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THE PROFITABILITY OF PURCHASING VS. GROWING FEEDS ON DAIRY FARMS IN SOUTHERN MICHIGAN

By

Joseph G. Hlubik

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ABSTRACT

THE PROFITABILITY OF PURCHASING VS. GROWING FEEDS
ON DAIRY FARMS IN SOUTHERN MICHIGAN

By

Joseph G. Hlubik

The profitability of three strategies of securing feeds on dairy farms in Southern Michigan was investigated considering equal investment levels. These include: 1) growing forages and grain (GFG), 2) growing forages only (GF) and purchasing all feed (PR). Alfalfa and corn silage were the forages and corn the grain.

The electronic spreadsheet program: Microsoft Multiplan (1982) was employed to synthetically model farms of herd sizes ranging from 40 to 500 cows (plus replacements). Budgeted analyses of profitability across various herd sizes (representing different investment levels) provided a basis to regress profit on dollars invested for each strategy. Strategies were then compared on the basis of profitability considering equal investment levels ranging from $.5 to 2.5 million.

The model employs a static budgeting approach and assumes crop yields, level of milk, and prices specified (by the user) are constant over the investment period.

The profitability and ranking of strategies was examined considering: levels of milk production ranging from 13 to 19 thousand lb, milk prices ranging from $11.40 to 12.60/cwt and corn prices ranging from $2.55 to

3.30/bu. These analyses revealed:

1) the ranking of strategies according to profit changes with the level of milk production and investment
2) GFG is profitable at levels of milk production $\geq$15 thousand lb
3) GF always ranks either 1st or 2nd and is profitable at levels of production $\geq$15 thousand lb
4) PR was a profitable strategy at levels of production $\geq$17 thousand lb

Land prices ranging from $500 to 1300/acre were examined assuming a soil classified in soil management group 3 and a level of milk production of 15 thousand lb. It was found that GFG and GF were much more profitable than PR until the price of land was $\geq$$1100/acre. It was also discovered that when different levels of soil productivity (i.e. different soil management groups) were considered profitability was not affected if the price of land was changed accordingly.

These analyses are a few examples of situations which can be examined using the dairy investment model developed in this dissertation.

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Special thanks to John Walter for his help in dealing with the computer and to Elaine Kibbey for typing this dissertation.

I dedicate this dissertation to the Sacred Heart of Jesus Christ.

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CHAPTER 1

INTRODUCTION

This research investigates the economies of different dairy farm organization alternatives relative to securing feed. These include: 1) farms with ownership of sufficient capital assets to grow forages and grain (GFG), 2) those with assets to grow forages only (GF) and, 3) those organized to purchase protein and minerals. The forages considered are alfalfa and corn silage and the grain is corn. Comparing the profitability of these alternative strategies and investigating the risks involved will indicate the preferred investment and shed light on the direction of expansion.

The more common Michigan dairy farm organization is a crop farm which markets its harvest through milk sales. Growing crops requires investments in or rental of land as well as a substantial investment in crop machinery in addition to investment requirements for the dairy enterprise. Also, additional labor is required to handle cropping operations which creates seasonal labor problems. Growing feeds can usually act to buffer against the effects of sudden changes in feed prices but also leaves the farmer the risk of crop failure due to drought or other adverse weather conditions; in such instances the farmer actually pays doubly for feed due to the incurred crop expense as well as higher purchased feed costs.

Crop land is also available for manure disposal when crops are not being raised which results in savings in fertilizer costs.

The essential question to ask becomes: Is it financially preferable for dairy farmers to grow their feeds or would they be just as well off or better purchasing feeds? Table 1.1 shows the time trend of returns to Michigan dairymen from 1971 to 1982. This table reveals that over the past 12 years dairymen have experienced a positive management income five of those years. Eleven out of 12 years dairymen have experienced positive management returns from the dairy enterprise whereas only in two of the past 12 years have they experienced positive management income from the cropping enterprise. This indicates that dairymen would have been better off if they had purchased feed instead of growing it.

Brown and Nott (1982), explained the negative returns to the cropping enterprise of Michigan Telfarm farms (mail-in farm accounting system at Michigan State University) in 1981 in the following manner: "..... lower yields and lower prices of crops produced .... Crop costs were up ..... Mechanical technology used in crop production requires a very high investment and few dairy farms work a large enough acreage to make economical use of the investment they have made."

Buying all feed, or at least the concentrate, reduces the initial capital investments in land and machinery and allows for a larger investment in cows (increasing herd size) and dairy facilities and equipment for a given amount of capital invested.

Table 1.1. Time Trends in Business of Michigan Telfarm Specialized Dairy Farms[a]

	Year											
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Number of farms	397	373	365	436	470	474	457	379	423	432	419	438
Number of cows	71.17	70.89	72.20	76.48	77.32	80.12	81.84	83.25	85.02	85.05	84.29	84.08
Number of people	2.40	2.32	2.46	2.63	2.66	2.72	2.75	2.82	2.89	2.74	2.73	2.73
Net cost/cwt milk	5.75	5.62	6.75	9.60	10.09	9.29	9.50	9.54	10.55	10.94	12.29	12.17
Total value of production	59,527	70,414	93,294	93,846	92,522	110,622	113,013	152,465	176,405	189,289	177,026	181,303
Total cost	63,663	67,242	81,446	97,240	106,371	118,378	128,363	142,132	169,085	188,073	209,098	212,010
Management income[b]												
$ Total farm	-4,136	3,172	11,848	-3,394	-13,849	-7,756	-15,350	10,333	7,320	1,216	-32,072	-30,707
Dairy Enterprise:												
Total value of[c] production/cow $	456	458	541	560	416	664	662	1,022	1,178	1,194	1,180	1,209
Total cost/cow $	412	450	506	547	565	584	629	696	823	912	990	1,021
Management income/ cow $	44	8	35	13	-149	80	33	326	355	282	190	188
Crop Enterprise:												
Total value of production/cow $	78	95	158	170	163	147	144	169	185	213	181	191
Total cost/acre $	100	105	135	156	170	184	188	211	241	268	293	301
Management income/ acre $	-22	-10	23	14	-7	-37	-44	-42	-56	-55	-112	-110
Corn-avg price/bu received by Michigan farmers $	1.03	1.49	2.52	2.85	2.35	2.04	1.95	2.22	2.46	3.05	2.39	2.20
Hay-avg price/ton received by Michigan farmers $	28.50	29.50	31.00	37.50	44.00	43.00	58.00	45.50	36.00	36.50	56.50	61.50
Soybean meal avg price paid/cwt by Michigan farmers $	5.94	6.75	14.21	10.56	9.24	10.92	13.20	11.85	13.28	14.00	15.40	13.30
Price of milk/cwt $	5.96	6.17	7.20	8.22	8.55	9.85	9.65	10.50	12.00	13.20	13.80	13.60

[a]Sources: Brown and Nott, 1982, 1978 and 1974. Michigan Dept. of Agric. 1973-1983.

[b]Management income is defined as: the value of production less total costs. Total costs include an 8% return to owner's equity as well as the value of paid and unpaid labor.

[c]The value of feed (purchased and grown) is deducted from gross income to estimate total value of production.

As herd size increases, farmers should be able to achieve any existing economies of size relative to the dairy operation. Increased herd size results in reducing the average fixed cost/cow of dairy facilities and may result in the ability to shift to technologies which may reduce some of the average variable costs of producing milk. For example, the least cost milking parlor for a herd size of 150 cows is a double-four herringbone parlor (no mechanization) with a throughput of approximately 37 cows/hour (Armstrong, 1980) and an annual cost/hour of daily milking time of approximately $3900 (Wetzel et al., 1979). The annual milking expense/cow/year is estimated as: (1 cow/37 cows/hour) * 2 milkings per day * $3900 annual charge/hour of daily milking = $210.00. A low-cost milking parlor for a herd size of 300 cows is a double-eight herringbone parlor (with detachers and a power gate) with a throughput of 70 cows/hour and an annual cost/hour of daily milking of $4170 (Wetzel et al., 1979). The annual milking expense/cow/year for this parlor considering a herd size of 300 cows was approximately $120.00. Thus, moving from a herd size of 150 to 300 cows and switching from a double-four to a double-eight herringbone parlor results in a savings of $90/cow/year.

The initial investment in a double-four herringbone parlor (without mechanization) was $124,560 (1980 prices obtained from Armstrong, 1980). Considering a herd size of 150 cows this is estimated as an investment of $124,500/150 cows equals $830/cow. The initial investment in a double-eight herringbone parlor (with detachers and a crowd gate) is $147,970 or $493/cow. This results in an investment savings/cow of $337 in moving from a double-four to a double-eight herringbone parlor and moving from a 150 to a 300 cow herd size. Similarly, as crop acreages increase farmers should be able to achieve economies of size relative to crop production.

Expanding both the dairy and crop enterprise requires an extensive capital outlay as well as a manager who is able to effectively handle both or two managers. Given a limited supply of capital, logical alternatives to obtain economies of size for those who are already established in dairying include: 1) expanding the dairy herd and keeping the crop acreage the same or reducing it, thus purchasing more feed, 2) cutting back or eliminating the dairy operation and expanding crop production, or 3) slightly expanding both dairy and cropping enterprise as capital becomes available. Investigating the profitability of alternatives of growing versus buying feeds should shed light on the direction of expansion farmers should consider.

When analyzing the profitability of growing versus purchasing feeds, the cost of producing feeds (including land cost, crop machinery cost, crop expenses, labor and feed storage costs) and the cost of purchasing supplements to complete the nutritional needs of cows must be compared to the cost of purchased feed and feed storage costs for those farms purchasing all or at least concentrates and supplements.

Advantages and Disadvantages

Problems associated with purchasing all or much of the feed supples include:

1) finding a reliable source of quality feed, especially forages,

2) obtaining credit to purchase large quantities of feeds,

3) unpredictable price fluctuations of feeds,

4) the management ability to secure good feed buys,

5) an increase in the number of cows/man,

6) disposing of manure produced on the farm.

Advantages include:

1) a farm with a smaller land base is needed,

2) less machinery is required; combined with savings in land purchases, this will result in a substantial savings in capital required to start or expand an operation,

3) farmers can take advantage of contracting feed supplies (e.g. hedging on the future's market and contracting with local farmers),

4) milking machinery and equipment and barns as well as other fixed costs can be lowered on a per cow unit basis (assuming herd size increases),

5) farmers purchasing most feeds will reduce irregular labor patterns in the spring and fall,

6) farmers purchasing feeds do not have to assume short term loans for crop supplies including fertilizer and seed in the spring,

7) farmers do not have to be crop managers as well as dairy managers,

8) there may be substantial savings in feed storage facilities.

Purchasing most or all feeds may be a viable alternative especially in an economy characterized by expensive land, high interest rates, low commodity prices and high fuel costs. Although purchasing all or most feeds is atypical of Midwestern dairymen, it is a common practice of many dairymen in California and the Southwest. Purchasing grain is common practice among Northeast dairymen.

CHAPTER 2

REVIEW OF THE LITERATURE AND BASIC THEORY

2.1 Review of the Literature

2.1.1 Growing vs. Buying Feed

The question of profitability of buying vs. purchasing feeds on dairy farms in the Midwest and East is not new. Several authors including Hoglund (1967), Speicher (1969) and Wysong (1967) have addressed this question. Hoglund and Wysong approached the problem by analyzing synthetic farm situations in which herd size and milk yield levels varied. They also looked at levels of crop productivity for those farms growing all feeds. Hoglund (1967) investigated the economics of growing vs. buying feed for dairy herds of 40 to 240 cows. The major reasons cited for increased interest in buying more of the feed needs were: 1) increased size and specialization in dairy farming, 2) recent low prices for feed grains, 3) increasing land prices and taxes and, 4) difficulties in buying land near the farmstead. An analysis was made of: 1) growing all the feed, 2) growing only the forage and buying the grain, and 3) buying both forage and grain. These alternatives were budgeted for 40, 80, 160 and 240 cow farms on which all of the replacements were grown. Crop yields were estimated under levels of good and average management. Yields under average management conditions were ~80% of those under good management. The analysis involved two levels of milk production, 12,000 lb/cow/year and 14,000 lb/cow/year.

The average acres/cow of tillable land that he estimated were needed to grow all feed under good management and at 14,000 lb of milk production was estimated to be approximately 3.3 acres/cow. Under average yield conditions it was 4 acres/cow. Hoglund estimated that buying the grain rather than producing it reduced acreage needed by about one third.

As herd size increased investments in a dry-lot operation became a smaller percentage of total investments compared to farms where all feed was grown. For the 80 cow operation buying all feed, the investment was about 53 percent as high as when all feed was grown. For the 240 cow herd, investments in a dry-lot operation were about 47 percent as much as when all feed was produced. Hoglund concluded that farmers should continue to grow feeds. Purchasing all feeds was not a very profitable enterprise unless herd size exceeded 240 cows. He did, however, state that/dollar invested, purchasing was more profitable than growing feed. He estimated that increasing the cost of land from $300/acre to $600/acre made all three alternatives equally profitable.

One of the problems Hoglund foresaw for Michigan dairymen wishing to purchase all feeds was that of contracting for delivery of high quality corn silage or hay in quantities needed. He also states, "The large scale dairyman usually has some price advantage in buying feeds.

He also may gain by his ability to bargain for lower costs of hauling milk. Some large scale dairymen in Michigan are saving at least 10¢/cwt in their hauling bill."

Wysong (1967) examined the feasibility of specialized dairying in Maryland for herd sizes ranging from 50 to 400 cows at a level of milk of 7,000 to 14,000 lb/cow. He essentially examined three types of operations: 1) specialized dry-lot dairy farms which purchased all forages and concentrate feeds and all dairy cow replacements; 2) standard specialized dairy farms with average crop yields which produced all of their forage requirements; and 3) intensive standard specialized dairy farms with 33% above average crop yields and 25% less crop and pasture land/cow and replacement. The intensive dairy farms also raised all replacements and all forages required.

Land was valued at $200/acre with an average of 3.6 acres of land/cow on standard specialized farms. He used a constant man-cow ratio of 50 cows and 33 replacement heifers to each worker. His objectives were: 1) to determine the comparative costs, net returns and investments of several types of dairy operations; and 2) to provide planning guidelines for farm managers who are making adjustments to stay competitive.

He found that dry-lot dairy farms had the highest costs/cwt of milk at all herd sizes when cows were producing at a level of 10,000 lb/cow. Costs/cwt milk on the dry-lot farms were lower at a level of production of 14,000 lb of milk. He also found that costs/cwt declined at a decreasing rate from 50 to 250 cows across all types of farms. The average costs of producing milk showed little decline between 250 and 400 cows. The most rapid declines in production costs occurred between the 50 and 100 cow herd sizes for each of the levels of milk output studied from 7,000 to 14,000 lb/cow. "These economies resulted from fuller utilization of fixed buildings and equipment on the larger farms as well as the use of larger buildings and items of equipment." Wysong concluded that even under the extreme minimum cost assumptions, the labor management incomes on dry-lot type dairy operations were lower than on the standard specialized dairy operations operated under average or above average crop yield assumptions. Both Hoglund and Wysong found profitability of the dry-lot type of dairy sensitive to the level of milk production.

Speicher approached the problem by examining returns to dairy farmers enrolled on Michigan State University's computerized farm accounting records. Partial enterprise accounting allows costs and returns to be attributed to either crops or livestock units. Examining these records, he concluded that the dairy herd carried the cropping program on Michigan farms based on conditions which existed in 1967-1969. He budgeted synthetic farms which either grew or purchased feed across herd sizes ranging from 35 to 300 cows. His conclusion was that/dollar invested, farmers who purchased feeds were most profitable.

2.1.2 What Combinations of Feeds to Grow

The authors discussed above realized that the question of profitability of growing versus buying feeds relied heavily upon the costs and returns to the cropping program. They essentially were concerned with categorizing the cropping program based on different levels of soil productivity which greatly influences the crop costs/acre and thus feed costs. Both Hoglund and Wysong assumed specific ratios of corn silage to hay in their models based on their conception of an economical cropping program and a specified amount of corn to achieve a given level of milk production.

Other studies such as Knoblauch (1977), Schwab (1969), Hoglund et al. (1972), Parsch (1982) and Knoblauch and Milligan (1979) and Nott (1974) were concerned with each crop (e.g. corn silage, corn grain, hay) which should be raised to supply feed needs. Work by Schwab (1969) and Hoglund, Schwab and Tesar (1972) looked specifically at the economics of growing and feeding various combinations of corn silage and alfalfa in Southern Michigan considering three major soil groups and their level of productivity, and two levels of management (good and excellent) for a 120 cow dairy herd. The level of milk production was assumed to be 13,000 lb/cow. Comparisons were done using partial budgeting. The farm size (acreage) was based on crop yield/acre and total feedstuff requirements.

Although all rations would supply adequate nutrition, the corn silage ration was the lowest cost for soil groups I and II which were highly productive soils. With group III soils (i.e. least productive), cost and yield relationships were such that the 50% corn silage ration was the least-cost. It would have required a yield of 5.2 tons/acre of alfalfa production in soil groups I and II for alfalfa to be competitive.

Parsch (1982) and Savoie (1982) developed a dairy forage model simulating growth, harvest, storage, handling and feeding to dairy cows. Parsch examined the impact of various ratios of corn silage and alfalfa production whereas Savoie was concerned primarily with machinery and storage alternatives and with management of the alfalfa crop. Using the model (jointly developed by both authors), Parsch simulated six alternative rations ranging between 0 and 100% corn silage (in increments of 20%), specified for milking herds of size 120 or 80 cows. For each ration, alternative dairy forage systems were designed and simulated over a 26 year period. Results suggested that systems low in corn silage (i.e. 20% corn silage) are preferred to those containing high levels of corn silage or no corn silage at all. Parsch also simulated the possibility of purchasing all corn grain for a farm with 120 cows vs. growing it. In that case, the 20% corn silage and the 40% corn silage systems were the most economical. He found that net feed costs were approximately $16,800 higher for the 120 cow systems that purchased corn grain than for 120 cow high-moisture homegrown corn systems. The trade-off was that the same 120 cow herd is fed with only 251 acres of home-grown crops as compared with the 382 acres required of the high-moisture corn systems. He implied that on the average, a farmer purchasing corn could afford to spend a total of $128/acre to grow corn (including land charge).

In a comparison of hay versus haylage systems for dairy farms in Michigan, Savoie (1982) estimated that a 100% hay system is generally less expensive than a 100% haylage system for farms growing less than 100 acres of alfalfa. Between 100 acres and 300 acres, haylage may become less expensive than hay. Although the hay system was more expensive, it offered less variability in amounts of hay-crop harvested. He also found that a haylage system can produce the same quantity of feed on about 16% less land.

Nott (1974) examined crop strategies for New England dairy farmers during a period of time when nitrogen and phosphorus costs were high and influenced the comparative profitability between corn silage and alfalfa. By analyzing alternative ration costs utilizing market prices instead of production costs, he identified the more profitable and less profitable feeding systems. Partial budgets computed with a least-cost ration generator indicated that the most profitable alternative was to feed all roughage as corn silage fortified with nonprotein nitrogen (NPN) to attain 13% crude protein (CP) on a 100% dry matter basis. He found that feeding alfalfa hay with 18.4% crude protein was better than all corn silage with no NPN added for dairies producing 13,500 lb milk/cow/year.

Whole farm budgeting was then utilized to indicate the profitability of alternative cropping systems. Farm budgets were computed for small and large farms which were either extensively or intensively operated (2.5 acres/cow vs. 1 acre/cow) for 45, 50 and 100 cow farms. On the smaller farms (45, 50 cows), hay (16% crude protein) was competitive only on the extensively operated farms. On the large farm (100 cows) 21% crude protein hay crop silage was the most profitable and high moisture ear corn was second. When land was scarce, the large farm would secure the most profit using NPN-fortified corn silage. However, there was little difference in profit between NPN-fortified corn silage and high quality hay crop silage.

Knoblauch et al. (1981) examined capital investments, crop production costs and feed purchases relative to economical forage systems in the production of milk and beef in the Northeast United States. Their objectives were to determine the most economical systems of forage production for: milk production, finishing steers to slaughter weight, and finishing steers of a traditional beef breed to slaughter weight on a productive vs. a marginal land resource base. They also compared profitability of the various enterprises. Forage systems consisting of different proportions of hay crop silage and corn silage were included. On the productive land resource, the three forage combinations were: 1) hay crop silage only, 2) equal parts hay crop silage and corn silage and 3) 70% corn silage and 30% hay crop silage.

Acreage, productivity and ration constraints were specified for two soil resource situations representative of the Northeast. The most economical forage system was determined by calculating the total production, storage and feeding costs for each forage combination. This calculation was comprised of three components: 1) formulation of rations for each forage composition, 2) determination of storage facilities and equipment required and the associated costs and 3) calculations of crop production costs and feed purchases or sales. On the marginal land resource system, all hay and equal parts hay and corn silage were considered.

Investments and annual costs increased as the level of corn silage in the ration increased up to a level of 50% of the forage and, then, decreased with increasing levels of corn silage greater than 50% of the forage.

They found the most economical forage system for the production of milk contained 50% of the forage dry matter from hay-crop silage and 50% from corn silage for the productive land resource. The system of mostly corn silage proved less economical because of large purchases of soybean meal. The most economical forage system for the smaller herd (35 cows) marginal land resource unit was that of 100% of the forage as hay.

Bratton (1982) in a management study of growing corn on New York dairy farms, analyzed dairy farm business summaries and found that the ratio of hay to corn silage in dairy rations has increased from an average of 5.3 to 1 (1956-1960) to 2.2 to 1 (1976-1980), and that corn silage comprises almost 26% of total crop acreages. It appears that dairy farmers are supplying about 30-40% of the forage in the ration in the form of corn silage.

Using Telfarm business analysis summary (1981) for 413 specialized dairy farms in Michigan, it is estimated that approximately 15% of the acres devoted to crop production for the dairy enterprises are in corn for silage.

One of the critical considerations in the analyses discussed above is the nutrient content of the feeds considered as well as amounts of nutrients produced/acre. NPN-treated corn silage is a viable alternative to hay or hay-crop silage for production levels considered by Nott (1974) (e.g. 13,000-15,000 lb milk). However, as farmers move to higher levels of milk production it is questionable that there is a linear positive relationship when substituting NPN for more slowly degraded protein sources such as alfalfa hay (Hlubik, 1980). This becomes an important consideration in ration formulation especially when NPN-treated corn silage makes such a difference in the cropping strategy. Another important nutritional constraint which most of the models recognize is the differences in the net energy content of the feeds. In his analysis, Nott (1974) gives hay a net energy value of .44 Mcal/lb as compared to corn silage with a value of .72. Based on N.R.C. (1978) this seems to be an unrealistically low energy value of hay.

2.1.3 Size Relationships in Dairying

When average total costs/unit of output decreases as the level of output increases economies of size exist. When average total costs/unit of output increase as output increases, diseconomies of size exist. Economies of size may be attributed to technical or pecuniary economies. Technical economies result from either fuller utilization of fixed assets, such as equipment, machinery and other durables, or from firm size adjustments. Pecuniary economies refer to prices paid by farmers for inputs and received for products.

For example, large farms may purchase fertilizer in bulk and secure price advantages compared to smaller farmers. Diseconomies of size may exist as farms become larger and include items such as costs associated with timeliness of crop and livestock operations, managerial ability, labor inefficiency, overhead costs, etc. (Harsh et al., 1981, pg. 57-58).

According to Hall and LeVean (1978), "overall economic efficiency is a function of both price (pecuniary) and technical efficience and a firm is only completely efficient economically if it minimizes cost/unit of output .... the relevant criterion is whether economic efficiency increases with farm size (i.e. whether the long run average cost curve declines as size increases)."

Raup (1969) states that as farm size increases management becomes a critical cost item. "Management skills must be learned and producing a superior manager is expensive. To discuss the efficiency of farms of alternative sizes without allowing for the differential costs of management error feedback and growth in skill, is to ignore one of the most important aspects of transition in size of farm."

Stanton (1978) discovered that, "it is difficult to recognize explicitly and specifically the nature of diseconomies in a budgeting or economic engineering model. The technical data and cost functions are simply not available to describe the rates at which either yields decline or costs increase when important diseconomies do exist. In the Lake States and Northeast where more than half of the nation's dairy cows are found, 1,000 cow producing units are almost non-existent and the number of farms with 500 or more cows is small. The logic of survivorship is rather clear. Some combination of technical relations and constraints limit the ability of most young entrepreneurs to expand much beyond 300 milking cows given current knowledge, technology and institutions."

According to Lund and Hill (1979), "an indirect method of analyzing the existence or otherwise of economies and diseconomies of size, and of any optimum farm size, lies in the examination of farm size distribution. The underlying theory is that if there exists some optimum farm size the force of competitive pressures will gradually lead to an increase in the proportion of farms of that size and the proportion of total industry output produced by them." They caution care in interpreting increases in farm size over time and relate two causes to it: profit and efficiency. Efficiency is defined as outputs/inputs and is an averaging concept. Profit maximization* is a marginal concept (i.e. the increase or decrease in total profit, given a unit increase/decrease in production). Under the assumptions of pure competition, firms maximize profit up to a level of production where marginal costs equal price of the product. This level of output will be above that at which its average costs are lowest and its efficiency highest. Thus, a more profitable farm may be technically less efficient than a less profitable one.

Lund and Hill (1979) and Stanton (1978) recognize that factors other than profitability influence farm firm decisions. According to

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*Profit is defined as gross returns-case and certain non-cash expenses.

Stanton, "Over the past 75 years that agricultural economists have been studying and observing farmers and their families both in Western societies and others, some generalizations begin to emerge. It is not returns to any single scarce resource that motivates farm decisions. A farm family tries to get the most it can out of the bundle of resources it controls. It is not net income by itself that matters to a family. Rather it is some larger combination of things including survival, net income over time, enlarging the bundle of resources that the family controls and increased prestige within the local social system."

Madden (1967) reviewed economies of size studies in crop production, specialized beef feedlots and dairy farms. Among the dairy studies was that of Fellows, Frich and Weeks (1952) which examined New England dairies using a synthetic farm budgeting technique. In this study farms with more than 35 cows were considered the larger units. Farms with 35 or more milk cows were found to have significantly lower average total cost/unit of output than the smaller dairy farms. The average cost curve was relatively flat from the 35 cow farm to a 105 cow farm. Madden found the study consistent with broad changes in size distribution of New England dairy farms during the 1950's.

Another study reviewed by Madden was that of Barker and Heady (1960) of Iowa dairy-cash-grain farms. Linear programming was used to select optimum crop rotations for herd sizes up to 64 cows. These authors found most economies were achieved by a herd size of 32 cows.

