
Cooling/Standby Equipment	29,320	22,800
Calf Facilities	57,300	54,300
Corrals	370,420	352,720
Cool Shades	162,000	144,000
Wells/Waste	60,400	60,400
Machinery	118,872	118,872
Cattle	1,908,250	1,831,850
Milk Base	986,010	1,088,590
Land/Excavation	491,800	451,800
TOTAL	4,355,732	4,355,180

[a]No Detachers.

Table 21. Summary of returns and costs: Trigon 18 vs Polygon 24 parlors.

	1,026 Cows, 2X/day Trigon 18		985 Cows, 3X/day Polygon 24	
	Amount	Per Cow	Amount	Per Cow
Returns				
Milk Sales	1,955,813	1,906	2,114,448	2,146
Livestock Sales	32,325	31	31,325	31
Non Cash Revenue (Replacement Heifers)	501,600	488	480,000	488
Costs				
Herd Replacement	250,115	243	239,590	243
Depreciation	89,791	87	87,713	89
Property Taxes	21,824	21	21,576	21
Insurance	14,827	14	14,968	15
Repairs & Maintenance	59,515	58	58,462	59
Fuel & Oil	24,729	24	24,729	25
Op. Capital Interest	12,000	11	12,000	12
Feed	1,357,809	1,323	1,368,294	1,389
Wages & Salaries	223,525	217	273,295	277
Hauling	37,552	36	41,460	42
Co-op Fees	37,553	36	41,459	42
Utilities	26,676	26	27,580	28
Supplies	44,118	43	63,040	64
Breeding	15,390	15	14,775	15
Prod. Testing	10,465	10	11,347	11
Veterinary	7,695	7	7,388	7
Pretax Returns				
Total Returns	2,489,738	2,426	2,625,773	2,665
Total Costs	2,233,584	2,176	2,307,676	2,342
Net Returns	256,154	250	318,097	323

net return for each dairy operation by the total new investment gives the projected rate of return on total investment as shown in Table 22.

This comparison also indicates that the 3X/day milking frequency is the better strategy even though the 985 cow, 3X/day budget was set up at less than economic capacity to achieve equal investment. The difference in net returns for these two herds is $61,943 or $62 per cow. If only 9.1% more milk was realized from 3X/day milking this difference would be erased. In this circumstance investment in milk base would also be reduced.

Comparison of Dairy Operations Having the Same Milking Parlors and Milking Parlor Usage; But, Different Total Investments, Herd Sizes, Facilities, and Milking Frequencies

This is a comparison of the investment and net returns of two dairy operations using the Trigon 18 milking parlor at technical capacity 24 hours a day. One has a 1,026 cow herd milking 2X/day and the other has a 718 cow herd milking 3X/day.

Table 23 gives the total investment for each dairy operation. The operation with the larger herd milking 2X/day has $1.133 million dollar greater investment. Table 24 is the summary of returns and costs for each operation. The 2X/day operation has $27,638 greater net return; however, the net return per cow is $68 less.

Table 25 is the comparison of the rates of returns on investment for each operation. The operation with the 718 cow herd milking 3X/day achieves 7.1% average rate of return on investment while the operation with the larger herd milking 2X/day has 5.9%. The marginal rate of return on the additional investment for the larger herd is 2.4%.

Table 22. Rate of return on investment: Trigon 18 vs Polygon 24 parlors.

	1,026 Cows, 2X/day 18 Stall Trigon	985 Cows, 3X/day 24 Stall Polygon
Net Return (Table 10)	256,154	318,097
÷ Total Investment (Table 9)	4,355,732	4,355,180
= Average Rate of Return on Investment	5.9%	7.3%

Table 23. Investment: Trigon 18 parlor, 2X/day and 3X/day milking.

Investment Items	1,026 Cows, 2X/day	718 Cows, 3X/day
Parlor	$ 79,740	$ 79,740
Equipment	63,200	63,200
Mechanization	28,420	28,420
Cooling/Standby (Equipment)	29,320	23,020
Calf Facilities	57,300	38,200
Corrals	370,420	258,900
Cool Shades	162,000	108,000
Wells/Waste	60,400	60,400
Machinery	118,872	103,802
Cattle	1,908,250	1,335,350
Milk Base	986,010	793,500
Land Excavation	491,800	330,200
Total	$4,355,732	$3,222,732
Difference	$1,133,000	

Table 24. Summary of returns and costs: Trigon 18, 2X/day vs 3X/day.

