This is to certify that the

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The Profitability of Milking
Cows Three Times a Day
Compared With Two Times A Day

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John A. Speicher
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THE PROFITABILITY OF MILKING COWS THREE TIMES A DAY COMPARED WITH TWO TIMES A DAY

By

David Mitchell Chlus

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ABSTRACT

The Profitability Of Milking Cows
Three Times A Day
Compared With Two Times A Day

By

David Mitchell Chlus

Profitability of milking cows three times a day (3X) compared with milking cows two times a day (2X) was examined. The electronic spreadsheet template: Lotus 123 (1983) was employed to synthetically model farms of herd sizes ranging from 50 to 400 cows. The model assumed a 15% increase in milk production from 3X milking compared with 2X milking. The price received for a hundred weight of milk was $12.10. The model is useful in projecting long term profit expectation.

Milking 3X revealed that profitability is reached according to changes in level of milk production and herd size. Milking 3X becomes profitable for a 50 cow herd producing 15,000 lb of milk/cow. For herd sizes of 100, 150, 200 and 400 cows producing 13,000 lb of milk/cow, 3X milking is profitable when compared to 2X milking.

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INTRODUCTION

Milk production costs have increased substantially during the past decade. This increasing economic pressure and the need for more efficient use of fixed assets have resulted in an upsurge of interest in milking cows three times per day (3X) compared with two times per day (2X). Economic rationale for 3X milking is an anticipated increase in net income resulting from increased efficiency of milk production. United States Department of Agriculture (USDA) 1984 summaries on U.S. milk production shows that herds milked 2X averaged 15,048 pounds (lb) of milk while 3X milked herds averaged 17,761 lb for an additional 2,713 lb of milk. Butterfat test for 2X herds was 3.74% versus 3.59% for 3X herds.

According to Owen (1985) the following conditions are needed for improved returns to 3X milking:

1) Labor force is currently not fully utilized, or extra labor is available at a relatively low cost.

2) Parlor is highly automated (including automatic take - off equipment), and fixed costs for milking are relatively high.

3) Milking equipment is maintained in excellent operating condition.

4) Herd is under "top" management.

The objective of the research reported in this thesis was to determine the many factors that effect the profitability of milking 3X. These factors will be analyzed to determine the conditions under which 3X milking is a feasible income generating alternative.

Review of Literature

2.1 Milk Production Response from 3X Milking

It is generally accepted that cows milked 3X produce more milk than cows milked 2X. Increase in milk production due to milking frequency ranges from minus 3% to plus 39%. This section of the literature review will discuss the changes in milk production and possible sources of variation in response.

The effects of milking frequency have been investigated as early as 1891. Hills (1891) reported that over a 14 day period 3X milking reduced milk production 3% compared with 2X. In addition, Walker (1915) failed to observe a change in milk production with increased frequency of milking. In contrast Dean (1899) and Dahlberg (1924) showed that milking 3X increased production 3% and 2%, respectively. Dean (1899) also indicated that milking 3X lowered milk fat percent from 3.65% (2X) to 3.51% (3X). However in above studies, few cows were utilized and data is confounded with stage of lactation.

In studies since 1909 milking cows 3X generally resulted in greater milk production than milking cows 2X. However, increase in milk yield over long periods was generally not determined, as only one or two of the trials

exceeded a few weeks in length. In addition, cows were not milked at equal time intervals during the day.

Early short term studies (Smeyers, 1909; Lund, 1911; Lalim and Grande, 1912; Riford, 1922; Nilsson, 1922; Hunyen, 1923) showed that milk production increased 1 to 10% in cows milked 3X compare with 2X. All of the studies were two weeks or less in length. Hungerford (1929) reported that 13 cows milked 3X produced 25% more milk than when milked 2X. Cows milked 2X had their peak milk production at 3 weeks postpartum compared with 6 weeks for cows milked 3X.

Woodward (1931) conducted two experiments which at that time gave the most accurate results in determining the extra milk production due to milking 3X. In the first study, four cows were milked 2X and 3X in nine alternate periods of days each. Results showed that milking 3X produced 11% more milk and nearly 10% more milk fat. In Woodwards second experiment cows milked 3X from day 217 to 365 of lactation gave 20% more milk and 21% more milk fat than contemporary cows milked 2X.

Many studies have shown that the highest estimates of the increase in milk yield due to 3X milking have come from a comparison of Dairy Herd Improvement (DHI) records of cows milked 3X with those milked 2X. Gaines (1943) reported that Milking Shorthorns milked 3X compared with 2X yielded 39% more milk based on 6,311 DHI records. Meinhold and Rosegger (1950) showed that 2,397 cows milked 3X produced 15% more than 438 cows which were milked 2X. Using records from the

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Holstein Association, (Lush et. al., 1950) reported an 18% increase in milk production for cows milked 3X compared with 2X.

Armstrong et. al. (1978) analyzed DHI records from Arizona and herd records from Israel and compared herds milked 2X and 3X. The Arizona data showed an increase of 15.2% for milk and 11.4% for milk fat, while the Israel data showed an increase of 25.9% for milk and a 17.7% for milk fat for cows milked 3X compared with cows milked 2X.

Relative to previously mentioned trials, later trials achieved greater accuracy when comparing 3X with 2X milking. For example, using identical twins (n = 2 pairs) Hansson and Bonnier (1947) reported 6.4% and 3% increases in yield of milk and milk fat, respectively, due to 3X milking, relative to 2X milking. Their study was conducted for the first 28 weeks of lactation and they saw no effect of milking frequency on milk total solids percent.

Using the "half udder" technique, Ludwick et. al. (1941) reported a 16% increase in milk yield from the 3X milked compared with the 2X milked udder halves. Their trial utilized five cows, was conducted over a five month period and treatments were reversed on a particular udder half every two weeks.

Cash and Yapp (1950) examined the effect of milking frequency on milk yield during entire lactations using the "half udder" technique. Their trial utilized seven cows. A given udder half was milked at the same frequency throughout

the trial. They found an increase of 32% in milk yield due to 3X milking when compared with 2X milking. Using the half udder technique in a 100d trial (Agarwala and Sundaresan, 1955) reported an 8.4% increase in milk yield due to 3X milking, when compared with 2X milking (mean daily milk yield 14 lb).

Elliot et. al. (1961) determined the effects of 3X milking on milk yield and milk fat %. Milking 3X compared with 2X for a 39d resulted in a 12% increase in both yields of milk and milk fat.

More recently, (Pearson et. al., 1979; Poole, 1982; DePeters et. al., 1984) conducted more controlled long term studies on the effect of 3X milking on milk yield. Pearson et. al. (1979) compared three milking frequency treatments; 2X milking; 3X milking until milk dropped below 53 lb and 3X milking until milk dropped below 68 lb.

Milking frequency had little effect on early lactation, but with time the superiority in yields significantly increased by 20% for 3X cows compared with 2X cows. Cumulative milk yields were greater for 3X groups than for the 2X group by 5% and 8% at 56d, 11% and 8% at 154d, 11% and 9% at 182d and 10% and 10% at 280d. Differences between 3X groups and the 2X group for cumulative milk yield were significant at 154 and 182d. Increased milk yield was primarily due to higher peak production and less subsequent decline. Switching from 3X to 2X milking decreased milk yield 7% in the first week. Thus, 3X milking had a

carryover effect on milk yield.

Poole (1982) assessed the effects of 3X versus 2X milking during weeks 1 - 20 of lactation on milk yield. After week 20 all cows were milked 2X. During weeks 1 - 20 the mean daily milk yields of primiparous cows were 42 lb (3X) and 38 lb (2X) ($P < .05$). Yields of multiparous cows were 62 lb (3X) and 53 lb (2X) ($P < .001$) during the same period. Total lactation milk yields from primiparous cows were 10,738 lb (3X) and 9,896 lb (2X) ($P < .01$) while for multiparous cows the equivalent milk yields were 14,208 lb (3X) and 12,527 lb (2X) ($P < .01$).

DePeters et. al. (1984) utilizing primiparous ($n = 15$) and multiparous ($n = 38$) cows for the entire lactation examined the effect of milking frequency on milk production. During the entire lactation multiparous cows milked 3X produced 17% more milk than 2X cows ($P < .05$). Primiparous cows milked 3X produced 6% more milk than their 2X contemporaries, although this increase was not significant.

The most recent approach in evaluating milk production is to use field studies. For example, Goff and Gaunya (1977) used records from six large dairy herds which had been switched to 3X from 2X milking. Records were extended from before the cows were switched and extended records were deviated from the cows' completed lactations. Cows were divided into two lactation groups (one and > one) and four stages of lactation groups (approximately 35, 65, 120 and 203d before switching to 3X milking). Milking 3X exceeded

the projected production with 2X milking by 7.5, 2.5, 7.9 and 10.5% for multiparous cows and 12.1, 11.8, 10.1 and 10.5% for primiparous cows in the four lactation stages, respectively. This study showed that primiparous cows had a better response than multiparous cows.

Pelissier et. al. (1978) used one hundred and forty six multiparous cows paired based on parity, season of calving and milk and milk fat production in their previous lactation. The control group was milked 2X during the entire lactation and cows in the 3X group were milked for periods varying from two to nine months depending on the stage of lactation of the cows at the start of the trial. Milking 3X increased milk and milk fat yield 16.6% relative to 2X milking and this difference was significant ($P < .01$).

During the times when the experimental group were milked 2X, they produced 2% less than their 2X contemporaries. During the first 4 months of lactation 3X cows produced 7% more milk than 2X cows and this increased to 16% during the later months (Pelissier et. al. 1978).

Quessenberry (1980) reported his observations about the effect of 3X milking on milk production in 32 herds. Within six to eight months after switching to 3X milking, average daily milk production increased an average of 19% relative to 2X milking (53 lb/cow/d on 2X to 63 lb/cow/d on 3X). The nine herds that had been on 3X more than 24 months had thei initial 19% increase (63 lb) drop to only 7% increase (57 lb) above their 2X average. Seven of those nine herds that

had milked 3X more than 36 months dropped to only a 5% increase (56 lb) over their 2X average.

Possible Causes for Increased Milk Production from 3X

In the past 50 years many researchers have shown that an increase in milk will occur if the daily frequency of milking is changed from 2X to 3X. Suggested causes for increased milk production as a result of increased frequency of milking are:

1) Reduced intramammary pressure and less negative feedback on the secretory cell by the buildup of milk components within the lumen of the alveolus.
2) Improved udder health
3) Improved reproduction
4) Improved feeding and management practices

2.2 Intramammary Pressure and Buildup of Milk Components

A possible beneficial effect of greater frequency of milking lies in the relief of high internal udder pressure. The period immediately after milking is charaterized by low intraalveolar pressure which facilitates transport of newly synthesized milk into the alveolar lumen (Ormiston et. al., 1967). As secretion into the lumen continues between milkings, back pressure is exerted on the secretory process by alveolar contents (Schmidt and Trimberger, 1963). At 35 hr (Tucker, 1961) luminal pressure exceeds force of

secretion as alveolar enlargement reaches its limit. It is presumed (Ormiston et. al., 1967) that lumen distention pressure exceeds strength of secretory mechanisms needed to push newly formed milk out of secretory cells. In turn, buildup of newly formed milk in cells retards uptake of milk precursors into the lumen by chemical feedback mechanisms and/or physical factors. Physical factors are a result of distended alveoli partially displacing all other intramammary compartments, including the blood vessels. With restricted blood flow (Ormiston et. al., 1967) less oxygen is available for metabolism, fewer nutrients are available for milk production, less hormones are available to drive the synthetic apparatus, removal of waste products of synthesis is retarded, oxytocin is restricted from reaching the myoepithelial cells and fewer leukocytes are available to ward off infections.

Tucker et. al. (1961) showed that thirty five hours was the estimated length of time before milk secretion approached zero. Increasing the interval between milkings decreases total milk and/or intramammary pressure. The average secretion rate starts to drop about 10 to 12 hr after the last milking, but the instantaneous secretion rate starts to drop before this time. Schmidt (1971) showed that 10 hr after milking, the average secretion rate begins to decrease and secretion stops after 35 hr. The hydrostatic pressure measured in the teat cistern increases in three phases. Within 1 hr following the previous milking

intramammary pressure rapidly increases to approximately 8 mm Hg., which is caused by residual milk moving into the cistern from the alveoli and small ducts. The second phase is slower and is an accumulation of newly synthesized milk that is released into the duct system from the alveolar lumen as they begin to accumulate milk (Schmidt, 1971). The third phase is marked by an accelerated pressure increase and represents overfilling of alveoli, ducts and gland cistern (Schmidt, 1971).

Gasnier, (1945); Edwards (1950); Eisenreich and Mennicke (1950) used milk accumulation to buildup intramammary pressre in the mammary gland. Therefore, the possibility exists that specific components of milk may act within the mammary cell to inhibit their own secretion independent of intramammary pressure.

Approximately 15 to 25% of the total amount of milk in the udder at the start of milking is not removed when milking is completed. In cows producing on average of 35 lb of milk/d (Laben, 1982) the residual milk removed after each milking varied with milking interval. Cows were milked at intervals of 4, 8, 12, 16, 20 and 24 hr and secretion rates of total milk milk and milk components monitored. Secretion rate of milk and solids not fat did not decline until the interval between milkings reached 16 hr. When cows were switched to an 8 hr interval between milkings from intervals of 4, 8, 12, 16, 20 and 24 hr, little effect on secretion rate found except in cows with previous intervals of 20 and

24 hr. Interval between milkings longer than 16 hr resulted in increased fat percentage and reduced fat yields. Similarly, milk and solids not fat yields fell markedly with intervals of longer than 16 hr. Production in cows milked at 24 hr intervals compared with 8 hr intervals was a decrease of 25% (Laben, 1982).

2.3 Improved Udder Health

In addition to increases in milk production, three milkings per day may improve udder health (Jarrett, 1977). Because dairy farmers lose more than 2 billion dollars annually from mastitis, good udder health is important (Jasper et. al., 1982). Pearson et. al. (1979) reported a reduction in amount of milk discarded due to mastitis in cows milked 3X compared with cows milked 2X.

In two trials Waterman et. al., (1982) compared the incidence of mastitis with cows milked 3X versus 2X. for 12 weeks. All teats of all cows were dipped with a broth containing Streptococcus agalactiae once daily to enhance the potential for cows to become infected during the study. Milk production in cows milked 3X versus 2X was 8% greater over the entire 12 week experiment. However, in the last 4 weeks 3X increased yield 11% compared with 2X.

Rate of infection was determined using somatic cell counts (SCC) and isolation of bacteria from milk. Although SCC in milk of cows milked 2X (465,000) were three to four

times greater than those milked 3X (125,000), this difference was not significant. In addition, there was no difference in number of new infections on groups. Clinical cases of mastitis were observed less frequently in the 3X group as compared to the 2X group. The researchers conclude that 3X milking raises production and lowers clinical mastitis.

Gisi et. al., (1985) monitored udder health in twenty eight dairy herds which were milked 3X for 36 mos. and were milked 2X for 3 to 17 mos. prior to switching to 3X. California Mastitis Test (CMT) scores were used to measure udder health. Proportion of animals in each herd that were CMT negative and trace, CMT 1, CMT 2 and CMT 3 was not affected by the change to 3X milking. There were no differences between multiparous and primiparous cows. In contrast, Allen et. al., (1985) reported that cows from first through third lactation milked 3X had higher CMT scores ($P < .01$) than cows milked 2X. Cows in fourth and later lactations milked 3X had lower CMT scores.

Jarrett (1977) suggested that 3X milking should have a beneficial effect on reducing incidence of mastitis. Incidence of mastitis should decrease providing milking equipment works properly including a good vacuum stability at the claw, a gentle and complete massage on the liner and relatively low vacuum (Jarrett, 1977). Increased frequency of milking may reduce the time bacteria remains in the udder between milkings and establish new infections. In a herd

with a low number of infected quarters, 3X milking may decrease clinical mastitis. On the other hand, if milking equipment and milking procedures are poor, the transmission of bacteria to uninfected animals may be greater because of the 50% increase in exposure to the bacteria in the milking machine (Jarrett, 1977).

2.4 Improved Reproduction

Improved reproduction performance may be possible as a result of 3X milking because more time is spent in the barn and improved heat detection may occur. Other problems also may be noticed sooner, such as illness, injury and calving difficulties.

Amos et. al. (1985) examined reproductive performance in cows milked 3X. Reproductive performance was not influenced by milking frequency ($P > .05$). However, cows milked 3X had a nonsignificant ($P > .10$) increased number of days from calving to first estrus (5.7d) and more days open (18.1d) than cows milked 2X. Services required per conception were 1.9 -/+ .2 for each group.

Allen et. al., (1985) using DHI records observed that cows milked 3X had fewer days to first breeding from parturition than their 2X herdmates. Primiparous cows milked 3X had increased number of days to conception, more services and consequently more days open than cows milked 2X. For second lactation cows milked 3X there was no

difference in days to conception or days open, but they required more breedings than cows milked 2X. Third and fourth lactation cows milked 3X had fewer days to last breeding, no difference in number of breedings and therefore, fewer daysopen than those milked 2X (Allen et. al., 1985).

Gisi et. al., (1985) reported that calving interval, days open and services per conception were not significantly affected by milking frequency for either the entire herd or when primiparous cows were considered alone. Reproductive indices like days open, services per conception and calving interval tended to worsen as time on 3X milking increased. Of the 28 herds studied for 3 years 19 had an increased calving interval, 20 had increased number of days open and 22 had increased services per conception in cows milked 3X versus cows milked 2X. The effect of 3X milking on reproductive indices were independent of the increase in milk production due to 3X milking and level of milk production within the herd.

2.5 Improved Feeding

Modifications in the feeding program are required to compensate for higher nutrient requirements of cows that are milked 3X to achieve positive effects from the extra milking (Bath, 1978). With increased milk production, nutrient requirements also increase, especially energy and protein

requirments. Without additional feed to meet the requirement, cows will utilize body reserves to maintain milk production. If body reserves are not restored by late lactation, reduced production may result in subsequent lactations (Bath, 1983). Possibly this is the cause of gradual decreases in production some herds have reported after several years of 3X milking (Bath, 1978).

DePeters (1984) utilized 38 multiparous and 15 primiparous cows for a full lactation (44 weeks) to compare the effects of 2X or 3X milking on feed intake and body weight change. All cows were managed similarly and were fed diets of high, medium and low energy concentration as lactation progressed from calving to 44 weeks. Cows milked 3X consumed 4% more feed. However, additional feed was not sufficient for cows to maintain body weight compared with cows milked 2X. Cows milked 2X gained 128 lb more than cows milked 3X after 44 weeks of lactation.

Cows milked 3X reached minimum weight between weeks 8 to 10 of lactation and gained little weight until after week 20 of lactation. The cows did not reach recommended weight at calving until weeks 38 to 40 of lactation. Assuming that weight gains equivalent to those for the 2X cows are required for optimum body condition in preparation for the subsequent lactation, cows milked 3X must gain the extra weight during the dry period. Weight gain of an extra 100 lb during the dry period is not unreasonable but emphasizes the importance of management of the feeding program for cows

milked 3X.

Efficiency of feed utilization for milk production in multiparous cows is enhanced with 3X milking. Despite the loss in body weight cows milked 3X produced approximately 3 lb more milk per pound of increased dry matter (DM) intake. This amounts to 3,000 lb extra milk for a total of about 1,000 lb extra DM intake (Bath, 1983).