Only a slight reduction in costs/cow was experienced as farm size expanded to 58 cows.

Madden also reviewed a study by Martin and Hill (1962) considering Arizona dairies. They found that the average cost curve declined sharply up to a herd size of approximately 150 head, gradually declining to 250 to 350 head and then gradually rising as herd size approached 600 head. The analysis did not consider alternative milking-barn technologies for each size group.

The last study reviewed by Madden was that of Buxton and Jensen (1964) who conducted a completely synthetic analysis of Minnesota dairy farms using linear programming. Alternative farm enterprises considered were: hogs, corn, soybeans, and herd sizes up to 90 cows. Buxton and Jensen estimated that all the economies of size were achieved by a 1-man, 48-cow dairy, using a double-6 herringbone milking parlor.

Madden found these studies difficult to compare for the following reasons: 1) assumptions and procedures varied from one study to the next; 2) there is no common measure of average total cost among the studies; 3) they differed in the degree to which the synthetic-firm economic engineering approach was used. The Iowa and Minnesota studies considered modern milking parlor arrangements for all dairy sizes, not limiting the resource combinations to those found on existing farms. The Arizona study considered only the typical barn technologies for each size group as they were observed in the sample dairies. The New England study considered only those technologies in use at the time. Madden commented that the coordination and supervision problems increased with the size of herd and the labor force in the Arizona study. He also noted that management experienced increased difficulty in coping with feed price uncertainty as there was not enough time for "shopping around" in buying feed.

Wysong (1965) examined the economies of large size in the production of fluid milk on specialized dairy farms in Maryland. His objectives were: 1) to obtain data on physical input-output relationships for the whole farm business, and 2) to determine cost economies and diseconomies on commercial dairy farms of different sizes. Survey data was obtained by personally interviewing dairymen in the Piedmont area of Maryland.

In examining herd sizes up to 400 cows/farm, labor efficiency showed little tendency to increase beyond the average level of about 30 cows/man. He found that farms between 50 to 100 cows can attain relatively high levels of labor and capital efficiency/worker. The major economies in the utilization of buildings and equipment were obtained at the 100 cow level, although additional economies did occur as size increased to 400 cows/farm. Therefore, the major advantage of moving to larger size farms beyond the 100-cow level lies in the increased net return/operator. The larger number of cows increased net returns primarily from greater milk sales, and only slightly from reduced average total costs/unit of output.

Matulich (1978) studied efficiencies in large scale dairying in the Chino Valley of California where dairying is intense. The average size herd there is 600 cows confined to 10 to 60 acres. Several herds are in excess of 2,000 cows. His analysis investigated herd sizes ranging from 375 to 3,600 cows. The dairy was dis-aggregated into: milking, housing and feeding components. Detailed input-output relationships were specified for each component and combined to model dairies of various sizes. Required quantities of fixed and variable inputs were combined with their market price to synthesize both short-run and long-run cost functions. This allowed analysis of typical and new, but not widely adopted dairy production technologies.

Alternative milking parlors and varying degrees of mechanization were of primary importance in determining the annual cost of the milking component. Herringbone, side-opening and polygon parlors were selected as relevant to large scale dairying.

The feeding component was analyzed in two parts. First, three alternative feeding programs were modeled with a linear program that maximizes income over feed costs. The typical feeding program was modeled as a single "commercial-mixed" ration fed in equivalent quantities to all lactating cows. Second, feed delivery and storage systems corresponding to the three feed programs were examined.

Dry-lot corrals and covered free-stalls with adjacent loafing pens were the housing systems considered. Significant economies over much of the 375 to 1,200 cow herd size range were found. Unit costs declined $64/cow from $1,056/cow to $992/cow in going from the 375 cow herd to the 750 cow herd. Costs/cow were approximately the same for the 900 and 1,200 cow dairies. Milking parlor automation and better capacity utilization were the principal origins of efficiencies.

Over 60% of available unit cost reductions were realized between the 375 cow herd (the only non-automated dairy) and the 450 cow herd. Further unit cost reductions to the 750 cow herd size resulted from better utilization of the milking parlor in conjunction with changes in particular parlor configurations.

Matulich emphasizes three major characteristics which distinguish industrialized dairying from that of small multi-enterprise dairying: 1) a well developed feed market and distribution center, 2) year-round availability of quality labor is essential, 3) the level of managerial and operational expertise required of industrialized dairying differs from small multi-enterprise operations. He states, "The long-run average cost curve derived in this study is representative of similar industrialized production regions (e.g. California, Arizona, Florida and Texas), but the analysis offers potentially broad implications regarding future structural change throughout the dairy industry. The reported efficiencies are not limited to the exclusive domain of specialized dairies. Much of this technology contributing to economies of size is mobile. However, specialized management over each of the enterprises is essential to achieve comparable efficiencies. Moreover, the technological advances may be transferable to dairies smaller than examined in this study."

2.2 Basic Economic and Management Theory

2.2.1 Management

Management is concerned with decision making. In an economic sense it is concerned with maximizing the rate of return to a given amount of capital invested, considering various possibilities of resource employment and the risks involved. The rate of return is that interest rate which equates the present value of cash receipts expected to flow from an investment over its lifetime, with the present value of all expenditures relating to the investment (Spencer et al., 1975). Managers deal with three basic interdependent questions: 1) what to produce? 2) how to produce it? and 3) how much to produce? (Harsh et al., 1981).

2.2.2 What to Produce and How Much?

Consider an investor (or group of investors) with a given amount of capital to invest in a dairy farm. An important consideration is whether to invest all capital in cows and dairy facilities or invest in cows and enough crop land and machinery to raise crops to feed the herd. Although crops are necessary complements to produce milk, the enterprises are competitive because the ability to trade allows for the purchase of crops. Thus, the dairy and cropping enterprises are in competition for the limited capital available for investment.

Model 1

First consider the cropping and dairy enterprises as selling their products in the market. Figure 2.1A is a hypothetical production possibility curve, and assumes constant returns to size. It shows the various combinations of dairy (milk) and crops which could be produced for a given number of dollars to invest in a dairy or in a cropping enterprise.

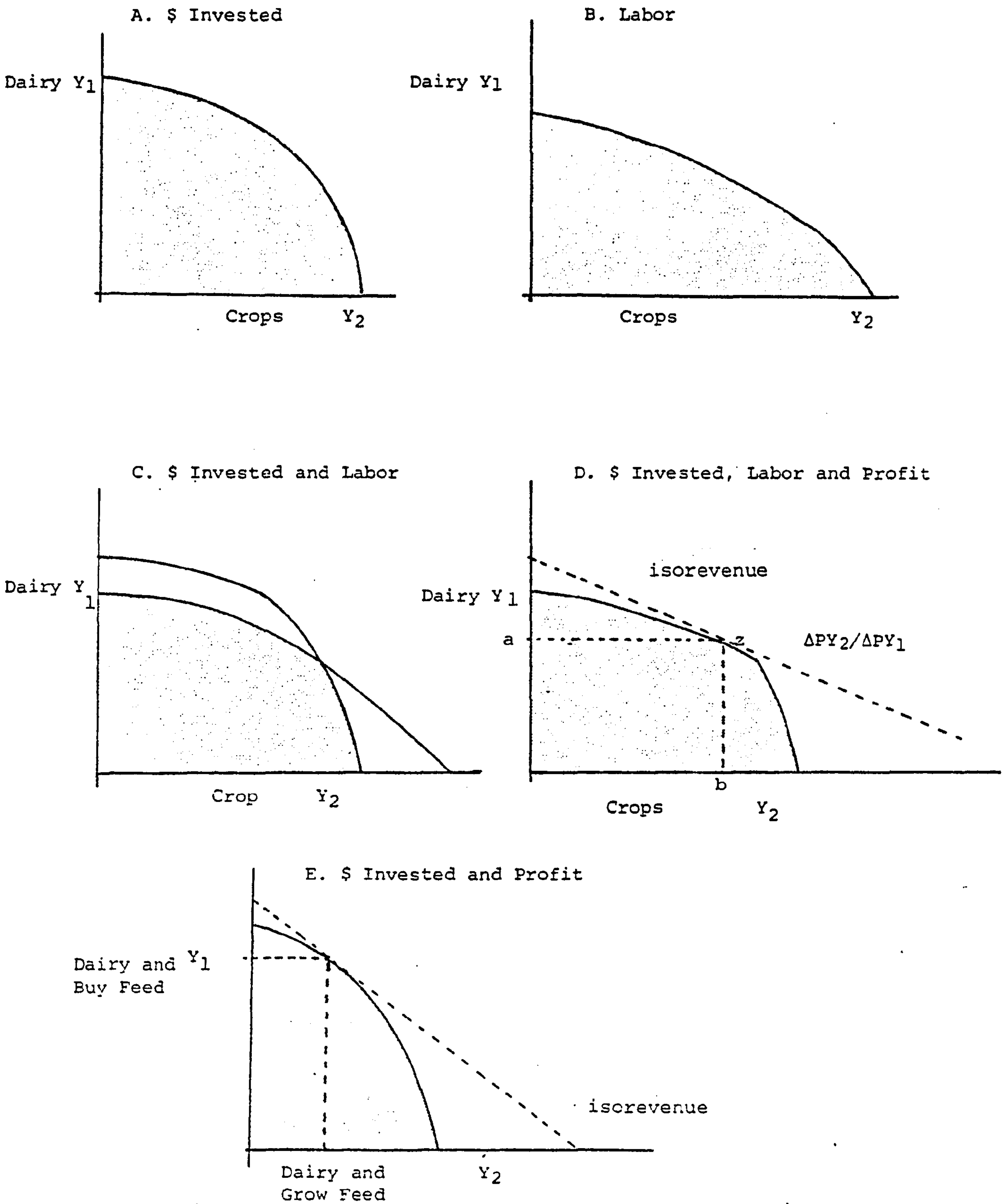

Figure 2.1. Production possibilities (heterogeneous inputs).

A maximum quantity of crops Y_2 could be grown if there is no dairy (Y_1). By giving up some crop production, investments can be made in a dairy operation. This process substitutes dairy cattle for crop production in the product mix. The basic problem is to select (within the constraints imposed) the "optimum" product mix.

The production possibility curve in Figure 2.1A is concave to the origin indicating a diminishing rate of marginal substitution of Y_2 for Y_1. As movement is made from point to point to the right, the absolute value of the slope of the curve ($\Delta Y_1/\Delta Y_2$) is increasing. To obtain one more unit of Y_2, more and more Y_1 must be foregone as Y_2 increases.

Each point on the curve in Figure 2.1A represents a feasible product mix that will utilize all of the available investment money. Each point in the shaded area represents a feasible product mix that will leave some of the investment unused.

A production possibility curve could be drawn for each of the limiting resources. Figure 2.1B shows the various combinations of crops and dairy assuming a fixed supply of labor. The curve would be linear if each unit of labor were homogenous.

Figure 2.1C shows the two production curves superimposed. The shaded region is a set of points common to both curves. Only those points within the shaded region of Figure 2.1C are feasible, given the limitations of labor and capital.

Once the set of feasible product mixes has been delineated the optimum product mix can be derived. This depends on the relative contribution of the two products. Contributions are determined by the prices of the products and by prices and amounts of the inputs required to produce them (i.e. by some measure of net profit/unit of product). An isorevenue (isoprofit) line shows the various combinations of two enterprises that will produce the same amount of income. There is an infinite number of isorevenue lines. The one which is just tangent to the production possibilities curve determines the optimum combination by its point of tangency. This is the point where:

$$\Delta Y_1/\Delta Y_2 = PY_2/PY_1$$

In Figure 2.1D the optimal product mix occurs at point z where "a" units of Y_1 are produced and "b" units of Y_2. The slope of the isorevenue line depends upon the relative contribution of Y_1 and Y_2, considering both product prices and input costs. The slope is critical in determining the product mix.

Using a straight line for an isorevenue line implies: 1) that product prices do not change with the amount of products produced, implying a horizontal demand curve, 2) costs/unit of input is constant. Constant unit costs is not typically observed in actual production. Diminishing marginal factor costs and diminishing marginal returns to production as output increases is more commonly the case in agriculture. Diminishing marginal factor costs would make the isorevenue line concave to the origin, diminishing marginal returns would make the isorevenue line convex to the origin (Haynes and Henry, 1974, pg. 265).

Model 2

Instead of selling the crops produced, assume they are used by the dairy enterprise as the feed input. The possibility exists to either grow or buy crops needed for the dairy. Since grown or purchased crops are perfect substitutes, the question becomes: Is it more profitable to grow or buy crops? This question cannot be answered using Figure 2.1D because there is no direct measure of profitability of growing crops used in the dairy enterprise to establish an isoprofit line.

As an alternative illustration, consider two enterprises: 1) "dairy and grow feeds" and 2) "dairy and buy feeds" as in Figure 2.1E. Now the question can be addressed by examining the profitability of each alternative "strategy" of dairying.

Model 3

From an investment standpoint the question of growing vs. purchasing crops is a critical consideration. Money invested in crop machinery and land could be used to establish a larger dairy. Establishing a larger dairy may achieve economies of size due to decreased average fixed costs of buildings and facilities/unit of output. A larger investment in the dairy enterprise also allows switching to a different level of technology, resulting in a more efficient level of production. Farms organized to dairy and crop farm have the potential to achieve economies of size in regard to both dairying and cropping *if* the investment is large enough. If the investment isn't substantial enough to achieve significant economies of size, it may well be that specialization in dairying is the more profitable alternative. It is a matter of discerning whether the economies of size achieved by specialization in dairying offsets a possible price advantage of reducing feed costs by growing feeds.

Figure 2.2A-D demonstrates how the production possibilities curve changes as the level of investment changes when economies of size exist. As the level of investment increases, economies of size relative to the "dairy and buy feed" are indicated in Figure 2.2A-C. At a level of investment indicated in Figure 2.2D, economies of size are experienced relative to the "dairy and grow feeds" enterprise. As these curves become concave to the origin (with increasing levels of investments), it is apparent that there will be a tendency to specialize in one strategy of dairying vs. the other. This will depend on the slope of the isorevenue line (determined by price ratios) as well as the level of investment.

2.2.3 Comparative Advantage

Another way of approaching the question, as to which is the most profitable strategy of investment, is through the concept of comparative advantage. This states that a product will tend to be produced by a firm when its relative advantage in producing one product compared with another product is greatest (Dolan, 1977). An example of comparative advantage would be the tendency of corn to be produced in the Midwest (Corn Belt) and milk to be produced in the Lake States. The crucial element in comparative advantage is comparing the marginal rate of product substitution.

Consider the following hypothetical situation in the Corn Belt and the Lake States in the production of corn and milk (Harsh et al., 1981). Notice in Table 2.1 that both milk and corn require less labor/ton of output in the Corn Belt than in the Lake States. Thus, the Corn Belt has an absolute advantage in producing both goods with respect to labor. There are differences in the opportunity costs of producing these commodities between the two regions. For example, consider the cost of each good in each region not in terms of labor, but in terms of the other good. In the Corn Belt producing a ton of milk means foregoing the use of 4 hrs of labor for corn production. The opportunity cost of labor in producing milk is: (4 hrs of labor used for milk production/1.5 hrs of labor used for corn). This results in the loss of the opportunity to produce 2.67 tons of corn for every ton of milk produced. The rate of substitution of corn for milk = 2.67. In the Lake States, producing a ton of milk means giving up 5 hrs of labor which would produce 2.5 tons of corn. Thus the rate of substitution of corn for milk is 2.5 in the Lake States which is different from the opportunity cost in the Corn Belt. In terms of relative opportunity cost, milk is cheaper in the Lake States than in the Corn Belt. The region in which the cost of producing a good is lower is said to have a comparative advantage in producing that good.

Although the Lake States have an absolute disadvantage in the production of both goods, they can maximize their position by specialization in the production of milk as opposed to producing corn. The Corn Belt can maximize its position by producing more corn, and trading the corn for milk from the Lake States. Comparative advantage explains why there is a tendency for specialized regions of

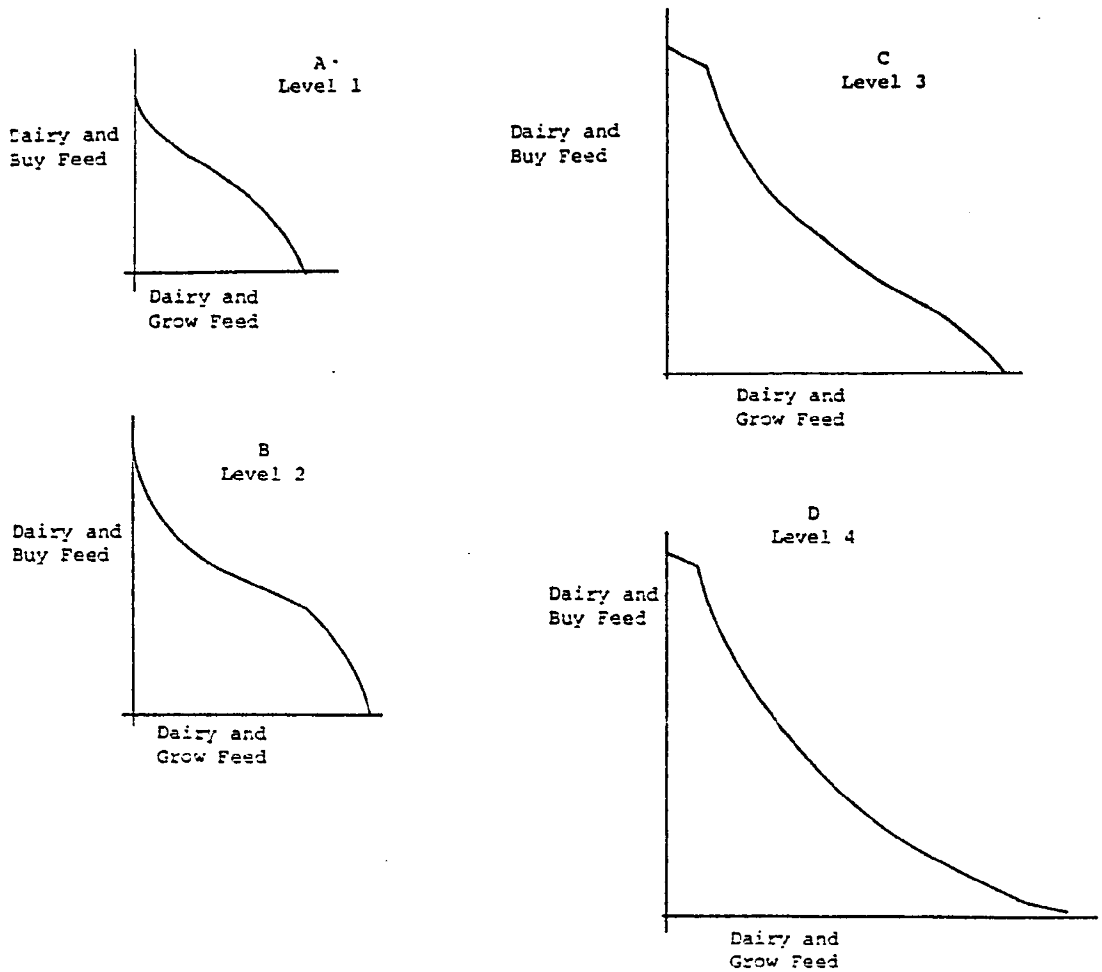

Figure 2.2. Production possibilities (increasing returns to size).

production for certain agricultural commodities.

Table 2.1. Hours of Labor Used in Producing Milk and Corn in the Lake States and Corn Belt (Hypothetical)

	Hrs of Labor/Ton Output	
	Lake States	Corn Belt
Milk	5	4
Corn	2	1.5

2.2.4 How to Produce

The firm seeks to produce a given amount of product at the cheapest cost considering the inputs and processes involved. For example, consider the amount of forage and grain needed to produce the level of milk shown in Figure 2.3. Any combination of X_1 and X_2 that will produce the same quantity of milk are located along the isoproduct line. For example, the same quantity of milk can be produced using a_1 amount of X_1 and b_1 amount of X_2 or a_2 amount of X_1 and b_2 amount of X_2. X_1 and X_2 are said to be complements in that some grain (X_2) and some forage (X_1) are required to produce the amount

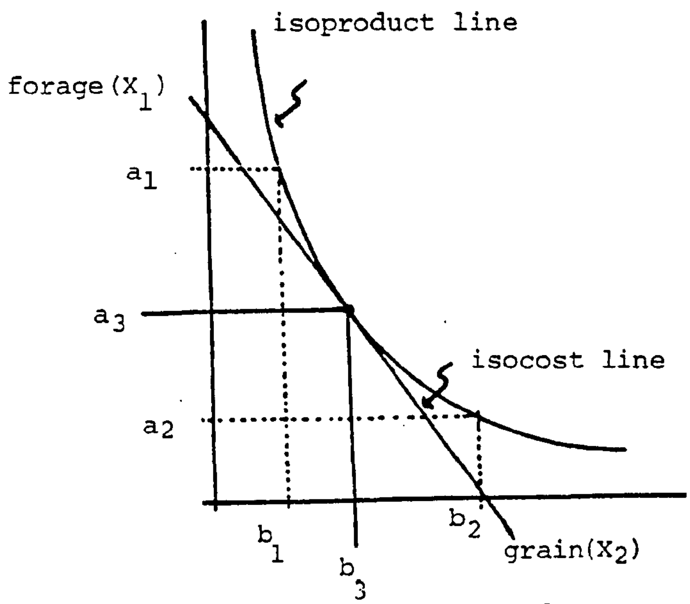

Figure 2.3. How to produce.

of milk represented by the isoproduct line. X_1 and X_2 are said to be substitutes in that we can exchange grain for forage in the proportions indicated on the isoproduct line and still produce the same amount of milk.

The relative costs of inputs determine the least-cost combination of inputs to use to produce a given amount of output. The isocost line indicates the amount of X_1 and X_2 which can be purchased for a given amount of money. The solution for the least-cost combination of inputs (considering these 2 inputs only) is determined at the point where the isoproduct line is tangent to be isocost line closest to the origin. That is, the marginal rate of substitution for the inputs is equal to the inverse price ratio (Harsh et al., 1981).

2.2.5 Capital Budgeting

Economic theory is useful in understanding behavior of the firm but is difficult to apply directly to any business. Managers do not have a complete set of information from which to make choices, and the alternatives available are limited. Also, there are varying degrees of risk involved which cannot be completely evaluated. Nonetheless, business managers do have methods of analyzing the profitability of business ventures. The process of allocating capital among alternative investment opportunities is called capital budgeting. The firm selects a product mix that appears to offer the best prospects for achieving its objectives by projecting the consequences of investing in plausible alternatives. Capital budgeting involves defining the revenues and costs over the horizon of the investment period for each alternative considered and involves several steps.

1. A search of profitable investment opportunities
2. Determining the amount of capital required by each alternative
3. A forecast of the cash flows which will likely result from each investment
4. A method for computing the cost of capital which takes into account the availability of funds
5. A method for computing future cash flows and the time value of money
6. Determining the criteria or methods to select the most profitable investment(s)

(Harsh et al., 1981)

Annual revenues and costs over the investment period can be projected using forecasts of prices of inputs and products for each investment. The value of future costs and returns can be discounted to the present enabling a common point in time as a basis for comparison. The average revenue/unit of time is then calculated since the profit objective involves maximizing average net revenue/unit of time. This is comparable to an annuity (Faris and Reed, 1960). Investments with a positive present value are profitable.

Ranking investments by the rate of return on investment enables comparisons of projects involving different amounts of dollars invested or different lengths of time.

2.2.6 Determining Annual Costs of Durable Assets

Total annual costs include a charge against all inputs used in the production of goods. Inputs which are used and whose life is less than 1 year are referred to as non-durable or current goods. Those which have a life greater than 1 year are referred to as durable goods. The firm expresses annual output as a function of current inputs and the stocks of durable equipment and inventories of inputs, and goods-in-process employed in production (Smith, 1961).

Consider a production function with only two inputs, one current (X_1) and one durable (X_2). Assume that the durable good has an infinite life and requires neither repairs or maintenance. The production function can be written as:

$$Y = F(X_1, X_2)$$

Assuming an infintely long planning horizon, the annual outlay for current inputs is $W_1 * X_1$, where W_1 is the price of X_1. If W_2 is the price of X_2 then $W_2 * X_2$ is the investment in durable goods. As X_2 has an infinite life, a method must be employed to assess an annual charge for the use of this durable good. This charge should be the opportunity cost of capital invested in X_2. The opportunity cost is the amount of money which the investor has foregone by employing capital in X_2 instead of the next most profitable alternative. The opportunity cost is reflected in the discount rate (r) which represents the required rate of return on investment by the investor. The annual cost on an initial investment is: $r * W_2 * X_2$.

Therefore, total annual cost is:

$$W_1 * X_1 + r * W_2 * X_2$$

The second term is the depreciation on the investment $W_2 * X_2$. Next, assume that the durable good requires replacement every L years but has zero salvage value. If the planning horizon is infinite, the annual cost of current inputs is $W_1 * X_1$. $W2 * X_2$ dollars must be invested initially and every L years thereafter. The opportunity cost of capital invested in X_2 becomes:

$$r * W_2 * X_2 / (1 - 1/(1+r)^L)$$

This formula is essentially that developed by Smith (1961). Smith's present value formula is based on continuous compounding using the expression $(1 - e^{-rL})$ to explain the value of the geometric series of investments in $W_2 * X_2$. The substitution of $(1 - 1/(1+r)^L)$ is based on compounding at yearly intervals.

If either the discount rate or the life of the durable is short, the depreciation charge becomes $W_2 * X_2 / L$ which is the ordinary straight-line method of depreciation.

Next, consider durable goods which have a salvage value at the end of every L years, when they are replaced. Using P to represent the initial investment in X_2 (formerly represented by $W_2 * X_2$) and S to represent the salvage value, the annual use charge for capital invested in durable goods with a fixed life and a salvage value can be approximated by the following formula:

$$r * P/(1 - 1/(1+r)^L) - (r * S/(1 - 1/(1+r)^L) + r * S$$

(Black and Fox, 1977)

This formula does not account for maintenance and repair costs of durable assets which must be included in the total cost estimate. Maintenance and repair of durables are typically estimated by engineering equations considering the rate of use and age and are dependent upon the particular investment in question. It is also necessary to include estimates of annual insurance and taxes if applicable.

2.2.7 Risk

Risks are also a major investment concern. Lacking perfect knowledge we can at best predict the future using probability distributions based on previous observations, correlations and knowledge. This is classified as statistical risk by Knight (1921). The confidence with which we can define the future, the ability to adapt to changes (flexibility) and the personal consequences of success or failure are three factors which influence willingness to engage in risky situations. Each investment has different risks and degrees of risk involved.