	1,026 Cows, 2X/Day		718 Cows, 3X/Day	
	Amount	Per Cow	Amount	Per Cow
Returns				
Milk Sales	1,955,813	1,906	1,541,250	2,146
Livestock Sales	32,325	31	22,675	31
Non Cash Revenue (Replacement Heifers)	501,600	488	349,200	486
Costs				
Herd Replacement	250,115	243	173,595	242
Depreciation	89,791	87	71,510	100
Property Taxes	21,824	21	16,311	23
Insurance	14,827	14	11,715	16
Repairs & Maintenance	59,515	58	48,977	68
Fuel & Oil	24,729	24	21,952	30
Op. Capital Interest	12,000	11	9,000	12
Feed	1,357,809	1,323	998,284	1,390
Wages & Salaries	223,525	217	176,599	246
Hauling	37,552	36	30,220	42
Co-op Fees	37,553	36	30,220	42
Utilities	26,676	26	25,848	36
Supplies	44,118	43	45,952	64
Breeding	15,390	15	10,770	15
Prod. Testing	10,465	10	8,271	11
Veterinary	7,695	7	5,385	7
Pretax Returns				
Total Returns	2,489,738	2,426	1,913,125	2,664
Total Costs	2,233,584	2,176	1,684,609	2,346
Net Returns	256,154	250	228,516	318

Table 25. Rates of returns with Trigon 18 parlor, 2X/day and 3X/day milking.

	1,026 Cows 2X/day	718 Cows 3X/day	Difference
Change in milk production		15% increase	
Net Return	256,154	228,516	27,638
Investment	4,355,732	3,222,732	1,133,000
Average Rate of Return on Investment	5.9%	7.1%	
Marginal Rate of Return on Investment			2.4%
Change in milk production		10% increase	
Net Return	256,154	179,132	77,022
Investment	4,355,732	3,188,197	1,167,535
Average Rate of Return on Investment	5.9%	5.6%	
Marginal Rate of Return on Investment			6.6%
Change in milk production		8.5% increase	
Net Return	256,154	164,184	91,970
Investment	4,355,732	3,177,778	1,177,954
Average Rate of Return on Investment	5.9%	5.2%	
Marginal Rate of Return on Investment			7.8%

In the first comparison of the Trigon 18 milking facility with a 718 cow herd milked 2X/day in 16 hours versus 3X/day in 24 hours, we found the break even production increase to be 8.5%. By extrapolating from the returns and costs of the budget summarized in Table 24, and of the investment in Table 23 the net returns and investment for 8.5% and 10% production increase are estimated. These estimated factors are used in Table 25 to develop marginal rates of returns for comparison with that achieved with the 15% production increase. The marginal rate of return on investment at the 8.5% production increase is 7.8%. If a dairyman anticipated this 8.5% production increase or less, and he could borrow money at 7.8% or less, the best decision would be to make the greater investment in cows and milk 2X day.

Results of Analysis of Milking Frequency

The three comparative analyses of 2X/day milking versus 3X/day milking clearly indicated that the 3X/day milking frequency with a 15% production increase is more profitable. Logan et al. reported that empirical data indicated the expected production increase with 3X/day milking would range from plus 6% to plus 20%. They concluded that a 15% production increase was attainable with good management. Therefore the conclusion here is that most dairymen would have more profitable dairy operations with 3X/day milking frequency.

The first comparison was of two dairy operations using the Trigon 18 milking parlor, each with 718 cow herds and therefore equal investments. The comparative analysis showed that the operation milking 3X/day in 24 hours achieved 45% higher net returns, with a 15% milk production increase, than the operation milking 2X/day in 16 hours. The break even milk production increase was calculated using the worksheet developed by Logan et al. This showed that an 8.5% milk production increase was necessary at the 1979 cost/price ratio for the 3X/day 24-hour operation to be more profitable.