The need for increased feed intake in cows milked 3X is to help maintain body weight and condition. Feeding methods that work well for 2X milked cows are not ideal for 3X milked cows (Quesenberry, 1980). Frequency of feeding is one important factor. Twice daily feeding may be adequate for cows milked 2X, but more frequent feeding is desirable for cows milked 3X (Bath, 1983). Each time new feed is offered, many cows will increase the number of times she eats, resulting in greater feed intake over a 24 hr period. This is especially important for high producing cows in early lactation because they are in negative energy and protein balances (Quesenberry, 1980).

The practice of grouping cows by level of production and stage of lactation, and feeding three or four different rations with gradually decreasing amounts of grains and other concentrates work very well for cows milked 2X (DePeters et. al., 1984). However, for 3X milked cows, higher energy and protein levels are necessary for a longer period during a lactation cycle to allow them to regain body weight lost in early lactation due to higher milk

production. Rather than three or four ration changes spanning the range of energy concentrations from high to low, a herd milked 3X may need only two rations (high and medium energy concentrations) during the lactation period (Bath, 1983).

Pearson et. al., (1979) showed that average DM intake was higher in 2X cows. When fat percentage and body weight were considered in addition to milk yield, the 2X cows were 44 to 66 lb heavier at parturition than the 3X cows and averaged 33 to 44 lb more body weight through the first 180d of lactation. Correspondingly, the lower fat percentage of milk from the 3X cows offset the feed necessary for the additional milk production. Thus, group feed intake apparently reflected the expected needs based on National Research Council requirements for all groups equally well (Pearson et. al. 1979).

Research by Flatt et. al. (1969) indicated that efficiency of utilization of metabolizable energy for milk or body tissue gain was unaffected by milk yield, amount of body tissue gain or loss, or stage of lactation in cows milked 2X. Flatt et. al. (1965) indicated that apparent body weight decreases in early lactation are not necessarily representative of energy loss or balance or actual body tissue loss but tend to even out over the complete lactation. It may be possible that the 3X cows converted more body tissue energy to milk than would be expected from just the body weight changes alone. It is conceivable that

the 3X group of cows lost more energy from body stores than the 2X group of cows and that body weight remained equal because water replaced the adipose tissue lost by the 3X group (Flatt et. al., 1969).

Considering the data in 3X studies, it is apparent that 3X milking increases the efficiency of feed utilization for milk production even if one considers extra feed required for added body gains during the dry period (Bath, 1983). It must be recognized that 3X milking results in a prolonged drain on body reserves during lactation with the result that a major proportion of replenishment must occur during the dry period. Feeding and management programs covering the entire cycle, including the dry period, must be designed to meet these added requiremnets (Bath, 1983).

2.6 Economics of 3X Milking

In determining profitability of 3X milking compared with 2X milking, increased cost of production must be considered. These costs include greater feed intake, increasing operational costs and machinery maintenance and additional labor. As herds get larger, fixed costs of milking parlors and equipment become greater and variable costs such as labor become a smaller portion of the total.

Several questions remain as to what are the extra costs for labor, feed and electricity (Hlubik et. al., 1986). Other questions that remain to be answered is how much extra

milk is needed in order to cover the added costs and how much extra milk is needed in order to cover the added costs and how profit can be expected.

Table 1 summarizes eight studies examining income and expenses from 3X milking. Most of the results and conclusions were derived from actual and theoretical data. There were two exceptions, namely Goff and Gaunya, (1977) who conducted a study of six commercial dairy farms practicing 3X milking and Agrifax data (unpublished, 1983) that analyzed 29 farms practicing 3X milking. The studies compared milk production increases from 3X milking, gross income, feed cost, labor cost, other miscellaneous costs and net income when farms switch from 2X to 3X milking. The net income in the studies ranged from a low of $.08/cow/d from Goff and Gaunya, (1978) to a high of $.26/cow/d from a study conducted by Edwards, (1980). The Agrifax data (unpublished, 1983) was the only study in Table 1 that showed a negative return to 3X milking (-.12/cow/d). A possible reason for the negative returns in farms milking 3X is that only 29 farms were analyzed in the study.

One additional study (Speicher, 1985) determined the profitability of 3X milking by using model herds. Increased milk production attributed to 3X milking in Table 1 ranged from 5.9 lb/cow for herds with 12,000 lb to 9.8 lb/cow for herds with 20,000 lb herd averages. When a $12.00 net price for milk is used, increased daily milk due to 3X milking resulted in additional daily gross income

Table 1. Review of income and expenses for 3X milking.

Authors	Number of Cows	Milk Production Inc. From 3X	Gross Income For 3X	Feed Cost For 3X	Labor Cost For 3X	Other Cost	Source of Cost	Net Income
Goff and Gaunya 1978		Multiparous Inc. 6.5%	$3.88/cwt of extra milk	$2.89/cow	$11.14/100 cows	$4.20/100 cows	Actual	$.08/ cow/d
Pelissier et al. 1978	400 cows	15% Inc.	$.71/cow/ day	$.18/cow/ day	$.13/cow/ day	$.15/cow/ day	Derived	$.25/ cow/d
Armstrong 1978	700 cows	15%	$.41/cow/ day	$.16/cow/ day	$.04/cow/ day	$.09/cow/ day	Derived	$.25/ cow/d
Edwards 1980		15%	$.69/cow/ day	$.06/cow/ day	$.14/cow/ day	$.23/cow/ day	Derived	$.26/ cow/d
Agrifax 1983	29 Farms	9%	$.31/cow/ day	$.17/cow/ day	$.18/cow/ day	$.08/cow/ day	Actual	$-.12/ cow/d
Bohling 1984	450 cows	12%	$.53/cow/ day	$.19/cow/ day	$.08/cow/ day	$.05/cow/ day	Derived	$.21/ cow/d
Owens 1985	100 cows	15%	$.66/cow/ day	$.20/cow/ day	$.25/cow/ day	$.08/cow/ day	Derived	$.13/ cow/d
Hlubik 1986	70 cows	10%	$.66/cow/ day	$.21/cow/ day	$.14/cow/ day	$.13/cow/ day	Derived	$.18/ cow/d

ranging from $.71/cow to $1.17/cow. Net returns exclusive of labor costs due to 3X milking ranged from $.26/cow/d for herd with 12,000 lb to $.42/cow/d for herds with 20,000 lb herd averages.

ASSUMPTIONS AND SPECIFICATIONS OF INVESTMENT MODEL

An investment model was developed that examined two strategies affecting economic profitability of milking dairy cows 3X; namely, herd size and level of milk production. An electronic spreadsheet template: Lotus 123 (Lotus Development Corp., 1983) was employed to project long term profit expectations. Simulated farms of various herd sizes and production levels were first assembled to generate estimates of costs, incomes and profits of 3X compared with 2X.

Herd sizes analyzed were 50, 100, 150, 200 and 400 cows. The herd averages for these herd sizes are 13,000, 15,000, 17,000, 19,000, 21,000 and 23,000 lb. of milk/cow/yr. The investment model developed permits the user to consider changing input variables.

User can specify:

Herd Size	(Total #)
Herd Average	(lb./cow/yr.)
Cattle Income/Cow	($/cow)
Price of Milk	($/cwt.)
Price of Labor for 2X	($/hr.)
Price of Labor for 3X	($/hr.)
Milk Loss	(% of milk/cow)
3X Milk Increase	(% of milk/cow)
Price of Corn	($/bushel)
Price of Hay	($/Ton)
Price of Soybean Meal	($/Ton)
Price of Corn Silage	($/Ton)
Cows Milked/hr.	(#/hr.)
Depreciation/Cow	($/cow)

The model estimates appropriate costs and incomes for each herd size and herd average. Profit is defined as gross income minus total expenses.

Using this model the user can:

1) Compare profits within each strategy across herd sizes for a given set of specifications.

2) Examine sensitivity of the analysis to changes in inputs.

Components of the model are discussed in four categories.

Incomes for the model

Items dealing with feed costs

Items dealing with labor costs

Dairy expenses other than feed and labor costs

Incomes for the model

Income for the model is derived from sale of milk and cattle income which is comprised of deacon calves, cull cows and excess replacement heifers. Milk sold is estimated as 95% of total produced (Speicher, 1967). Difference between amount of milk produced and amount sold can be attributed to abnormal milk during the first week of lactation, mastitic milk from udders treated with antibiotics and other milk consumed by the farm family. Rundell and Speicher (1967) estimated average difference in amount produced versus the amount sold as 700 lb/cow.

Anticipated production increase resulting from 3X milking is approximately 15% (Allen et. al., 1985; Amos et. al., 1985; Gisi et al., 1985). If the user so desires, the milk production increase can be changed to a value that is either a more conservative or a more generous percent.

Milk hauling and marketing charges are accounted for in the livestock budgets. A milk price of $12.10/cwt. (Hamm, 1986) was used in the model and this price can be changed by the user. Gross milk sales are figured as 95% X cwt. of milk produced + (milk increase from 3X) X price of milk/cwt. Cattle income which consists of income from cull cows, deacon calves and changes in cattle inventory was estimated using Telfarm records. Telfarm records are a business analysis summary of Michigan dairy farms.

Items dealing with feed costs

The feed cost was calculated using the Michigan State University Dairy Ration Evaluator (MSU Animal Science Dept., 1986). The model includes rations for levels of milk production of 13, 15,17,19,21 and 23 (thousand lb.) rolling herd average production. The ration composition is critical in achieving a particular level of milk output given the genetic potential to produce at that level. There are many combinations of feeds that will meet the cow's nutrient requirements. Typical dairy rations in Michigan include corn grain, corn silage, alfalfa hay, brewers grains and soybean meal. These then are the feeds that form the basis

for the rations formulated for the model shown in Appendix 1. The nutrient content of feeds is based on values in the Spartan Dairy Ration Evaluator. Feed nutrient densities are located in Appendix 2.

Quantities of feeds needed are based on amounts to meet nutrient requirements of lactating cows according to their level of milk production as well as feed needs of heifers and dry cows. Expected feed intake, nutrient content of feeds and losses in feeding and storage are considered. The quantity of feed needed for extra milk production resulting from 3X milking is 1 lb. of extra feed from the total diet equals 3 lb. more milk (Bath, 1978). Quantities of feeds needed/cow and her replacement are located in Appendix 3.

Purchased feed costs are estimated by multiplying the feed purchase prices by the quantity of each feed needed which are determined by the level of milk production and herd size. Costs used for each crop are $2.00/bu. for corn, $75.00/T for hay, $208/T for soybean meal and $23.00/T for corn silage. Other feed costs that are built into the model is $23/T for brewers grains, $.16/lb for dicalcium phosphate, $.05/lb. for limestone, $.09/lb for calcium sulfate, $.13/lb for magnesium oxide and $.07/lb for trace mineral salt.

The rations were balanced on the assumptions that the breed was Holstein, body weight of the cow was 1350 lb, age of the cow was 48 months and the milk fat percent was 3.5.

Items dealing with labor costs

Labor costs for each herd size and herd average are calculated based on the technology employed (i.e. the buildings, facilities and equipment). The labor costs for 2X milking was derived from using Telfarm records. This includes the cash cost for hired labor including paid perquisites and social security plus the value of operator's and unpaid family labor at $5.00/hr. The values are shown in Appendix 4 with all other livestock expenses/cow.

Herds milking 3X require higher labor costs than herds milking 2X. The difference between 3X milking and 2X milking labor costs are based on the following assumptions.

1) It was assumed that all cows milked 3X will be fed three times a day compared to twice per day for herds milked 2X. This allows for delivery of extra feed required for 3X milked cows.

2) Farms with a herd size of 50 cows will be milked in a pipeline system. The additional labor required for the third feeding is 11.52 hr/cow/yr (Norrell et. al., 1978).

3) Farms with a herd size of 100 cows will be milked in a double 4 herringbone parlor with no mechanization. The additional labor required for the third feeding is 7.7 hr/cow/yr (Norrell et. al., 1978).

4) Farms with a herd size of 150 cows will be milked in a double 6 herringbone parlor with detachers. The additional labor required for the third feeding is 6.9 hr/cow/yr (Norrell et. al., 1978).

5) Farms with a herd size of 200 cows will be milked in a double 6 herringbone parlor with detachers and a crowd gate. The additional labor required for the third feeding is 6.0

hr/cow/yr (Norrell et. al., 1978).

6) Farms with a herd size of 400 cows will be milked in a double 8 herringbone parlor with detachers and a crowd gate. The additional labor required for the third feeding is 5.4 hr/cow/yr (Norrell et. al., 1978).

7) Values for milking throughputs, (Kelso, 1979) are based on degree of milking system automation and are shown in Appendix 5.

8) For the third milking, (Bickert, 1983) 20 min. is needed for parlor setup, 30 - 45 min. is needed for cleanup and changing cows requires 15 min/100 cows.

9) Pipeline setup is 15 min. while 25 min. is required for cleanup (Bath et. al., 1978).

10) For consistency, all milking systems will be operated by one milker.

The price of labor for 3X milked herds was figured at $7.00/hr. The reason for the 40% increase compared with $5.00/hr for 2X milked herds is the added incentive needed to milk and complete all chores required for the additional milking each day. The user can change the hourly wage to any value to more accurately predict his farm situation.

Dairy expenses other than feed and labor costs

Machinery expenses for the dairy herd includes the following items: repairs and supplies for upkeep on machinery including tractors, repairs and upkeep on trucks and farm share of automobiles including fuel, gas, oil and grease, custom hire of machinery, depreciation on machinery and interest on investment in machinery. Telfarm records

report interest on total investment in two segments -- interest paid and interest on equity. The interest paid is reported by the farmer. The amount of debt is estimated by capitalizing the amount of interest reported at 8.5%. The estimated debt is subtracted from the total investment to determine equity. Interest is computed on the equity at 8.5%. Interest is allocated to machinery, improvements, land and livestock according to investment. Machinery expenses have been assumed to not increase when a herd is switched from 2X to 3X milking.

Improvement expenses included repairs on buildings, fences, wells, cleaning ditches, bulldozing, fence rows; which are classified as conservation expense for income tax purposes. Improvement expenses further includes fire and wind insurance premiums, depreciation and interest on improvement investment. Improvement expenses have also been assumed to hold constant as a herd switches from 2X to 3X milking.

Livestock expenses included breeding, veterinary and medicine, milk and livestock marketing, milkhouse supplies, registration, advertising, heat for livestock buildings and other livestock service and supply items. Marketing costs for milk were calculated at a $1.30/cwt. of milk. The $1.30 /cwt. is comprised of $.05/cwt. to zone differential, $.50/ cwt. for milk hauling, $.15/cwt. for milk promotion, $.08/cwt. for milk cooperative fees and $.52/cwt. for the whole herd buyout assessment (Hamm, 1986). All livestock

expenses except the marketing and trucking expense were increased 50% when herds are milked 3X.

The land charge was interest on the investment in land plus taxes paid. Land values were estimated by county extension staff members throughout the state of Michigan. An effort was made to keep them comparable between farms. An attempt was made to use an agricultural value and not reflect urban real estate values. Land charge will not be affected by herds milking 3X.

Other expenses included in the model are for utilities and other miscellaneous expenses not included elsewhere. Utilities and miscellaneous expenses were increased 50% for 3X milking compared with 2X milking.

All dairy expenses for each herd average and herd size are shown in Appendix 4. Values shown in Appendix 4 include the average long run outlook of Telfarm data from 1980 to 1985. Since this is an decision making analysis involving stategic planninng (i.e. long range planning), forecast expenses are used to establish the expected economic conditions for the forecast period 1986 - 1991.

RESULTS

The Effect of Milking Frequency on Net Income for Various Herd Sizes and Milk Production Averages

Figures 1 through 4 show the net incomes of 3X milking compared with 2X milking. For a 50 cow herd at milk production levels ranging from 13,000 - 23,000 lb of milk/cow, 15,000 lb of milk/cow is needed to show increased net income for 3X milking compared with 2X milking. Figure 2 illustrates that 3X milking is more profitable than 2X milking for a 200 cow herd at all milk production levels. For herds with 200 cows that are practicing 3X milking, 15,000 lb of milk/cow is needed to reach the breakeven point ($0 profit point).

At a level of 19,000 and 23,000 lb of milk/cow, (see Figures 3 and 4) all herd sizes show added net income when milked 3X compared with 2X. Figures 1 through 4 show that 3X net income increases at a faster rate than 2X net income as herd size and herd average increases.

The Effect of Milk Price on Profitability of 3X Milking Compared with 2X Milking

Figure 1.

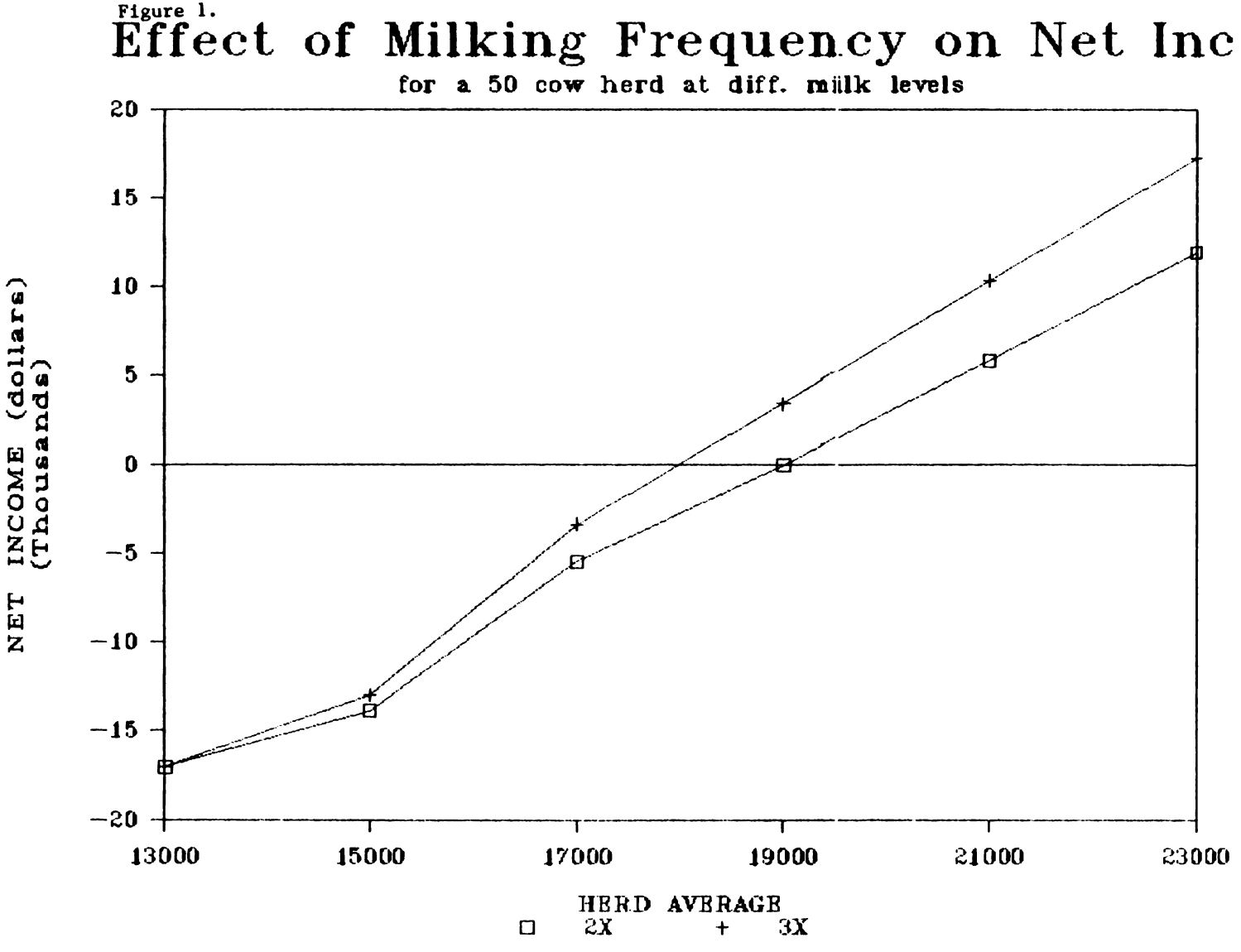

Effect of Milking Frequency on Net Inc.
for a 50 cow herd at diff. milk levels
NET INCOME (dollars)
(Thousands)
20
15
10
5
0
-5
-10
-15
-20
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