The traditional Midwest dairy farm includes a land base to grow feeds and has been viewed as a relatively safe investment. Land is a secure investment in that the value of land increases with time and land is a flexible asset which can produce a wide variety of products. Farms with both dairy and cropping enterprises depend upon this diversification to stabilize their income. This will be true: 1) as long as income from the two enterprises varies in opposite directions (i.e. they are negatively correlated) or 2) there are complementary relationships which makes this combination more profitable than either one considered separately, or 3) the combination allows the flexibility to shift emphasis from one enterprise to the other to take advantage of short term comparative advantages or opportunities which arise.

Specialization is a consequence of trying to become more efficient and reduce costs. Specialization usually involves devoting one's resources to the one most profitable enterprise and becoming as large as possible in regard to that enterprise for a given number of dollars to invest. From the traditional viewpoint of risk, specialized dairy farms (i.e. those with a limited land base which purchase feeds) increase risk in that they are less flexible and there is no supplemental income from other enterprises to rely on when dairying is unprofitable. On the other hand, as an enterprise becomes more specialized and size increases (for a given number of dollars invested) and feed costs are lowered/unit of output produced, the impact of changing input and product prices will have less affect on total profitability due to these decreased costs and also due to increased output from a larger sized operation. In this sense then, specialization is actually a form of risk reduction.

The question of which strategy (specialization vs. diversification) is most profitable should consider these factors (i.e. the complementary relationships of diversification and the economies of size that exists with specialization). The sensitivity of the profitability of these strategies to change in milk prices, feed prices, and other inputs should reveal which strategies are most risky.

CHAPTER 3

PROTOCOL

3.1 Objective

The objective of this research is to examine the profitability of different strategies for securing feeds on dairy farms in Southern Michigan and similar areas. These strategies include: 1) farms with ownership of sufficient capital assets to grow forages and grain (GFG), 2) those with assets to grow forages only (GF) and, 3) those organized to purchase all feeds (PR). All strategies purchase supplemental protein and minerals. The forages considered are alfalfa and corn silage and corn is the grain crop. The impact of various levels of milk production, categories of soil productivity (as estimated by soil management groups), feed prices, milk prices and land prices on profitability is analyzed for different levels of investment.

3.2 Protocol

The electronic spreadsheet template: Microsoft Multiplan (Zenith Data Systems, 1982) is employed to model the three strategies: GFG, GF and PR. Synthetic farms of various herd sizes are first assembled to generate estimates of investments, costs, incomes and profits for each herd size within each strategy. These budgets are assembled based on assumptions and specifications outlined in Chapter 4.

Estimates of profit according to herd size (representing different investment levels) provides a basis to regress profit on dollars invested for each strategy. Strategies can then be compared on the basis of profit, given equal levels of investments across all strategies, to determine the most profitable strategy (see Figure 3.1).

This is a static model which is useful in projecting long-term profit expectations. It does not consider within year or across years price and yield variations, income taxes, method or details of financing or yearly cash-flow requirements necessary to keep the business solvent. Real interest rates are used and the model assumes that income and expenses inflate at the same rate.

Total investments for each farm include investments in feed storage facilities, dairy housing and facilities and equipment, and dairy cows. Investments in crop land and machinery are included for the strategies which include crop production (i.e. GFG, GF).

Annual costs are divided into two categories: feed costs and other dairy costs. Annualized costs of feed storage facilities and purchased feed costs (including interest) comprise the feed cost for farms PR. Annualized costs charged for crop land, crop machinery, crop labor, crop expenses (including interest), feed storage facilities and purchased feed costs are summed to compute total feed costs for farms GFG and GF. Annualized costs charged to dairy cows, housing and facilities and dairy equipment and livestock labor are added to feed costs to estimate total annual costs for each herd size within each strategy.

The annual cost of capital (C) invested in durable assets (e.g. feed storage facilities, crop machinery, housing and facilities and equipment) is based on the opportunity cost of capital approximated by the real interest rate (r), the purchase price of the asset (P), the useful life of the asset (L) and its salvage value (S). The capitalization formula below is used to estimate this charge.

$$C = r * P/(1 - 1/(1+r)^{L} - (r * S/(1 - 1/(1+r)^{L}) + r * S$$

(see Black and Fox, 1977)

Land and cows are considered durable assets with an infinite life. The annual cost of these capital items is estimated by multiplying the interest rate by the purchase price.

Annual income is derived from the sale of milk, cull cows, and heifers, deacon calves and excess replacement heifers. Consideration of the fertilizer value of manure, savings in soybean meal purchases for farms GF and GFG, and savings in machinery and equipment costs due to complementary relationships are accounted for when appropriate.

Profit is defined as annual income - total annual costs. Profit is actually returns to management as labor and capital are accounted for in the estimate of total annual costs.

Farms of herd sizes of: 40, 75, 150 and 300 cows (plus replacements) are synthesized for strategies GFG and GF. Herd sizes of 40, 75, 150, 300 and 500 cows are budgeted for farms PR. Spanning these herd sizes within each strategy includes changing investments, costs and returns as herd sizes and crop acreages expand and considers the technical economies which exist for the specific set of resources and technology modeled.

Linear estimates of profit, rate of return on investment (RROI), number of cows and number of laborers are summarized across all strategies for levels of investment of: $.5, 1.0, 1.5, 2.0 and 2.5 million.

The budgeting model developed permits the user to consider milk production levels (rolling herd averages) of: 13, 15, 17 or 19 thousand lb. Soils in management groups: 2.5, 3 or 4 can be specified as well as the prices of milk, corn, and land. Other prices (e.g. labor, fuel, fertilizer and the interest rate) can also be changed by the user. The prices of hay, corn silage and soybean meal are endogenous and depend upon the price of corn. The prices of cull cows and heifers, deacon calves, and excess replacement heifers are endogenous and depend upon the price of milk.

This model is employed to estimate profitability and relative ranking of strategies based on the most likely economic conditions facing the dairy industry for the 1980's considering:

1) various levels of milk production
2) changes in the milk/feed price ratio caused by changing the price of milk or by changing the price of the feeds
3) various land prices
4) various soil management groups

The user specifies:

soil management group = 2.5, 3 or 4
milk production (thousand lb) = 13, 15, 17 or 19
price of land ($/acre)
Price of milk ($/cwt)
price of corn ($/bu)

and can also specify:

price of nitrogen, phosphorus and potassium ($/lb)
prices of dicalcium phosphate, salt and limestone ($/lb)
property tax charge, insurance, real growth rate in land values and real interest rate
price of labor ($/hr) and price of fuel ($/gal)

↓

The model estimates the appropriate investments and costs and incomes for each herd size (40, 75, 150 and 300 cows for the strategies GFG or GF and additionally 500 cows for the strategy PR). Total profit, rate of returns on investment (RROI), total investments, total man equivalents and costs/cwt milk are projected.

↓

Estimates of profit across herd sizes are regressed on total dollars invested for each strategy to enable a comparison of strategies based equal dollars invested in farms of all three strategies. Projections are summarized for levels of investments of: $.5, 1.0, 1.5, 2.0 and 2.5 million.

Using this model the user can:

1) compare profits within each strategy across herd sizes for a given set of specifications.
2) compare strategies across herd sizes on the basis of profit/dollar invested.
3) examine the sensitivity of the analysis to changes in the inputs.

Figure 3.1. Flow Chart of the Dairy Investment Model

CHAPTER 4

ASSUMPTIONS AND SPECIFICATIONS OF THE INVESTMENT MODEL

This chapter discusses the formulation of the model. The components of the model are discussed in four categories.

4.1 Items dealing with feed costs

4.2 Dairy expenses (other than feed costs)

4.3 Incomes and adjustments to costs

4.4 Setting prices in the model

4.1 Feed Costs

Investments for all strategies include feed storage facilities. Land and crop machinery are also included for farms growing grain and/or forages.

Annual feed costs include annual expenses incurred from the investments above plus cash crop expenses, interest charged to cash crop expenses, crop labor and purchased feed costs. For those farms purchasing all feed, interest on purchased feed costs is also included.

4.1.1 Ration

Specifying the ration sets the stage for the analysis as it determines the feeds and quantities of feeds that are to be purchased and grown. This dictates the number of acres of crops needed to grow feeds (based on expected crop yields), which defines the crop machinery complement needed, which defines the crop labor needed and so forth. The model includes rations for levels of milk production of 13, 15, 17 and 19 (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 nutrient requirements. Typical dairy rations in Michigan include corn grain, corn silage, alfalfa and soybean meal. These feeds form the basis for the rations formulated for the model which are presented in Table 4.1. They are based on the following assumptions:

1) The forage dry matter for the lactating herd is 60% alfalfa and 40% corn silage. This is significant in that it dictates the cropping program and machinery complement for farms growing forages. It also implies that farmers purchasing feeds live near sources of corn available as silage. This combination of forages was one of the low cost systems found by Parsch (1982). This cropping combination also permits a more even distribution of labor over the cropping season than an all hay or all corn silage forage system. Including corn silage helps ensure an energy dense ration which is important for herds at high levels of performance. Alfalfa is important for its contribution as a source of fiber and protein and helps to offset soybean meal purchases.

2) Alfalfa is fed in the form of hay to all herds; haylage is included in the rations for all but the smallest herd size (i.e. 40 cows) for the strategies which grow forages. Including haylages

permits harvesting alfalfa under unfavorable weather conditions for hay. It is a common practice to harvest much of the first cutting hay crop as haylage due to rainy weather conditions in Michigan in late May and early June. Haylage is not included for the 40 cow herd as it is not deemed to be cost effective due to the added machinery and feed-storage investment incurred. Harvesting alfalfa as haylage results in a higher harvested yeild/acre and an increase in the nutrient content (particularly protein) due to decreased leaf losses. It is assumed that haylage supplies 60% of the total alfalfa dry matter when it is included in the ration.

3) Corn is considered as high moisture shelled corn. This saves in drying expenses and allows corn to be ensiled.

4) The nutrient content of feeds are based on the sample means of Michigan feeds analyzed at Ohio, adjusted by a safety factor (fraction of a standard deviation) to ensure feeds satisfy nutrient specifications a given percent of the time. Feed nutrient densities are located in Tables 4.2 and 4.3. The protein and energy content of alfalfa are very important determinants of feed cost and production level. It is not uncommon for the protein content of haylage to exceed 20% for an alfalfa crop that is well managed. For the purpose of this analysis however, the adjusted mean value of alfalfa and alfalfa mixed with grass is used (see Table 4.3).

5) The dry matter content of feeds are: shelled corn, 70%; corn silage, 35%; hay, 87%; haylage, 50%; soybean meal, 87% and dicalcium phosphate, limestone and salt, 100%.

Table 4.1 Characteristics of Rations for Lactating Cows

Characteristic	305 Day Milk Yield			
	13,000	15,000	17,000	19,000
Forage:Concentrate (DM basis)[a]	70:30	60:40	50:50	43:57
Energy conc.(NE,Mcal/lb DM)	.68	.70	.73	.74
Crude protein conc.(% DM)	13.0	14.0	15.0	15.5
Average daily milk production	42.6	49.2	55.7	62.3
Level of production balanced for (lb milk/day) (lead factor - 1.15)	49.0	56.0	64.0	71.0
Estimated dry matter intake (lb/day)	39.5	41.5	43.5	45.5
Net energy required (Mcal)	26.0	28.0	31.0	33.0
Crude protein required (lb)	5.1	5.7	6.3	6.9
Net energy required(Mcal/lb DM)	.67	.68	.72	.73
Crude protein required($ DM)	13.0	14.0	14.5	15.3
Crude protein (% grain DM)	14.0	16.3	17.5	18.0
Grain(% of grain as soybean meal)	10.0	15.0	18.0	20.0
Calcium (% in ration DM before minerals added)	.6	.52	.45	.41
Phosphorus (% in ration DM before minerals added)	.26	.27	.28	.28
Dicalcium phosphate (lb/day)	.22	.22	.24	.24
Limestone added (lb/day)	0	0	.10	.15
Salt added (lb/day)	.2	.2	.2	.2
Calcium (% in ration after minerals added)	.72	.63	.67	.64
Phosphorus (% in ration after minerals added)	.36	.37	.38	.38
Corn (shelled) (lb DM/day)	10.5	13.9	17.6	20.0
Soybean meal (lb DM/day)	1.2	2.5	3.9	5.2
Corn silage (lb DM/day)	10.9	9.8	8.6	8.0
Hay crop (lb DM/day)	16.4	14.8	12.9	11.8

[a]Assumes the NE content of the grain mix ≃ .87 Mcal/lb and the NE content of the forage mix ≃ .6 Mcal/lb.

Table 4.2. Nutrient Content of Michigan Feeds Analyzed at Ohio[a] (Dry Matter Basis)

Feed		% DM			% CP			% TDN				% ADF			% Ca			% P		
	no.	$\bar{x}$	SD	% CV	$\bar{x}$	SD	% CV	$\bar{x}$	SD	%CV	no.	$\bar{x}$	SD	% CV	$\bar{x}$	SD	% CV	$\bar{x}$	SD	% CV
Shelled corn	76	77	5	6.5	10.8	1.7	15.7	90.5	3.1	3.4	1	2.8	---	----	.113[c]	.07	66.1	.22	.07	31.4
Corn silage	270	37	11	29.7	9.2	2.2	23.9	70.1	5.9	8.4	6	27.2	1.9	7.0	.33[d]	.18	54.5	.27	.07	25.9
Alfalfa hay	175	87	4	4.5	17.0	3.2	18.8	57.8	4.9	8.5	9	36.1	6.2	17.2	1.34	.32	23.9	.28	.08	28.6
Alfalfa-grass hay	102	89	3	3.3	14.5	3.8	26.2	55.1	3.5	6.4	2	42.1	2.1	5.0	1.17	.44	37.6	.27	.08	29.6
Alfalfa-alfalfa-grass hay[b]	277	87	3.6	----	16.1	3.4	----	56.8	4.4	---	-	38.4	4.7	----	1.28	.36	28.1	.276	.08	29.0

[a] Source: Thomas, 1979.
[b] This is the composition of the weighted average of samples of alfalfa and alfalfa-grass hay.
[c] Shelled corn calcium content is quite different than that listed in 1978 N.R.C.
[d] The calcium content reported ranged from .11 to 1.67%; 1.67 is either aldulterated corn silage or a printing mistake.

6) Nutrient requirements for protein and energy are based on N.R.C. (1978).

Table 4.3. Nutrient Content of Feeds Used in Estimating Feed Budgets (Dry Matter Basis) for the Model

Feed	% DM	% CP[c]	Mcal NE/lb[c]	% ADF	% Ca	% P
Shelled corn (dry)	85	10.3	.89[c]	2.8[c]	.02	.20
Corn silage	35	8.5[c]	.68[c]	26.8[c]	.29	.26
Alfalfa hay crop[a]	89	15.0[d]	.55	37.6[c]	1.21	.26
Soybean meal[b]	89	50.0	.85	10.0	.36	.75
Dicalcium phosphate	--	----	---	----	22	18
Limestone	--	----	---	----	38	--

[a]The weighted average of nutrient values of alfalfa and alfalfa-grass hay was used as an estimate of the nutrient content of hay used in the analysis in regard to protein, energy and fiber.

[b]The nutrient content of soybean meal was estimated using N.R.C. (1978).

[c]The nutrient content of feeds is based on the average content of Michigan feeds analyzed at Ohio weighed by a fraction of the standard deviation of that nutrient, e.g. shelled corn protein = 10.8 - .3 * (1.7) = 10.3. Using .3 * SD estimates the nutrient value which should be surpassed by 62% of the population (using Z table distribution; Zar, 1974, pg. 412).

[d]As hay is of the most important protein sources the average value for alfalfa protein is estimated as 16.1 - .3 * (3.4) = 15.0. This value should be surpassed by 62% of the hay population. Using these safety factors, approximately only 5% of the time will hay and corn silage and shelled corn nutrients be less than the table values for all three feeds (assuming feed nutrient contents are not correlated among feeds).

Only 14% of the time will 2 of the 3 feeds have values lower than the mean and 38% of the time at least one feed will have a protein value lower than the mean.

7) Dry matter intakes for lactating cows are based on the average daily milk produced over the entire lactation using the equation: Dry matter intake (DMI) = (2 + .022 * lb of 3.5% fat milk) * (cwt body weight) (Hlubik and Thomas, 1980). It is assumed that cows weigh 1350 lb.

8) Rations for lactating cows are balanced using a lead factor of 1.15 x average daily milk production. This is approximately the same as dividing the herd into a high and low group, balancing the high group based on requirements and intake 60 days into lactation and the low group balanced at 150 days into lactation.

9) 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. Quantities of feeds needed/cow and replacement are located in Table 4.4. Quantities of feeds needed are similar to those summarized for Telfarm farmers as reported in Table 4.5.

Table 4.4. *Quantities of Feed Needed/Cow and Replacement/Year by Production Level*

Feed	Lactating[a] cow	Dry[b] cows	Youngstock[c]	Total	Storage and feed loss[d]	Total needed
			Production level of 13,000 lb, 3.5% milk			
Shelled corn (87% DM)	66 bu	2 bu	12 bu	82 bu	8%	87 bu
Soybean meal (87% DM)	410 lb	----	100 lb	510 lb	5%	535 lb
Hay crop (87% DM)	2.9 ton	.5 ton	2.2 ton	5.6 ton	16%	6.5 ton
Corn silage (35% DM)	4.8 ton	.8 ton	3 ton	8.6 ton	18%	10.1 ton
Dicalcium phosphate (100% DM)	70 lb	------	25 lb	95 lb	5%	100 lb
Salt (100% DM)	60 lb	5 lb	25 lb	90 lb	5%	95 lb
			Production level of 15,000 lb, 3.5% milk			
Shelled corn (87% DM)	88 bu	2 bu	12 bu	102 bu	8%	110 bu
Soybean meal (87% DM)	863 lb	----	100 lb	963 lb	5%	1011 lb
Hay crop (87% DM)	2.6 lb	.5 ton	2.2 ton	5.3 ton	16%	6.2 ton
Corn silage (35% DM)	4.3 ton	.8 ton	3 ton	8.1 ton	18%	9.6 ton
Dicalcium phosphate (100% DM)	70 ton	5 lb	25 lb	95 lb	5%	100 lb
Salt (100% DM)	60 lb	5 lb	25 lb	90 lb	5%	95 lb
			Production level of 17,000 lb, 3.5% milk			
Shelled corn (87% DM)	110 bu	2 bu	12 bu	124 bu	8%	134 bu
Soybean meal (87% DM)	1357 lb	----	100 lb	1457 lb	5%	1529 lb
Hay crop (87% DM)	2.3 ton	.5 ton	2.2 ton	5.3 ton	16%	6.2 ton
Corn silage (35% DM)	4.3 ton	.8 ton	3 ton	8.1 ton	18%	9.6 ton
Dicalcium phosphate (100% DM)	70 lb	-----	25 lb	95 lb	5%	100 lb
Limestone (100% DM)	30 lb	-----	-----	30 lb	5%	32 lb
Salt (100% DM)	60 lb	5 lb	25 lb	90 lb	5%	95 lb
			Production level of 19,000 lb, 3.5% milk			
Shelled corn (87% DM)	131 bu	2 bu	12 bu	144 bu	8%	157 bu
Soybean meal (87% DM)	1820 lb	----	100 lb	1920 lb	5%	2020 lb
Hay crop (87% DM)	2.0 ton	.5 ton	2.2 ton	4.7 ton	16%	5.6 ton
Corn silage (35% DM)	3.5 ton	.8 ton	3.0 ton	7.3 ton	18%	8.6 ton
Dicalcium phosphate (100% DM)	70 lb	-----	25 lb	95 lb	5%	100 lb
Limestone (100% DM)	30 lb	-----	-----	30 lb	5%	32 lb
Salt (100% DM)	60 lb	5 lb	25 lb	90 lb	5%	95 lb

[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 before 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 haylage stored in an upright silo (i.e. .4 * 12 + .6 * 19 = 16).

Table 4.5. Telfarm Estimates of Feed Disappearance by Level of Milk Production[a] (1980 and 1981 Summary Data)[b]

No. Observations[c] (farms)	Avg. Milk Sold/Cow	Corn Eq.[d] (bu)	Hay Eq. (ton)	Corn Silage (ton)	Purchased Feed $
263	14,950	115	6.6	8.9	340
157	17,041	118	6.1	9.2	370
27	18,871	136	6.8	6.5	402

Source: Mulvaney, 1982.

[a]Telfarm accounts for total milk sold and not all milk produced.

[b]These estimates are weighted average amounts estimated from Telfarm production sorts. In addition to including dairy heifers these estimates include feed disappearance for bulls and steers.

[c]As these observations include 1980 and 1981 data many observations are of the same farms over 2 years time.

[d]Corn equivalent includes estimates of barley and oats fed, converted to a corn equivalent basis by weight.

4.1.2 Feed Storage Facilities

A. Assumptions

There is a wide variety of possible feed storage investment alternatives. For example, silages can be stored in bunker silos, upright cement stave silos, oxygen limiting upright silos and more recently in vacuum-sealed plastic silage bags. The choice of storage systems depends on such factors as: purchase price, annual use costs/unit of feed stored, compatibility with the harvesting and feeding systems, feed storage losses, feed quality, labor requirements, ease of handling and rate of feedout.

1) Shelled corn is stored as high moisture corn in upright cement stave silos. All but the smallest herd size are assumed to

have a top unloader for the silo. All strategies are assumed to ensile a year's supply of corn during the fall harvest season (see Appendix B). This allows farmers to take advantage of reduced harvest season prices and also eliminate the cost of drying corn which is estimated as approximately $.30/bu (Schwab et al., 1983). It is assumed that farmers purchasing corn (i.e. PR and GF) can contract with neighboring crop farmers to supply their needs.

2) Corn silage is stored in bunker silos for farms of herd sizes of 75, 150, 300 and 500 cows. Corn silage is stored in an upright cement stave silo for herd sizes of 40 cows. Bunker silos are a low investment silo compared to oxygen limiting or cement stave silos. They are well suited to mixer wagon feeding but require careful management. Storing silage in bunker silos typically results in greater feed storage losses compared to upright silos (Knoblauch, 1977). Storing silage in a bunker for a herd size of 40 cows is considered impractical because the small size needed would not provide adequate room to maneuver tractors for packing during ensiling which would result in excessive feed spoilage and storage losses.

3) Haylage is stored in upright cement stave silos with top unloaders for herd sizes $\geq$75 cows for farms GF and GFG. As the crop is harvested throughout the growing season (late May to early October), storage facilities are sized to accomodate 70% of the total annual hay crop harvested as haylage.

4) Hay is stored in pole barns for all strategies and herd sizes. Storage facilities are sized to accomodate 70% of the total annual hay

crop harvested as hay for farms GFG and GF. Farms PR have facilities adequate to store 40% of their annual needs (see Appendix B).

The model estimates total investments in feed storage facilities by summing the investments for facilities to store shelled corn, corn silage, hay and haylage (when included) for each herd size within each strategy.

The annual use cost of capital invested in feed storage facilities is based on the opportunity cost of capital for durable assets as outlined in section 3.2 considering an expected life of 20 years, a salvage value of zero, and the real interest rate at 4%.

B. Estimating Feed Storage Costs

Table 4.6 presents some recent estimates of costs of cement stave upright silos with top unloaders. From this table, equations estimating feed storage costs for silage, haylage and high moisture corn are derived. Predicted costs of silos are compared to actual costs in Tables 4.7 and 4.8. Costs to build bunker silos were obtained from a Michigan builder and are presented below:

Vertical silo costs (cement stave, top unloading, including unloader)

$$Y = \$12,918 + 66.8 * (X)$$

where Y = cost of silo
X = tons of silage or haylage dry matter

$$Y = \$11,542 + .902 * (X)$$

where Y = cost of silo
X = bushels of corn at 70% dry matter

Horizontal silo costs: (12 ft high walls, concrete)

$100 per foot of wall
$1.40 per square ft concrete floor
20' apron in front of silo
site work estimated at $300

Y = $12,560 + 55 * (X)

where Y = cost of silo
X = tons of 32% DM silage

Hay storage costs:

Assuming $3.50/square ft to build a pole barn for hay and straw storage, the barns are 14 foot high to the eaves, and that hay occupies 250 square feet/ton, hay storage investment = $62.50/ton.

(250 sq ft/14 ft) * $3.50/sq ft = $62.50/ton

Table 4.6. Vertical Silo Sizes and Costs (Cement Stave)

Silo Size diameter & height	Volume ft^3	Silage storage + (DM)	Corn storage bu	Silo cost $	Unloader cost $	Total cost $	Source	Corn/Ton silage $	Cost/Bu corn $
12' x 30'	3,390	21	2,354	5,000	-----	5,000	MSR Silo Co. (1983)	112.00	2.12
16' x 50'	10,050	78	6,980	11,000	5,300	16,300	Tri State (1983)	208.00	2.33
20' x 50'	15,560	122	10,900	14,300	5,500	20,600	Tri State[a] (1983)	169.00	1.89
20' x 60'	18,840	159	13,080	17,100	5,500	22,600	Central Dairy (1983)	142.00	1.73
20' x 70'	21,980	198	15,260	19,900	5,500	25,400	Central Dairy (1983)	128.00	1.66
20' x 80'	25,120	214	17,800	22,700	6,300	29,000	Tri State[a] (1982)	135.50	1.63
24' x 60'	27,120	228	18,830	21,700	8,500	30,200	Tri State[a] (1982)	132.50	1.60
24' x 80'	36,160	341	25,640	28,300	8,500	36,800	Tri State[a] (1982)	108.00	1.44
30' x 60'	42,360	357	30,030	28,800	9,300	38,100	Tri State[a] (1982)	107.00	1.26
30' x 80'	56,480	529	40,040	36,700	9,300	46,000	Tri State[a] (1982)	107.00	.91

[a]Savoie, P. 1982.

Table 4.7. Estimated Vertical Silo Costs (Cement Stave, Including Top Unloader) vs. Costs Predicted by Linear Equations for Corn Grain, Silage and Haylage

Silo size[a]	Silage[b] capacity	Corn capacity	Estimated[c] cost,$	Predicted[d] cost, $	Predicted[e] cost, $
	ton DM	bu			
16' x 50'	78	6,800	16,300	18,128	17,676
20' x 50'	122	10,900	20,600	21,067	21,374
20' x 60'	159	13,083	22,600	23,539	23,343
20' x 70'	198	15,263	25,400	26,144	25,309
20' x 80'	214	17,800	29,000	27,213	27,598
24' x 60'	228	18,833	30,200	28,148	28,529
24' x 80'	341	25,635	36,800	35,697	34,665
30' x 60'	357	30,030	38,100	36,766	38,629
30' x 80'	529	40,040	46,000	48,255	47,658

[a]Vertical silo sizes are diameter * height in feet.
[b]DM refers to dry matter.
[c]Costs are estimated from Table 4.8.
[d]Predicted as: $12,918 + 66.8 * (tons of silage or haylage DM).
[e]Predicted as: $11,542 + .902 * (bushels of shelled corn).