The second comparison was of two situations each with equal investment but with different milking parlors and herd sizes. The first situation was the Double-6 Herringbone and the Trigon 18 facilities with maximum utilization. Each operation entailed approximately equal investments of $3.2 million. The operation with the larger parlor (Trigon 18) and fewer cows milking 3X/day achieved a significantly higher rate of return on investment than the operation with the smaller parlor (Double 6 Herringbone) and more cows milking 2X/day. This advantage would be erased if 3X/day milking resulted in less than 6.8% milk production increase although investment in milk base would also be reduced.

The second situation was of the Trigon 18 and Polygon 24 facilities under maximum utilization. In this situation the investments were approximately $4.3 million. Here again the operation with the larger parlor (Polygon 24) and fewer cows milking 3X/day achieved a significantly higher rate of return on investment than the operation with the smaller parlor (Trigon 18) and more cows milking 2X/day. This advantage would be erased if 3X/day milking resulted in less than 9.1% milk production increase although investment in milk base would also be reduced.

The break even milk production increases for these two situations were not determined because of the complexity of the calculations. Comparison of these dairy operations at various rates of milk production increase with the 3X/day milking frequency, while holding investments equal would require a change in the milk base, cattle, and corral investments. Calculations with so many variables changing simultaneously would require repetitive budget generation or a tailored computer program.

The third comparison was of two dairy operations using the Trigon 18 milking facility at maximum capability 24 hours per day. One operation had a larger investment with a 1,026 cow herd milking 2X/day and the other had less investment with a 718 cow herd milking 3X/day. This comparative analysis showed that the operation milking fewer cows 3X/day, with a 15% milk production increase, had a higher rate of return on investment. The marginal rate of return for the additional investment required in this case, for the larger herd, was 2.4%. This means that the decision to buy additional cows, planning 2X/day milking, would be feasible only if the real interest rate on the additional funds were less than 2.4$. A 2.4% interest rate seems unacceptable; however, it is emphasized that this is the real interest rate. In recent years, with high inflation, the real interest rate has been lower than 2.4% and in many instances has been negative.

The marginal rate of return on investment was extrapolated for 10% increase in milk production with 3X/day milking and for 8.5% increase. The marginal rates of return on investments with these increases were 6.6% and 7.8% respectively. This means that a dairyman who anticipated a 10% increase in milk production with 3X/day milking would be better off to go with the larger investment, planning 2X/day milking, if he could borrow money for the increased investment at less than 6.6% real interest rate. Similarly, if he anticipated an 8.5% increase with 3X/day milking (8.5% increase was calculated as the break even increase in the first comparison), he would be better off to go with the larger investment, planning 2X/day milking, if he could borrow money at less than 7.8% real interest rate.

The comparative analyses in this chapter support the conclusion that most dairymen would have more profitable dairy operations with 3X/day milking frequency and should plan expansion investments accordingly. The last comparative analysis of two dairy operations with unequal investments supports this conclusion; but, it suggests that inflation is a factor in the decision. If the inflation rate is high such that the real interest rate is very low or negative, the dairyman might be better off to accept the relatively low short term returns from the 2X/day milking frequency and invest in the additional land, cattle, and corrals which would inflate in value over the long term thereby increasing the dairyman's net worth although where investment in a new parlor is contemplated, the 3X/day milking frequency would be indicated.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The Arizona Dairy Industry is growing to meet the increasing aggregate demand for milk and dairy products. The producer sub-sector is encountering a dynamic situation with a trend of fewer dairymen producing more milk with larger herds of higher producing cows. Most dairymen are expanding herd sizes and facilities, at a time when all costs are escalating, in order to meet the increased demand for their product. Evaluation of the technological and organizational alternatives for expansion is required to best use investment capital.

The objective of this study was to develop economic information for the initiation of a dry lot dairy herd expansion. The current costs and technical capabilities of milking parlors with various mixes of equipment, mechanization, milking frequency and replacement options were presented and methodology for systematic evaluation of these technological and organizational alternatives was developed. The analysis of a typical investment situation demonstrated the usefulness of the methodology for a dairyman with a capital constraint who is initiating an expansion of his production capability. Synthetic budgets were the basis for all analyses. Accurate cost/price information and input/production levels are important in establishing the credibility of the budgets; but, are not critical to the analysis since discrepancies affected various alternatives equally with little or no change in the relative returns and rates of return used to evaluate the alternatives.