Figure 2

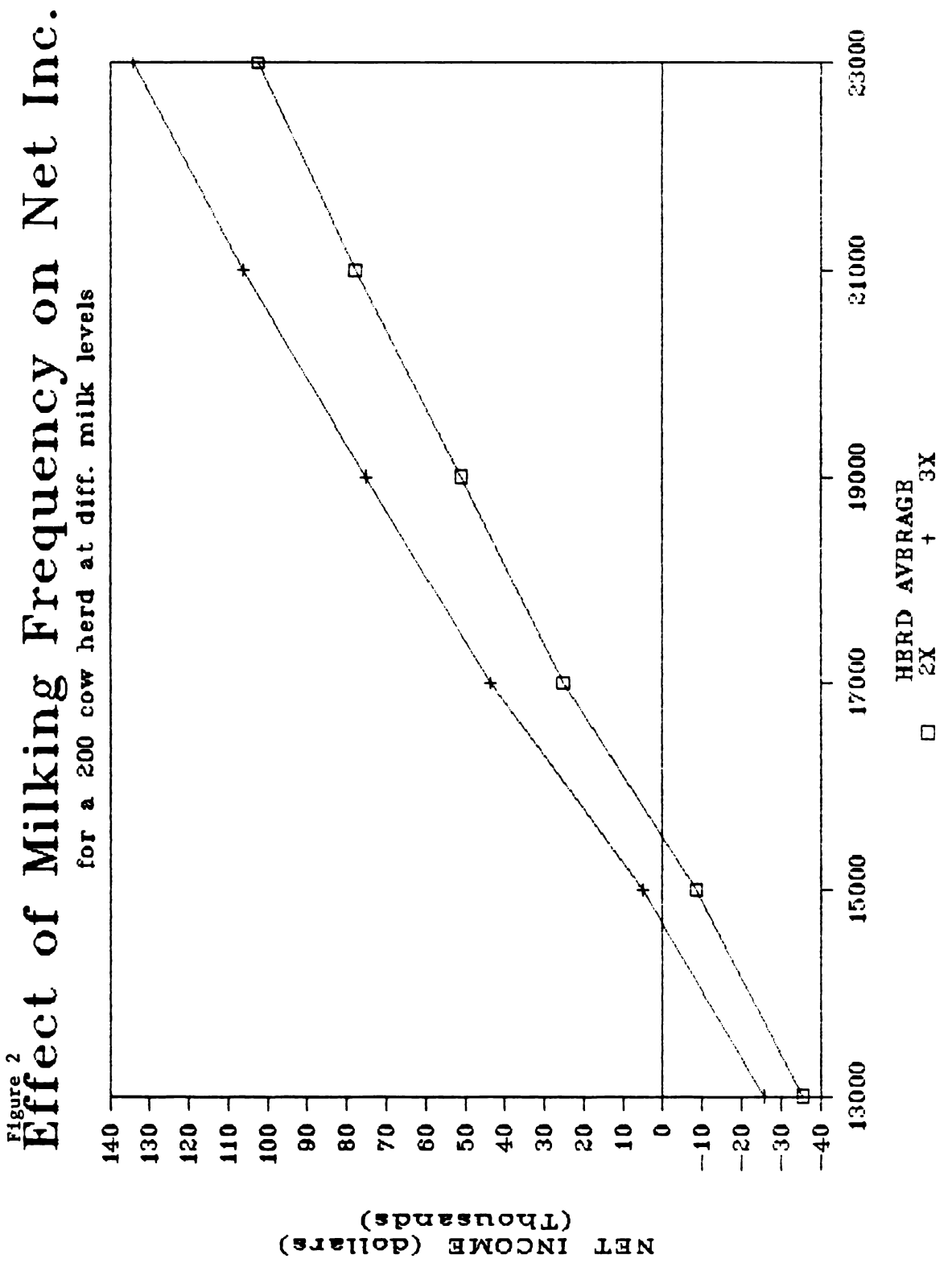

Effect of Milking Frequency on Net Inc.
for a 200 cow herd at diff. milk levels
NET INCOME (dollars)
(Thousands)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

Figure 3.

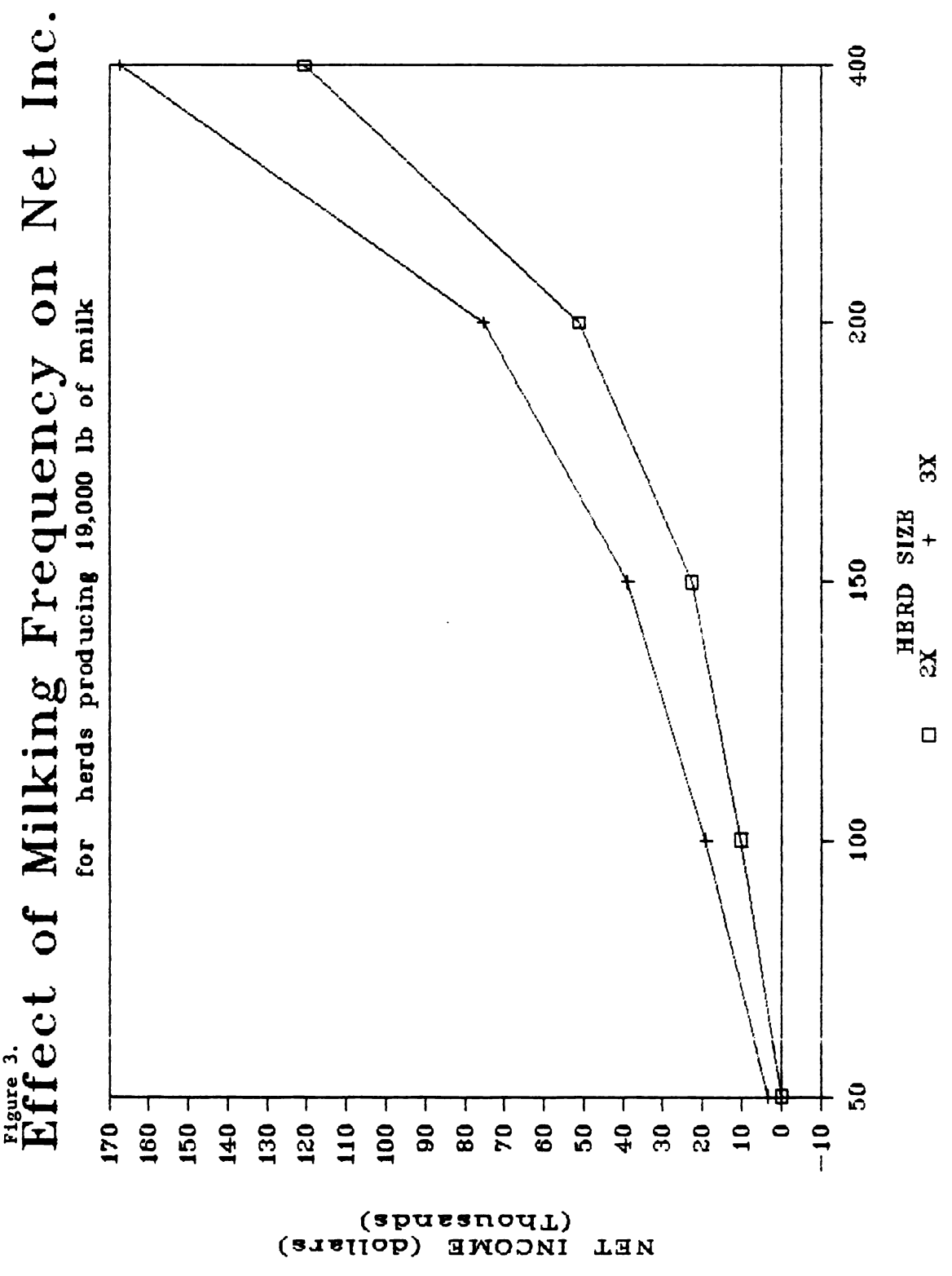
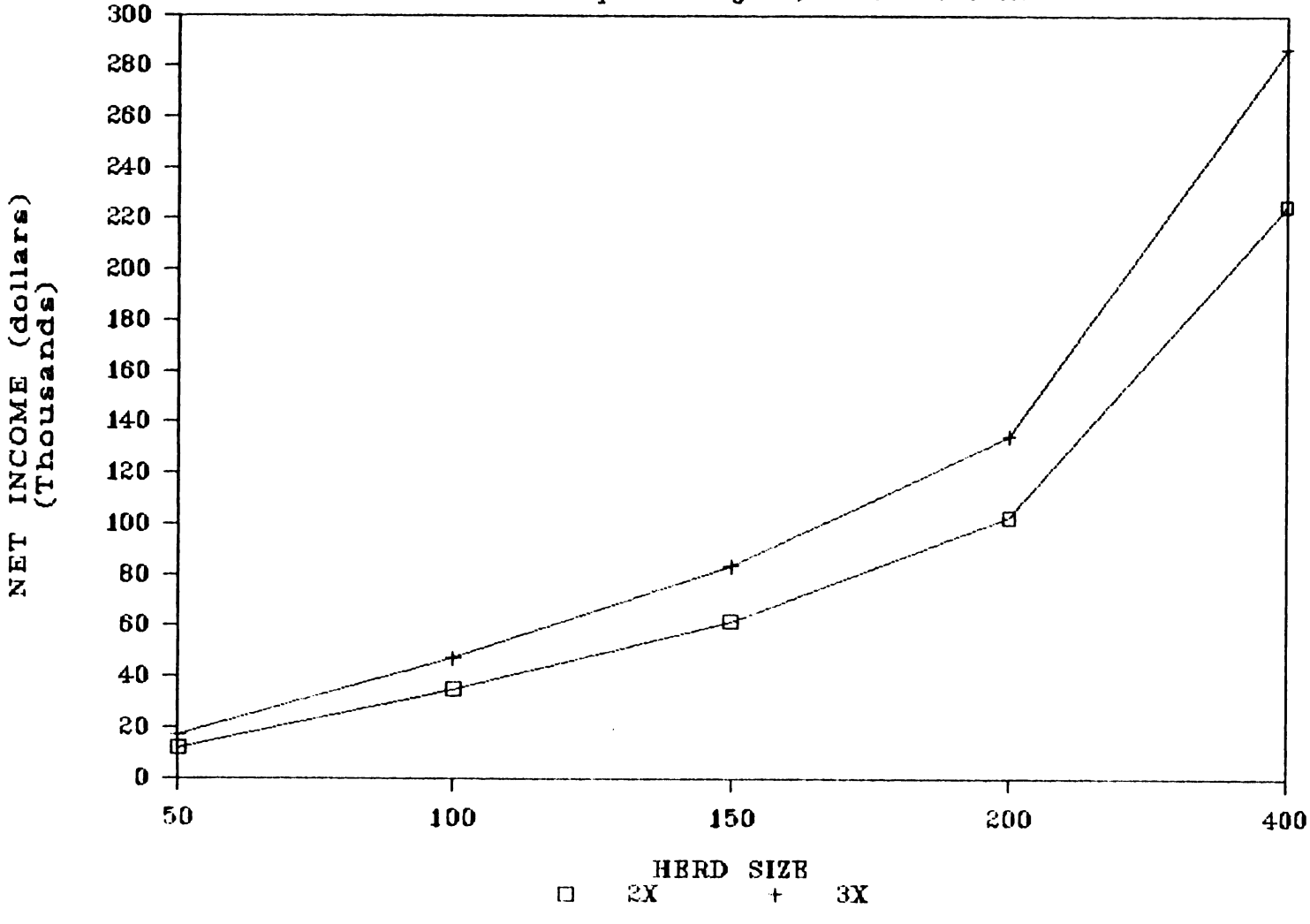

Effect of Milking Frequency on Net Inc.
for herds producing 19,000 lb of milk
NET INCOME (dollars)
(Thousands)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
50
100
150
200
400
HERD SIZE
2X
3X

Figure 4.

Effect of Milking Frequency on Net Inc.

for herds producing 23,000 lb of milk



Figures 5 through 8 illustrate the impact of reducing the price of milk from $12.10/cwt. to $11.10/cwt. have on profitability of 3X milking compared with 2X milking. At a level of milk production of 13,000 lb of milk/cow, (see Fig. 5) herd sizes of 150 cows and greater show that 3X net income is greater than 2X net income. When herd sizes ranging from 50 to 400 cows produce 13,000 lb of milk/cow, profitability never reaches the breakeven point for 2X and 3X milking. At a level of 19,000 lb of milk/cow (see Fig. 6) the 50 and 100 cow herds do not reach positive net income. However, all herd sizes producing 19,000 lb of milk cow show added net income when milking 3X compared with 2X.

A herd size of 50 cows (see Fig. 7) that produces 17,000 lb of milk/cow shows that 3X milking is more profitable than 2X milking. When the herd average is increased to 19,000 lb of milk/cow, 3X milking surpasses the breakeven point. At herd sizes of 200 cows (see Fig. 8) all herd averages have added net income for 3X milking compared with 2X milking. At levels of 17,000 lb of milk/cow and greater a 200 cow herd reaches positive net income.

The Effect of Changing the Price of Labor on Profitability of 3X Milking Compared with 2X Milking

Figure 5.

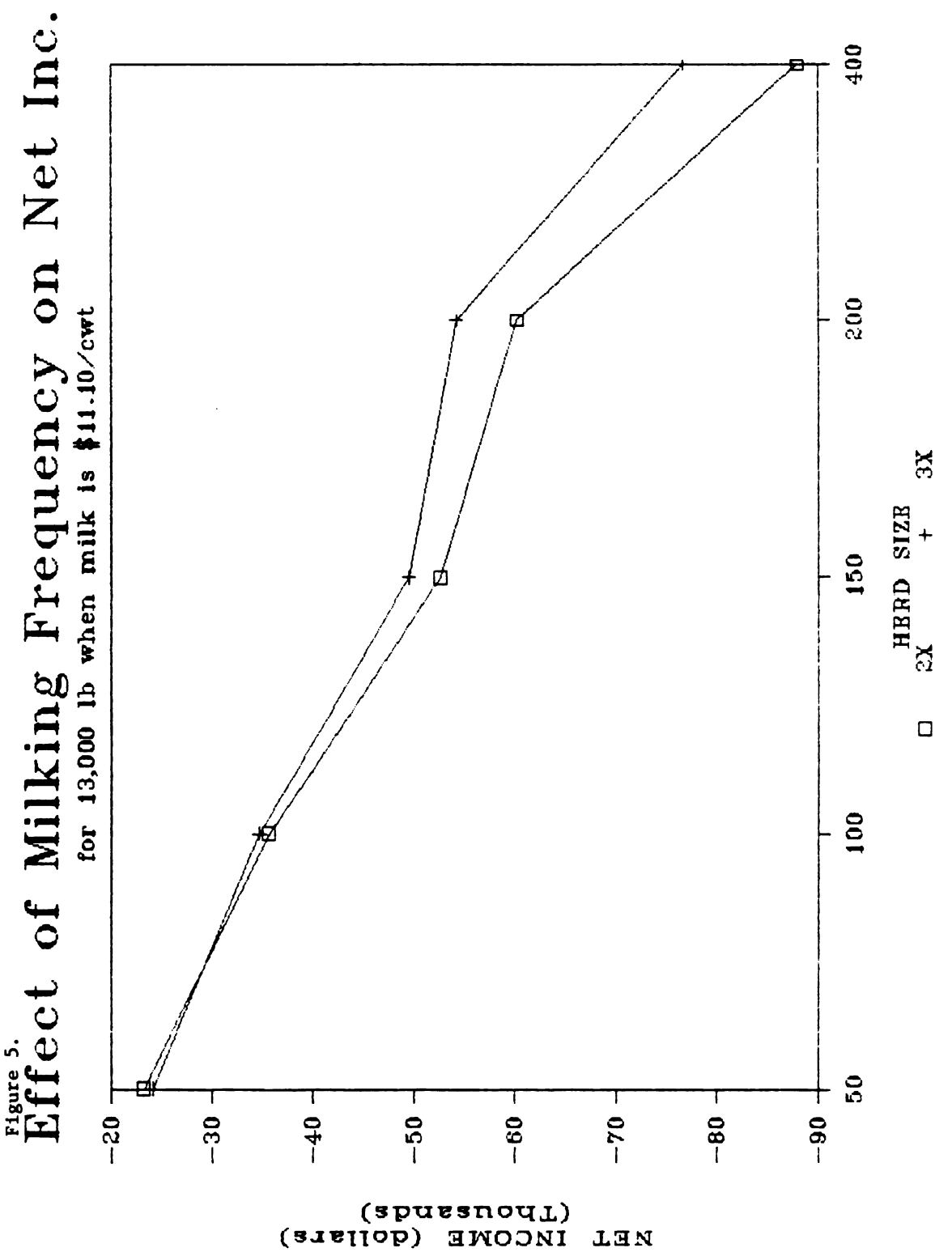

Effect of Milking Frequency on Net Inc.
for 13,000 lb when milk is $11.10/cwt
NET INCOME (dollars)
(Thousands)
-20
-30
-40
-50
-60
-70
-80
-90
50
100
150
200
400
HERD SIZE
2X
3X

Figure 6.