Table 4.8. Estimated Horzontal Silo Costs (Cement Sides, Floor and Back Wall) vs. Costs Predicted by Linear Equations, for Corn Silage (32% DM)

Silo size[a]	Silage tons 32% DM capacity	Silage ton DM capacity	Estimated[b] cost $	Predicted[c] cost $
20' x 60' x 10'	328	105	16,540	18,335
30' x 80' x 10'	631	202	23,500	23,670
30' x 100' x 10'	790	253	28,340	26,475
50' x 120' x 10'	1521	487	39,100	39,345
50' x 150' x 10'	1903	609	47,200	46,055
60' x 180' x 10'	2715	869	59,100	60,355

[a]Horizontal silos are expressed as width * length * height; it is assumed that the average height of silage will be 2 ft higher than the walls when figuring capacity.

[b]Estimated costs are based on: $100/sq ft wall (concrete); $1.40/ sq ft floor (concrete); $300 for site preparation. The cost includes 3 sides plus an apron (20') extension on the open end; these costs were estimated using cost information from a Michigan builder, W. Steer from Vassar, Michigan.

[c]Cost is predicted as: $12,560 + 55 * (tons of silage DM).

4.1.3 Land

The model estimates the number of acres of cropland needed by dividing the quantities of each feed needed by the expected yield/acre for each crop grown. An additional 5% above required acreages is included to account for headlands. Expected yield/acre for each crop is determined in the model by the soil management group. There are three soil management groups which can be specified by the user. These are discussed below.

A. Purchase Price of Land

The investment value of land is estimated by multiplying the purchase price/acre by the number of acres. In the model, the purchase price/acre is specified by the user it should be consistent with the market value and productivity of the land. Average values/acre and the index values of land prices in Michigan over the last 5 years are listed in Appendix Table A1. Note that the value of cropland has decreased since 1981. The investment cost/acre can be approximated from cash crop rents. Table A2 presents cash crop rents and average land values of Michigan farmland from 1960 to 1979. Extension Bulletin E-683 (Schwab, 1983b) provides estimates of cash rents for Michigan by crop production districts considering the crop grown.

Michigan soils are divided into eight productivity groups to assess their value for property tax purposes (Michigan State Tax Commission, 1972). A soil of productivity group 1 is given a value of 100%; 2, 95%; 3, 90%, 4, 80%; 5, 75%; 6, 65%; 7, 55%, and 8, 45%. Thus, when properties in a township are sold and their productivity is known, values of other properties can be adjusted using this scale. Soils are placed in productivity groups based on their crop production potential under average management conditions; this is determined by classifying them into soil management groups and is based on productivity according to Extension Bulletin E-550 (Warncke and Christenson, 1981). Broadly speaking, soils in soil management group 2.5 include productivity groups 1 and 2, soils in management group 3 include productivity groups

3 and 4 and soils in management group 4 include productivity groups 5 and 6. Valuing soil management group 2.5 at 100%, soils in management groups 3 and 4 should have approximately 87% and 72% of the value of soils in management group 2.5. This can be used as a guideline to estimate relative value of crop land.

B. Annual Use Cost of Land

In estimating the annual cost/acre to charge against land, consideration is given to the opportunity cost of capital. This reflects what the investor could earn on the next best alternative. The real interest rate is used to approximate the opportunity cost of capital invested in land. The MSU Agricultural Model (Ross et al., 1983) predicts the real interest rate to average 4.1% over the period from 1983 to 1990. The long-run real interest rate is generally assumed to be about 3%. This cost should be adjusted by the expected change in the real (deflated) value of the investment which is referred to as the growth rate.

The average real growth rate of land has been approximately 5%/ year from the period 1960-1980 (Barry, 1983); recently (1981-1982) land values have declined 9%/year (see Appendix A). Based on the pessimistic price outlook for farm commodities (Christenson and Sorenson, 1983), it is estimated that the real growth in land value will be similar to that experienced in the 1960's (Barry, 1983, pg. 129) which was approximately 1.45%/year. The real growth rate in land value is approximated as 1%/year in the model.

Property taxes are another expense item to account for when estimating the annual cost of land. In the model, the value of property multiplied by .02 is used to estimate the annual property tax charge. This estimate was derived by regressing property taxes on the value of the taxable assets and is reported in Table 4.9. This charge is comparable to the estimate of .017 used by (Knoblauch, 1977) in his study analyzing hay crop production, storage and feeding on New York dairy farms.

Table 4.9. 1982 Property Taxes and Insurance Paid and Farm Capital Owned by Michigan Telfarm Specialized Dairy Farms[a] According to Herd Size

Herd size (no. cows)	<50	50-75	75-100	>100
No. of farms	119	113	80	126
Avg. value of taxable property[b]	$139,975	$234,854	$277,321	$474,807
Avg. property taxes paid	$ 3,243	$ 5,422	$ 5,973	$ 10,613
Avg. value of insured property	$ 88,475	$147,368	$194,468	$312,543
Avg. insurance paid	$ 1,103	$ 1,678	$ 1,967	$ 3,426

[a]Source: Brown and Nott, 1983.
[b]Includes land (agric value), buildings and improvements.
[c]Includes the value of buildings and improvements and machinery.
Property taxes can be approximated as: $125 + .022 * (avg. value of property) r = .99 for the 4 estimates.
Insurance can be approximated as: 123 + .010 * (avg. value of insured property) r = .99 for the 4 estimates.

C. Land Productivity

Land productivity depends upon the soil characteristics relative to crop requirements. Soils with similar properties and yield potentials form soil management groups. This combines soils with similar profiles, management requirements and responses to like management practices.

Mineral soils are given a number based on the dominant profile texture as follows: 0 - fine clay, more than 60% clay; 1 - clay, 40 to 60% clay; 1.5 - clay loam and silty clay loam; 2.5 - loam and silt loam; 3 - sandy loam; 4 - loamy sand and 5 - sand. Soils are further subclassified according to natural drainage conditions, slope and degree of erosion which has occurred (Mokma and Robertson, 1976). With over 275 soils series mapped in Michigan, the concept of classifying soils according to management groups greatly aids the ability to communicate soils information.

The model can investigate the growing strategies considering soils broadly classified into management groups 2.5, 3 or 4. Soils in management group 2.5 are loams considered to be very productive. Capec, Conover, Celina, Dunbridge, Isabella, Miami, Tuscola, Brookston and Kokomo soils are among those in group 2.5. Group 3 soils are sandy loams and considered moderately productive. Hillsdale, Lapeer, Osktemo soils are among those in this group. Soils in management group 4 are considered to be loamy sands and not very productive. Gilchrist, Gladwin, Leelanau, Montcalm and Spinks soils are examples of group 4 soils. Expected harvest yields/acre for corn, corn silage and alfalfa for soils in Southern Michigan with a growing season of over 140 consecutive frost free days are reported in Table 4.10. It is assumed that alfalfa harvested as haylage yields more dry matter/acre than that harvested as hay due to reduced leaf losses during harvest (McGuffey and Hillman, 1976; Savoie, 1982). In the model this is estimated as 10% more dry matter/acre of haylage vs. hay.

The model also assumes that alfalfa lasts 5 years and is re-seeded during the end of the fifth year; therefore, 16.7% of the hay crop is replaced each year and the reduction in yield due to re-seeding is accounted for.

Table 4.10. Expected Crop Yields/Acre by Soil Management Group[a]

Soil Management	Crop Yields[b]			
	Corn bu	Corn Silage[c] tons @ 35%DM	Alfalfa-Grass Hay[d] tons @ 87% DM	Alfalfa-Grass Haylage[e] tons @ 50% DM
2.5	120	16.8	4.6	9.0
3	105	15.3	4.0	7.9
4	86	13.2	3.5	6.9

[a]Source: Warncke and Christenson, 1981.
[b]Crop yields are derived as the average harvested yields for soils classified in management groups 2.5, 3 or 4 as reported in E-550 by Warncke and Christenson, 1981.
[c]It is assumed that corn silage yields in E-550 are expressed in tons of 32% DM corn silage; this table expresses yields at 35% DM.
[d]Alfalfa-grass hay and haylage yields are adjusted to reflect a re-seeding of 16.7% of the crop/year with a yield on the re-seeded acreage of 2 tons/year.
[e]Haylage is assumed to yield 10% more crop than hay due to reduced leaf losses.

4.1.4 Cash Crop Expenses

Estimated cash crop expenses for cropping enterprises are presented in Table 4.11 and are expenses/acre for each crop grown. Some expenses such as fertilizer, seeds and fuel vary depending on the crop yield. These items are linearly approximated considering expenses across the various yield categories presented by Schwab et al. (1983) considering non-irrigated crops. Amounts of phosphorus and

Table 4.11. Cash Crop Budgets[a]: Expenses/Acre

Item	Acronym	Crop			
		Corn	Corn Silage	Alfalfa Hay[b]	Alfalfa Haylage[c]
Seeds and plants	SDS	(8.16+.06* Bu[d]/A)*$1.25/lb	(6.5+.534*T[e]/A)*$1.25/lb	$ 5.00	$ 5.00
Weedspray	WS	$11.20	$11.20	$ 1.75	$ 1.75
Insecticides	INSCT	$ 2.00	$ 2.00	$ 5.00	$ 5.00
Nitrogen	N	(17.2+1.1* Bu/A)*($/lb N)	(6.3+9.3* T/A)*($/lb N)	0.00	0.00
Phosphorus[f]	P	(10.45+.409* Bu/A)*($/lb P)	(4.35*T/A)*($/lb P)	(10.7*T/A)*($/lb P)	(5.9*T/A)*($/lb P)
Potassium[g]	K	75 * ($/lb K)	8.64 * ($/lb K)	45 * T/A * ($/lb K)	25 * T/A * ($/lb K)
Limestone[h]	LMSTN	95 * ($/lb LMSTN/.38)	5.94*T/A*($/lb LMSTN/.38)	59*T/A*($/lb LMSTN/.32)	32.8*T/A*($/lb LMSTN/.38)
Utilities	UTLTS	$.041 + .021 * Bu/A	$.339 * T/A	0	0
Trucking	TRCK	$.105 * Bu/A	$-1.6 + 1.08 * T/A	$1.47 * T/A	$.45 * T/A
Fuel	FL	11.3 * ($/gal FL)	(6.92+.336*T/A)*($/gal FL)	(6.02+.44*T/A)*($/gal FL)	19.9 * ($/gal FL)
Repairs	RPRS	$13.60	$18.20	$12.94 + 1.91 * T/A	$18.9 + .725 * T/A
Crop Supplies	OTHR	0	0	2.35 * T/A	3.00 * T/A

[a]Source: Schwab et al., 1983. Approximations of expenses for SDS, N, P, K, LMSTN, UTLTS, TRCK, FL, RPRS, OTHR are based on yields/acre, considering expenses/acre for the various yield categories for crops as reported by Schwab et al.

[b,c]Budgets for alfalfa are based on the assumption that alfalfa will be re-seeded every 6th year.

[d,e]Yield is expressed as bushels/acre or tons/acre.

[f,g,h]The amount of P, K, LMSTN for alfalfa and corn silage are estimated by multiplying the nutrient content of these forages by the quantities of dry matter harvested/acre.

potassium needed for corn silage and alfalfa are estimated by multiplying the nutrient content of these forages presented in Table 4.3 by the quantities of dry matter harvested/acre. The model estimates cash crop expenses/acre by multiplying the number of acres of each crop by the total cash crop expenses/acre.

4.1.5 Crop Machinery

Appendix Tables C1 through C8 contain machinery complements for farms of sizes 40, 75, 150 and 300 cows which grow forages and grains (GFG) or grow forages only (GF). Machinery is assembled based on the size of machinery needed to complete cropping programs in a timely manner relative to the size of the farm and the costs of the machinery. These machinery complements are summarized in Table 4.12.

Table 4.12. Summary of Machinery Investments by Herd Size and Feeding Strategy[a]

Strategy:	Herd Size 40	75	150	300
	$	$	$	$
Grow Forages & Grain				
Total	145,700	161,400	207,900	323,520
Per Cow	3,643	2,152	1,386	1,078
Grow Forages Only				
Total	129,700	143,000	176,400	240,400
Per Cow	3,243	1,907	1,176	801

[a]Based on Appendix C.

The annual cost of capital invested in machinery is approximated considering an expected life of 8 years, a salvage value of 25% and a real interest rate of 4%. Salvage value is estimated as the remaining value of crop machinery (at the end of 8 years) as a percent of the list price (John Deere and Co., 1981, pg. 62).

Other costs comprising the annual use cost of machinery includes insurance and shelter. Insurance is estimated as 1% of the average investment in machinery. This cost is based on Table 4.12. The annual cost of shelter is estimated to be 1 to 2% of the value of machinery (John Deere and Co., 1981, pg. 63). The estimate used in this analysis is 1.5% of the average investment in machinery. Repairs and maintenance costs are estimated in the cash crop budgets (see Table 4.11).

4.1.6 Crop Labor Requirements

Crop labor requirements are derived by estimating the hours of labor needed for each crop based on the tasks to be accomplished, crop machinery sizes and rates of work, and acres of each crop grown. Machinery sizes change with changes in the acres of crops grown. Labor requirements for various acres of each crop are budgeted in Appendix D. These estimates are used to derive the following linear approximations of hours of labor needed/acre for corn, corn silage, haylage and hay based on the acres of each crop grown.

Table 4.13. Crop Labor Requirements

Corn grain	Y = 2.2 + 125/X
Corn silage	Y = 3.7 + 90/X
Hay	Y = 5.4 + 250/X
Haylage	Y = 4.6 + 284/X
Where X = no. acres of each crop; Y = hrs of labor/acre	

4.1.7 Purchased Feed Costs

Purchased feed costs are estimated by multiplying the feed purchase prices by the quantity of each feed needed which is determined by the level of milk production (see Table 4.4) and herd size. Costs of soybean meal, dicalcium phosphate, limestone and salt are calculated in this manner for all herd sizes and strategies. Costs of corn grain are estimated for farms purchasing corn (GF,PR), and costs of alfalfa hay and corn silage are estimated for farms purchasing forages. These costs are estimated considering the quantities of these feeds needed (based on the level of milk production and the price of the feeds specified). It is assumed that corn is purchased in the fall as high moisture shelled corn, and silage is purchased in the fall as well; hay is purchased throughout the year and there is a 4 month inventory on the farm (see Appendix B for the logic of these assumptions).

4.2 Dairy Expenses

4.2.1 Dairy Buildings and Facilities, Land for Facilities and Dairy Equipment

Investments for dairy buildings and facilities, land for facilities, equipment and dairy cattle are included. Annual costs include annual expenses incurred from the investments above plus livestock and labor expenses. These are considered to be the same across strategies depending on the herd size.

The annual use cost of capital invested in dairy buildings and facilities is estimated based on an expected life of 20 years, a salvage value of zero and a real interest rate of 4%. The annual use cost of capital invested in dairy equipment is estimated based on an expected life of 8 years, a salvage value of 25% and a real interest rate of 4%.

The total costs of investments in dairy buildings and facilities and equipment include property taxes and insurance. Maintenance and repairs of buildings and equipment are estimated in the livestock budgets. The total annual use cost of capital invested in land for dairy buildings is estimated based on an opportunity cost of capital at 4%, property taxes and an annual rate of growth in value of land of 1%.

Investments in dairy cattle are estimated by multiplying the purchase price of cows by the number of cows. The annual use cost of capital invested in cows is approximated by multiplying the value of the dairy cattle by the interest rate. Cows are considered a durable asset with an infinite life. Investments in buildings and facilities and equipment are based on the following assumptions.

1) Farms of herd size of 40 cows are housed in confinement-stall barns with a pipeline milking system.

2) Farms of herd sizes of: 75, 150, 300 and 500 cows are housed in free stall barns and milked in a herringbone parlor.

3) Farms of herd sizes 75 or 150 cows are milked in a double-4-herringbone parlor with no mechanization.

4) Farms of herd sizes 300 or 500 cows are milked in double-8-herringbone parlor with detachers and power gates.

5) All farms have 6 months manure storage.

6) Manure is stored as a solid for 40 cow herds, on a concrete slab with 3 side walls using a gutter cleaner and a manure stacker.

7) Manure and parlor wastes are stored in an uncovered earthen pit for herd sizes >75 cows.

8) All farms feed total mixed rations.

9) All farms have youngstock facilities; hutches for newborn calves, Virginia style barns for calves weaned through freshening.

10) Approximately 85% of the cows are milking, 15% are dry at any given time.

11) The number of heifers on the farm at any time is: 1.05 * (number of cows in the herd) (see section 4.3.3).

12) The layout of physical facilities requires 1 acre of land for every 20 cows.

Appendix Tables E1 through E5 contain dairy buildings and facilities and equipment for farms ranging in herd size from 40 to 500 cows.

These are summarized in Table 4.14.

Table 4.14. Summary of Dairy Buildings and Equipment Investments by Herd Size[a]

	Herd Size				
	40	75	150	300	500
	$	$	$	$	$
Dairy buildings	71,350	119,800	202,850	368,700	590,300
Equipment	66,250	101,100	136,950	205,450	221,400

[a]Based on Appendix Table E1 through E8.

4.2.2 Livestock Expenses, Labor and Investments

Livestock expenses/cow (including replacements) are presented in Table 4.15 and vary according to the production level. Total livestock expenses are calculated by multiplying total expenses/cow (based on the level of production) by the herd size. Labor requirements for each herd size are calculated in Table 4.16 based on the technology employed (i.e. the buildings, facilities and equipment). From these estimates a linear relationship was formulated to estimate labor requirements/cow/year for a given number of cows. Livestock labor (hrs/cow/year) = 36 + (1480/herd size).

4.3 Incomes and Adjustments to Costs

Income is derived from the sale of milk, deacon calves, cull cows and heifers and excess replacement heifers.

4.3.1 Milk Income

Milk sold is estimated as 95% of that produced. The difference between the amount of milk produced and the amount sold can be

Table 4.15. Dairy Livestock Budgets: Selected Cash Expense[a] by Production Level

Item	Level of Production					
	11,000	13,000	14,000	15,000	16,000	18,000
	$	$	$	$	$	$
Building repairs	11.10	10.40	12.00	12.70	13.00	13.30
Equipment repairs	50.70	49.40	56.20	57.00	58.00	58.10
Livestock supplies	30.20	58.40	58.50	58.90	61.80	68.30
Breeding fees	9.60	20.30	20.60	33.80	35.00	43.50
Vet and medicine	28.40	38.00	39.00	47.80	55.50	69.40
Gasoline,fuel,oil	8.70	10.00	10.30	10.80	11.40	11.50
Insurance	10.20	12.40	14.40	14.60	15.00	15.70
Utilities	43.00	50.40	53.30	53.50	53.90	57.20
Marketing	71.30	84.80	88.50	96.80	105.00	118.20
Other cash expense	6.60	11.90	12.70	12.70	12.70	19.10
Total selected cash expense	269.80	346.00	365.50	398.60	421.30	474.30

[a]Source: Schwab et al., 1983. These cash expenses are approximated using the linear expression: livestock cash expense = -36.2 + .0286 * (lb of milk production), r^2 = .99 for the equation developed using the 6 estimates above.

Table 4.16. Estimated Annual Dairy Labor Requirements by Herd Size (Hours/Year)

Item	Herd Size				
	40	75	150	300	500
Milking[a]	1113	1879	3149	3927	6099
Manure handling[b]	230	346	526	886	1366
Feeding[c]	511	620	1022	1716	2592
Bedding[d]	117	141	208	343	523
Other:[d]					
Heat detection	94	133	215	380	600
Breeding	24	45	90	180	300
Youngstock	340	533	945	1170	2870
Dry cow care	30	60	112	225	375
Records	40	75	150	300	500
Turn in and out of stall	161	---	---	---	---
Miscellaneous	178	290	530	1010	1650
Total hours/year	2838	4122	6947	10737	16875
Total hours/cow/year	71	55	46	36	34

[a]Milking time for a 40 cow herd is based on: Bath et al., 1978, Appendix Table V-I, pg. 531.

Milking time for other herd sizes is based on: Wetzel, 1979, Table 3.

Hours/milking is estimated assuming that 85% of the herd is milking. hrs/milking = .833 + .0273 * (herd size * .85) for a double-4-herringbone parlor with no mechanization. This is used to estimate labor for herd sizes of 75 and 150 cows.

hrs/milking = .917 + .0175 * (herd size * .85) for a double-8-herringbone parlor with detachers and power gates. This is used to estimate labor for herd size of 300 and 500 cows.

[b]Manure handling labor is based on: Bath et al., 1978, Appendix Table V-I, pg. 531.

[c]Feeding labor for corn, corn silage and haylage is based on: Norell et al., 1978, Table 4, pg. 15.

Feeding labor for hay is based on: Bath et al., 1978, Appendix Table V-I, pg. 531.

[d]Bedding and other labor costs with the exception of records and dry cow care are based on: Bath et al., 1978, Appendix Table V-I, pg. 531.

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, and calves. Rundell and Speicher (1967) estimated the average difference in the amount produced vs. that sold as approximately 700 lb/cow. Milk hauling and marketing charges are accounted for in the livestock budgets (see Table 4.15). Milk income is estimated as: 95% * (cwt of milk produced) * (price of milk/cwt).

4.3.2 Cull Cows Income

The income from cull cows is calculated by multiplying the cwt of cull cows sold by the price of cull cows. It is assumed that cull cows average 1350 lb. The cwt of cull cows depends on the number of cows culled and their body weight. Since death losses contribute to the number of cows culled, this must also be taken into account. Assuming a culling rate of 25% (Etgen and Reaves, 1978, pg. 330) and a death loss of 1% (Salisbury et al., 1978, pg. 582) income from cull cow sales is approximated as: (24%) * (13.5 cwt/cow) * price/cwt cull cows * (herd size) = 3.24 * price/cwt cull cows * herd size.

4.3.3 Income From Deacon Calves, Replacements Sold and Cull Heifers

Income from deacon calves, cull heifers, and the sale of replacement heifers depends on the culling rate and calf and heifer mortality. The following logic was used to determine income from these sources.

Given: 100 cows, a 12 month calving interval (CI) and a replacement rate of 25%/year, there are a possible 125 calves born/year. Assuming 1/2 of the cull cows calve before they are removed from the herd, there remain a possible 112 births. Assuming good management, approximately 6% of the calf crop potential is lost due to abortions and stillbirths (Salisbury et al., 1978, pg. 688) resulting in 105 live calves born for every 100 cows. Based on an average calf mortality rate of 12% (Salisbury et al., 1978, pg. 688) there are 92 calves that survive, 1/2 of which are males. Thus, there are 46 possible replacements added/year. Assuming that 3% of these heifers are unable to conceive (Fogwell et al., 1981) and that 2% will die from weaning to freshening (Etgen and Reaves, 1978, pg. 330) there remain approximately 44 heifers added/year. If the interval from birth to freshening is 27 months (D.H.I.A., 1982), then 44 heifers * (24 months/27 months) = 39 heifers available/year to replace heifers in the herd.

With a calving interval of 13 months instead of 12, the number of replacements would be reduced by 8%. This results in approximately 36 heifers available to replace cows in the herd each year. Based on a replacement rate of 25% there are 11 heifers available for sale as dairy replacements for every 100 cows in the herd.

The total number of female youngstock on the farm at any given point in time is 46 possible replacements/year * (27 months to freshen/24 months in 2 years) = 103.

The number of deacon calves for sale assuming a 13 month calving interval is: (105(calves) * .5 (males) * .9 (10% death loss) * .923 (13 mo. calving interval)) $\simeq$ .44. Assuming that deacon calves weigh

100 lb, income from the sale of deacon calves/cow is estimated as:

.44 * 1 cwt * (price/cwt of deacon calves) * (herd size)

Estimating the weight of cull heifers to be 1,000 lb and the number of cull heifers sold/cow as .014 (i.e. 3% of 46), the income from the sale of cull heifers = .014 * (10 cwt) * (price of cull heifers) * (herd size). Assuming there are 36 heifers/100 cows available for replacement and the culling rate is 25%, the income from the sale of replacement heifers/year can be estimated as:

(36-25% cows culled/yr) * (price of replacements) * (herd size)

4.3.4 Estimated Fertilizer Cost Savings and the Value of Manure

The fertilizer value of manure saves cash crop expenses for fertilizer as well as the interest charge on fertilizer purchases for farms growing crops. This savings can be estimated assuming that each cow and replacement produces 164 lb of manure/day containing .82 lb nitrogen (N), .146 lb phosphorus (P) and .54 lb potassium (K). This amounts to 300 lb N, 54 lb P and 200 lb K/cow and replacement/year. Fifty percent of the N is assumed to be available considering handling and storage losses (Midwest Plan Services, 1979, pg. 4,5,82,83). Thus, the amount of savings/cow is estimated as:

(150 lb N * price of N) + (54 lb P * price of P) + (200 lb K * price of K)

It is assumed that farms growing forages only (GF) use approximately 1/2 of the manure produced to fertilize corn silage and 1/2 to fertilize the hay crop. Because the alfalfa hay crop does not need the nitrogen the value of nitrogen is excluded from the estimated value of 1/2 of the manure. Thus, for farms growing forages (GF), the value of manure is estimated as:

(75 lb N * price of N) + (54 lb P * price of P) - (200 lb K * price of K)

Farms PR are assumed to contract with nearby crop farms to dispose manure on their property and net .25 * the value of the manure produced.

4.3.5 Estimated Soybean Meal Savings for Farms Growing Forages

Those farms harvesting forage as haylage (farms growing forages with herd sizes greater than 40 cows) are assumed to save soybean meal costs due to the increased protein content of the haylage vs. hay resulting from reduced field leaf losses (McGuffey and Hillman, 1976). The difference in protein/lb of dry matter is estimated to be 1.5% greater for haylage than hay for this analysis. The amount of soybean meal saved/cow/year is estimated as:

42 lb DMI * 60% DM as forage * 60% forage as hay * 60% hay crop as haylage * (1.5% crude protein difference/lb DM)/(44% crude protein/lb soybean meal) * 305 days/lactation = 94 lb soybean meal/cow/year. This is rounded to 100 lb/cow in the model.