Conclusions

Conventional cost and production theory establishes the framework for expansion planning. The LRAC curve suggests that the larger size dairy operations achieve the lowest average costs. Since there are numerous producers in Arizona and since milk prices across the nation are interrelated by the Federal Milk Market Orders, an increase in production by one or several producers will not affect the price received for milk. Therefore, expansion should be towards the largest possible size and the commensurate lower average cost.

Drylot dairy operations are capital intensive enterprises that require specialized labor and management skills. The borrowing capability to expand dairy operations is limited and significant leverage with equity capital is unattainable. Approximately 75% of the investment in a dairy operation is personal property (cattle, equipment and machinery) and milk base. Approximately 25% is real property. Typical lending practices require 50% equity for intermediate term loans on personal property and lending institutions do not loan money for, or accept as security, milk base. So, equity capital requirements are high and normally constrain expansion investment in a dairy operation at a lower level than minimum cost indicated by the LRAC curve.

There is difficulty in developing simple per cow cost and return figures to evaluate the technological and organizational alternatives that are available. This is due to the indivisibility of many inputs and the complex interrelationship between costs, production level and prices. Synthetic budgets which reveal total investments, annual revenues and costs provide the most complete data for evaluating the alternatives under consideration for expansion investment.

The methodology developed in this study used before tax decision factors, i.e., before tax rates of returns on equity and on investments, as well as before tax annual net cash flows, to compare the alternatives. It is likely that these decision factors provide the same comparative results; however, the after tax rates of returns and cash flows must be projected for the alternative selected to verify that after tax cash flow and rate of return was maximized. Initially this study attempted to calculate after tax financial factors but found the numerous tax management options too diverse to generalize. Considerations such as investment credit, various depreciation methods, capital gains possibilities, personal exemptions, tax bracket, and stage in the life of amortized debts significantly affect the after tax income. All alternatives have potential tax problems at large herd size and high production levels in that the high net returns can place the dairyman in such a high tax bracket that there is insufficient after tax net cash flow for debt service of maximum borrowing capability of the business.

The study added to the knowledge regarding 3X/day milking. The projected cash flows and rates of returns with 3X/day milking frequency surpass the 2X/day milking frequency with either equal total investment or equal equity investment. Table 14 lists the investment items for 2X/day milking of 755 cows in a Double 6 Herringbone parlor and for 3X/day milking of 718 cows in a Trigon 18 parlor. Due to the different mixes of long term investment items, intermediate term investment items and equity milk base, the 3X/day operation would require approximately \$54,000 more equity. This \$54,000 equates to approximately 18 cows plus replacements, facilities, etc. As shown on Table 13 the total return per cow with the 3X/day milking operation is \$2664. If the additional \$54,000 equity investment was not available and the total return from 18 cows was sacrificed, the 3X/day milking operation would still achieve \$10,000 more before tax net return than the 2X/day milking operation with a smaller Double 6 Herringbone parlor. The findings here suggest that if one can expect an 8.5% or greater increase in milk production from 3X/day milking, then this milking frequency would be most profitable. However, investing in additional cows and switching to 2X/day milking might be the best way to grow until sufficient capital is available to invest in a larger milking parlor, and then switch back to 3X/day milking frequency.

Milk base possession is crucial to the profitability of a dairy operation. The UDA "over-quota" price is the price received by dairymen for milk sold in excess of milk base possessed. This "over-quota" price is typically 14-17 percent less than the quota price and this price difference markedly affects the cash flows and rates of returns. Dairy herd expansion should be commensurate with the increase in milk base possessed.

Recommendations

Manual calculation of financial factors to compare the milking parlor/herd size/alternative combinations is cumbersome and precludes quick adjustments in cost/prices and input/production levels to measure their effects on cash flows and returns. This study and most previous work has used historical empirical data as a basis for projection of size of business for dairy operations. In many instances inflation, changes in cost/price ratios and new technology have quickly negated the accuracy of these projections. A responsive computer program would facilitate development of comparisons of milking parlor/herd size/alternative combinations using forecasted financial factors. This would provide the industry with more timely information for decisions regarding expansion investment.

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