Effect of Milking Frequency on Net Inc.

for 19,000 lb when milk is $11.10/cwt

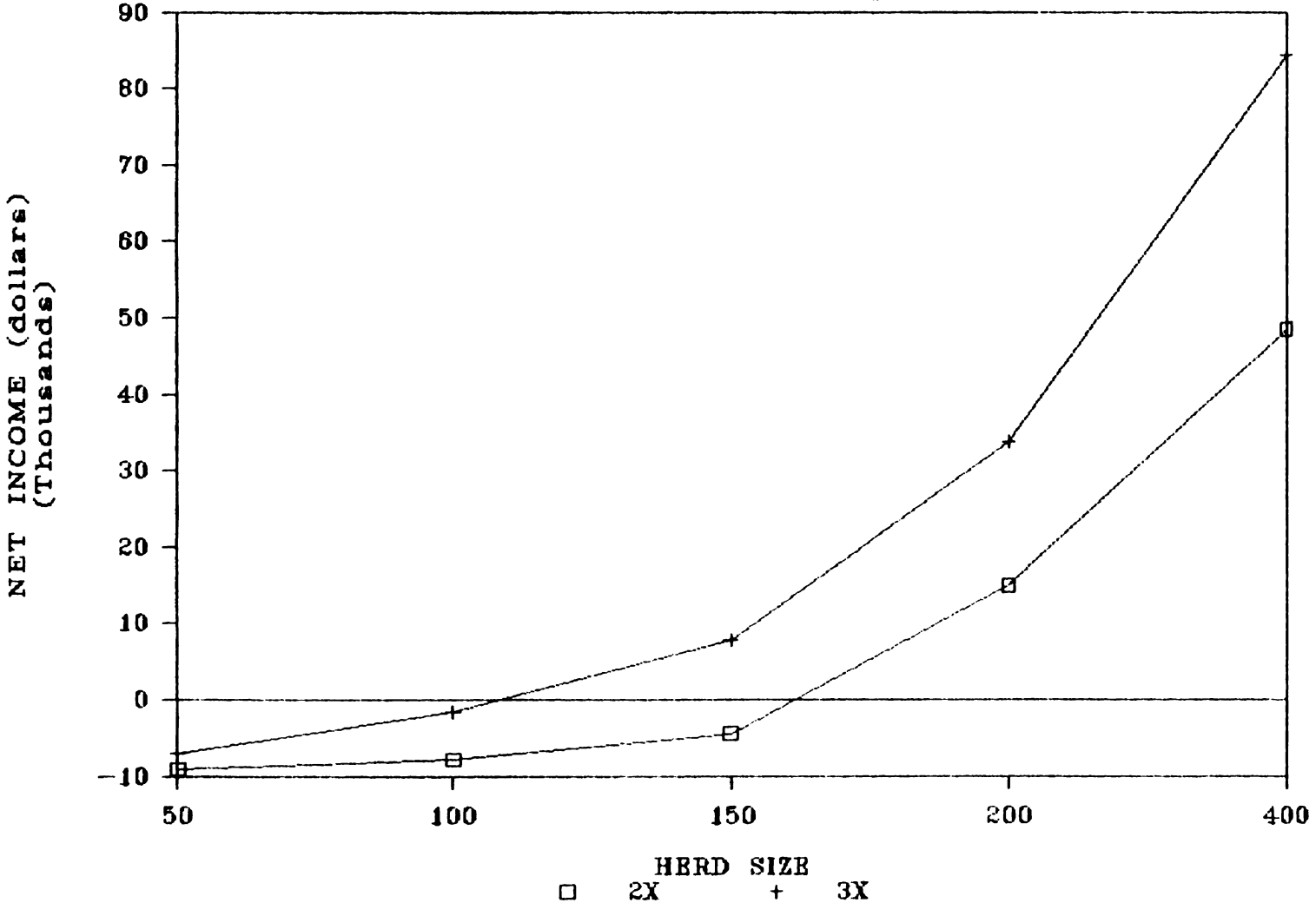


Figure 7.

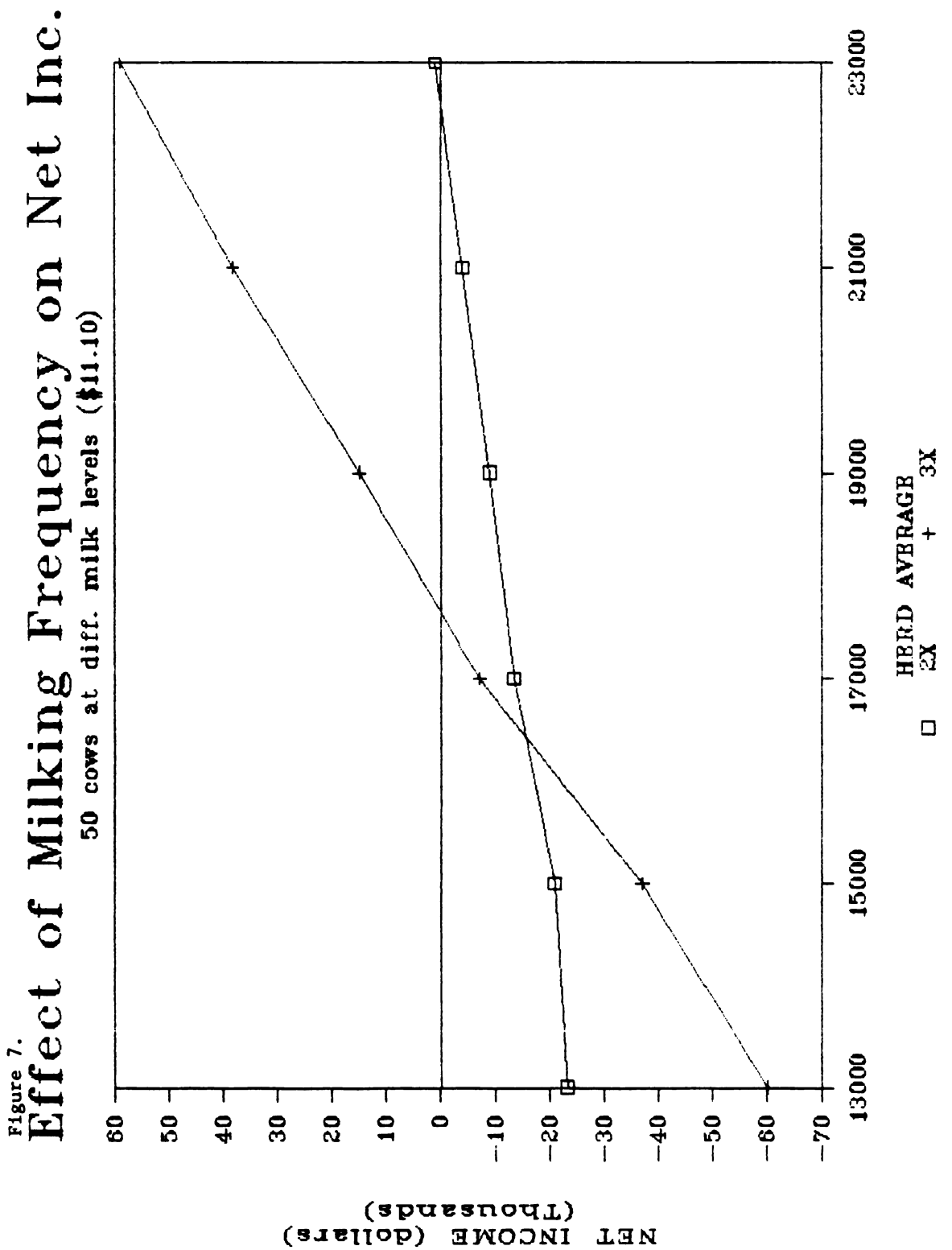

Effect of Milking Frequency on Net Inc.
50 cows at diff. milk levels ($11.10)
NET INCOME (dollars)
(Thousands)
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

Figure 8.

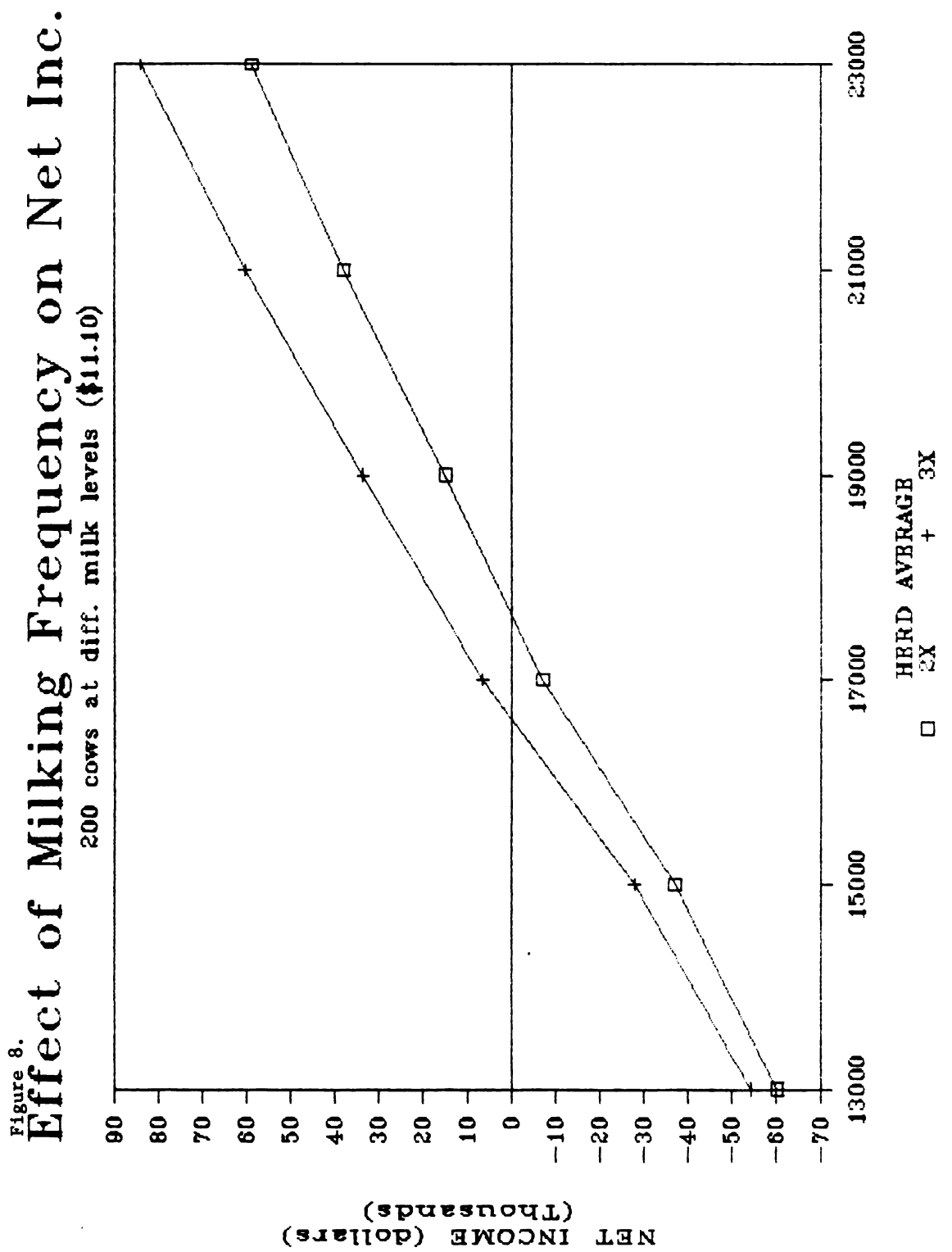
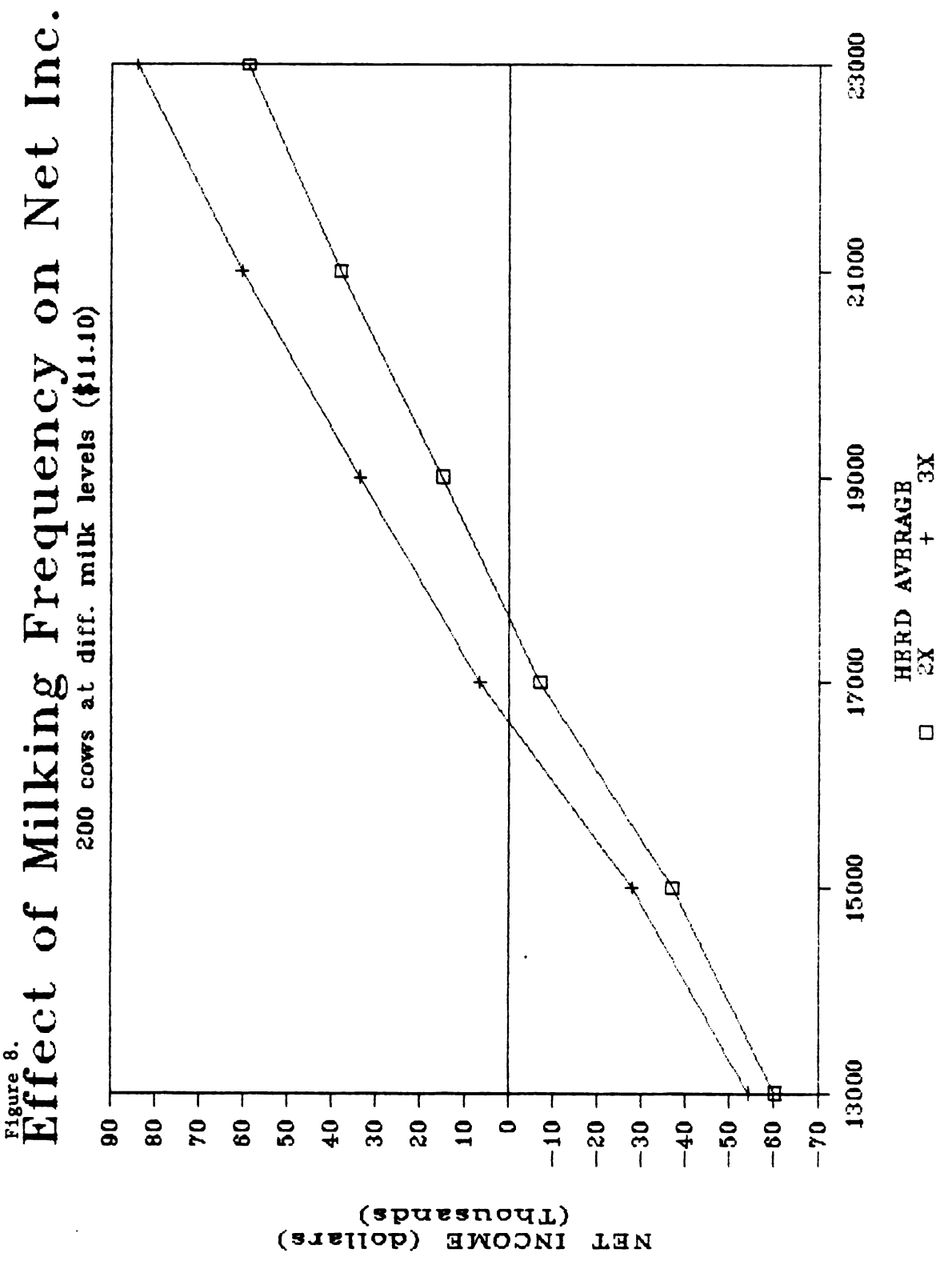

Effect of Milking Frequency on Net Inc.
200 cows at diff. milk levels ($11.10)
NET INCOME (dollars)
(Thousands)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

Figure 8.


Effect of Milking Frequency on Net Inc.
200 cows at diff. milk levels ($11.10)
NET INCOME (dollars)
(Thousands)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
13000
15000
17000
19000
21000
23000
HERD AVERAGE
□ 2X
+ 3X

Figures 9 through 11 illustrate the consequences of raising the price for 3X labor from $7.00/hr to $10.00/hr have on profitability of 3X milking compared with 2X milking. At a level of 19,000 lb of milk/cow, (see Fig. 9) only 200 and 400 cow herds. show increased net income for 3X milking compared with 2X milking.

A 50 cow herd (see Fig. 10) has to produce 19,000 lb of milk/cow before it becomes economically justifiable to shift from 2X to 3X milking. Herd size of 200 cows (see Fig. 11) illustrates a positive net income for 3X milking at a level of milk production of 17,000 lb of milk/cow. It further shows that as milk production per cow increases then 3X milking net income increases at a faster rate than 2X milking.

The Effect of Increasing the Price of Feed Forty Percent on Profitability of 3X Milking Compared with 2X Milking

Figures 12 and 13 illustrate the profitability of 3X milking compared with 2X milking was examined by analyzing the impact of increasing feed prices 40% relative to current feed prices. At a level of 17,000 lb of milk/cow, (see Fig. 12) is when a 50 cow herd shows increased net income from 3X milking. Even when milk production reaches 23,000 lb of milk/cow for a herd size of 50 cows, the breakeven point is not attained for 2X and 3X milking. At a herd size of 200 cows (see Fig. 13), profitability becomes positive when the

Figure 9.

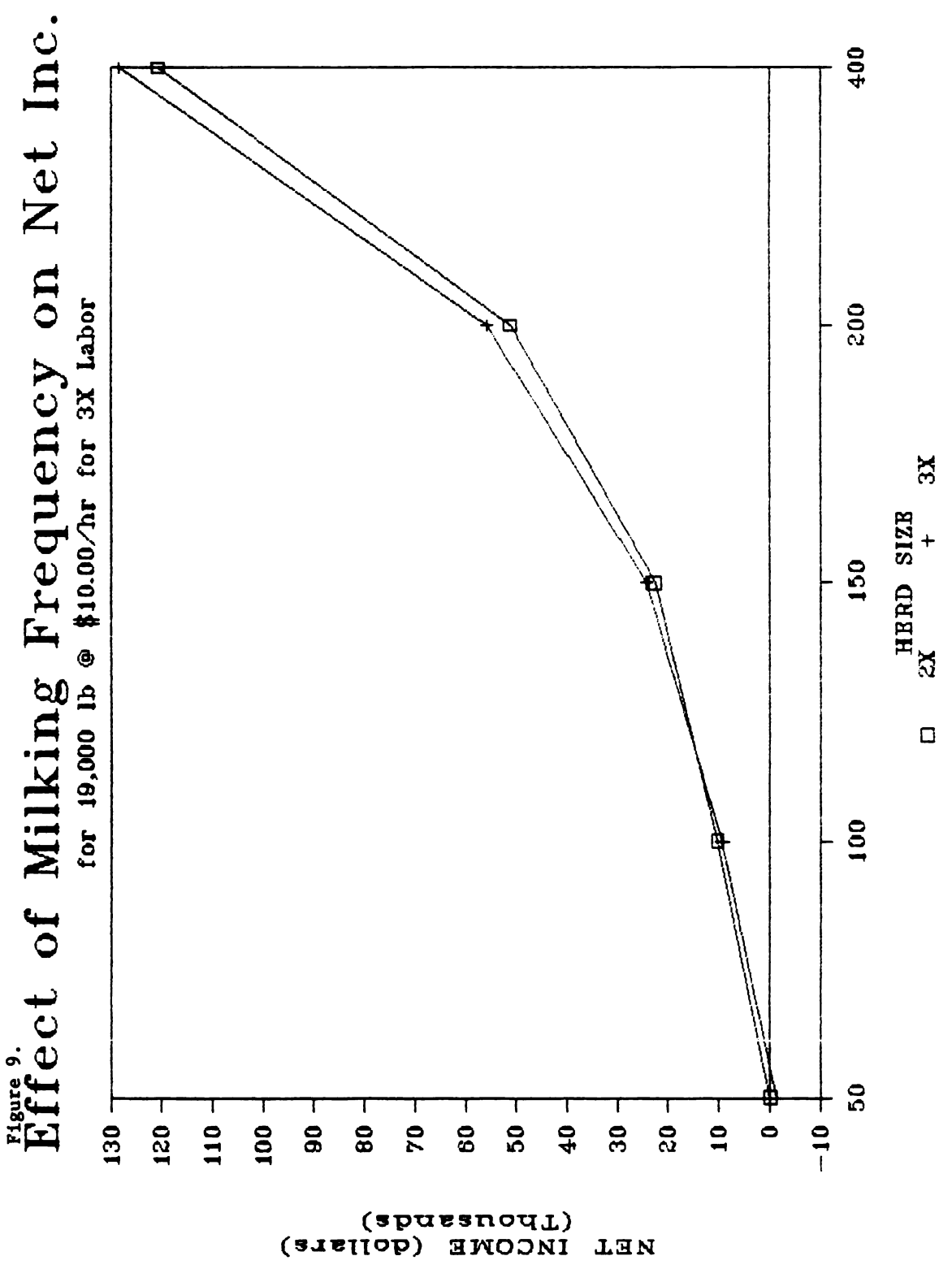

Effect of Milking Frequency on Net Inc.
for 19,000 lb @ $10.00/hr for 3X Labor
NET INCOME (dollars)
(Thousands)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
50
100
150
200
400
HERD SIZE
□ 2X + 3X

Figure 10.