4.3.6 Savings in Dairy Equipment and Crop Machinery

The cropping and dairy enterprises complement each other in that some of the equipment can be shared by both. Table 4.17 specifies the value of this equipment. Since equipment is specified separately for the dairy and cropping programs, the value of this "savings" in investment costs is subtracted from the total investment in equipment and machinery.

The annual savings on capital invested, property taxes and shelter is approximated in the same way annual costs were estimated for machinery in section 4.1.5.

Table 4.17. Savings in Machinery Investments for Farms Growing Crops

Item	Herd Size (No. Cows)			
	40	75[b]	150[c]	300[d]
	$	$	$	$
Investment savings	20,200	45,200	50,200	50,200
Annual savings	2,680	6,057	6,727	6,727

[a]This is based on the cost of a 40 hp tractor at $14,000 and a pickup truck valued at $6,200.

[b]This is based on the cost of a 40 hp tractor at $14,000, a pick-up truck at $6,200 and an 80 hp tractor at $25,000.

[c]This is based on the cost of a 40 hp tractor at $14,000, a pick-up truck at $6,200 and a 90 hp tractor at $90,000.

[d]N.B. These cost estimates can be traced in the dairy equipment costs in Appendix Tables E1 through E8.

4.4 Price Expectations

4.4.1 Setting Prices in the Model

Expected prices of relevant variables are needed to project incomes and expenses to determine profit. Since this is an investment analysis involving strategic planning (i.e. long-range planning), forecast prices (1983 dollars) should include the average long-run outlook of prices considered. Many prices are highly correlated and if one price changes it will likely affect the others.

Prices forecast by the MSU Agricultural Model (Ross et al., 1983; Christenson and Sorenson, 1983) and other sources of information are used to establish the expected economic conditions for the forecast period 1983-1991 contained in Table 4.20. Absolute values as well as price ratios determine the ranking of strategies according to profitability. Two of the most important prices in this regard are the price of milk compared to the price of corn.

4.4.2 Level of Milk Production and Milk/Feed Price Ratios

There has been a recent trend of overproduction of milk in the U.S. as a result of excessive milk prices compared to the cost of feed. Current government policy is to adjust milk prices to bring supply in line with consumption. According to Ross (1983) it will be necessary to close the gap on the milk price/feed cost ratio from 1.75 to below 1.55 to accomplish this. This will result in an average milk price below $12.10/cwt (1983 dollars) for the period 1983-1991 based on price forecasts of the MSU Agricultural Model (Ross, 1983). The milk price/feed cost ratio is based on the average price received by farmers for milk and the cost/cwt of a 16% protein dairy concentrate mix. It is estimated that a ratio of approximately 1.5 will equilibrate the quantity of milk supplied with that demanded.

The relationship of the milk/feed price ratio as it is reported by the U.S.D.A. is related to a milk/corn, hay and soybean meal price ratio (see Table 4.18). This provides a means to approximate the milk/feed price ratio, given the milk price and corn, soybean meal and hay prices specified in the model.

4.4.3 Prices Related to the Price of Milk

Important prices related to the price of milk include cull cows, cull heifers, dairy cows, and deacon calves. Table 4.19 contains

Table 4.18. Milk/Feed Price Ratios Over Time[a]

Year	M/F[b]	M/HSC[c]	MP[d]	AM/F[e]	AM/HSC[f]
1973	1.39	1.89	10189	1.42	1.92
1974	1.24	2.04	10206	1.26	2.08
1975	1.26	2.18	10327	1.30	2.25
1976	1.34	2.26	10627	1.42	2.40
1977	1.38	2.41	11050	1.53	2.66
1978	1.47	2.61	11225	1.64	2.92
1979	1.54	2.71	11366	1.75	3.08
1980	1.51	2.62	11689	1.77	3.06
1981	1.46	2.69	12018	1.76	3.23

[a]Source of prices: USDA, 1982.
[b]Milk:feed price ratio (2 yr avg).
[c]Milk:hay, soybean meal, shelled corn price ratio (2 yr avg): price/lb of hay * .55 + price/lb of soybean meal * .15 + price/lb of shelled corn * .30. These prices are weighted to approximate the feed composition of dairy rations.
[d]MP is the level of milk production/cow/yr (lb).
[e,f]AM/F is the adjusted milk:feed price ratio (adjusted by the time trend of efficiency of production and is estimated by multiplying AM/F by MP/10000.
Regression: AM/F (1973-1981) = .522 + .388 * (AM/HSC), r = .928.

the average yearly prices for these commodities for the U.S. for the years 1965 to 1981. The relationship of these prices to each other and the price of milk is defined by the regression outlined there. Ultimately all of these prices are tied to the price of milk.

The price of dairy cows (as well as the price of heifers) is influenced by the level of milk production as well as the price of milk. The regression estimate of the price of cows is adjusted to reflect this difference by multiplying the difference in milk production from the national herd average of 13,000 lb by $85, for every 1,000 lb difference (Hillman, 1983) (see Table 4.20). Since heifers are not expected to produce as much milk as more mature cows in the herd, the price of heifers reflects this lower milk production level.

4.4.4 Feed Prices and Relationships

A. Price of Corn

The Agricultural and Food Act of 1985 is expected to reduce the loan rate on corn to $2.35/bu which would be approximately 30 to 50 cents lower than the expected market price according to Ferris (1983). This results in an expected corn price of $2.70/bushel.

The price of corn specified is the expected purchase price. Since all corn is assumed to be purchased as high moisture shelled corn, the drying cost is subtracted from the cost entered in the model to estimate the cost to farms purchasing corn. This drying cost is estimated as: $.025/pt to dry * 12 pts = $.30/bu (Schwab, 1983).

B. Price of Hay and Soybean Meal

The price of hay is highly correlated to the price of corn as revealed in Table 4.19. Since the price in this table is a price farmers received for hay, a transportation and handling charge of $18.50/ton is added to the intercept of the regression estimated in Table 4.19 to estimate the hay purchase price in the model (see Koszarek, 1983). The price of soybean meal is highly correlated to the price of hay and is approximated based on the regression estimated from Table 4.19.

C. Purchase Price of Corn Silage

There are different ways of estimating the value of corn silage. One approach is to consider corn silage as a substitute for hay, and using the purchase price of hay, adjust the hay price considering the difference in the dry matter content between hay and silage. This typically results in overestimating the value of corn silage relative to its protein content and underestimating its value as an energy source. Also, in the Midwest corn silage would more than likely be purchased "in the field", and harvested and transported to the buyer during the fall harvest season. The seller (theoretically) would have two choices: 1) sell the corn for silage, or 2) sell it as corn grain. If the option is to sell corn for silage then silage must return more profit than grain. The following procedure outlines how corn harvested as silage vs. grain is valued.

The purchase price of corn silage is based on the value of the corn grain plus the nutrient value of the stalk. The value of the corn grain takes into account the savings in corn drying expense as the crop is harvested as silage. The value of the stalk takes into account the difference in quantities of nutrients harvested which present a cost to the grower. This difference is calculated for phosphorus and potassium and calcium; the nitrogen is assumed lost regardless of the method of harvest.

Based on an expected yield of 100 bu of shelled corn/acre or 15 tons of 35% dry matter corn silage, the additional quantity of

Table 4.19. Time Trends and Relationships of Relevant Commodity Prices[a]

Year	Milk Price	Cows Dairy	Cows Utility	Calves Deacon	Heifers Cull	Corn	Soybean Meal	Hay
	$/cwt	$/head	$/cwt	$/cwt	$/cwt	$/bu	$/cwt	$/ton
1965	4.23	212	14.44	22.00	21.74	1.16	81.46	23.20
1966	4.81	246	17.83	26.00	22.85	1.24	78.83	25.00
1967	5.02	260	17.22	26.30	22.80	1.03	76.93	24.50
1968	5.24	274	17.92	27.60	23.89	1.08	74.12	23.60
1969	5.49	300	20.29	31.60	26.13	1.16	78.45	24.70
1970	5.71	332	21.32	34.50	26.42	1.33	78.51	26.10
1971	5.87	358	21.62	36.40	28.52	1.08	90.20	28.10
1972	6.07	397	25.21	44.70	32.24	1.57	228.99	31.30
1973	7.14	496	32.82	56.60	40.43	2.55	146.35	41.60
1974	8.33	500	25.56	35.20	38.00	3.02	130.86	50.90
1975	8.75	412	21.09	27.20	37.60	2.54	147.78	52.10
1976	9.66	477	25.31	34.10	34.10	2.15	199.80	60.20
1977	9.72	504	25.32	36.90	35.20	2.02	163.56	53.70
1978	10.60	675	36.78	59.10	46.11	2.25	190.06	49.80
1979	12.00	1040	50.10	88.70	61.47	2.52	181.91	59.50
1980	13.00	1190	45.72	76.80	61.22	3.11	218.18	71.00
1981	13.80	1200	41.93	64.80	59.46	2.45	216.00	67.10

[a]Source: U.S.D.A., 1982. Agricultural Statistics.

Regression: Cows (dairy) with milk price = $-260.77 + 98.26 * (milk price), r = .937.

Utility cow price with milk price = $2.63 + 3.07 * (milk price), r = .882.

Deacon calves with utility cow prices = $-5.99 + 1.80 * (utility cow price), r = .984.

Cull heifers prices with utility cow prices = $2.91 + 1.23 * (utility cow prices), r = .972.

Hay price with corn price = $2.44 + 20.80 * (corn price), r = .891.

Soybean meal price with hay price = $23.50 + 2.78 * (hay price), r = .816.

nutrients removed from the soil when corn is harvested as silage is estimated to be:

80.5 lb of potassium
18.6 lb of phosphorus
29.5 lb of calcium

Because different machinery is used to harvest corn as silage, the difference in the cost of thrashing vs. ensiling is important in determining the value of silage for sale. The custom rate to harvest and ensile corn silage is reported as $31.30/acre for horizontal silos and the custom rate to harvest shelled corn was reported as $20.85/acre for 1982 (Schwab, 1983a). The difference in these harvest costs = $10.45/acre. With these considerations in mind, the purchase price of corn silage/acre is estimated as:

> ((price of corn/bu - drying expense) * (potential grain yield/acre) + difference in custom rate to ensile vs. harvest as grain + (price of potassium) * (additional lb of potassium removed by harvesting corn as silage as compared to grain) + (price of phosphorus) * (additional lb of phosphorus removed by harvesting corn as silage) + (price of limestone (38% Ca)) * (additional lb of calcium removed by harvesting corn as silage/.38)).

Dividing the cost/acre of corn silage by the number of tons harvested/acre estimates the cost/ton of corn silage. The formula for estimating this cost is presented in Table 4.20.

Table 4.20. Estimates of Prices to Use in the Model

Item	Acronym	Value	How Estimated	Source
Corn	PSCORN	$2.70/bu	exogenous	Ferris, 1983
Corn silage	PCSLG		((PSCORN-.3)* yield of shelled corn/ acre) + 10.45 + 18.6 * PP + 80.5 * PK + 77.6 * PLMSTN/yield/acre of corn silage)	
Alfalfa hay	PALFHY	/ton	21 + 20 * PSCORN	
Soybean meal	PSYML	/lb	24.72 + 2.74 * PALFHY/2000	
Salt	PSLT	$.07/lb	exogenous	Schwab et al., 1983
Dicalcium phosphate	PDCL	$.19/lb	exogenous	
Limestone	PLMSTN	$.05/lb	exogenous	
Milk	PMLK	$12.00/cwt	exogenous	Ross 1983
	PCWS		(milk production - 13000) * 85 - 260.77 + 98.26 * (PMLK)	
Replacements	PHFRS		(.9 * milk production - 13000) * 85 - 260.77 + 98.26 * PMLK	
Cull cows	PCLLCW		2.63 + 3.07 * PMLK	
Cull heifers	PCLLHFR		2.91 + 1.23 * PCLLCW	
Deacon calves	PDCNCLVS		-5.99 + 3.07 * PMLK	
Land	PLND	$1100/acre	exogenous	Robinson and Espel 1981
Nitrogen	PN	$.16/lb	exogenous	Schwab et al., 1983
Phosphorus	PP	$.20/lb	exogenous	
Potassium	PK	$.12/lb	exogenous	
Interest rate	INTRT	.05	exogenous	Ross et al., 1983
Labor	PLBR	$6.00/hr	exogenous	Schwab et al., 1983
Fuel	PFL	$1.10/gal	exogenous	"

CHAPTER 5

RESULTS AND DISCUSSION

This chapter contains examples of the effects of various price scenarios, levels of production and soil management groups on the profitability of the strategies of growing forages and grain (GFG), growing forages only (GF) and purchasing all feeds (PR). Levels of investments in each strategy of $.5, 1.0, 1.5, 2.0 and 2.5 million are projected to examine how profitability, rate of return on investment, number of cows in the herd and number of laborers changes by level of investment, according to strategy.

The first analysis considers the returns to each strategy for each level of investment, based on an expected milk/feed price ratio of 1.50 and a price of corn of $2.70/bu. This results in a price of $12.00/cwt for milk. These prices reflect the average of those anticipated to be encountered by dairymen over the next 8-10 years (Christenson and Sorenson, 1983; Ross, Black and Sorenson, 1983). Returns to each strategy are compared across levels of milk production of: 13, 15, 17 and 19 thousand lb milk. The ranking of strategies on the basis of profitability depends on absolute prices as well as price ratios. This is especially true in regard to milk and feed prices.

The second analysis examines the consequences of changing the milk/feed ratio to either 1.45 or 1.55. The price of corn is maintained at $2.70/bu and the price of milk is set to either $11.40 or $12.60/cwt respectively.

The third analysis examines the consequences of different corn prices of: $2.55, 2.70, 2.85, 3.10 and 3.30/bu on the profitability of each strategy. The milk price is maintained at $12.00/cwt. This results in milk/feed price ratios of: 1.55, 1.50, 1.46, 1.39 and 1.35. The effect of these prices across levels of production of 13,000, 15,000, 17,000 and 19,000 lb are examined.

Section 5.4 examines the effect of changing the price of land on the profitability of each strategy, assuming a level of milk production of 15,000 lb, soil management group of 3, a price of milk at $12.00/cwt and a corn price at $2.70/bu.

The effect of soil management group on profitability of the strategies is discussed in section 5.5, considering soil management groups 2.5, 3 or 4, and respective land prices of $1300, 1100 and $900/acre.

5.1 The Effect of Level of Milk Production on Profitability Across Strategies

Tables 5.1 through 5.4 and Figures 5.1 and 5.2 illustrate the impact that levels of milk production ranging from 13,000 to 19,000 lb milk have upon profitability.

At a level of production of 13,000 lb milk, the strategies rank in order of profitability as: GF>GFG>PR, across all levels of investment. PR is clearly not desirable when the level of production is ≥13,000 lb of milk. Figure 5.1 reveals that the breakeven point ($0 profit point) is not reached until levels of investment exceed $1,000,000 for the strategies GFG or GF, and not until a level of investment >$1,500,000 for the strategy of PR. This illustrates that there is a critical size of investment in dairying for any of the strategies to be profitable and this changes according to strategy.

At a level of production of 15,000 lb, the strategies PR and GF are the two most profitable. However, there are minimal differences among all three strategies at this level of production.

As the level of milk production increases, PR emerges as a more profitable alternative; at a level of production of either 17,000 or 19,000 lb, it is the most profitable strategy across all levels of investment.

Table 5.1 reveals that the labor requirement is greatest for the strategy PR. For example, it requires 175% more labor for PR than for GFG considering a level of investment of $1,000,000.

The number of cows on farms PR is substantially greater than for those GFG or GF. For example, Table 5.2 shows that the number of cows on farms PR is over 3.1 times the number on farms GFG (at a level of investment of $500,000). This tapers off to approximately 2.6 to 2.7 at levels of investment ≥$1,500,000.

The strategy of GF ranks either first or second across all levels of investment, considering all levels of production.

Notice that the number of cows for a given level of investment and strategy changes as the level of production changes. The model assumes that the price of dairy cows is dependent upon the level of production. The investment in cows is determined by the price of dairy cows, and thus for a given level of investment, the number of cows changes as the production level changes.

Figure 5.3 reveals that most economies of size (as indicated by the slope of the plot of rate of return on investment (RROI) vs. level of investment) are realized between a level of investment of $500,000 and $1,000,000 for all strategies. The strategies GFG and GF continue to experience substantial economies of size at all levels of investment examined. An investment of $1,000,000 represents herd sizes of ~104, 132 and 290 cows for the strategies GFG, GF and PR, respectively.

TABLE 5.1 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 13000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression:	
GFG						profit by $invested	
$PROFIT	-24784	-5675	13433	32542	51651	a=	-43893
RROI(%)	-0.96	3.43	4.90	5.63	6.07	b=	0.038
COWS(#)	40.25	107.86	175.48	243.09	310.70	R2=	0.999
LBR(#)	1.29	2.36	3.43	4.50	5.57		
GF							
						a=	-42812
$PROFIT	-21967	-1122	19724	40569	61414	b=	0.042
RROI(%)	-0.39	3.89	5.31	6.03	6.46	R2=	0.996
COWS(#)	49.21	131.87	214.53	297.20	379.86		
LBR(#)	1.36	2.62	3.88	5.13	6.39		
PR							
						a=	-25817
$PROFIT	-18695	-11573	-4450	2672	9794	b=	0.014
RROI(%)	0.26	2.84	3.70	4.13	4.39	R2=	0.804
COWS(#)	129.51	303.53	477.54	651.56	825.57		
LBR(#)	2.05	4.14	6.22	8.31	10.40		

Returns to levels of investment beyond $ 2416296 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2008516 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1540477 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	918.35
Price of land ($/acre) =	1100	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	807.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.2 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)=	15000		
Corn Price ($/bu) =	2.70	Milk/feed ratio=	1.50
Milk Price ($/cwt) =	12.00		

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression: profit by $invested	
GFG							
$PROFIT	-21229	3955	29140	54325	79509	a=	-46414
RROI(%)	-0.25	4.40	5.94	6.72	7.18	b=	0.050
COWS(#)	38.64	103.66	168.67	233.69	298.71	R2=	0.999
LBR(#)	1.26	2.29	3.32	4.35	5.38		
GF							
						a=	-45712
$PROFIT	-17864	9984	37833	65681	93530	b=	0.056
RROI(%)	0.43	5.00	6.52	7.28	7.74	R2=	0.997
COWS(#)	48.74	130.75	212.75	294.76	376.77		
LBR(#)	1.34	2.58	3.82	5.05	6.29		
PR							
						a=	-29931
$PROFIT	-7048	15835	38718	61601	84484	b=	0.046
RROI(%)	2.59	5.58	6.58	7.08	7.38	R2=	0.970
COWS(#)	122.01	286.21	450.40	614.60	778.79		
LBR(#)	1.96	3.93	5.90	7.87	9.84		

Returns to levels of investment beyond $ 2505532 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2023625 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1627287 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	1100	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.3 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 17000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression: profit by $invested	
GFG							
$PROFIT	-17861	13090	44042	74993	105944	a=	-48813
RROI(%)	0.43	5.31	6.94	7.75	8.24	b=	0.062
COWS(#)	37.34	100.27	163.20	226.12	289.05	R2=	1.000
LBR(#)	1.24	2.23	3.23	4.22	5.22		
GF							
						a=	-48650
$PROFIT	-13718	21213	56144	91075	126007	b=	0.070
RROI(%)	1.26	6.12	7.74	8.55	9.04	R2=	0.998
COWS(#)	48.67	130.69	212.70	294.72	376.73		
LBR(#)	1.33	2.55	3.77	4.99	6.21		
PR							
						a=	-33772
$PROFIT	3678	41127	78577	116027	153476	b=	0.075
RROI(%)	4.74	8.11	9.24	9.80	10.14	R2=	0.987
COWS(#)	115.51	271.19	426.88	582.57	738.25		
LBR(#)	1.88	3.75	5.62	7.48	9.35		

Returns to levels of investment beyond $ 2582724 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2024019 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1711374 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1258.35
Price of land ($/acre) =	1100	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	1113.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.4 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 19000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY: GFG						regression: profit by $invested	
$PROFIT	-15068	20726	56519	92312	128106	a=	-50861
RROI(%)	0.99	6.07	7.77	8.62	9.12	b=	0.072
COWS(#)	35.85	96.35	156.86	217.36	277.87	R2=	1.000
LBR(#)	1.22	2.18	3.13	4.09	5.05		
GF						a=	-51293
$PROFIT	-10074	31145	72364	113583	154802	b=	0.082
RROI(%)	1.99	7.11	8.82	9.68	10.19	R2=	0.998
COWS(#)	48.04	129.13	210.21	291.30	372.39		
LBR(#)	1.32	2.51	3.71	4.90	6.10		
PR						a=	-36849
$PROFIT	12110	61070	110029	158988	207948	b=	0.098
RROI(%)	6.42	10.11	11.34	11.95	12.32	R2=	0.991
COWS(#)	109.45	257.20	404.95	552.70	700.45		
LBR(#)	1.81	3.58	5.35	7.13	8.90		

Returns to levels of investment beyond $ 2678708 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2045586 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1798472 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1428.35
Price of land ($/acre) =	1100	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	1266.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

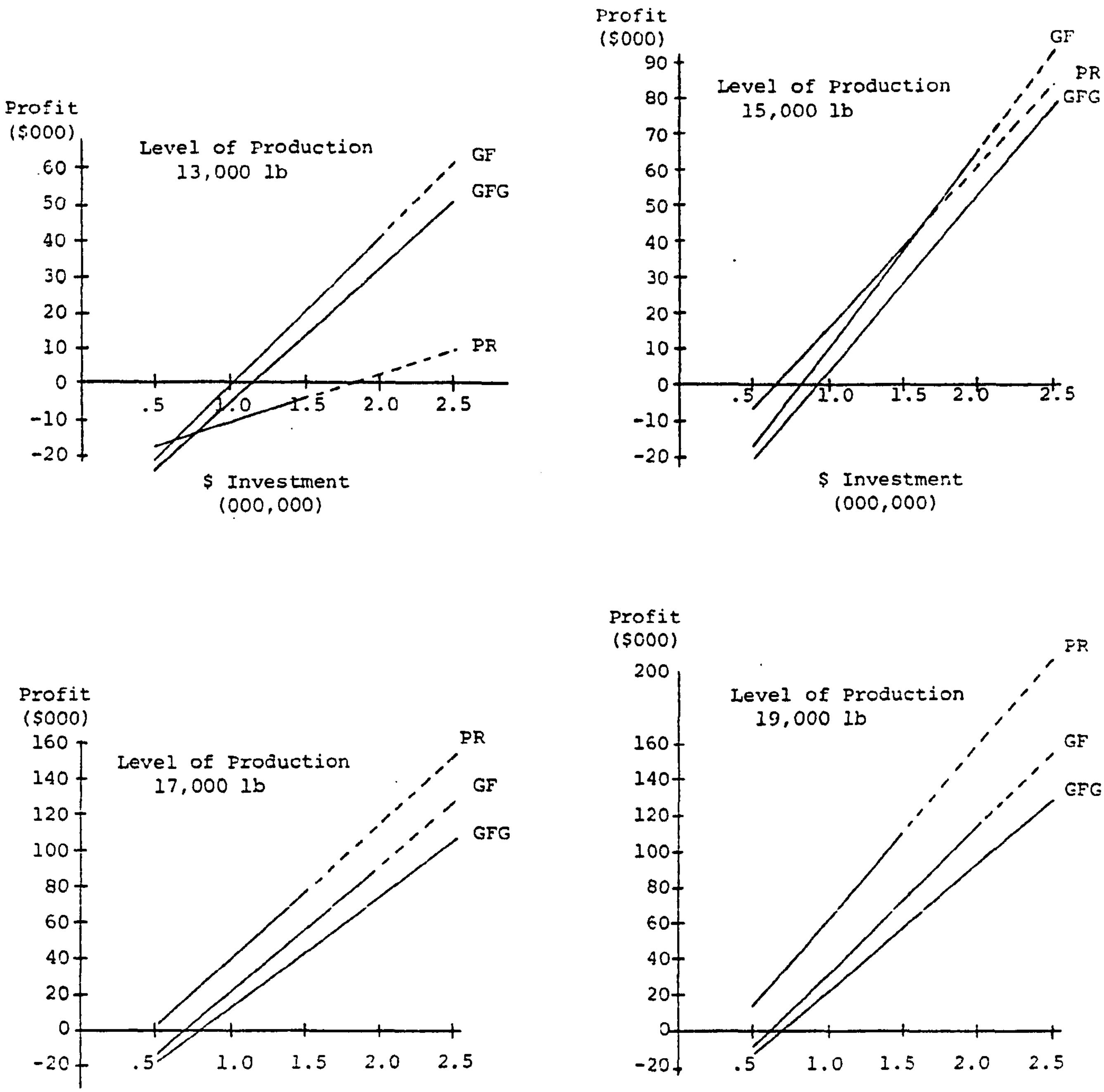

Figure 5.1. Profitability by level of investment according to strategy and level of production.

Milk price ($/cwt)	=	12.00
Corn price ($/bu)	=	2.70
Milk/feed price ratio	=	1.5

Dashed line indicates extrapolated values.