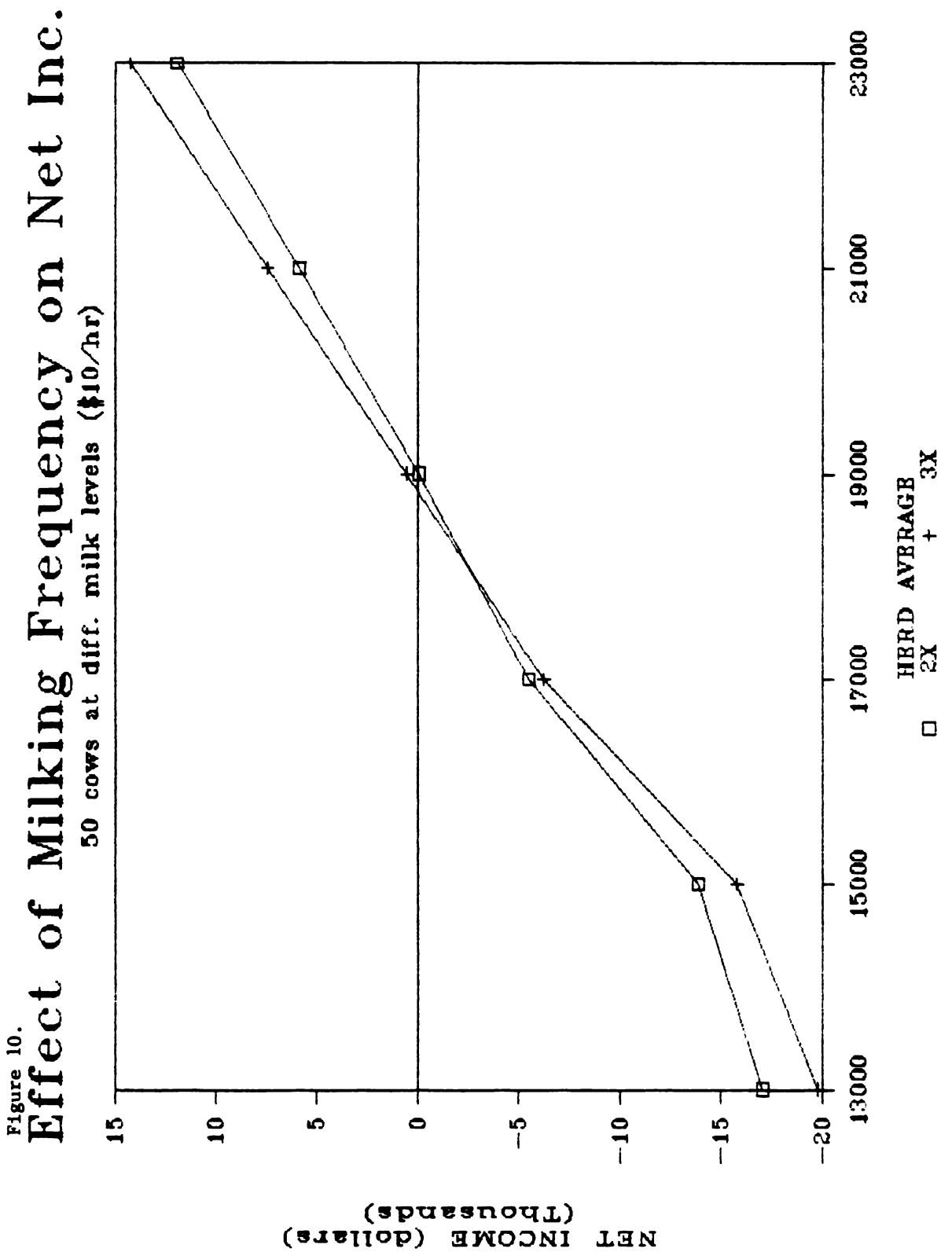

Effect of Milking Frequency on Net Inc.
50 cows at diff. milk levels ($10/hr)
NET INCOME (dollars)
(Thousands)
15
10
5
0
-5
-10
-15
-20
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

Figure 11.

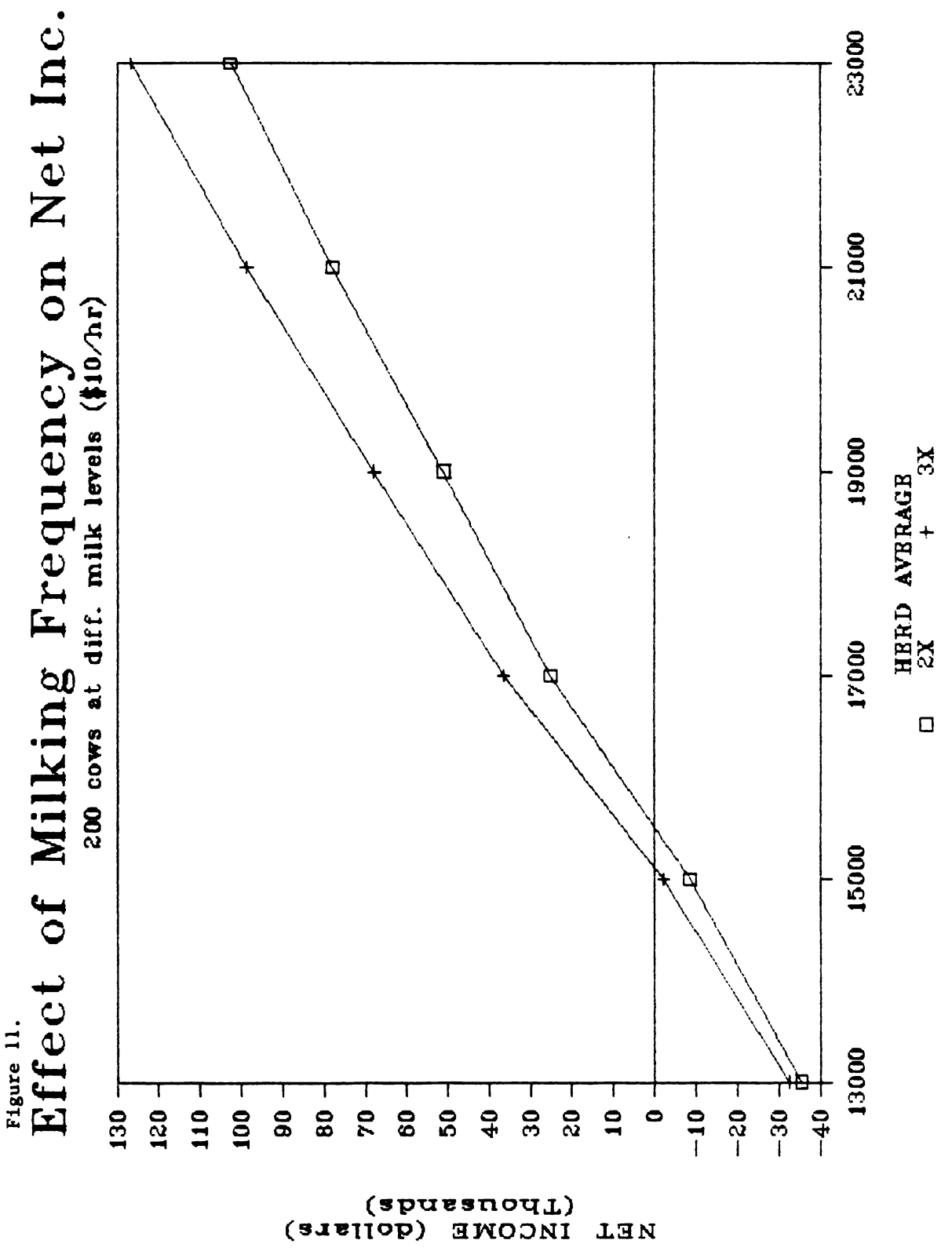

Effect of Milking Frequency on Net Inc.
200 cows at diff. milk levels ($10/hr)
NET INCOME (dollars)
(Thousands)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

Figure 12.

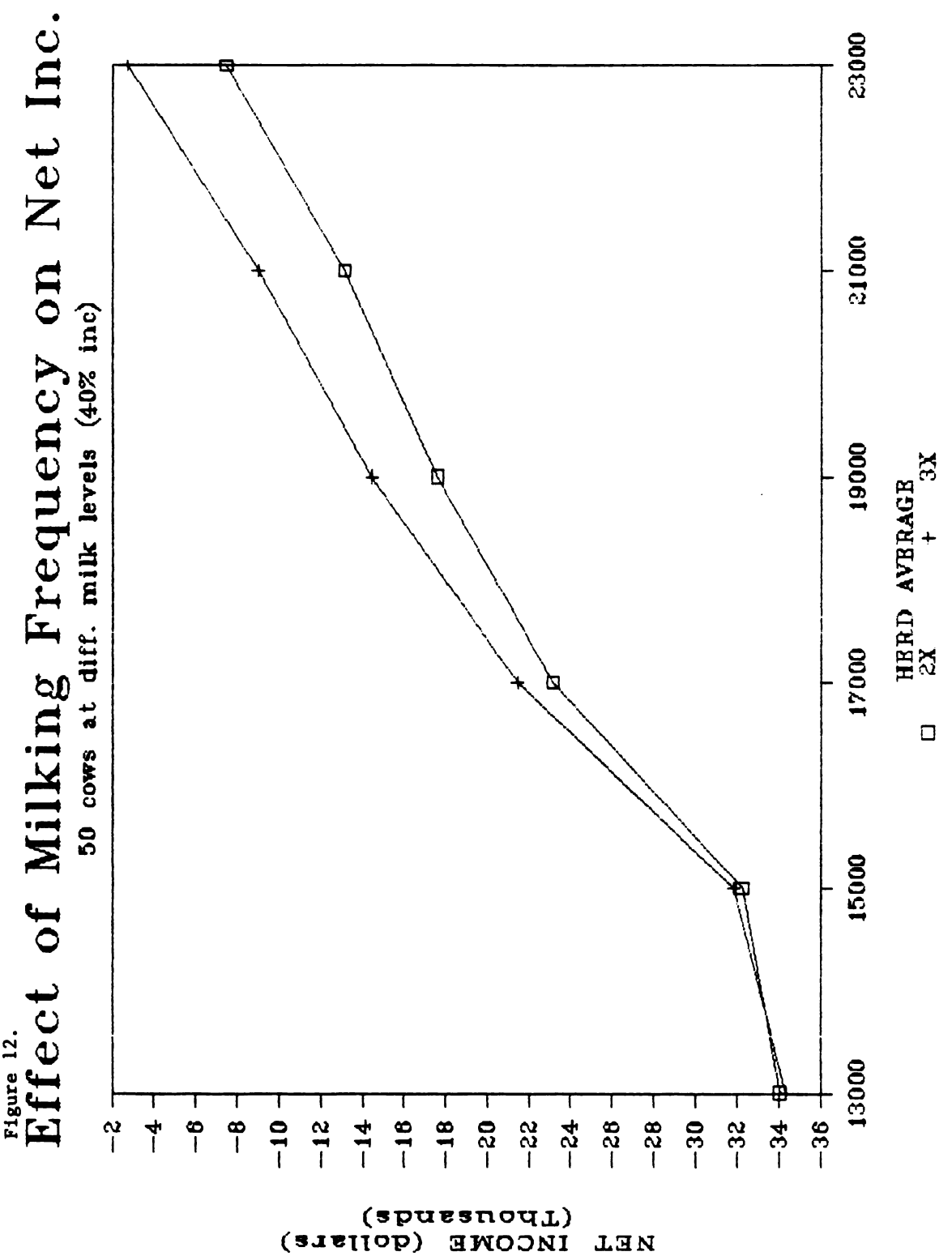
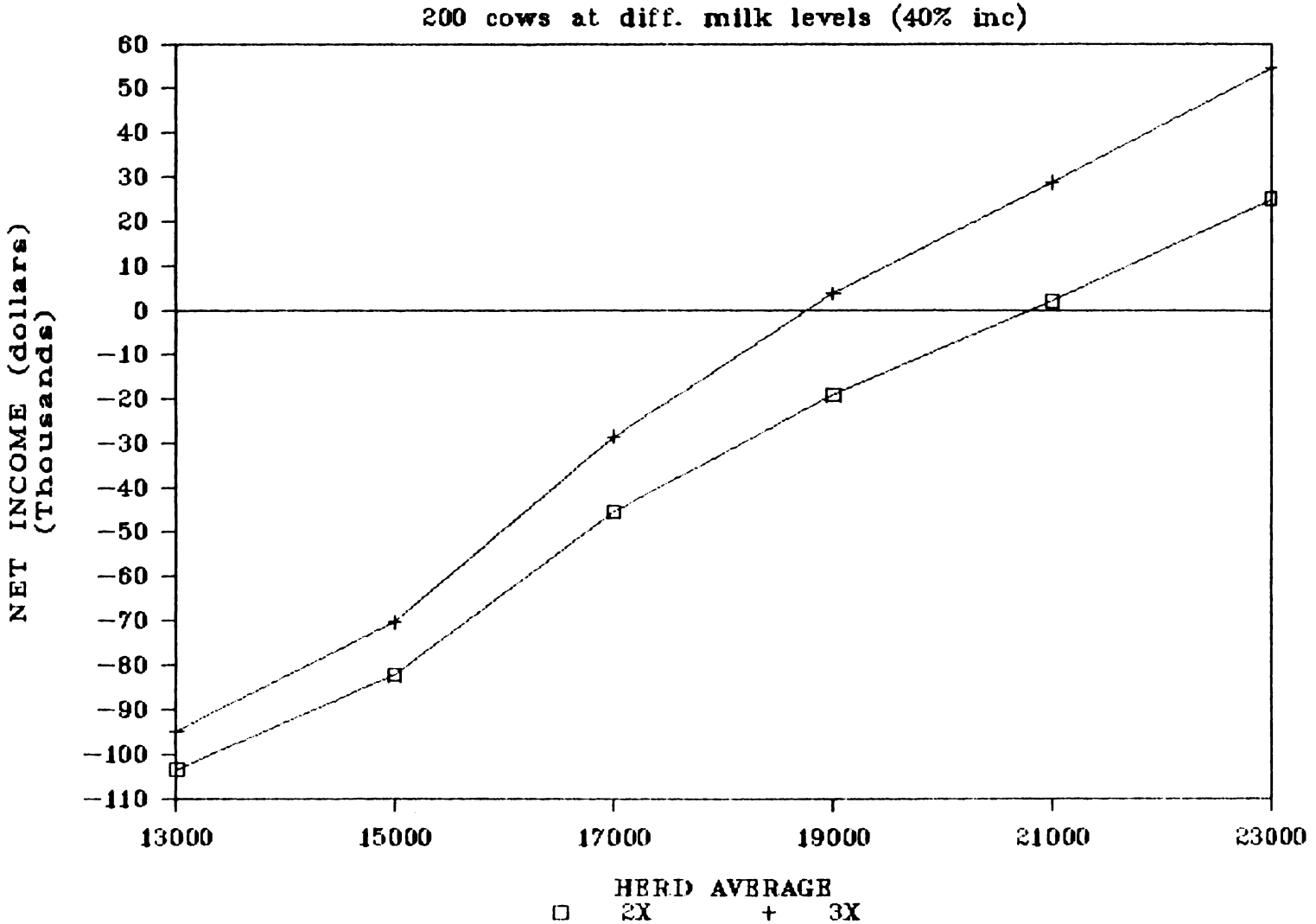

Effect of Milking Frequency on Net Inc.
50 cows at diff. milk levels (40% inc)
NET INCOME (dollars)
(Thousands)
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

Figure 13.

Effect of Milking Frequency on Net Inc.



milk production is 19,000 lb of milk/cow or greater.

The Effect on Profitability by Changing the Milk Production Response to Ten Percent when Milking Cows 3X Compared with 2X

Figures 14 through 17 illustrate the effect on profitability by reducing the increase in milk production from 3X milking compared with 2X milking from 15% to 10%. At a level of milk production of 13,000 lb of milk/cow (see Fig. 14) 2X milking is more profitable than 3X milking at all herd sizes. When production increases to 19,000 lb of milk/cow (see Fig. 15) it is not until herd sizes of 200 cows and larger that 3X milking is more profitable than 2X milking.

It is not profitable for a herd of 50 cows (see Fig. 16) to milk 3X when milk production increases only 10% compared with 2X milking. However, when herd size is 200 cows (see Fig. 17) 19,000 lb of milk/cow is needed before 3X milking is more profitable than 2X milking.

Figure 14.

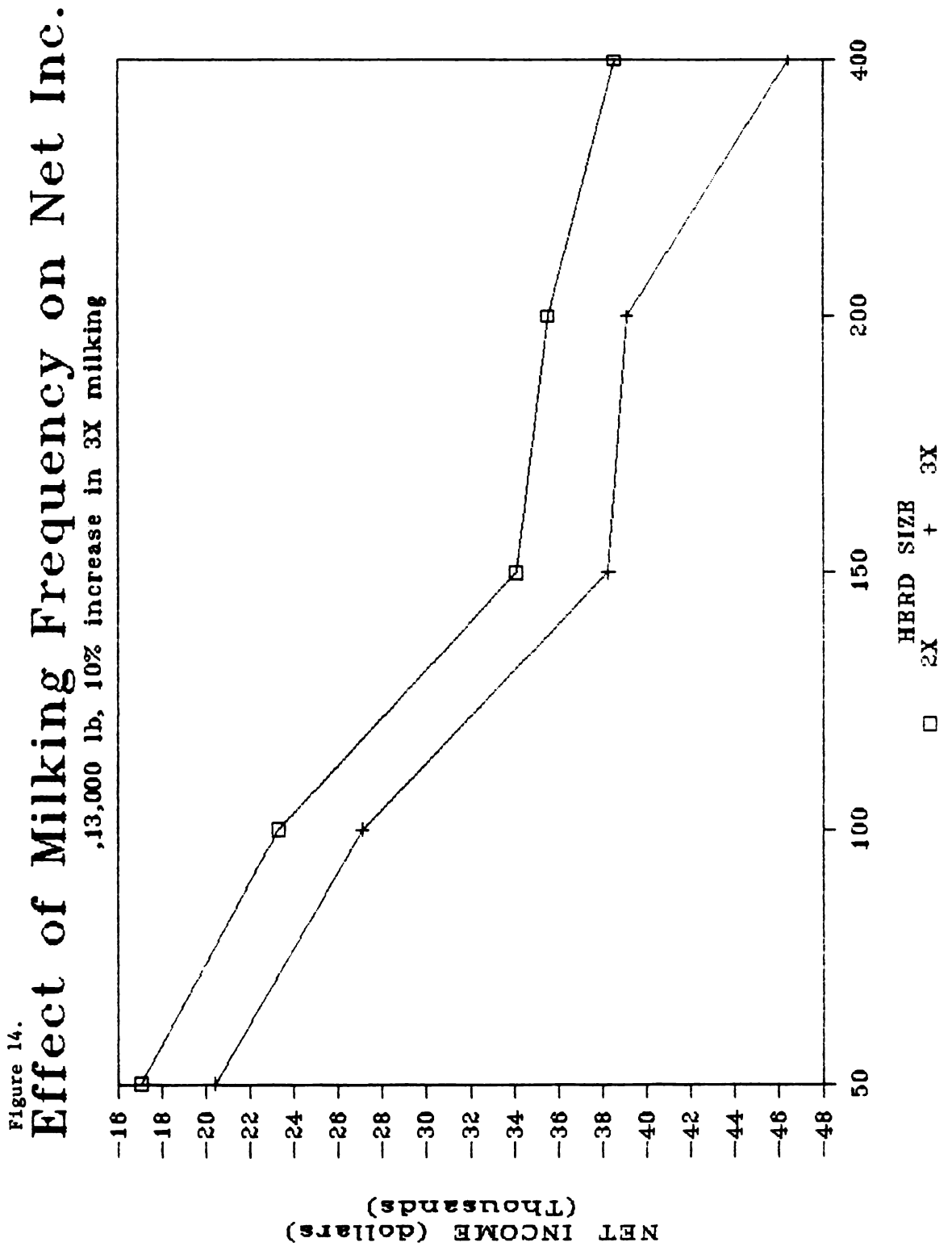

Effect of Milking Frequency on Net Inc.
,13,000 lb, 10% increase in 3X milking
NET INCOME (dollars)
(Thousands)
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36
-38
-40
-42
-44
-46
-48
50
100
150
200
400
HERD SIZE
2X
3X

Figure 15.

Effect of Milking Frequency on Net Inc.

,19,000 lb, 10% increase in 3X milking

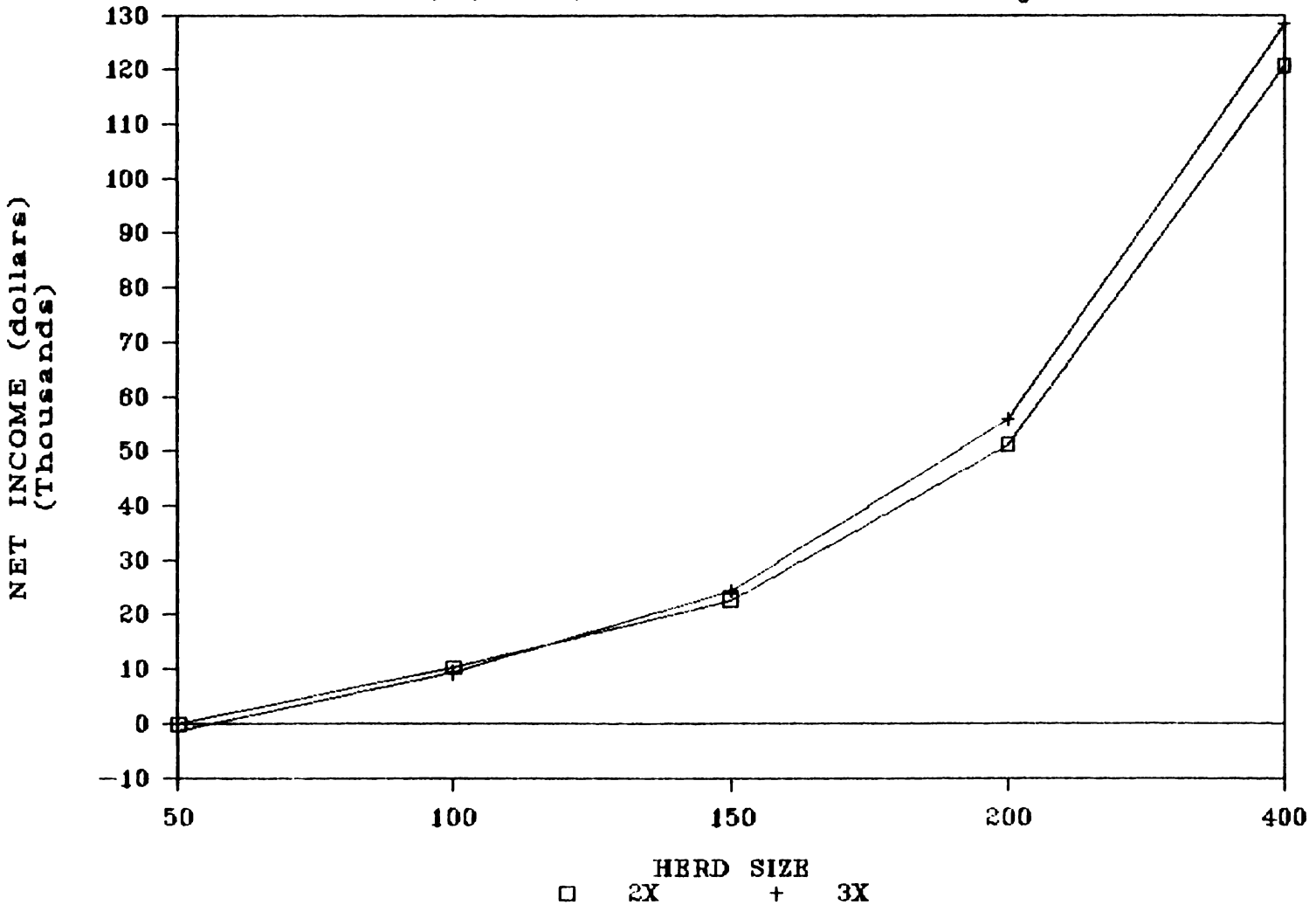


Figure 16.

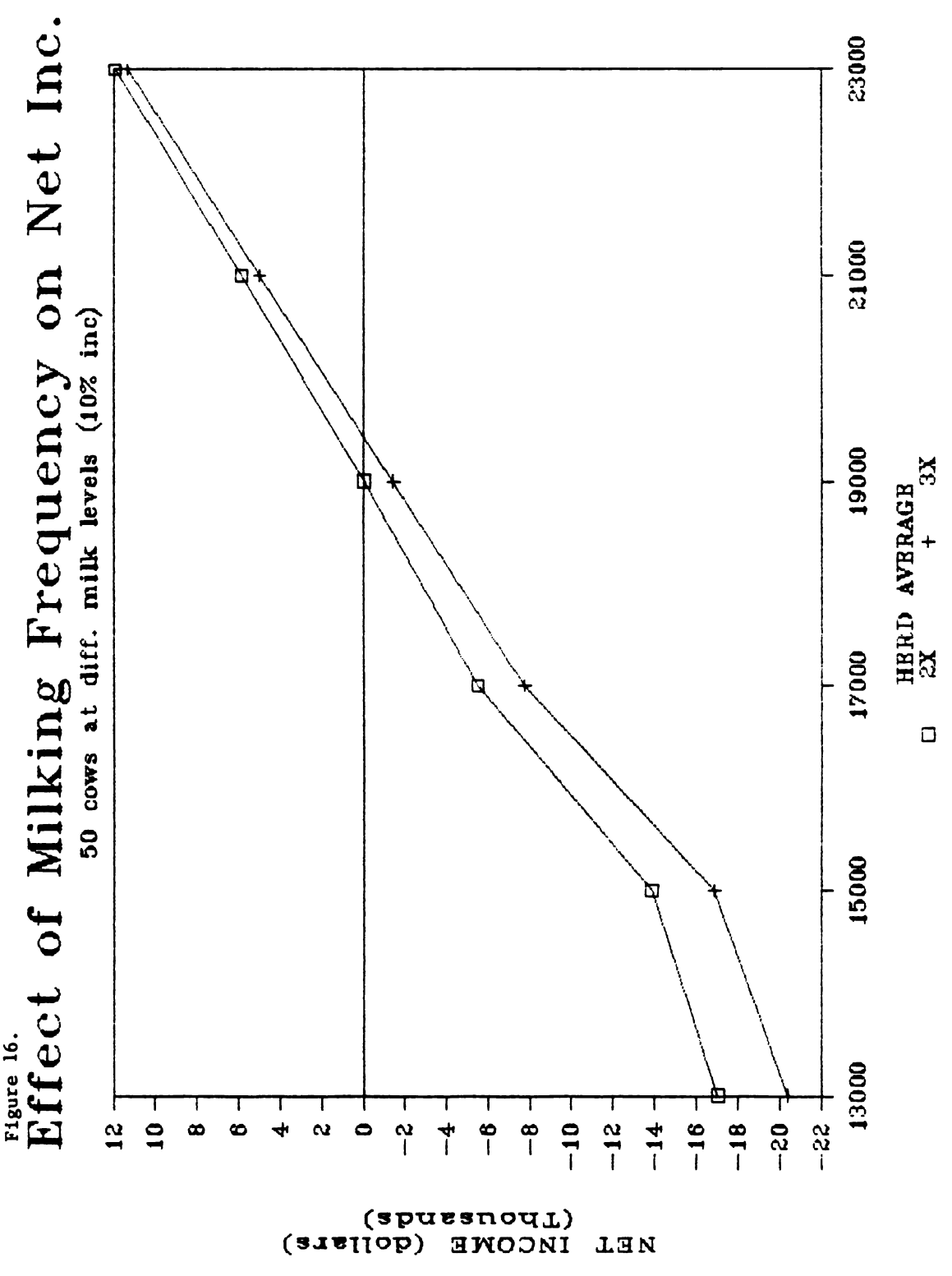
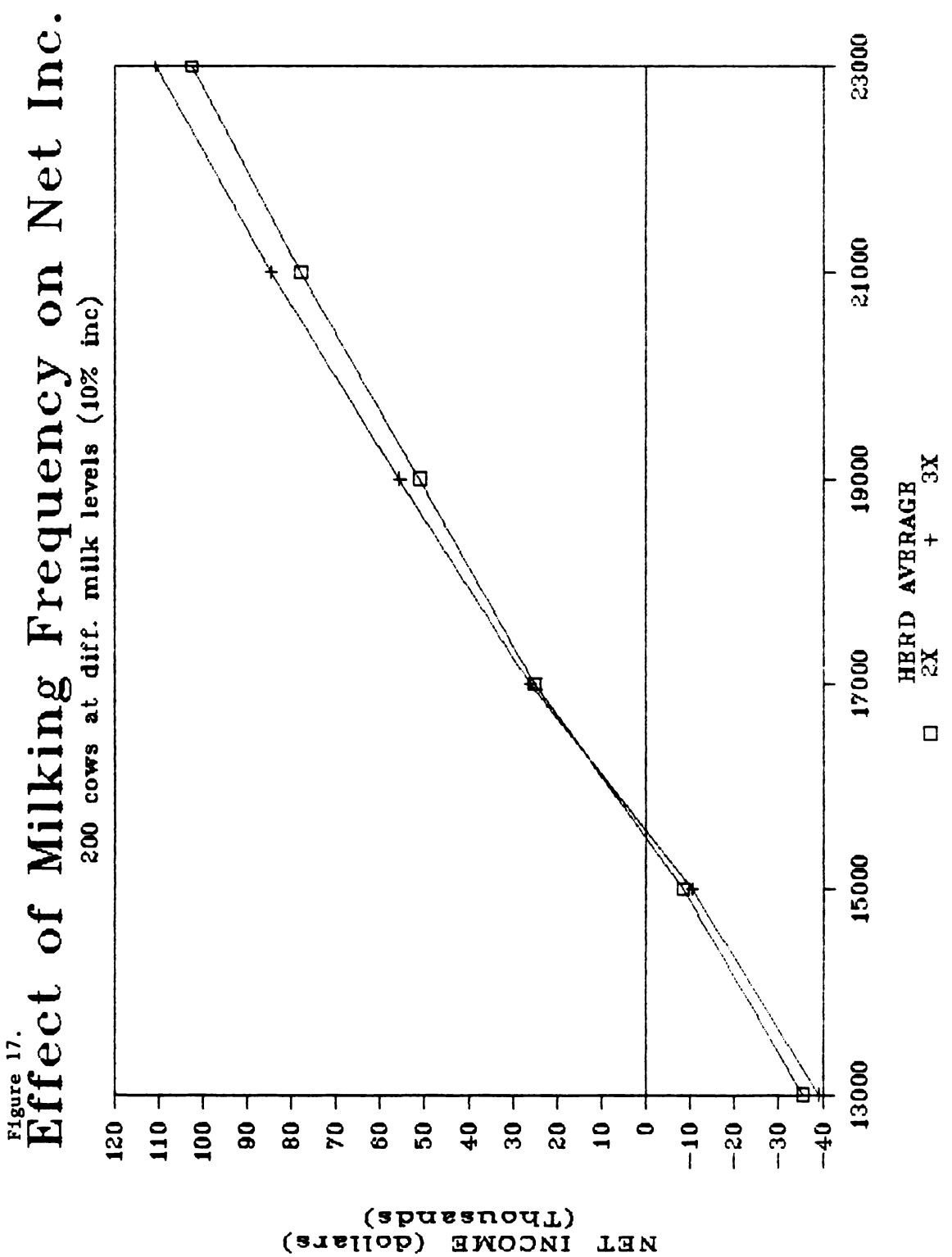

Effect of Milking Frequency on Net Inc.
50 cows at diff. milk levels (10% inc)
NET INCOME (dollars)
(Thousands)
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
13000
15000
17000
19000
21000
23000
HERD AVERAGE
□ 2X + 3X

Figure 17.


Effect of Milking Frequency on Net Inc.
200 cows at diff. milk levels (10% inc)
NET INCOME (dollars)
(Thousands)
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
13000
15000
17000
19000
21000
23000
HERD AVERAGE
2X
3X

DISCUSSION

In contrast to numerous experiments where only one net income was shown for cows being milked 3X compared with 2X, many net incomes are shown from the dairy investment model. Experimental conditions of the present studies and conditions in previous work were not identical. These differences may account for the contrasting results. For example, various herd sizes and herd averages were examined to determine profitability of milking cows 3X compared with 2X.

Goff and Gaunya, (1978) and Owens, (1985) never examined the impact of different prices on the profitability of milking 3X compared with 2X. For example, profitability in the current study was looked at over different milk prices, labor prices and feed prices. In addition different production responses from 3X milking were examined to see its effectiveness on 3X net income. Profitability of milking cows 3X compared with 2X was greatly altered when different prices and 3X production responses were used.

Total net income per cow per day was examined over herd sizes of 50, 100, 150, 200 and 400 cows and herd averages of 13, 15, 17, 19, 21 and 23 (thousand) lb of milk/cow. Net income was calculated using a milk price of $12.10/cwt, a price of labor for 3X of $7.00/hr, a milk production

increase from 3X of 15%, $2.00/bu for corn, $60.00/T for hay, $208.00/T for soybean meal and $23.00/T for corn silage.

For a 50 cow herd producing 13,000 lb of milk/cow, 3X milking shows a loss of $.01/cow/d compared with 2X milking. Hlubik, (1986) showed that a 70 cow herd can increase net income $.18/cow/d when milking 3X compared with 2X. When milk production is at 19,000 lb of milk/cow then 3X milking compared with 2X milking has higher net returns of $. 20/cow/d. When the herd average is 23,000 lb of milk/cow the added net income from 3X milking is $.29/cow/d.

When the herd size is 100 cows, 3X milking has a more positive effect on net income than a herd size of 50 cows. Owen, (1985) using a 100 cow model herd showed an increase of $.13/cow/d when 3X milking was practiced. At a level of milk production of 13,000 lb of milk/cow, 3X milking compared with 2X milking shows a gain of $.08/cow/d. When the herd average is increased to 15,000 lb of milk/cow the added net income from 3X milking is $.13/cow/d. When a 100 cow herd is producing 23,000 lb of milk/cow net income is increased $.34/cow/d for 3X milking compared with 2X milking.

At a herd size of 150 cows producing 13,000 lb of milk/cow, net income is $.10/cow/d greater for 3X milking compared with 2X milking. When the herd average is 17,000 lb of milk/cow, added net returns of $.23/cow/d from 3X milking is realized. At a level of milk production of 23,000 lb of milk/cow the added net income for 3X milking compared with 2X milking is $.40/cow/d.

A herd size of 200 cows depicts profitability at all herd averages based on current prices and costs. At a level of milk production of 13,000 lb of milk/cow net income is increased $.14/cow/d when a herd shifts from 2X milking to 3X milking. When the herd average is at 23,000 lb of milk/cow the added net income from 3X milking is $.43/cow/d. On a per cow basis, the 200 cow herd is more profitable at herd averages of 13, 15, 19 and 23 (thousand) lb of milk/cow than a 400 cow herd at herd averages of 13, 15, 19 and 23 (thousand) lb of milk/cow. A possible reason for the increase in net income on a per cow basis for a 200 cow herd compared with a 400 cow herd is assumptions built into the dairy investment model on the number of cows milked/hr. It was assumed that a 200 cow herd would be milked in a double 6 herringbone parlor with detachers and a crowd gate while the 400 cow herd would be milked in a double 8 herringbone parlor with detachers and a crowd gate. The values used in the dairy investment model for milking cows/hr are a major cause for the increase in net income on a per cow basis for a 200 cow herd compared with a 400 cow herd.

A herd size of 400 cows shows added net income for all herd averages. Pelissier et. al. (1978); Edwards, (1980); Bohling, (1980) calculated a return around $.25/cow/d for a 400 cow herd. This is very similar to the present results for a 400 cow herd producing 19,000 lb of milk/cow, however, Pelissier fails to show if 3X is proftable for other herd averages. A 400 cow herd producing 13,000 lb of milk/cow

will receive added net income of $.12/cow/d. Furthermore, if a 400 cow herd is producing 23,000 lb of milk/cow then the added net income from 3X milking is $.31/cow/d.

SUMMARY AND CONCLUSIONS

Profitability of milking cows 3X compared with milking cows 2X was examined across levels of production of 13, 15, 17, 19, 21 and 23 (thousand) lb of milk/cow. Using the electronic spreadsheet template Lotus 123 (1983), simulated farms of herd sizes of 50, 100, 150, 200 and 400 cows were modeled for 3X milking and 2X milking. The dairy investment model employs a static budgeting approach and assumes that all costs, prices and other input variables specified by the user are constant over the investment period. The model is useful in projecting long term profit expectation.

Milking 3X revealed:

1) Profitability is reached according to changes in level of milk production and herd size.

2) 3X milking becomes profitable for a 50 cow herd producing 17,000 lb of milk/cow.

3) For a 100 cow herd producing 13,000 lb of milk/cow, 3X milking shows added net income in comparison to 2X milking.

4) For herd sizes of 150, 200 and 400 cows, all herd averages show that 3X milking is profitable when compared to 2X milking.

Milking 3X is not likely to be for everyone because there are many factors involved and these factors vary widely in dairy herds. A feasability estimate for the herd must be made with the owner's cost and price data and management circumstances. To determine whether an individual dairy

operation should switch to 3X milking, the producer should: determine if there is profit potential in switching to 3X, assure that a dependable labor supply and excellent management is available, be able to meet the special management required for success with 3X milking and have a strong desire and commitment to make the system succeed.

There are limitations to the techniques and procedures developed and examined in this study. The key to improviong the model is to use available data and information, be it historical series or predictions, to the fullest extent possible. A good decision only improves the chance of a favorable outcome, it does not guarantee one.

APPENDIX A TABLES

Appendix table 1. Characteristics of rations for lactating cows.

Characteristics	305 Day Milk Yield					
	13,000	15,000	17,000	19,000	21,000	23,000
Energy conc. (NE, Mcal/lb DM)	.70	.74	.73	.74	.74	.76
Crude protein conc. (% DM)	13.53	15.32	15.36	14.84	15.04	15.78
Average daily milk production for 2X	42.6	49.2	55.7	62.3	69.0	75.4
Average daily milk production for 3X	49.0	56.6	64.1	71.6	79.2	86.7
Estimated dry matter intake (lb/day)	35.5	36.6	38.9	41.9	44.8	46.3
Net energy required (Mcal)	24.10	26.24	28.34	30.48	32.65	34.72
Crude Protein required (lb)	4.6	5.13	5.66	6.19	6.73	7.24
Net energy required (Mcal/lb DM)	.61	.64	.66	.68	.69	.71
DiCalcium Phosphate (lb/day)	.126	.130	.142	.162	.178	.199
Limestone added (lb/day)	.062	.154	.198	.253	.294	.314
TR mineral salt added (lb/day)	.175	.184	.193	.202	.210	.219
Calcium (% in ration after minerals added)	.67	.70	.72	.73	.73	.75
Phosphorus (% in ration after minerals added)	.33	.35	.36	.37	.37	.38
Calcium Sulfate	.097	.075	.070	.069	.058	.041
Magnesium Oxide	.026	.032	.037	.041	.036	.041

Appendix table 2. Nutrient content of feeds used in the model.