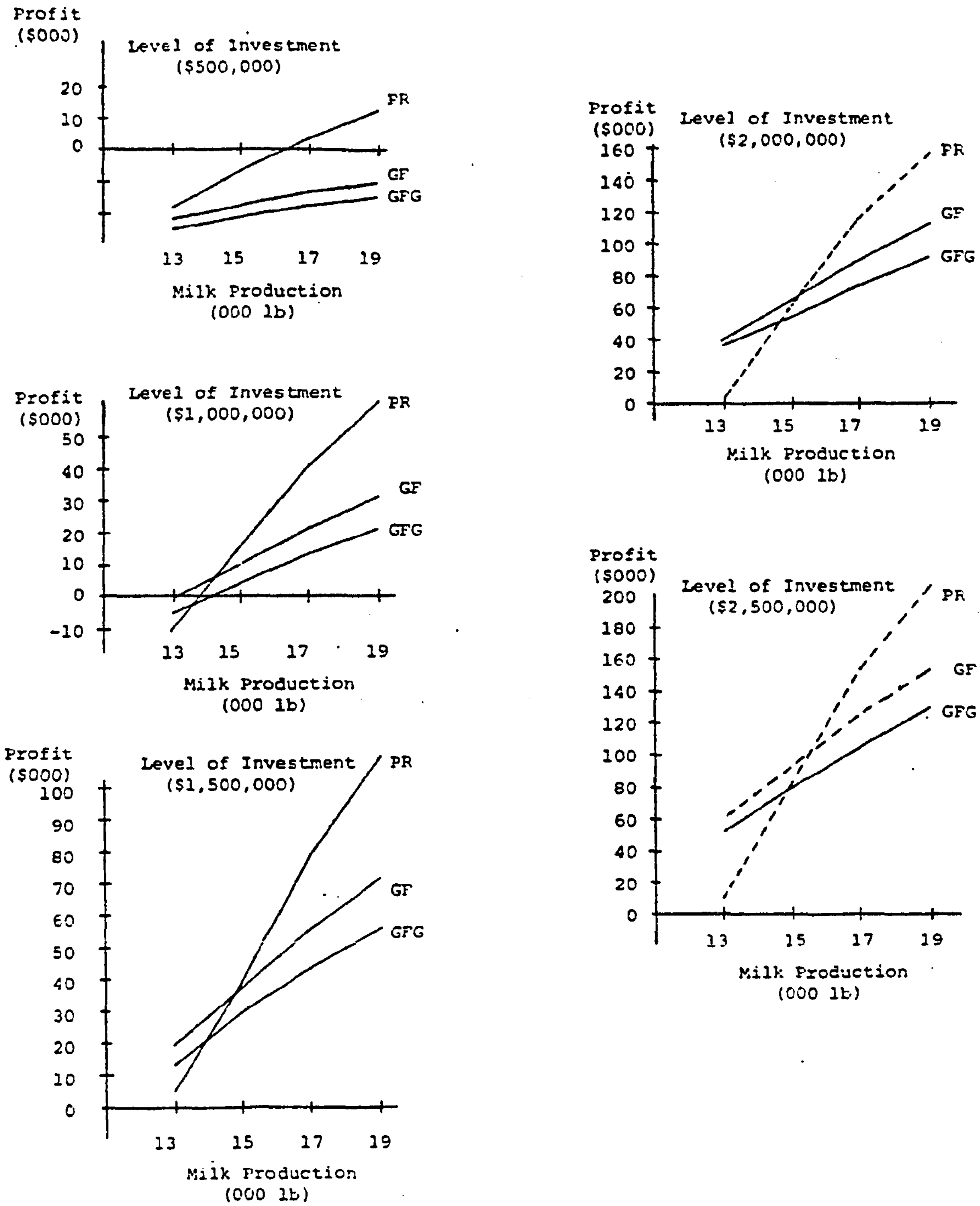

Figure 5.2. Profitability by level of production according to strategy and level of investment.

Milk price ($/cwt) = 12.00
Corn price ($/bu) = 2.70
Milk/feed price ratio = 1.5

Dashed line indicates extrapolated values.

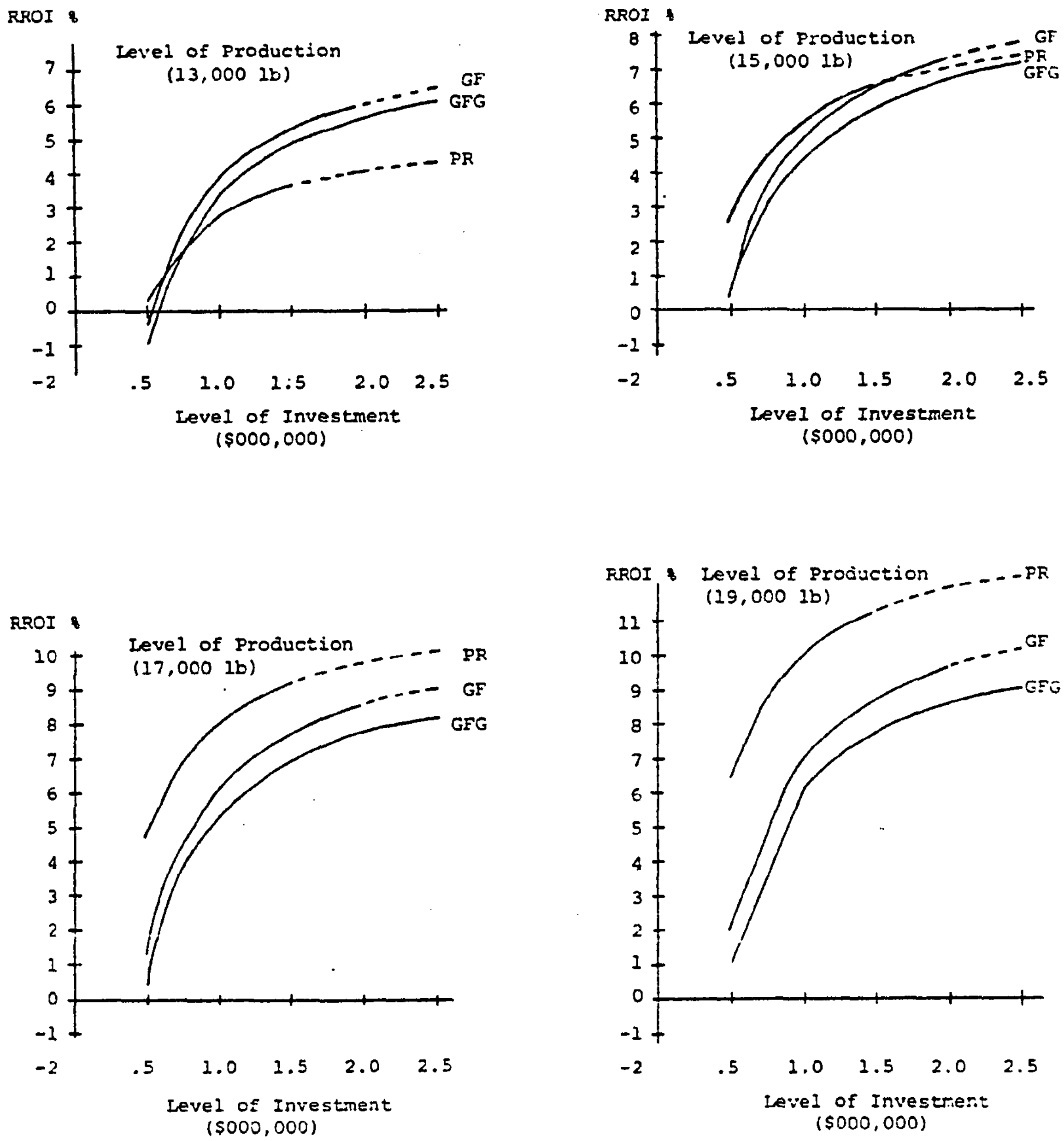

Figure 5.3. Rate of return on investment (RROI) by level of production according to level of investment and strategy.

Milk price ($/cwt) = 12.00
Corn price ($/bu) - 2.70
Milk/feed price ration = 1.5

Dashed line indicates extrapolated values.

5.2 The Effect of Changing the Milk/Feed Price Ratio on Profitability by Changing the Price of Milk

The ranking of strategies depends upon prices relative to each other and the absolute value of these prices. The milk/feed price ratio can be changed by changing either the price in the numerator or the denominator or both.

Table 5.5 analyzes the impact of changing the milk/feed price ratio to 1.55 by changing the milk price to $12.60/cwt keeping the corn price at $2.70/bu.

Increasing the milk price has the impact of making all strategies more profitable. This impact is greatest for farms PR as the number of cows is greatest for a given number of dollars invested. The strategy of PR becomes a profitable alternative even at levels of production of 13,000 lb milk. The strategy of GF is the most profitable at a level of production of 13,000 lb milk (see Table 5.5). At levels of production ≥15,000 lb, the strategy of PR is the most profitable, followed by GF and lastly GFG (see Figure 5.4).

Table 5.6 analyzes the impact of changing the milk/feed price ratio to 1.45 by changing the milk price to $11.40/cwt, keeping the corn price at $2.70/bu. This has the impact of making the strategy of PR the least favorable option until levels of production ≥17,000 (see Table 5.6). The strategy of GF ranks as the most profitable at levels of production of 13,000 and 15,000 lb milk. Regardless of whether milk price is $11.40, $12.00 or $12.60, the strategy of PR is the most profitable for levels of production of 19,000 lb. The strategy of GF ranks either first or second across all levels of production at milk prices $11.40, 12.00 or 12.60/cwt. When the price of milk is $11.40/cwt there is little difference in profitability between the strategies of GF or GFG.

Figure 5.6 demonstrates the sensitivity of all three strategies to the price of milk for a given level of production and level of investment. The strategy of PR is, of course, the most sensitive. The strategies of GF and GFG diverge as the price of milk increases (due to the greater number of cows) for a given level of investment for farms GF. Although profitability of the strategy of PR is the most sensitive to the price of milk, it is always the most profitable at level of production at 19000 lb, even at a milk price of $11.40/cwt.

5.3 The Effect of Changing the Milk/Feed Ratio on Profitability by Changing the Price of Corn

Figure 5.7 and Tables 5.7 through 5.10 illustrate that the strategy of PR is most sensitive to changing the price of corn. At a level of production of 13,000 lb (given a level of investment of $1,000,000), PR becomes unprofitable once the corn price >$2.55/bu. When the price of corn ≥$3.10/bu, the strategy GFG is the most profitable.

At a level of production of 15,000 lb, PR is a profitable strategy until the price of corn >$2.85/bu; at 19,000 lb, PR is still a profitable alternative with a corn price at $3.30/bu.

The strategy GF ranks as either 1st or 2nd across all levels of production and all levels of investment.

Table 5.5. Profitability by Level of Investment According to Level of Production and Strategy

Corn Price ($/bu)	=	2.70
Milk Price ($/cwt)	=	12.60
Milk/feed ratio	=	1.55

Level of milk production (lb) and strategy		Level of Investment ($ million) .5	1	1.5	2	2.5
		$	$	$	$	$
13,000	GFG	-21,300	3,600	28,500	53,500	78,400
	GF	-17,800	10,200	38,100	66,100	94,000
	PR	- 7,500	14,600	36,800	58,900	81,000
15,000	GFG	-17,500	14,000	45,500	77,000	108,400
	GF	-13,200	22,600	58,300	94,100	129,800
	PR	4,600	43,200	81,900	120,500	159,100
17,000	GFG	-13,900	23,800	61,600	99,300	137,000
	GF	- 8,500	35,200	78,900	122,600	166,300
	PR	15,900	69,700	123,600	177,400	231,300
19,000	GFG	-10,900	32,100	75,100	118,000	161,000
	GF	- 4,500	46,300	97,000	147,800	198,500
	PR	24,700	90,700	156,800	222,800	288,800

Return to levels of investment beyond ~$2,000,000 are extrapolated for the strategy GF.
Returns to levels of investment beyond ~$1,500,000 are extrapolated for the strategy PR.

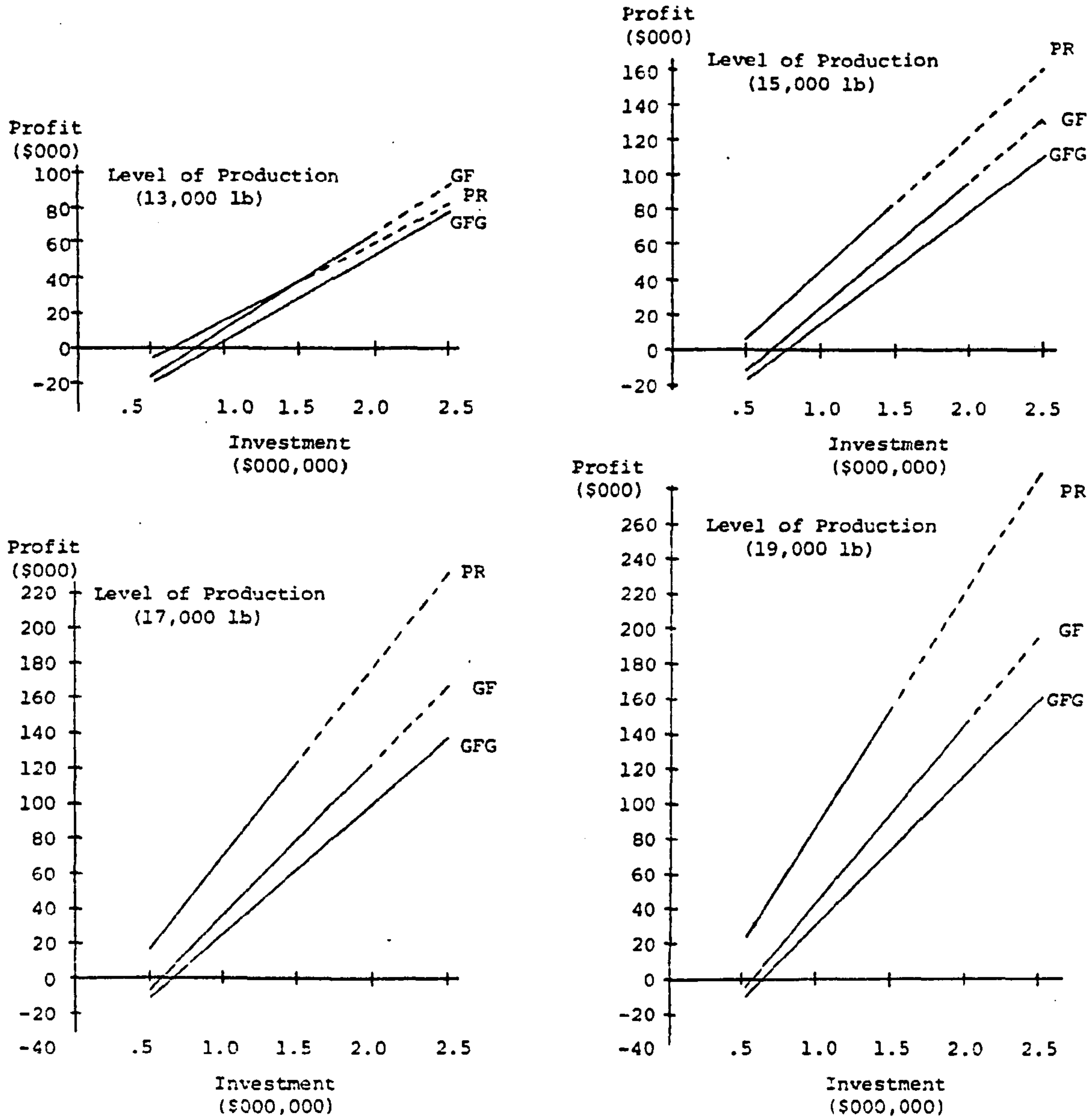

Figure 5.4. Profitability by level of investment according to strategy and level of production (increasing the milk price).

Milk price ($/cwt) = 12.60
Corn price ($/bu) = 2.70
Milk/feed price ratio = 1.55

Dashed line indicates extrapolated values.

Table 5.6. Profitability by Level of Investment Accroding to Level of Production and Strategy

Corn Price ($/bu)	=	2.70
Milk Price ($/cwt)	=	11.40
Milk/feed ratio	=	1.45

Level of Milk Production(lb) and Strategy		Level of Investment ($ million) .5	1	1.5	2	2.5
		$	$	$	$	$
13,000	GFG	-28,300	-15,100	- 1,800	11,400	24,600
	GF	-26,300	-12,600	1,100	14,700	28,400
	PR	-30,300	-38,800	-47,300	-55,800	- 64,300
15,000	GFG	-25,000	- 6,200	12,600	31,500	50,300
	GF	-22,600	-28,000	17,100	36,900	56,800
	PR	-19,200	-12,600	- 6,100	500	7,100
17,000	GFG	-21,900	2,200	26,300	50,500	74,600
	GF	-19,000	7,000	33,100	59,200	85,200
	PR	- 8,900	11,500	32,000	52,400	72,900
19,000	GFG	-19,400	9,200	37,800	66,400	94,900
	GF	-15,800	15,800	47,300	78,900	110,500
	PR	- 900	30,400	61,700	93,100	124,000

Returns to levels of investment beyond ~$2,000,000 are extrapolated for the strategy GF.
Returns to levels of investment beyond ~$1,500,000 are extrapolated for the strategy PR.

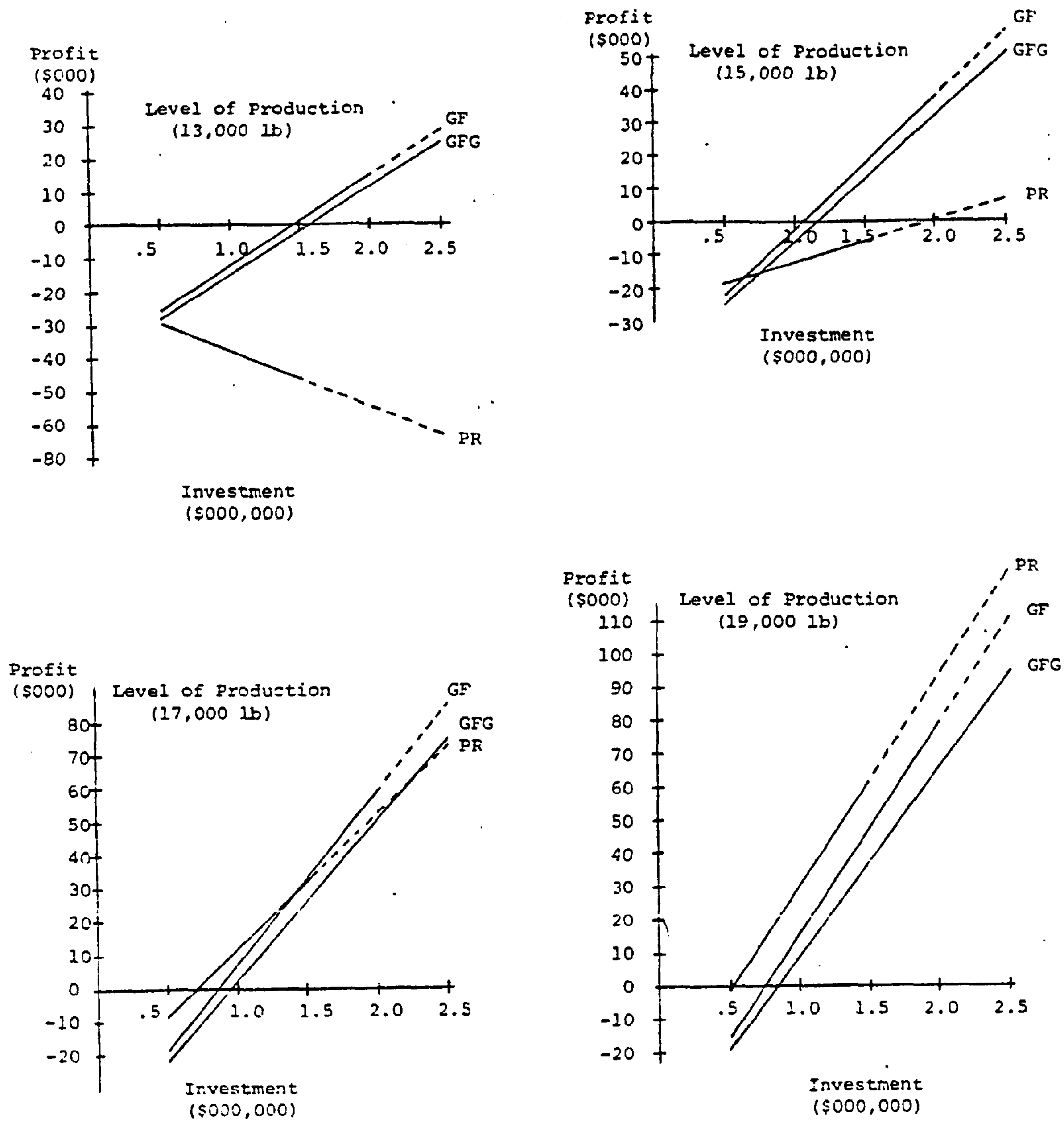

Figure 5.5. Profitability by level of investment according to strategy and level of production (decreasing the milk price).

Milk price ($/cwt) = 11.40
Corn price ($/bu) = 2.70
Milk/feed price ratio = 1.45

Dashed line indicates extrapolated values.

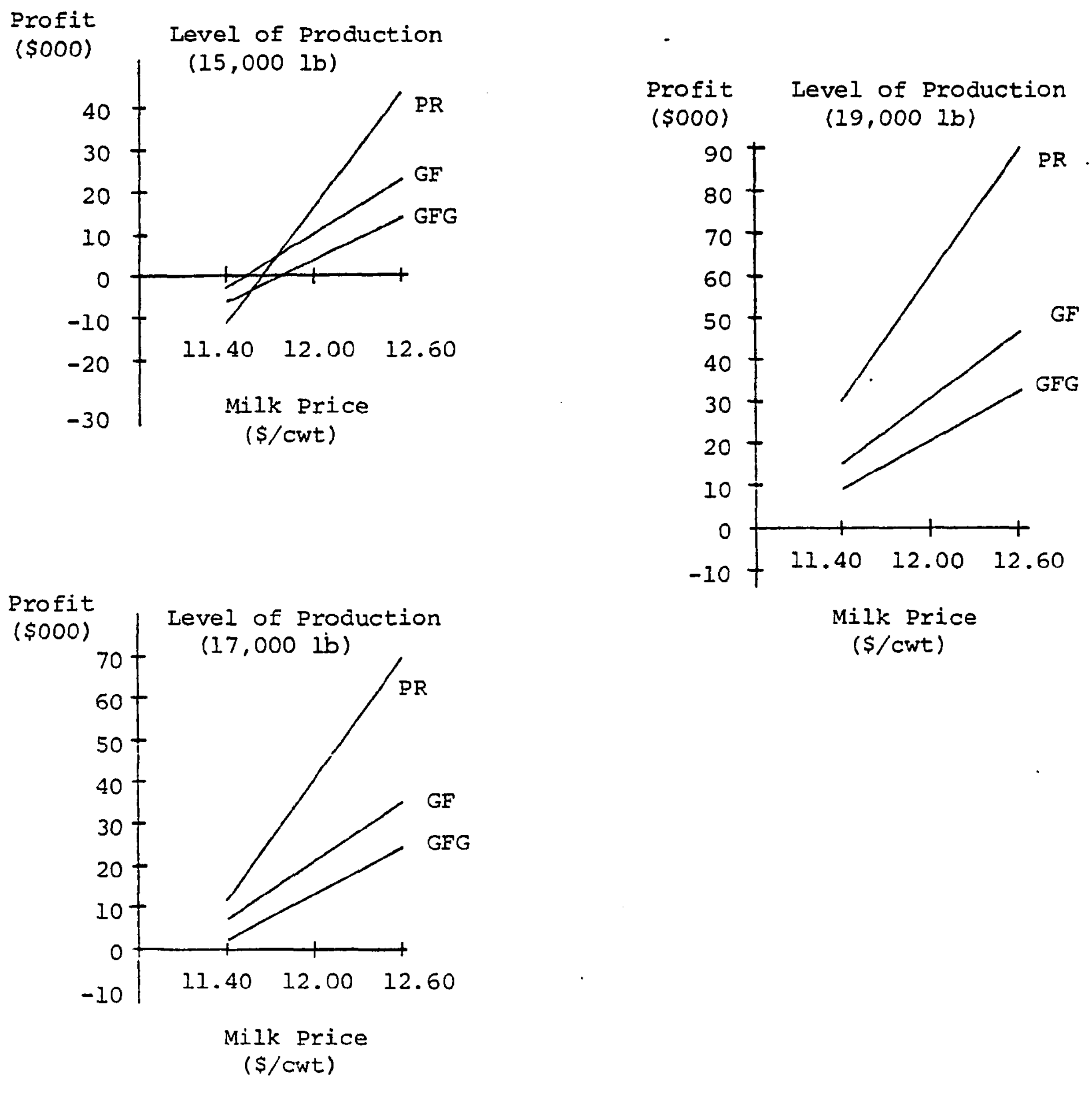

Figure 5.6. The impact of changing the price of milk on profitability.

Price of corn ($/bu) = 2.70
Level of investment = $1,500,000

Profitability changes slightly for the strategy of GFG as the price of corn changes. This is a result of the price of soybean meal being correlated to the price of corn in the model.

Figure 5.8 reveals that the impact on profitability of changing the milk/feed price ratio by changing the numerator (i.e. the price of milk) is different than the impact of changing the denominator (i.e. the price of corn). Changing the price of milk has the most dramatic effect on profitability across all strategies. Changing the milk/feed price ratio by changing the price of corn has little effect upon the strategy of GFG and a moderate affect on the strategy of GF.

5.4 The Impact of Changing the Price of Land on Profitability

Figure 5.9 and Tables 5.11 through 5.15 illustrate the impact of changing the price of land without changing the soil management group (SMG), considering: SMG = 3, level of production at 15,000 lb, price of milk at $12.00/cwt and corn at $2.70/bu. At a land price of $500/acre, both GFG and GF are equally profitable and returns to these strategies are almost double those received under the strategy of PR. At a land price of $700/acre the strategy of GF is slightly more profitable than that of GFG and again, both yield substantially greater returns than the strategy of PR. At a land price of $900/acre the strategy of GF is the most profitable. The strategy of PR yields greater returns than GFG until an investment level of $1,500,000. At this level GFG is a more profitable strategy than PR. At a land price of $1100/acre the strategy of PR yields the greatest returns until investment levels approach $1,500,000. Beyond this

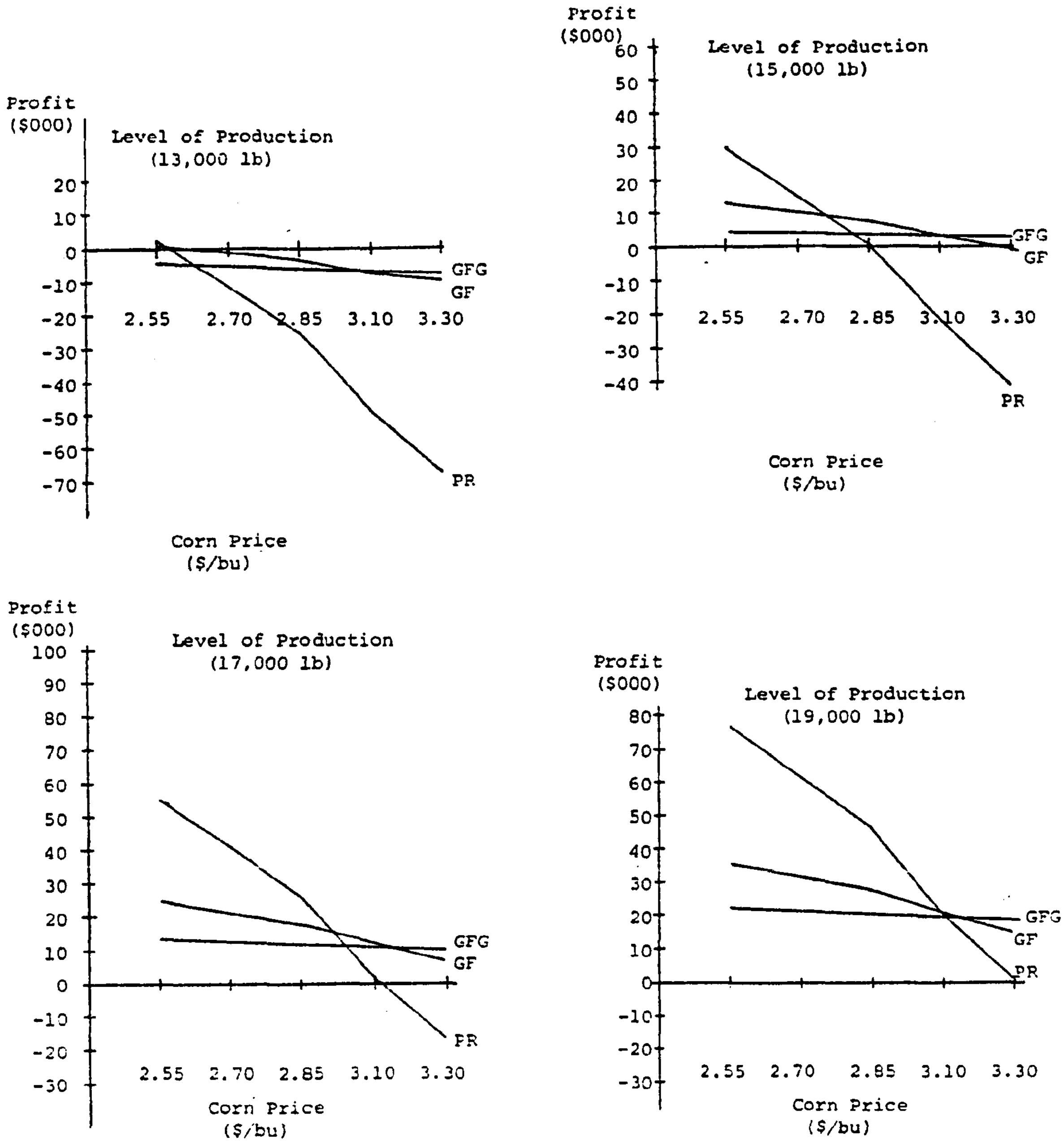

Figure 5.7. The impact of changing the price of corn on profitability.