	Alfalfa Mid	Brewers Grains	Corn,Gr Shelled	Corn Silage NPN	Soybean Meal
% DM	88	22	88	35	90
Crude Protein %	18	28	10	11.30	48.9
Net Energy MCal/#	.59	.72	.93	.69	.84
Acid Detergent Fiber %	.36	25.0	1.0	28.0	10.0
Calcium %	1.25	.30	.02	.30	.34
Phosphorus %	.25	.54	.26	.26	.70
Magnesium %	.25	.15	.14	.20	.30
Potassium %	2.10	.05	.45	1.00	2.20
Sodium %	.02	.01	0	.01	.04
Chloride %	.31	.10	.03	.10	.04
Sulfur %	.23	.30	.14	.14	.47
Iron ppm	125	220	30	180	130
Zinc ppm	27	30	30	40	48
Copper ppm	9.0	20.0	5.0	7.0	25.0
Manganese ppm	28	41	15	38	31
Iodine ppm	0	0	0	0	0
Selenium ppm	0	0	0	0	0

Appendix table 3. Quantities of feed needed/cow and replacement/year by production level.

Feed	Lactating[a] Cow	Dry[b] Cow	Young-[c] stock	3X Cow	Storage & Feed Loss	Total Needed 2X	Total Needed 3X
	Production level of 13,000 lb, 3.5% milk						
Alfalfa, Mid.	1.4 T	.5 T	2.2 T	1.8 T	16%	4.8 T	5.2 T
Corn Gr. Shelled	31 bu	2 bu	12 bu	40 bu	8%	49 bu	58 bu
Corn Silage, NPN	9.2 T	.8 T	3 T	12 T	18%	15.3 T	18.6 T
Soybean Meal	339 lb	-	100 lb	457 lb	5%	461 lb	579 lb
DiCal Phosphate	38 lb	-	25 lb	38 lb	5%	66 lb	66 lb
Limestone	19 lb	-	-	19 lb	5%	20 lb	20 lb
Calcium Sulfate	29 lb	-	-	29 lb	5%	30 lb	30 lb
Magnesium Oxide	8 lb	-	-	8 lb	5%	9 lb	9 lb
Tr. Mineral Salt	53 lb	5 lb	25 lb	33 lb	5%	87 lb	87 lb
	Production level of 15,000 lb, 3.5% milk						
Alfalfa, Mid.	1.4 T	.5 T	2.2 T	1.8 T	16%	4.8 T	5.2 T
Corn Gr. Shelled	62 bu	2 bu	12 bu	83 bu	8%	82 bu	105 bu
Corn Silage, NPN	6.5 T	.8 T	3 T	8.7 T	18%	12.2 T	11.6 T
Soybean Meal	1017 lb	-	100 lb	1353 lb	5%	1173 lb	1526 lb
DiCal Phosphate	40 lb	-	25 lb	40 lb	5%	68 lb	68 lb
Limestone	47 lb	-	-	47 lb	5%	50 lb	50 lb
Calcium Sulfate	23 lb	-	-	23 lb	5%	24 lb	24 lb
Magnesium Oxide	10 lb	-	-	10 lb	5%	11 lb	11 lb
Tr. Mineral Salt	56 lb	5 lb	25 lb	56 lb	5%	90 lb	90 lb
	Production level of 17,000 lb, 3.5% milk						
Alfalfa, Mid.	1.4 T	.5 T	2.2 T	1.8 T	16%	4.8 T	5.2 T
Brewers Grain	2.1 T	-	-	2.8 T	8%	2.3 T	3.o T
Corn Gr. Shelled	63 bu	2 bu	12 bu	84 bu	8%	83 bu	106 bu
Corn Silage, NPN	6.5 T	.8 T	3 T	8.7 lb	18%	12.1 T	11.6 T
Soybean Meal	678 lb	-	100 lb	900 lb	5%	817 lb	1050 lb
DiCal Phosphate	43 lb	-	25 lb	43 lb	5%	71 lb	71 lb
Limestone	60 lb	-	-	60 lb	5%	63 lb	63 lb
Calcium Sulfate	21 lb	-	-	21 lb	5%	22 lb	22 lb
Magnesium Oxide	11 lb	-	-	11 lb	5%	12 lb	12 lb
Pot. Chloride	15 lb	-	-	15 lb	5%	16 lb	16 lb
Tr. Mineral Salt	59 lb	5 lb	25 lb	59 lb	5%	93 lb	93 lb

table 3. (continued)

Feed	Lactating[a] Cow	Dry[b] Cow	Young-[c] stock	3X Cow	Storage & Feed Loss	Total Needed 2X	Total Needed 3X
	Production level of 19,000 lb, 3.5% milk						
Alfalfa, Mid.	1.4 T	.5 T	2.2 T	1.8 T	16%	4.8 T	5.2 T
Brewers Grain	3.5 T	-	-	4.7 T	8%	3.8 T	5.1 T
Corn Gr. Shelled	81 bu	2 bu	12 T	108 lb	8%	103 bu	132 bu
Corn Silage, NPN	6.1 lb	.8 T	3 T	8.1 lb	18%	11.7 T	10.9 T
Soybean Meal	339 lb	-	100 lb	451 lb	5%	461 lb	579 lb
DiCal Phosphate	49 lb	-	25 lb	49 lb	5%	78 lb	78 lb
Limestone	77 lb	-	-	77 lb	5%	81 lb	81 lb
Calcium Sulfate	21 lb	-	-	21 lb	5%	22 lb	22 lb
Magnesium Oxide	13 lb	-	-	13 lb	5%	14 lb	14 lb
Pot. Chloride	38 lb	-	-	38 lb	5%	40 lb	40 lb
Tr. Mineral Salt	62 lb	5 lb	25 lb	62 lb	5%	97 lb	97 lb
	Production level of 21,000 lb, 3.5% milk						
Alfalfa, Mid.	1.4 T	.5 T	2.2 T	1.8 T	16%	4.8 T	5.2 T
Brewers Grain	2.8 T	-	-	3.7 lb	8%	3.0 T	4.0 T
Corn Gr. Shelled	87 bu	2 bu	12 bu	116 lb	8%	109 bu	140 bu
Corn Silage, NPN	7.0 T	.8 T	3 T	9.3 lb	18%	12.8 T	12.3 T
Soybean Meal	678 lb	-	100 lb	900 lb	5%	817 lb	1050 lb
DiCal Phosphate	54 lb	-	25 lb	54 lb	5%	83 lb	83 lb
Limestone	90 lb	-	-	90 lb	5%	95 lb	95 lb
Calcium Sulfate	18 lb	-	-	18 lb	5%	19 lb	19 lb
Magnesium Oxide	11 lb	-	-	11 lb	5%	12 lb	12 lb
Pot. Chloride	22 lb	-	-	22 lb	5%	23 lb	23 lb
Tr. Mineral Salt	64 lb	5 lb	25 lb	64 lb	5%	99 lb	99 lb
	Production level of 23,000 lb, 3.5% milk						
Alfalfa, Mid.	1.7 T	.5 T	2.2 T	2.3 T	16%	5.1 T	5.8 T
Brewers Grain	3.5 T	-	-	4.7 T	8%	3.8 T	5.1 T
Corn Gr. Shelled	111 bu	2 bu	12 bu	148 bu	8%	135 bu	175 bu
Corn Silage, NPN	4.4 T	.8 T	3 T	5.9 T	18%	9.7 T	8.3 T
Soybean Meal	813 lb	-	100 lb	1080 lb	5%	959 lb	1240 lb
DiCal Phosphate	61 lb	-	25 lb	61 lb	5%	90 lb	90 lb
Limestone	96 lb	-	-	96 lb	5%	101 lb	101 lb
Calcium Sulfate	13 lb	-	-	13 lb	5%	14 lb	14 lb
Magnesium Sulfate	13 lb	-	-	13 lb	5%	14 lb	14 lb
Potassium	28 lb	-	-	28 lb	5%	29 lb	29 lb
Tr. Mineral Salt	67 lb	5 lb	25 lb	67 lb	5%	102 lb	102 lb

Table 3. (continued)

[a]Quantities of feed for lactating cows are based upon a 305 day lactation.

[b,c]Quantities of feeds for dry cows and youngstock are estimated from: Thomas, Emery, Hlubik (1980). It is assumed that dry cows will be brought onto grain approximately 2 weeks befor freshening.

[c]According to Telfarm summary data (1981) there is approximately one replacement heifer/cow/year. It is assumed that 1/2 of replacements are between 0 and 1 yr of age and 1/2 between 1 and 2 years of age. Therefore, for every heifer the amount of feed needed is the amount needed between birth and freshening/2.

[d]Storage and feeding losses are based on: Knoblauch (1977), pg. 17 and Parsch (1982), pg. 134. Losses include feeding and storage losses. Losses for corn are those for high moisture corn stored in an upright silo. Losses for corn silage are losses based on bunker silo storage. Losses of hay crop are estimated as 40% dry hay and 60% of the losses of haylange stored in an upright silo (i.e. .4 * 12 + .6 * 19 =16).

Appendix table 4. Steady state throughputs of cows.

	Cows milked/hr				
Herd Average	50	100	150	200	400
13,000	36	40	62	68	81
15,000	32	36	57	62	76
17,000	28	31	52	58	71
19,000	24	28	48	53	67
21,000	20	25	44	49	63
23,000	17	21	40	45	59

Appendix table 5.

The effect of milking frequency on net income for various herd sizes and milk production averages.

Herd Average	Herd Size (Cows) 50	100	150	200	400
13,000 (2x)	-17,058	-23,292	-34,099	-35,529	-38,538
13,000 (3x)	-17,066	-20,419	-28,243	-25,792	-19,782
15,000 (2x)	-13,860	-11,993	-14,819	-8,478	10,691
15,000 (3x)	-13,010	-7,421	-6,069	4,956	36,800
17,000 (2x)	-5,493	-881	10,435	25,189	72,111
17,000 (3x)	-3,399	5,287	22,869	43,604	107,355
19,000 (2x)	-60	10,247	22,659	51,048	120,680
19,000 (3x)	3,422	19,152	38,967	75,198	167,440
21,000 (2x)	5,851	22,671	42,457	77,955	173,611
21,000 (3x)	10,352	33,530	61,811	106,252	229,077
23,000 (2x)	11,933	34,908	61,855	102,558	224,980
23,000 (3x)	17,218	47,087	83,615	134,267	287,071

Appendix table 6.

The effect of reducing the milk price from $12.10/cwt. to $11.10/cwt. have on profitability of 3x milking compared with 2x milking.

	Herd Size (Cows)				
Herd Average	50	100	150	200	400
13,000 (2x)	-23,233	-35,642	-52,624	-60,229	-87,938
13,000 (3x)	-24,167	-34,621	-49,547	-54,197	-76,592
15,000 (2x)	-20,985	-26,243	-36,194	-36,978	-46,309
15,000 (3x)	-21,204	-23,809	-30,650	-27,819	-28,750
17,000 (2x)	-13,568	-17,031	-13,790	-7,111	-7,511
17,000 (3x)	-12,686	-13,286	-4,989	6,459	33,065
19,000 (2x)	-9,085	-7,803	-4,416	14,948	48,480
19,000 (3x)	-6,957	-1,605	7,831	33,683	84,410
21,000 (2x)	-4,124	2,721	12,532	38,055	93,811
21,000 (3x)	-1,120	10,587	27,397	60,367	137,307
23,000 (2x)	1,008	13,058	29,080	58,858	137,580
23,000 (3x)	4,655	21,959	45,924	84,012	186,561

Appendix table 7.

The effect of changing the price of labor from $7.00/hr. to $10.00/hr. on profitability of 3x milking compared with 2x milking.

	Herd Size (Cows)				
Herd Average	50	100	150	200	400
13,000 (2x)	-17,058	-23,292	-34,099	-35,529	-38,538
13,000 (3x)	-19,821	-24,661	-33,800	-32,615	-34,276
15,000 (2x)	-13,860	-11,993	-14,819	-8,478	10,691
15,000 (3x)	-15,791	-11,746	-11,721	-2,037	21,917
17,000 (2x)	-5,493	-881	-10,435	25,189	72,111
17,000 (3x)	-6,214	827	17,103	36,477	92,026
19,000 (2x)	-60	10,247	22,659	51,048	120,680
19,000 (3x)	562	14,589	33,092	67,876	151,708
21,000 (2x)	5,581	22,671	42,457	77,955	173,611
21,000 (3x)	7,430	28,838	55,808	98,745	212,890
23,000 (2x)	11,933	34,908	61,855	102,558	224,980
23,000 (3x)	14,230	42,166	77,459	126,542	270,367

Appendix table 8.

The effect of increasing the price of feed forty percent on profitability of 3x milking compared with 2x milking.

Herd Average	Herd Size (Cows) 50	100	150	200	400
13,000 (2x)	-34,060	-57,296	-85,103	-103,535	-174,550
13,000 (3x)	-34,332	-54,951	-80,041	-94,856	-157,911
15,000 (2x)	-32,264	-48,801	-70,031	-82,094	-136,541
15,000 (3x)	-31,827	-45,055	-62,520	-70,311	-113,735
17,000 (2x)	-23,153	-36,202	-42,546	-45,452	-69,171
17,000 (3x)	-21,446	-30,806	-31,270	-28,581	-37,015
19,000 (2x)	-17,602	-24,836	-29,966	-19,118	-19,652
19,000 (3x)	-14,446	-16,584	-14,637	3,726	24,495
21,000 (2x)	-13,164	-15,360	-14,589	1,894	21,489
21,000 (3x)	-9,019	-5,212	3,698	28,769	74,110
23,000 (2x)	-7,472	-3,902	3,641	24,938	69,740
23,000 (3x)	-2,271	7,209	23,799	54,511	127,560

Appendix table 9.

The effect on profitability by changing the milk production response to ten percent when milking cows 3x compared with 2x.

Herd Average	Herd Size (Cows) 50	100	150	200	400
13,000 (2x)	-17,058	-23,292	-34,099	-35,529	-38,538
13,000 (3x)	-20,400	-27,088	-38,247	-39,130	-46,458
15,000 (2x)	-13,860	-11,993	-14,819	-8,478	10,691
15,000 (3x)	-16,857	-15,116	-17,611	-10,434	6,020
17,000 (2x)	-5,493	-881	10,435	25,189	72,111
17,000 (3x)	-7,760	-3,434	-9,788	26,162	72,471
19,000 (2x)	-60	10,247	22,659	51,048	120,680
19,000 (3x)	-1,452	9,405	24,347	55,704	128,452
21,000 (2x)	5,851	22,671	42,457	77,955	173,611
21,000 (3x)	4,965	22,757	45,651	84,706	185,985
23,000 (2x)	11,933	34,908	61,855	102,558	224,980
23,000 (3x)	11,319	35,288	65,917	110,669	239,875

by David Chlus

Dairy Farm Analysis of Three Times A Day Milking On Michigan Dairy Farms using Michigan TELFARM Data.

Herd Size:	50	100	150	200	400	
Herd AVE.:	13000	15000	17000	19000	21000	23000
Cattle Inc./cow	160	192	230	240	255	270
Milk Price:	12.10					
Price of Labor	5.00	for 2X				
per hour:	7.00	for 3X				
Milk Loss:	0.05	%				
Milk Increase:	0.15					
Price of Corn:	2.00	/bu.				
Price of Hay:	75.00	/T				
Price of SBM:	208.00	/T				
Price of CSLG:	23.00	/T				
Cows milked per hour:	0	Default values for each production level.				
Deprec./cow:	0.00	Enter your own values if you want to override spreadsheet values.				

<Alt> <P> = Print the answer
<Alt> <S> = Save the answer

			50	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	13000	13000	15000	15000	17000	17000
MilkInc.		1950		2250		2550
Milkloss	650	748	750	863	850	978
Milk/Cow	12350	14203	14250	16388	16150	18573
Tot.MilkShipp.	617500	710125	712500	819375	807500	928625
Grossmilksal.	74718	85925	86213	99144	97708	112364
Cat.Inc	160	160	192	192	230	230
GrossCat.Inc.	8000	8000	9600	9600	11500	11500
Gross Inc.	82718	93925	95813	108744	109208	123864
FeedCost	881.44	894.82	952.15	972.96	993.29	1016.05
LaborCost	395.00	523.58	431.00	560.80	440.00	571.36
Reprs&Veh.Main	54.17	54.17	56.33	56.33	58.22	58.22
Fuel,Oil,Grea.	8.43	8.43	9.45	9.45	9.95	9.95
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	68.65	68.65	71.25	71.25	74.23	74.23
Int. Alloc.	16.84	16.84	22.50	22.50	24.39	24.39
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	8.05	8.05	9.14	9.14	9.55	9.55
Insur.	12.45	12.45	13.98	13.98	14.20	14.20
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	48.72	48.72	59.92	59.92	64.49	64.49
Int. Alloc.	38.33	38.33	42.77	42.77	43.50	43.50
Semen&Breed.	17.73	17.73	21.27	21.27	22.81	22.81
Vet.Med&Drug	36.84	36.84	41.25	41.25	43.28	43.28
Mktg.Truck	160.55	184.63	185.25	213.04	209.95	241.44
Lvstck Supp.	28.41	42.62	29.91	44.87	30.38	45.57
DHIA&Bedd.	23.92	35.88	29.89	44.84	32.17	48.26
Int. Alloc.	118.36	118.36	136.36	136.36	140.04	140.04
Land Tax	11.84	11.84	12.55	12.55	12.93	12.93
LandInt.Alloc.	1.58	1.58	1.80	1.80	1.88	1.88
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	52.94	79.41	54.23	81.35	55.61	83.42
Misc.	11.26	16.89	12.45	18.68	13.13	19.70
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	50	50	50	50	50	50
Total Exp.	99776	110991	109673	121754	114700	127263
Net Income	-17058	-17066	-13860	-13010	-5493	-3399

			50	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	19000	19000	21000	21000	23000	23000
MilkInc.		2850		3150		3450
Milkloss	950	1093	1050	1208	1150	1323
Milk/Cow	18050	20758	19950	22943	21850	25128
Tot.MilkShipp.	902500	1037875	997500	1147125	1092500	1256375
Grossmilksal.	109203	125583	120698	138802	132193	152021
Cat.Inc	240	240	255	255	270	270
GrossCat.Inc.	12000	12000	12750	12750	13500	13500
Gross Inc.	121203	137583	133448	151552	145693	165521
FeedCost	1041.11	1060.84	1089.17	1113.66	1135.64	1169.05
LaborCost	470.00	603.44	495.00	631.36	525.00	664.45
Reprs&Veh.Main	60.08	60.08	62.86	62.86	63.51	63.51
Fuel,Oil,Grea.	10.32	10.32	11.72	11.72	11.85	11.85
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	75.63	75.63	78.87	78.87	81.14	81.14
Int. Alloc.	28.46	28.46	31.13	31.13	32.15	32.15
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	9.86	9.86	10.41	10.41	10.89	10.89
Insur.	15.35	15.35	15.86	15.86	16.17	16.17
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	68.12	68.12	71.21	71.21	73.48	73.48
Int. Alloc.	45.78	45.78	47.37	47.37	48.98	48.98
Semen&Breed.	23.52	23.52	25.25	25.25	27.17	27.17
Vet.Med&Drug	45.29	45.29	46.66	46.66	48.36	48.36
Mktg.Truck	234.65	269.85	259.35	298.25	284.05	326.66
Lvstck Supp.	32.17	48.26	33.41	50.12	35.01	52.52
DHIA&Bedd.	33.06	49.59	34.50	51.75	34.96	52.44
Int. Alloc.	142.37	142.37	146.38	146.38	149.61	149.61
Land Tax	13.40	13.40	13.75	13.75	14.08	14.08
LandInt.Alloc.	2.10	2.10	2.25	2.25	2.29	2.29
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	60.13	90.20	62.31	93.47	65.83	98.75
Misc.	13.85	20.78	14.46	21.69	15.02	22.53
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	50	50	50	50	50	50
Total Exp.	121262	134161	127596	141201	133760	148303
Net Income	-60	3422	5851	10352	11933	17218