Price of milk ($/cwt) = 12.00
Level of investment = $1,000,000

Table 5.7. Changes in Profitability by Level of Investment According to Strategy Considering Different Prices of Corn (Level of Production = 13,000 lb)

GFG					
No. cows	40	108	176	243	311
No. laborers	1.3	2.4	3.4	4.5	5.6
Corn					
2.55	-24,700	- 5,500	13,800	33,000	52,300
2.70	-24,800	- 5,700	13,400	32,500	51,600
2.85	-24,900	- 5,900	13,100	32,200	51,200
3.10	-25,000	- 6,200	12,600	31,400	50,200
3.30	-25,100	- 6,500	12,200	30,800	49,500
GF					
No. cows	49	132	215	297	380
No. laborers	1.4	2.6	3.9	5.1	6.4
Corn					
2.55	-21,200	900	23,000	45,100	67,300
2.70	-22,000	- 1,100	19,700	40,600	61,400
2.85	-22,700	- 3,100	16,500	36,100	55,800
3.10	-24,000	- 6,400	11,100	28,600	46,200
3.30	-25,000	- 9,100	6,800	22,600	38,500
PR					
No. cows	130	304	478	652	826
No. laborers	2.1	4.1	6.2	8.3	10.4
Corn					
2.55	-12,700	2,400	17,600	32,700	47,900
2.70	-18,700	-11,600	- 4,500	2,700	9,800
2.85	-24,700	-25,500	-26,400	-27,300	-28,200
3.10	-34,600	-48,800	-63,100	-77,300	-91,600
3.30	-42,500	-67,500	-92,400	-117,300	-142,300

Returns to levels of investment beyond $2,415,596 are extrapolated for the strategy GFG.
Returns to levels of investment beyond $2,007,816 are extrapolated for the strategy GF.
Returns to levels of investment beyond $1,540,477 are extrapolated for the strategy PR.

Table 5.8. Changes in Profitability by Level of Investment According to Strategy Considering Different Prices of Corn (Level of Production = 15,000 lb)

	Level of Investment ($ million)				
	.5	1.0	1.5	2.0	2.5
GFG					
No. cows	39	104	169	234	299
No. laborers	1.3	2.3	3.3	4.3	5.4
Corn					
2.55	-21,100	4,400	29,800	55,300	80,700
2.70	-21,200	4,000	29,100	54,300	79,500
2.85	-21,400	3,600	28,500	53,500	78,500
3.10	-21,600	2,900	27,500	52,000	76,500
3.30	-21,800	2,400	26,600	50,800	75,000
GF					
No. cows	49	131	213	295	377
No. laborers	1.3	2.6	3.8	5.1	6.3
Corn					
2.55	-16,900	12,700	42,300	71,900	101,400
2.70	-17,900	10,000	37,800	65,700	93,500
2.85	-18,900	7,300	33,500	59,700	85,900
3.10	-20,600	2,800	26,200	49,500	72,900
3.30	-21,900	- 800	20,300	41,400	62,500
PR					
No. cows	122	286	450	615	779
No. laborers	2.0	3.9	5.9	7.9	9.8
Corn					
2.55	- 900	30,200	61,300	92,500	123,600
2.70	- 7,000	15,800	38,700	61,600	84,500
2.85	-13,200	1,500	16,200	30,800	45,500
3.10	-23,300	-22,400	-21,500	-20,500	-19,600
3.30	-31,500	-41,500	-51,600	-61,600	-71,600

Returns to levels of investment beyond $2,504,832 are extrapolated for the strategy GFG.
Returns to levels of investment beyond $2,022,925 are extrapolated for the strategy GF.
Returns to levels of investment beyond $1,627,287 are extrapolated for the strategy PR.

Table 5.9. Changes in Profitability by Level of Investment According to Strategy Considering Different Prices of Corn (Level of Production = 17,000 lb)

	Level of Investment ($ million)				
	.5	1.0	1.5	2.0	2.5
GFG					
No. cows	37	100	163	226	289
No. laborers	1.2	2.2	3.2	4.2	5.2
Corn					
2.55	-17,700	13,700	45,100	76,400	107,800
2.70	-17,900	13,100	44,000	75,000	105,900
2.85	-18,100	12,500	43,100	73,700	104,300
3.10	-18,500	11,500	41,500	71,400	101,400
3.30	-18,800	10,700	40,200	69,600	99,100
GF					
No. cows	49	131	213	295	377
No. laborers	1.5	6.5	8.1	9.0	9.4
Corn					
2.55	-12,400	24,700	61,800	99,000	136,100
2.70	-13,700	21,200	56,100	91,100	126,000
2.85	-15,000	17,800	50,600	83,400	116,200
3.10	-17,200	12,000	41,200	70,300	99,500
3.30	-18,900	7,400	33,700	60,000	86,200
PR					
No. cows	116	271	427	583	738
No. laborers	1.9	3.8	5.6	7.5	9.4
Corn					
2.55	9,900	55,800	101,700	147,500	193,400
2.70	3,700	41,100	78,600	116,000	154,500
2.85	- 2,500	26,500	55,600	84,600	113,700
3.10	-12,900	2,100	17,100	32,200	47,200
3.30	-21,300	-17,400	-13,600	- 9,800	- 6,000

Returns to levels of investment beyond $2,582,024 are extrapolated for the strategy GFG.
Returns to levels of investment beyond $2,023,319 are extrapolated for the strategy GF.
Returns to levels of investment beyond $1,711,374 are extrapolated for the strategy PR.

Table 5.10. Changes in Profitability by Level of Investment According to Strategy Considering Different Prices of Corn (Level of Production = 19,000 lb)

	Level of Investment ($ million)				
	.5	1.0	1.5	2.0	2.5
GFG					
No. cows	36	96	157	217	278
No. laborers	1.2	2.2	3.1	4.1	5.1
Corn					
2.55	-14,800	21,500	57,800	94,100	130,400
2.70	-15,100	20,700	56,500	92,300	128,100
2.85	-15,400	20,000	55,300	90,600	126,000
3.10	-15,900	18,700	53,200	87,700	122,200
3.30	-16,200	17,600	51,500	85,400	119,200
GF					
No. cows	48	129	210	291	373
No. laborers	1.3	2.5	3.7	4.9	6.1
Corn					
2.55	- 8,500	35,300	79,200	123,000	166,900
2.70	-10,100	31,100	72,400	113,600	154,800
2.85	-11,600	27,000	65,700	104,300	143,000
3.10	-14,200	20,100	54,400	88,800	123,100
3.30	-16,200	14,600	45,500	76,300	107,200
PR					
No. cows	109	257	405	553	701
No. laborers	1.8	3.6	5.4	7.1	8.9
Corn					
2.55	18,500	76,100	133,700	191,300	248,900
2.70	12,100	61,100	110,000	159,000	207,900
2.85	5,700	46,100	86,400	126,800	167,200
3.10	- 4,900	21,100	47,100	73,048	99,032
3.30	-13,400	1,100	15,600	30,000	44,500

Returns to levels of investment beyond $2,678,008 are extrapolated for the strategy GFG.
Returns to levels of investment beyond $2,044,886 are extrapolated for the strategy GF.
Returns to levels of investment beyond $1,798,472 are extrapolated for the strategy PR.

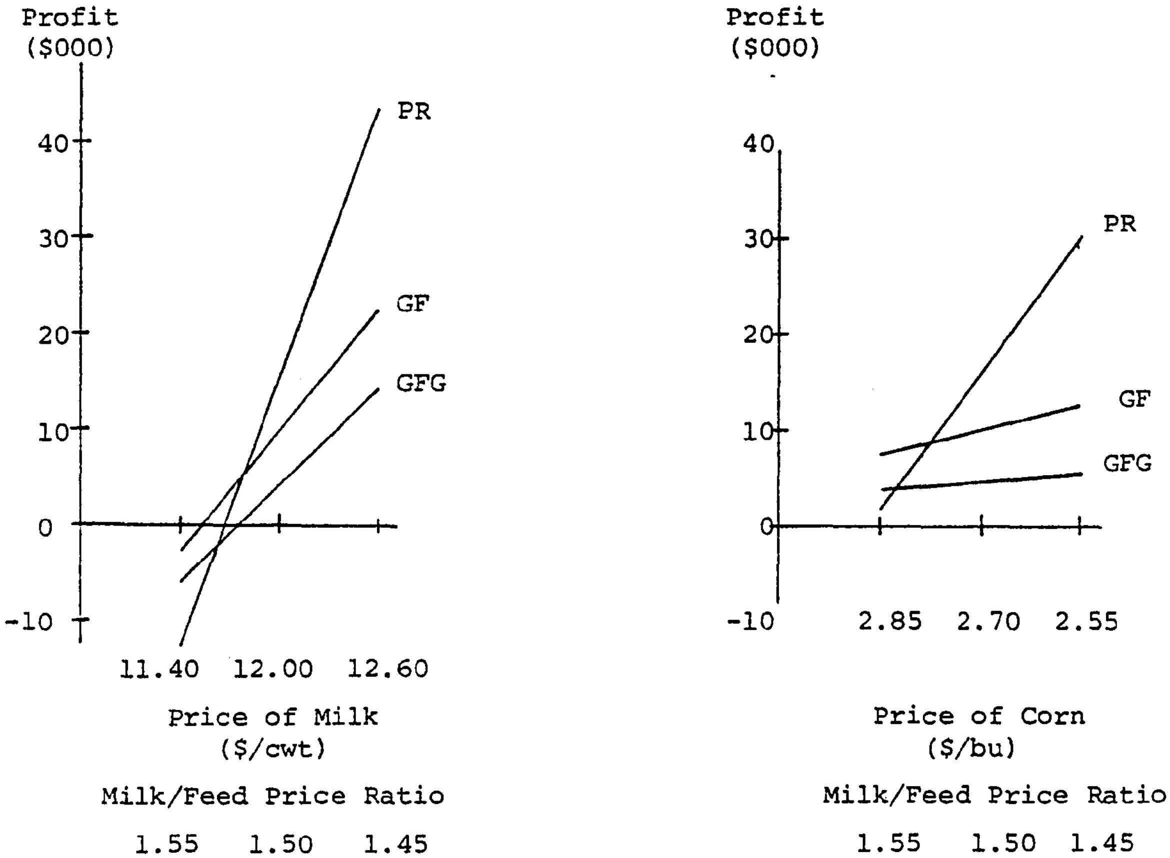

Figure 5.8. The impact of changing the milk/feed price ratio by changing the price of milk vs. changing the price of corn.

Level of investment = $1,000,000
Level of production = 15,000 lb

level of investment, GF is the most profitable strategy followed by the strategy of PR. At a land price of $1300/acre, the strategy of PR is the most profitable across all levels of investment.

Notice that profitability for the strategy PR changes slightly as the land price changes. This is because the model assumes that land is purchased for facilities for the dairy at the same price/acre as is charged for land for crops.

5.5 The Impact of Changing the Soil Management Group and Price of Land on Productivity

Tables 5.16 through 5.18 indicates that there is little change in profit when the soil management group (SMG) is changed to either 2.5 or 4 if the price of land is adjusted to reflect the difference in soil productivity. Assuming a price of $1100/acre for land in SMG 3, the price of land in SMG 2.5 is approximated as: ($1100/acre)/.87 = 1260, or ~1300/acre. The price of land in SMG 4 is approximated as: ($1100/acre)/1.20 ≑ $900/acre (see thesis section 4.1.3A). The fact that there is little difference in profitability across SMG of 2.5, 3 or 4 when the price of land is adjusted, indicates that the method of assessing land values defined in the Tax Assessor's Manual (1972) adequately estimates the difference in land value in regard to hay and corn production.

Notice that the profitability of PR changes slightly as SMG changes in Tables 5.16 through 5.18. This is due to the fact that the price of corn silage, as estimated in the model, is dependent on the productivity of the soil on which it is produced. The model assumes that farms PR will be buying corn silage from farms with the same SMG as farms organized to GFG or GF.

TABLE 5.11 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY: GFG						regression: profit by $invested	
$PROFIT	-10160	33264	76687	120110	163534	a=	-53583
RROI(%)	1.97	7.33	9.11	10.01	10.54	b=	0.087
COWS(#)	52.98	141.63	230.27	318.92	407.56	R2=	0.999
LBR(#)	1.49	2.89	4.30	5.70	7.10		
GF						a=	-51429
$PROFIT	-8917	33596	76109	118622	161135	b=	0.085
RROI(%)	2.22	7.36	9.07	9.93	10.45	R2=	0.997
COWS(#)	62.62	167.39	272.16	376.92	481.69		
LBR(#)	1.55	3.13	4.71	6.29	7.87		
PR						a=	-30063
$PROFIT	-6701	16661	40023	63385	86747	b=	0.047
RROI(%)	2.66	5.67	6.67	7.17	7.47	R2=	0.971
COWS(#)	123.20	289.04	454.88	620.72	786.57		
LBR(#)	1.97	3.96	5.95	7.94	9.93		

Returns to levels of investment beyond $ 1888377 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 1624001 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1612287 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	500	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.12 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

STRATEGY:	LEVEL OF INVESTMENT ($ million) 0.5	1	1.5	2	2.5	regression: profit by $invested	
GFG							
$PROFIT	-14647	21383	57413	93443	129474	a=	-50678
RROI(%)	1.07	6.14	7.83	8.67	9.18	b=	0.072
COWS(#)	47.17	126.23	205.30	284.37	363.44	R2=	0.999
LBR(#)	1.40	2.65	3.90	5.15	6.41		
GF							
						a=	-49202
$PROFIT	-12405	24393	61191	97988	134786	b=	0.074
RROI(%)	1.52	6.44	8.08	8.90	9.39	R2=	0.997
COWS(#)	57.21	153.11	249.00	344.90	440.80		
LBR(#)	1.47	2.92	4.36	5.81	7.25		
PR							
						a=	-30019
$PROFIT	-6818	16384	39585	62786	85987	b=	0.046
RROI(%)	2.64	5.64	6.64	7.14	7.44	R2=	0.970
COWS(#)	122.80	288.09	453.38	618.67	783.96		
LBR(#)	1.97	3.95	5.93	7.92	9.90		

Returns to levels of investment beyond $ 2094095 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 1757209 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1617287 are extrapolated for the strategy PR

Soil management group = 3
Price of land ($/acre) = 700
Price of hay ($/ton) = 75.00
Price of corn silage ($/ton)= 18.31
Price of soybean meal ($/lb)= 0.115

Price of dairy cows ($/cow)=1088.35
Price of cull cows ($/cwt)= 39.47
Price of hfrs ($/heifer)= 960.85
Price of cull hfrs ($/cwt)= 51.46
Price of cull clvs ($/cwt)= 65.06

TABLE 5.13 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression: profit by $invested	
GFG							
$PROFIT	-18259	11819	41898	71977	102056	a=	-48338
RROI(%)	0.35	5.18	6.79	7.60	8.08	b=	0.060
COWS(#)	42.49	113.84	185.20	256.56	327.91	R2=	0.999
LBR(#)	1.32	2.45	3.58	4.71	5.84		
GF						a=	-47322
$PROFIT	-15348	16626	48600	80574	112548	b=	0.064
RROI(%)	0.93	5.66	7.24	8.03	8.50	R2=	0.997
COWS(#)	52.64	141.05	229.46	317.87	406.28		
LBR(#)	1.40	2.74	4.07	5.40	6.73		
PR						a=	-29975
$PROFIT	-6933	16108	39150	62191	85233	b=	0.046
RROI(%)	2.61	5.61	6.61	7.11	7.41	R2=	0.970
COWS(#)	122.40	287.14	451.89	616.63	781.37		
LBR(#)	1.96	3.94	5.92	7.89	9.87		

Returns to levels of investment beyond $ 2299814 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 1890417 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1622287 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	900	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.14 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

STRATEGY:	LEVEL OF INVESTMENT ($ million) 0.5	1	1.5	2	2.5	regression: profit by $invested	
GFG							
$PROFIT	-21229	3955	29140	54325	79509	a=	-46414
RROI(%)	-0.25	4.40	5.94	6.72	7.18	b=	0.050
COWS(#)	38.64	103.66	168.67	233.69	298.71	R2=	0.999
LBR(#)	1.26	2.29	3.32	4.35	5.38		
GF							
						a=	-45712
$PROFIT	-17864	9984	37833	65681	93530	b=	0.056
RROI(%)	0.43	5.00	6.52	7.28	7.74	R2=	0.997
COWS(#)	48.74	130.75	212.75	294.76	376.77		
LBR(#)	1.34	2.58	3.82	5.05	6.29		
PR							
						a=	-29931
$PROFIT	-7048	15835	38718	61601	84484	b=	0.046
RROI(%)	2.59	5.58	6.58	7.08	7.38	R2=	0.970
COWS(#)	122.01	286.21	450.40	614.60	778.79		
LBR(#)	1.96	3.93	5.90	7.87	9.84		

Returns to levels of investment beyond $ 2505532 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2023625 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1627287 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	1100	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.15 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression:	
GFG						profit by $invested	
$PROFIT	-23714	-2625	18464	39554	60643	a=	-44804
RROI(%)	-0.74	3.74	5.23	5.98	6.43	b=	0.042
COWS(#)	35.42	95.13	154.84	214.55	274.26	R2=	0.999
LBR(#)	1.21	2.16	3.10	4.05	4.99		
GF							
						a=	-44320
$PROFIT	-20040	4239	28519	52799	77078	b=	0.049
RROI(%)	-0.01	4.42	5.90	6.64	7.08	R2=	0.997
COWS(#)	45.36	121.83	198.30	274.77	351.24		
LBR(#)	1.29	2.45	3.60	4.75	5.90		
PR							
						a=	-29887
$PROFIT	-7162	15563	38289	61014	83739	b=	0.045
RROI(%)	2.57	5.56	6.55	7.05	7.35	R2=	0.970
COWS(#)	121.62	285.27	448.93	612.58	776.24		
LBR(#)	1.95	3.92	5.88	7.84	9.81		

Returns to levels of investment beyond $ 2711250 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2156833 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1632287 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	1300	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

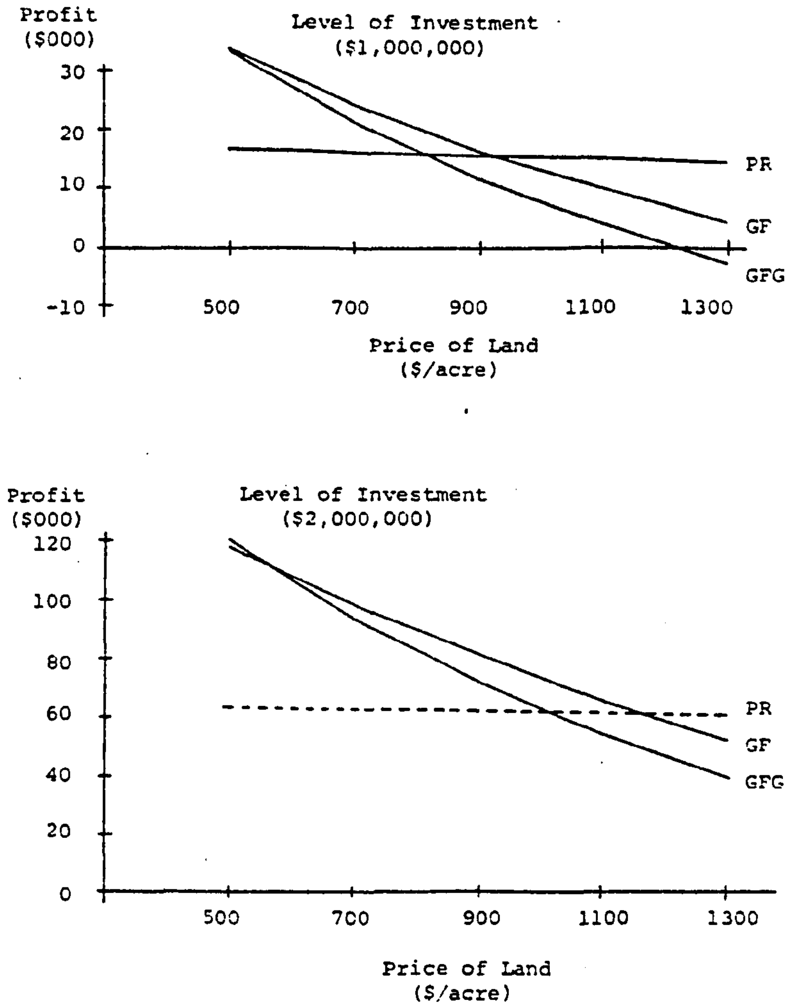

Figure 5.9. The impact of changing the price of land on profitability.

Milk price ($/cwt)	=	12.00
Corn price ($/bu)	=	2.70
Level of investment	=	$1,000,000
Level of production	=	15,000 lb

TABLE 5.16 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression:	
GFG						profit by $invested	
$PROFIT	-20793	5120	31034	56948	82861	a=	-46707
RROI(%)	-0.16	4.51	6.07	6.85	7.31	b=	0.052
COWS(#)	37.84	101.46	165.09	228.72	292.34	R2=	0.999
LBR(#)	1.23	2.21	3.19	4.17	5.15		
GF							
						a=	-45863
$PROFIT	-17637	10588	38814	67040	95266	b=	0.056
RROI(%)	0.47	5.06	6.59	7.35	7.81	R2=	0.997
COWS(#)	47.82	128.23	208.64	289.05	369.46		
LBR(#)	1.31	2.49	3.68	4.86	6.04		
PR							
						a=	-29678
$PROFIT	-7767	14143	36054	57965	79875	b=	0.044
RROI(%)	2.45	5.41	6.40	6.90	7.20	R2=	0.969
COWS(#)	121.62	285.27	448.93	612.58	776.24		
LBR(#)	1.95	3.92	5.88	7.84	9.81		

Returns to levels of investment beyond $ 2555707 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2059768 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1632287 are extrapolated for the strategy PR

Soil management group =	2.5	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	1300	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	13.81	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.17 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression:	
GFG						profit by $invested	
$PROFIT	-21229	3955	29140	54325	79509	a=	-46414
RROI(%)	-0.25	4.40	5.94	6.72	7.18	b=	0.050
COWS(#)	38.64	103.66	168.67	233.69	298.71	R2=	0.999
LBR(#)	1.26	2.29	3.32	4.35	5.38		
GF							
						a=	-45712
$PROFIT	-17864	9984	37833	65681	93530	b=	0.056
RROI(%)	0.43	5.00	6.52	7.28	7.74	R2=	0.997
COWS(#)	48.74	130.75	212.75	294.76	376.77		
LBR(#)	1.34	2.58	3.82	5.05	6.29		
PR							
						a=	-29931
$PROFIT	-7048	15835	38718	61601	84484	b=	0.046
RROI(%)	2.59	5.58	6.58	7.08	7.38	R2=	0.970
COWS(#)	122.01	286.21	450.40	614.60	778.79		
LBR(#)	1.96	3.93	5.90	7.87	9.84		

Returns to levels of investment beyond $ 2505532 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2023625 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1627287 are extrapolated for the strategy PR

Soil management group =	3	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	1100	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	18.31	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

TABLE 5.18 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

	LEVEL OF INVESTMENT ($ million)						
	0.5	1	1.5	2	2.5		
STRATEGY:						regression:	
GFG						profit by $invested	
$PROFIT	-22182	1305	24791	48278	71764	a=	-45669
RROI(%)	-0.44	4.13	5.65	6.41	6.87	b=	0.047
COWS(#)	39.50	105.90	172.31	238.72	305.13	R2=	0.999
LBR(#)	1.30	2.40	3.49	4.58	5.68		
GF						a=	-45432
$PROFIT	-18130	9173	36475	63778	91080	b=	0.055
RROI(%)	0.37	4.92	6.43	7.19	7.64	R2=	0.997
COWS(#)	50.03	134.14	218.26	302.38	386.49		
LBR(#)	1.39	2.69	4.00	5.31	6.61		
PR						a=	-30200
$PROFIT	-6283	17633	41549	65465	89381	b=	0.048
RROI(%)	2.74	5.76	6.77	7.27	7.58	R2=	0.972
COWS(#)	122.40	287.14	451.89	616.63	781.37		
LBR(#)	1.96	3.94	5.92	7.89	9.87		

Returns to levels of investment beyond $ 2456857 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 1977491 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1622287 are extrapolated for the strategy PR

Soil management group =	4	Price of dairy cows ($/cow)=	1088.35
Price of land ($/acre) =	900	Price of cull cows ($/cwt)=	39.47
Price of hay ($/ton) =	75.00	Price of hfrs ($/heifer)=	960.85
Price of corn silage ($/ton)=	17.76	Price of cull hfrs ($/cwt)=	51.46
Price of soybean meal ($/lb)=	0.115	Price of cull clvs ($/cwt)=	65.06

CHAPTER 6

SUMMARY AND CONCLUSIONS

Profitability of three different strategies of securing feeds on dairy farms in Southern Michigan and other similar areas was examined. These strategies are: 1) grow forages and grain (GFG), 2) grow forages only (GF) and 3) purchase all feeds (PR).