			100	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	13000.00	13000	15000	15000	17000	17000
MilkInc.		1950		2250		2550
Milkloss	650	748	750	863	850	978
Milk/Cow	12350	14203	14250	16388	16150	18573
Tot.MilkShipp.	1235000	1420250	1425000	1638750	1615000	1857250
Grossmilksal.	149435	171850	172425	198289	195415	224727
Cat.Inc	160	160	192	192	230	230
GrossCat.Inc.	16000	16000	19200	19200	23000	23000
Gross Inc.	165435	187850	191625	217489	218415	247727
FeedCost	881.44	894.82	952.15	972.96	993.29	1016.05
LaborCost	270.00	368.98	278.00	378.92	314.00	418.06
Reprs&Veh.Main	52.56	52.56	59.33	59.33	65.66	65.66
Fuel,Oil,Grea.	8.76	8.76	9.14	9.14	9.34	9.34
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	63.62	63.62	69.93	69.93	70.50	70.50
Int. Alloc.	17.25	17.25	17.83	17.83	18.74	18.74
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	7.52	7.52	7.93	7.93	8.48	8.48
Insur.	10.98	10.98	11.89	11.89	12.45	12.45
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	65.81	65.81	71.73	71.73	76.06	76.06
Int. Alloc.	38.71	38.71	40.43	40.43	41.09	41.09
Semen&Breed.	19.54	19.54	25.14	25.14	31.18	31.18
Vet.Med&Drug	41.18	41.18	46.07	46.07	56.18	56.18
Mktg.Truck	160.55	184.63	185.25	213.04	209.95	241.44
Lvstck Supp.	28.69	43.04	29.36	44.04	31.94	47.91
DHIA&Bedd.	24.04	36.06	29.08	43.62	43.51	65.27
Int. Alloc.	116.93	116.93	119.32	119.32	123.90	123.90
Land Tax	12.90	12.90	13.46	13.46	14.06	14.06
LandInt.Alloc.	1.57	1.57	1.79	1.79	1.82	1.82
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	52.41	78.62	55.35	83.03	57.35	86.03
Misc.	12.81	19.22	13.00	19.50	13.46	20.19
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of Cows	100	100	100	100	100	100
Total Exp.	188727	208269	203618	224910	219296	242440
Net Income	-23292	-20419	-11993	-7421	-881	5287

			100	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	19000	19000	21000	21000	23000	23000
MilkInc.		2850		3150		3450
Milkloss	950	1093	1050	1208	1150	1323
Milk/Cow	18050	20758	19950	22943	21850	25128
Tot.MilkShipp.	1805000	2075750	1995000	2294250	2185000	2512750
Grossmilksal.	218405	251166	241395	277604	264385	304043
Cat.Inc	240	240	255	255	270	270
GrossCat.Inc.	24000	24000	25500	25500	27000	27000
Gross Inc.	242405	275166	266895	303104	291385	331043
FeedCost	1041.11	1060.84	1089.17	1113.66	1135.64	1169.05
LaborCost	320.00	426.48	335.00	444.48	350.00	464.81
Reprs&Veh.Main	68.41	68.41	69.90	69.90	73.32	73.32
Fuel,Oil,Grea.	10.56	10.56	11.10	11.10	11.80	11.80
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	78.16	78.16	82.56	82.56	85.50	85.50
Int. Alloc.	20.83	20.83	21.54	21.54	23.05	23.05
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	9.22	9.22	11.21	11.21	12.68	12.68
Insur.	12.92	12.92	13.53	13.53	14.46	14.46
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	78.32	78.32	81.46	81.46	84.21	84.21
Int. Alloc.	42.37	42.37	43.83	43.83	45.89	45.89
Semen&Breed.	35.82	35.82	39.16	39.16	42.14	42.14
Vet.Med&Drug	58.69	58.69	60.42	60.42	65.31	65.31
Mktg.Truck	234.65	269.85	259.35	298.25	284.05	326.66
Lvstck Supp.	33.18	49.77	34.67	52.01	36.32	54.48
DHIA&Bedd.	45.48	68.22	47.61	71.42	48.96	73.44
Int. Alloc.	139.60	139.60	145.21	145.21	150.09	150.09
Land Tax	14.52	14.52	15.15	15.15	15.86	15.86
LandInt.Alloc.	2.10	2.10	2.38	2.38	2.84	2.84
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	60.49	90.74	62.36	93.54	65.18	97.77
Misc.	15.15	22.73	16.63	24.95	17.47	26.21
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	100	100	100	100	100	100
Total Exp.	232158	256014	244224	269575	256477	283956
Net Income	10247	19152	22671	33530	34908	47087

			150	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	13000	13000	15000	15000	17000	17000
MilkInc.		1950		2250		2550
Milkloss	650	748	750	863	850	978
Milk/Cow	12350	14203	14250	16388	16150	18573
Tot.MilkShipp.	1852500	2130375	2137500	2458125	2422500	2785875
Grossmilksal.	224153	257775	258638	297433	293123	337091
Cat.Inc	160	160	192	192	230	230
GrossCat.Inc.	24000	24000	28800	28800	34500	34500
Gross Inc.	248153	281775	287438	326233	327623	371591
FeedCost	881.44	894.82	952.15	972.96	993.29	1016.05
LaborCost	245.00	331.45	260.00	347.93	275.00	364.70
Reprs&Veh.Main	52.17	52.17	54.86	54.86	57.16	57.16
Fuel,Oil,Grea.	8.89	8.89	9.50	9.50	9.66	9.66
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	65.63	65.63	68.69	68.69	69.26	69.26
Int. Alloc.	17.20	17.20	17.80	17.80	18.22	18.22
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	9.31	9.31	9.51	9.51	9.81	9.81
Insur.	9.55	9.55	10.44	10.44	11.00	11.00
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	66.47	66.47	68.50	68.50	69.95	69.95
Int. Alloc.	37.15	37.15	38.00	38.00	38.23	38.23
Semen&Breed.	23.81	23.81	25.93	25.93	26.31	26.31
Vet.Med&Drug	46.32	46.32	48.50	48.50	52.61	52.61
Mktg.Truck	160.55	184.63	185.25	213.04	209.95	241.44
Lvstck Supp.	25.50	38.25	27.54	41.31	30.08	45.12
DHIA&Bedd.	31.18	46.77	33.00	49.50	33.96	50.94
Int. Alloc.	123.67	123.67	125.45	125.45	128.25	128.25
Land Tax	11.23	11.23	11.96	11.96	12.17	12.17
LandInt.Alloc.	0.86	0.86	0.95	0.95	1.16	1.16
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	53.91	80.87	54.50	81.75	55.30	82.95
Misc.	11.83	17.75	12.51	18.77	13.21	19.82
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	150	150	150	150	150	150
Total Exp.	282251	310018	302256	332302	317187	348722
Net Income	-34099	-28243	-14819	-6069	10435	22869

			150	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	19000	19000	21000	21000	23000	23000
MilkInc.		2850		3150		3450
Milkloss	950	1093	1050	1208	1150	1323
Milk/Cow	18050	20758	19950	22943	21850	25128
Tot.MilkShipp.	2707500	3113625	2992500	3441375	3277500	3769125
Grossmilksal.	327608	376749	362093	416406	396578	456064
Cat.Inc	240	240	255	255	270	270
GrossCat.Inc.	36000	36000	38250	38250	40500	40500
Gross Inc.	363608	412749	400343	454656	437078	496564
FeedCost	1041.11	1060.84	1089.17	1113.66	1135.64	1169.05
LaborCost	290.00	381.39	300.00	393.37	315.00	410.76
Reprs&Veh.Main	57.91	57.91	58.72	58.72	59.88	59.88
Fuel,Oil,Grea.	10.04	10.04	10.63	10.63	11.10	11.10
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	75.39	75.39	75.82	75.82	77.46	77.46
Int. Alloc.	23.08	23.08	25.44	25.44	26.13	26.13
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	11.52	11.52	12.96	12.96	14.10	14.10
Insur.	13.33	13.33	14.10	14.10	14.96	14.96
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	73.69	73.69	76.22	76.22	78.81	78.81
Int. Alloc.	41.82	41.82	44.66	44.66	46.22	46.22
Semen&Breed.	33.55	33.55	35.39	35.39	38.27	38.27
Vet.Med&Drug	68.21	68.21	74.19	74.19	78.56	78.56
Mktg.Truck	234.65	269.85	259.35	298.25	284.05	326.68
Lvstck Supp.	31.27	46.91	33.10	49.65	35.18	52.77
DHIA&Bedd.	35.71	53.57	38.18	57.27	41.16	61.74
Int. Alloc.	137.92	137.92	140.36	140.36	143.66	143.66
Land Tax	14.38	14.38	14.80	14.80	16.25	16.25
LandInt.Alloc.	1.24	1.24	1.48	1.48	1.91	1.91
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	64.05	96.08	66.50	99.75	67.72	101.58
Misc.	14.12	21.18	14.83	22.25	15.42	23.13
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	150	150	150	150	150	150
Total Exp.	340948	373781	357885	392846	375222	412949
Net Income	22659	38967	42457	61811	61855	83615

			200	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	13000	13000	15000	15000	17000	17000
MilkInc.		1950		2250		2550
Milkloss	650	748	750	863	850	978
Milk/Cow	12350	14203	14250	16388	16150	18573
Tot.MilkShipp.	2470000	2840500	2850000	3277500	3230000	3714500
Grossmilksal.	298870	343701	344850	396578	390830	449455
Cat.Inc	160	160	192	192	230	230
GrossCat.Inc.	32000	32000	38400	38400	46000	46000
Gross Inc.	330870	375701	383250	434978	436830	495455
FeedCost	881.44	894.82	952.15	972.96	993.29	1016.05
LaborCost	230.00	309.60	240.00	321.59	250.00	333.15
Reprs&Veh.Main	50.46	50.46	52.18	52.18	54.36	54.36
Fuel,Oil,Grea.	8.10	8.10	8.62	8.62	9.75	9.75
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	62.18	62.18	64.10	64.10	65.57	65.57
Int. Alloc.	16.30	16.30	16.75	16.75	17.94	17.94
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	8.10	8.10	8.25	8.25	8.75	8.75
Insur.	8.85	8.85	9.13	9.13	9.75	9.75
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	59.13	59.13	61.72	61.72	63.52	63.52
Int. Alloc.	33.72	33.72	34.26	34.26	36.20	36.20
Semen&Breed.	23.50	23.50	25.21	25.21	27.10	27.10
Vet.Med&Drug	41.62	41.62	43.23	43.23	45.72	45.72
Mktg.Truck	160.55	184.63	185.25	213.04	209.95	241.44
Lvstck Supp.	24.50	36.75	26.20	39.30	29.10	43.65
DHIA&Bedd.	29.20	43.80	30.75	46.13	31.98	47.97
Int. Alloc.	119.75	119.75	122.65	122.65	125.24	125.24
Land Tax	10.66	10.66	11.40	11.40	12.51	12.51
LandInt.Alloc.	0.81	0.81	1.19	1.19	1.25	1.25
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	52.15	78.23	53.75	80.63	53.98	80.97
Misc.	10.97	16.46	11.85	17.78	12.24	18.36
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	200	200	200	200	200	200
Total Exp.	366399	401493	391728	430021	411641	451850
Net Income	-35529	-25792	-8478	4956	25189	43604

			200	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	19000	19000	21000	21000	23000	23000
MilkInc.		2850		3150		3450
Milkloss	950	1093	1050	1208	1150	1323
Milk/Cow	18050	20758	19950	22943	21850	25128
Tot.MilkShipp.	3610000	4151500	3990000	4588500	4370000	5025500
Grossmilksal.	436810	502332	482790	555209	528770	608086
Cat.Inc	240	240	255	255	270	270
GrossCat.Inc.	48000	48000	51000	51000	54000	54000
Gross Inc.	484810	550332	533790	606209	582770	662086
FeedCost	1041.11	1060.84	1089.17	1113.66	1135.64	1169.05
LaborCost	260.00	345.43	265.00	352.58	275.00	365.12
Reprs&Veh.Main	55.62	55.62	55.98	55.98	57.26	57.26
Fuel,Oil,Grea.	10.25	10.25	11.02	11.02	11.66	11.66
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	66.33	66.33	69.14	69.14	72.23	72.23
Int. Alloc.	19.63	19.63	22.47	22.47	24.19	24.19
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	10.53	10.53	11.76	11.76	13.18	13.18
Insur.	10.93	10.93	12.33	12.33	14.06	14.06
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	65.38	65.38	68.22	68.22	72.83	72.83
Int. Alloc.	38.65	38.65	40.36	40.36	42.98	42.98
Semen&Breed.	28.25	28.25	30.15	30.15	34.06	34.06
Vet.Med&Drug	50.31	50.31	55.19	55.19	63.75	63.75
Mktg.Truck	234.65	269.85	259.35	298.25	284.05	326.66
Lvstck Supp.	30.44	45.66	32.81	49.22	33.41	50.12
DHIA&Bedd.	35.10	52.65	37.90	56.85	38.38	57.57
Int. Alloc.	129.18	129.18	133.65	133.65	138.56	138.56
Land Tax	13.69	13.69	14.65	14.65	15.95	15.95
LandInt.Alloc.	1.29	1.29	1.45	1.45	1.86	1.86
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	54.64	81.96	55.31	82.97	58.29	87.44
Misc.	12.83	19.25	13.26	19.89	13.72	20.58
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	200	200	200	200	200	200
Total Exp.	433762	475133	455835	499957	480212	527819
Net Income	51048	75198	77955	106252	102558	134267

			400	COWS		
	2X	3X	2X	3X	2X	3X
Herd Ave.	13000	13000	15000	15000	17000	17000
MilkInc.		1950		2250		2550
Milkloss	650	748	750	863	850	978
Milk/Cow	12350	14203	14250	16388	16150	18573
Tot.MilkShipp.	4940000	5681000	5700000	6555000	6460000	7429000
Grossmilksal.	597740	687401	689700	793155	781660	898909
Cat.Inc	160	160	192	192	230	230
GrossCat.Inc.	64000	64000	76800	76800	92000	92000
Gross Inc.	661740	751401	766500	869955	873660	990909
FeedCost	881.44	894.82	952.15	972.96	993.29	1016.05
LaborCost	205.00	289.55	220.00	306.82	235.00	324.42
Reprs&Veh.Main	48.34	48.34	49.17	49.17	50.96	50.96
Fuel,Oil,Grea.	6.88	6.88	7.37	7.37	8.10	8.10
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	53.17	53.17	55.27	55.27	57.42	57.42
Int. Alloc.	13.96	13.96	14.51	14.51	16.32	16.32
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	7.59	7.59	8.66	8.66	9.99	9.99
Insur.	7.36	7.36	7.47	7.47	9.10	9.10
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	49.38	49.38	52.18	52.18	54.75	54.75
Int. Alloc.	29.18	29.18	31.16	31.16	33.10	33.10
Semen&Breed.	21.92	21.92	23.81	23.81	25.63	25.63
Vet.Med&Drug	33.82	33.82	38.62	38.62	43.31	43.31
Mktg.Truck	160.55	184.63	185.25	213.04	209.95	241.44
Lvstck Supp.	23.17	34.76	25.35	38.03	28.17	42.26
DHIA&Bedd.	27.77	41.66	29.16	43.74	31.18	46.77
Int. Alloc.	110.35	110.35	115.41	115.41	119.89	119.89
Land Tax	10.14	10.14	11.37	11.37	12.91	12.91
LandInt.Alloc.	1.10	1.10	1.23	1.23	1.46	1.46
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	49.61	74.42	50.75	76.13	52.11	78.17
Misc.	9.96	14.94	10.63	15.95	11.23	16.85
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	400	400	400	400	400	400
Total Exp.	700278	771183	755809	833155	801549	883554
Net Inc.	-38538	-19782	10691	36800	72111	107355

			400 COWS			
	2X	3X	2X	3X	2X	3X
Herd Ave.	19000	19000	21000	21000	23000	23000
MilkInc.		2850		3150		3450
Milkloss	950	1093	1050	1208	1150	1323
Milk/Cow	18050	20758	19950	22943	21850	25128
Tot.MilkShipp.	7220000	8303000	7980000	9177000	8740000	10051000
Grossmilksal.	873620	1004663	965580	1110417	1057540	1216171
Cat.Inc	240	240	255	255	270	270
GrossCat.Inc.	96000	96000	102000	102000	108000	108000
Gross Inc.	969620	1100663	1067580	1212417	1165540	1324171
FeedCost	1041.11	1060.84	1089.17	1113.66	1135.64	1169.05
LaborCost	250.00	341.77	260.00	354.42	275.00	372.44
Reprs&Veh.Main	52.23	52.23	53.46	53.46	54.92	54.92
Fuel,Oil,Grea.	9.54	9.54	9.85	9.85	10.15	10.15
Cust.hirs&lea.	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	60.03	60.03	63.28	63.28	66.39	66.39
Int. Alloc.	17.63	17.63	18.93	18.93	20.53	20.53
Conserv.	0.00	0.00	0.00	0.00	0.00	0.00
Repairs	11.10	11.10	12.51	12.51	13.10	13.10
Insur.	10.88	10.88	11.22	11.22	12.69	12.69
Lease	0.00	0.00	0.00	0.00	0.00	0.00
Deprec.	56.18	56.18	60.15	60.15	63.17	63.17
Int. Alloc.	35.37	35.37	36.90	36.90	38.64	38.64
Semen&Breed.	27.86	27.86	29.42	29.42	32.86	32.86
Vet.Med&Drug	49.16	49.16	54.55	54.55	58.76	58.76
Mktg.Truck	234.65	269.85	259.35	298.25	284.05	326.66
Lvstck Supp.	30.28	45.42	31.53	47.30	32.98	49.47
DHIA&Bedd.	32.93	49.40	33.65	50.48	35.73	53.60
Int. Alloc.	123.44	123.44	129.18	129.18	133.18	133.18
Land Tax	13.60	13.60	14.03	14.03	14.76	14.76
LandInt.Alloc.	1.55	1.55	1.69	1.69	1.76	1.76
Rent	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	52.66	78.99	53.10	79.65	53.38	80.07
Misc.	12.15	18.23	12.95	19.43	13.71	20.57
'3x Deprec.	0.00	0.00	0.00	0.00	0.00	0.00
# of COWS	400	400	400	400	400	400
Total Exp.	848940	933223	893969	983340	940560	1037100
Net Inc.	120680	167440	173611	229077	224980	287071

Net Incomes For 3X Milking Strategies

HERD SIZE	50	100	150	200	400
13,000 - 2X	-17058	-23292	-34099	-35529	-38538
13,000 - 3X	-17066	-20419	-28243	-25792	-19782
15,000 - 2X	-13860	-11993	-14819	-8478	10691
15,000 - 3X	-13010	-7421	-6069	4956	36800
17,000 - 2X	-5493	-881	10435	25189	72111
17,000 - 3X	-3399	5287	22869	43604	107355
19,000 - 2X	-60	10247	22659	51048	120680
19,000 - 3X	3422	19152	38967	75198	167440
21,000 - 2X	5851	22671	42457	77955	173611
21,000 - 3X	10352	33530	61811	106252	229077
23,000 - 2X	11933	34908	61855	102558	224980
23,000 - 3X	17218	47087	83615	134267	287071

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