Using the electronic spreadsheet template: Microsoft Multiplan (1982), synthetic farms of herd sizes of: 40, 75, 150 and 300 cows (plus replacements) were modeled for the strategies GFG and GF. An additional herd size of 500 cows was examined for the strategy of PR. The model employs a static budgeting approach and assumes crop yields, level of milk production, and prices specified by the user are constant over the investment period. The model is useful in projecting long-term profit expectation. It does not consider within year or across years price or yield variations, income taxes, method or details of financing or yearly cash flows necessary to keep the business solvent. Real interest rates are used and the model assumes that incomes and expenses inflate at the same rate.

Budgeted analyses of profitability across various herd sizes, representing different investment levels within each strategy, provided a basis to regress profit on dollars invested for each strategy. Strategies were then compared on the basis of profitability, considering equal dollars invested. Levels of investment compared were: $.5, 1.0, 1.5, 2.0 and 2.5 million.

The first analysis examined returns to each strategy, considering prices expected for milk and corn over the next several years (i.e. a milk price of $12/cwt and a corn price of $2.70/bu). Profitability across levels of production of: 13, 15, 17 and 19 thousand lb of milk within each level of investment in each strategy was examined.

This analysis revealed:

1) The ranking of strategies according to profit changes with the level of investment and level of milk production. At a level of production of 13,000 lb, the strategies rank in order of profitability as: GFG>GF>PR across all levels of investment. At a level of production of 15,000 lb, the strategies PR and GF are the two most profitable. However, there are minimal differences among all three strategies. At levels of production of 17,000 or 19,000 lb, the strategies rank in order of profitability as: PR>GF>GFG.

2) The amount of labor required for a given level of investment and production is 1.5 to 1.9 times greater for the strategy PR compared to GFG.

3) The numbers of cows for a given level of investment and production level is 2.5 to 3.2 times greater for the strategy PR compared to GFG.

4) The strategy GF ranks either first or second across all levels of investment and milk production.

5) Most economies of size are realized between a level of in-

vestment of $500,000 and $1,000,000 for all strategies. The strategies GFG and GF continue to experience economies of size at all levels of investment examined.

The second analysis examined the consequence of changing the milk/feed price ratio to 1.45 and 1.55 by changing the price of milk to $11.40 or $12.60/cwt, respectively. This analysis revealed that the ranking of strategies depends upon relative prices (i.e. price ratios) in addition to absolute values. Increasing the milk price to $12.60/cwt had the obvious effect of making all strategies more profitable. At this price, PR was a profitable strategy with the level of milk production as low as 13,000 lb, at a level of investment ≥$1.0 million. Decreasing the milk price had a dramatic negative impact across all strategies, but PR was the most sensitive. When the milk price was dropped to $11.40/cwt, the strategy PR was the least profitable until a level of milk production ≥17,000 lb. The strategy of GF ranked either 1st or 2nd across all levels of investment and production.

The third analysis examined the consequences of changing the milk/feed price ratio by changing the price of corn. Corn prices of: $2.55, 2.70, 2.85, 3.10 and 3.30/bu were budgeted across levels of production of: 13, 15, 17 and 19 thousand lb of milk. The analysis revealed:

1) At a level of milk production of 13,000 lb and a level of investment of $1,000,000, the strategy PR becomes unprofitable once corn price >$2.55/bu. When the price of corn ≥$3.10/bu, the strategy GFG is the most profitable.

2) At a level of production of 15,000 lb, the strategy of PR is profitable until the price of corn >$2.85/bu; at 19,000 lb PR is still a profitable alternative with a corn price at $3.30/bu.

3) The strategy GF ranks either 1st or 2nd across all levels of production.

Analyses 2 and 3 reveal that the consequences of changing the milk/feed ratio by changing the price of milk (the numerator) is different than changing the price of feed (the denominator).

The fourth analysis examined the effect of the price of land on the profitability of each strategy, assuming a level of milk production of 15,000 lb, soil management group 3, a price of milk of $12.00/cwt, and a corn price at $2.70/bu. This analysis revealed:

1) At a price of $500/acre, both GFG and GF are equally profitable and returns to these strategies are almost double those received under the strategy PR.

2) At a price of $700/acre, the strategy of GF is slightly more profitable than that of GFG and both yield substantially greater returns than PR.

3) At a price of $900/acre the strategy GF is most profitable. The strategy PR yields greater returns than GFG, until an investment level of $1,500,000. At this level, GFG is a more profitable strategy than PR.

4) At a land price of $1100/acre, the strategy of PR yields the greatest returns until investment levels approach $1,500,000. Beyond this level of investment, GF is the most profitable strategy followed

by the strategy of PR.

5) At a land price of $1300/acre, the strategy of PR is the most profitable across all levels of investment.

The fifth analysis examined the effect on profitability of changing the soil management group (SMG) to either 2.5, 3 or 4, and consequently changing the price of land. There were no differences in profitability for the strategies as the SMG was changed, when the price of land was adjusted accordingly.

All of the analyses showed minimal to negative returns for levels of investment of $500,000.

These results show:

1) The strategy of PR is a viable strategy of dairying in Michigan, given an expected milk price of $12.00/cwt, a corn price of $2.70/bu, a level of production ≥17,000 lb milk and an investment level ≥$1,000,000.

2) the strategy of GF is a profitable strategy of dairying for all levels of production provided the level of investment ≥$1,000,000.

3) The strategy of GFG is a profitable strategy of dairying across all levels of production, provided the level of investment ≥$1,500,000.

4) The impact of changing the price of milk or corn on profitability is greatest for the strategy of PR.

5) High levels of production (≥17,000) are most important to make PR a profitable enterprise.

6) The strategy of GF usually ranks 1st or 2nd in terms of profit

for a given level of investment or production. The tremendous variability in profit and potential for lower profit for given levels of investment and production considering corn prices ranging from $2.55 to $3.10/bu indicate that PR is not the strategy of choice for risk averse investors. Although the variability in profit is greater for the strategy of GF compared to GFG, the potential for lower profit is not substantially less than GFG but the potential for greater income makes this option the strategy of choice. Further research should focus on the consequences of shifting from the strategy of GFG to GF or PR, considering cash flow implications in addition to total profit.

The results presented here are a few examples of the possible situations that can be analyzed using the dairy investment model. The impact on profitability of different interest rates, fertilizer prices, fuel prices, labor costs, etc. can be examined.

These results should not encourage farmers to switch from their current strategy of securing feeds on dairy farms to either grow forages only or to purchase all feeds. These results are based on a specific set of resources (i.e. complements of machinery, buildings, etc.) and conditions simulated in the model. It does not examine the consequences of shifting from one strategy to another or the specific circumstances of any particular farm. It does indicate, however, that as more resources are invested in dairying, many farmers would be better to concentrate on increasing herd size and milk production level, and purchase corn grain from neighboring crop farmers as high moisture shelled corn to meet additional grain needs.

Another important factor which is not taken into account is management ability. Someone who is a good dairy farmer is not necessarily a good crop farmer. One who is a good manager of an 80 cow herd may not have the ability or desire to manage 300 cows. These factors must all be accounted for in making an initial investment or expansion decision.

This is a static model which does not consider cash-flow commitments over time, method of debt financing or the ability to project the impact of different prices or price variability over different time periods of the investment. These components would substantially add to the value of the model.

APPENDIX A

MICHIGAN LAND VALUES
AND AVERAGE CASH RENTS

From the early 1970's to 1981 farm real estate values increased annually and unrealized capital gains were a major component in the total returns to agricultural production assets (Burghardt, 1982). Depressed farm income, high interest rates and higher returns to money markets since that time have resulted in a negative growth rate in the value of farm real estate.

After adjusting for inflation, the average value of U.S. farmland slipped equal amounts in 1981-82 and 1982-83. During this first period the value of land decreased 1%; coupled with an 8% increase in the Consumer Price Index (CPI), this resulted in the real value of land declining by 9%. At 6% decline in price plus a 3% gain in the CPI during 1982-83 again resulted in a decline of 9% in the real value of land (Doane's Agric. Report, 1983).

Because of the low number of farm real estate transactions over the past few years as well as the fact that many of these have resulted from forced sales for estates or liquidations, caution is urged when interpreting these numbers. According to several observers, land prices seem to have leveled off or improved somewhat since the beginning of 1983 (Doane's Agric. Report, 1983).

Henderson (1983) states that improved crop prices and higher farm incomes should spark increased interest in buying farmland by farmers with reasonable debt loads for expansion purposes. He notes that a number of factors such as: relatively high interest rates, modest inflation, increased distress sales of those who fell into financial difficulties in 1981 and 1982 and a hesitancy of farm lending agencies to make farm real estate loans limit land price increases in 1983.

Table A1. Average Michigan Farmland Values and Indexes During the Last 5 Years[a]

Year	1979	1980	1981	1982	1983
Value ($/acre)	975	1082	1232	1192	1109
Index (1977=100)	124	138	157	152	141

[a]Source: Doane's Agric. Report, 1983.

Table A2. Average Per Acre Cash Rents and Farmland Values in Michigan from 1960 to 1980[a]

Year	Avg. Rent	Avg. Land Value (as of Feb.)	Predicted[b] Land Rent	Predicted Land Value[c]
	$	$	$	$
1960	14.08	228	16.45	240
1961	14.00	239	16.94	237
1962	14.58	248	17.33	252
1963	14.81	241	17.02	257
1964	15.42	258	17.77	272
1965	16.12	271	18.34	289
1966	17.24	301	19.66	316
1967	20.49	328	20.85	395
1968	18.48	350	21.82	346
1969	19.15	359	22.22	362
1970	18.00	341	21.42	334
1971	20.21	328	20.85	388
1972	19.85	393	23.71	380
1973	22.77	448	26.13	448
1974	26.23	563	31.19	534
1975	28.50	564	31.24	589
1976	31.17	631	27.76	653
1977	37.51	786	41.00	807
1978	38.00	811	42.10	819
1979	40.00	885	45.36	867
1980	46.40	1039	52.14	1022

[a]Source: Robison and Espel, 1981.

[b]The predicted land rental rate is calculated as: 6.42 + .044 * avg. land value (r = .987, 20 observations). If a property tax of 1.6% of the value of land is assumed, then the real after tax rate of return expected by those who rent land is approximately .044 - .016 = .028 or 2.8%.

[c]The predicted land value is calculated as: -100.9 + 24.2 * average cash rental rate. r = .99 for observations from 72 to 80.

APPENDIX B

LOGIC OF FEED PURCHASING

DECISIONS

A. Purchasing Corn

Once the decision is made to purchase all feeds or at least the grain, the next decision is to determine how much should be purchased and stored at any given time. It seems reasonable to assume that feeds purchased at harvest time would cost less than they would if purchased month by month. As a matter of fact, for the past 7 out of 10 years it would have cost those purchasing corn more if they purchased throughout the year than if they purchased all of their corn at harvest time as shown in Table B1. However, this does not take into account the costs of: storage, interest paid on the corn purchased, or the physical cost to store corn. Another important consideration to account for is drying costs. Corn purchased at harvest time can be ensiled as high moisture shelled corn. This would eliminate the drying cost which is assumed to be passed to the feed purchaser. Adjusting the average harvest price of corn over the past 10 years (expressed in 1983 dollars; see Table B2) by these costs and comparing them with the average season price adjusted by a margin paid to the grain elevator reveals, that based on the expected price of corn and today's costs, farmers would be as well off if they purchased corn at harvest season from nearby grain farmers and ensile as high moisture corn.

Savings in drying cost is estimated as:

$.025/point to dry * 12 points/bushel = $.30/bushel (Schwab et al., (1983)

Corn storage cost is calculated based on the cost of a 20'x60' silo with a top unloader using a 20 year expected life and a 4% interest rate. In 1983 the initial investment amounts to over $22,600 (see Table 4.6). The annual use cost of the silo is estimated using the formula:

$$\frac{r * \text{purchase price}}{1 - \frac{1}{(1+r^{L})}}$$

where: r = interest rate = 4%
L = years of life= 20 years

$$\frac{.04 * \$22,600}{1 - \frac{1}{(1.04^{20})}}$$

= .074 * 22,600 = 1672/year
1672 ÷ 13000 bu = .13/bu/year

Interest cost of corn is based on:

4% interest rate * average harvest season price * 1/2

.04 * 3.56 * .5 ≅ $.07/bu interest

Cost to fill the silo is estimated based on the labor and fuel estimated to be needed. Assuming a farm with a 20'x60' silo holding 455 tons of high moisture corn at 30% moisture and a filling rate of 10 tons/hr (the slow rate of filling due to the harvest capacity limitation of the combining process) it should take (455 tons)/10 tons/hr = 45.5 hr to fill the silo. Assuming that ensiling requires one person to transport wagons and ensile, it would require 45.5 hr of labor. At $5.00/hr this would amount to 45.5 hr * $5.00/hr = $228 for labor. Assuming that the blower requires a 40 hp tractor (requiring 3 gal diesel fuel/hr) and that the blower is operating about 1/2 of the time = 1.5 gal/hr. Assuming that tractors transporting corn are 40 hp also, then total fuel consumed/hr = 4.5 gal/hr. Thus, 45.5 hr * 4.5 gal/hr = 205 gal of diesel fuel. Using a price of $1.20/gal of fuel required, results in a fuel cost of 205 gal * $1.20/gal = $246 fuel cost to fill the silo.

The total cost to ensile would be: \$246 + \$228 = \$474. Since the capacity of a 20'x60' silo is 13,000 bu of high moisture corn, then the cost/bushel to ensile is estimated to be \$474 ÷ 13,000 = \$.036 or ~\$.04/bushel to ensile corn.

The margin paid to the elevator is estimated as the difference in price that the elevator will pay to buy corn and the price they charge when they sell it to the farmers. This is estimated as \$.15 per bushel (Ecker, 1983).

The cost to buy corn at harvest and ensile as high moisture corn =

Corn avg. harvest price		Storage cost		Interest charge		Savings in drying		Cost to fill silo		Adjusted harvest price
(1983 dollars) \$3.56	+	.13	+	.07	-	.30	+	.04	=	\$3.50/bu

Cost to buy corn through the year as needed:

Corn avg. yearly price		Margin paid to elevator		Adjusted yearly price
(1983 dollars) \$3.61	+	.15	=	\$3.76

B. Purchasing Hay

Table B1 shows the harvest season price and the yearly price of hay received by Michigan farmers over the past 10 years. This table reveals that in 8 out of 10 years, farmers purchasing hay would have paid less if they purchased all hay during the harvest season. However, this does not consider the cost to store hay or the interest cost to purchase hay at harvest time. Once these costs are included it is calculated that it cost approximately \$2.15 more/ton to purchase hay at harvest time than purchasing it evenly throughout the year, assuming hay is purchased directly from other farmers.

Hay storage cost is estimated based on the cost to construct a pole barn with an expected life of 20 years and a real interest rate of 4%. Assuming a barn 14' to the eaves and that hay occupies 250 cubic feet/ton then: (250 cu ft/ton)/14 ft = 17.85 square ft needed/ton. Assuming a cost of \$3.50/square ft to construct a pole barn then 17.85 ft * \$3.50 = \$62.50/ton to store hay. Since storage would be needed for about 70% of the hay at any one time then: \$62.50 * .7 = \$43.70/ton investment cost/ton of hay. The annual use cost of the hay barn is estimated using the formula:

$$\frac{r * \text{purchase price}}{1 - \frac{1}{(1+r^L)}}$$

where: r = interest rate
L = years of life

= .074 * 43.70 = \$3.23/ton/year storage cost

Interest charge for hay is based on 4% interest * 1/2 * average season price

4% * .5 * \$61/ton = \$1.22/year interest cost for hay

Cost to purchase hay at harvest time and store it:

Hay harvest price	+	Hay storage cost	+	Interest charge	=	Adjusted harvest price
(1983 dollars)						
\$61/ton	+	3.23	+	1.22	=	\$65.45/ton

Cost to purchase hay throughout the year

Average season price

(1983 dollars)
\$67.60/ton

Based on the estimates above, it is assumed, in this analysis, that farmers purchasing corn purchase their annual corn needs at harvest time and ensile it as high moisture corn. It is also assumed that farmers purchasing hay purchase hay throughout the year as needed and when the price is right. To allow flexibility in hay purchasing and to guard against dramatic seasonal price changes there is a 4 month inventory of hay on the farm.

Table B1. Nominal Prices of Corn and Hay Received by Michigan Farmers from 1972 to 1982[a]

Year	Corn		Hay	
	Harvest Season[b] Price ($/bu)	Avg. Yearly[c] Price ($/bu)	Harvest Season[d] Price ($/ton)	Avg. Yearly[e] Price ($/ton)
1972-73	1.22	1.59	27.50	29.40
1973-74	2.16	2.51	30.10	31.20
1974-75	3.29	2.82	31.00	40.90
1975-76	2.28	2.42	43.50	42.00
1976-77	2.10	2.02	38.40	44.90
1977-78	1.73	1.99	53.00	60.00
1978-79	1.98	2.28	43.10	45.40
1979-80	2.28	2.43	36.00	36.40
1980-81	3.05	3.05	30.00	37.70
1981-82	2.30	2.35	40.60	58.90

[a]Source: Michigan Dept. Agric. 1973-1983.

[b]Corn harvest season price is estimated as the average of the average monthly prices received in October, November and December.

[c]Corn average yearly price is estimated as the average of the average monthly prices received from October to October.

[d]Hay harvest season price is estimated as the average of the average monthly prices received in June, July, August and September.

[e]Hay average yearly price is estimated as the average of the average monthly price received from June to June.

Table B2. Adjusted (1983 Dollars)[a] Prices of Corn and Hay Received by Michigan Farmers from 1972 to 1982[b]

Year	Corn		Hay	
	Harvest Season[c] Price ($/bu)	Avg. Yearly[d] Price ($/bu)	Harvest Season[e] Price ($/ton)	Avg. Yearly[f] Price ($/ton)
1972-73	2.81	3.54	64.10	67.40
1973-74	4.59	5.07	65.70	65.90
1974-75	6.23	5.18	60.90	77.60
1975-76	4.02	4.18	78.20	74.30
1976-77	3.53	3.29	65.50	75.10
1977-78	2.73	3.02	84.80	94.00
1978-79	2.87	3.13	63.90	65.30
1979-80	2.93	2.94	47.90	46.30
1980-81	3.47	3.33	35.30	42.90
1981-82	2.40	2.41	43.20	61.60
$\bar{x}$	3.56	3.61	60.95	67.04
SD	1.15	.92	15.17	14.92
CV	.32	.25	.25	.22

[a]1983 adjusted prices are estimated using the Consumer Price Index of: purchasing power of the dollar, obtained from: Bureau of Economic Analysis, 1983,1980,1978,1976. Index values of the appropriate months are used. For example, the appropriate CPI's to use for corn harvest season for 1972-73 for October, November and December are: .790, .788 and .786. The average of these values is .788. The CPI value used to convert to 1983 dollars is .341. Thus, to convert corn harvest season price for 1972-73 to 1983 dollars multiply the corn price ($1.22) * (.788/.341) = $2.81.

[b]Source: Michigan Dept. of Agric. 1973-1983.

[c]Corn harvest season price is estimated as the average of the average monthly prices received in October, November and December.

[d]Corn average yearly price is estimated as the average of the average monthly prices received from October to October.

[e]Hay harvest season prices is estimated as the average of the average monthly prices received in June, July, August and September.

[f]Hay average yearly price is estimated as the average of the average monthly prices received from June to June.

APPENDIX C

CROP MACHINERY COMPLEMENTS

Machinery complements were assembled using information from the following:

Maddex and White
John Deere and Co., 1969
White, 1978
White, 1977
White, 1972

Sources of prices used to estimate costs in Table C1 through C8 are listed below:

Abbreviation	Source
OG	National Farm Power and Equipment Dealers Assoc., 1982
PPFI	Crop Reporting Board, 1982a,b
T	Dealer: Thesier's John Deere Farm Equipment, N. Cedar St., Mason, MI, 1983 - via phone conversation
CAP	Shaudys, 1980
EST	Estimated price based on similar equipment: Crop Reporting Board, 1983a,b
AC	Dealer: William's Farm Equipment, 1983 1115 Lansing St., Charlotte, MI, 1983 - via phone conversation
SN	Nott, 1980
Make:	JH = John Deere IH = International Harvester NI = New Idea

Table C1. Crop Machinery and Equipment (Grow All Feed); Herd Size = 40 Cows

Equipment	No.	Price each ($)	Source	Yr	Make
40 hp tractor	1	14,000	OG	82	JD 2040
60 hp tractor	2	18,600	OG	82	JD 2440
Plow (3 bottom)	1	2,300	PPFI	82	
Disk (10 ft)	1	3,500	EST		
Corn planter (4 row)	1	6,900	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Sprayer	1	1,600	PPFI	82	
Cultivator (4 row)	1	2,200	PPFI	82	
Picker sheller (2 row)	1	10,600	OG	82	IH 234
Gravity box	2	1,600	PPFI		
Forage harvester - with attachments	1	10,700	PPFI	82	
Mower conditioner	1	8,100	OG	82	
Rake (9 ft)	1	2,200	SN	80	
Baler (med. duty)	1	6,800	PPFI	82	
Wagon (hay)	3	1,400	EST		
Forage wagons	3	6,000	T	83	
Forage blower	1	3,000	T	83	
Pickup (3/4 ton)	1	6,200	CAP	80	
Total		145,700			
Per Cow		3,643			

Table C2. Crop Machinery and Equipment (Grow Forages Only); Herd Size = 40 Cows

Equipment	No.	Price each($)	Source	Yr	Make
40 hp tractor	1	14,000	OG	82	JD 2040
60 hp tractor	2	18,600	OG	82	JD 2440
Plow (3 bottom)	1	2,300	PPFI	82	
Disk (8 ft)	1	3,500	EST		
Sprayer	1	1,600	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Corn planter	1	6,900	PPFI	82	
Forage harvester - with attachments	1	10,700	PPFI	82	
Mower-conditioner	1	8,100	OG	82	
Rake (9 ft)	1	2,200	SN	80	
Baler (med. duty)	1	6,800	PPFI	82	
Wagons (hay)	3	1,400	EST		
Forage wagons	3	6,000	T	83	
Forage blower	1	3,000	T	83	
Pickup (3/4 ton)	1	6,200	CAP	80	
Total		129,700			
Per Cow	3,243				

Table C3. Crop Machinery and Equipment (Grow All Feeds); Herd Size = 75 Cows

Equipment	No.	Price each($)	Source	Yr	Make
40 hp tractor	1	14,000	OG	82	JD 2040
80 hp tractor	2	25,000	OG	82	JD 2440
Plow (3 bottom)	1	2,300	PPFI	82	
Disk (10 ft)	1	4,000	EST		
Sprayer	1	1,600	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Corn planter (4 row)	1	6,900	PPFI	82	
Cultivator (4 row)	1	2,200	PPFI	82	
Picker shelled	1	11,400	PPFI	82	
Gravity box	3	1,600	PPFI	82	
Forage harvester - with attachments	1	10,700	PPFI	82	
Mower-conditioner (9 ft)	1	8,100	OG	82	JD 1209
Rake (9 ft)	1	2,200	SN	82	
Baler (med. duty)	1	6,800	PPFI	82	
Wagon (hay)	3	1,400	EST		
Forage wagons	3	6,000	T	83	
Forage blower	1	3,000	T	83	
Pickup truck	1	6,200	CAP	80	
Total		161,400			
Per Cow		2,152			

Table C4. Crop Machinery and Equipment (Grow Forages Only); Herd Size = 75 Cows

Equipment	No.	Price each($)	Source	Yr	Make
40 hp tractor	1	14,000	OG	82	JD 2040
80 hp tractor	2	25,000	OG	82	
Plow (3 bottom)	1	2,300	PPFI	82	
Disk (10 ft)	1	4,000	EST		
Sprayer	1	1,600	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Corn planter	1	6,900	PPFI	82	
Forage harvester - with attachments	1	10,700	PPFI	82	
Mower-conditioner(9 ft)	1	8,100	OG	82	JD 1209
Rake (9 ft)	1	2,200	SN	82	
Baler (med. duty)	1	6,800	PPFI	82	
Wagon (hay)	3	1,400	EST		
Forage wagons	3	6,000	T	83	
Forage blower	1	3,000	T	83	
Pickup truck	1	6,200	CAP	80	
Total		143,000			
Per Cow		1,907			

Table C5. Crop Machinery and Equipment (Grow All Feeds); Herd Size = 150 Cows

Equipment	No.	Price each ($)	Source	Yr	Make
40 hp tractor	1	14,000	OG	82	JD 1250
80 hp tractor	1	25,000	OG	82	JD 2940
110 hp tractor	1	34,400	OG	82	JD 4240
Plow (5 bottom)	1	6,700	PPFI	82	
Disk (12 ft)	1	5,100	PPFI	82	
Sprayer	1	1,600	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Corn planter (4 row)	1	6,900	PPFI	82	
Cultivator (4 row)	1	2,200	PPFI	82	
Combine (SP)	1/2	49,000	PPFI	82	
Gravity box	3	1,600	PPFI	82	
Windrower	1	12,000	PPFI	82	
Tandem rakes (set)	1	5,000	PPFI	82	
Baler (heavy duty)	1	8,500	T	83	
Automatic (55 bale-PTO wagon)	1	11,000	AC	83	
Forage wagon	3	6,000	T	83	
Forage harvester (med. duty)	1	14,000	T	83	
Forage blower	1	3,000	T	83	
Pickup truck (3/4 ton)	1	6,200	CAP	80	
Total		207,900			
Per Cow		1,386			

Table C6. Crop Machinery and Equipment (Grow Forages Only); Herd Size = 150 Cows

Equipment	No.	Price each ($)	Source	Yr	Make
40 hp tractor	1	14,000	OG	82	JD 1250
80 hp tractor	1	25,000	OG	82	JD 2940
110 hp tractor	1	34,400	OG	82	JD 4240
Plow (5 bottom)	1	6,700	PPFI	82	
Disk (13 ft)	1	5,100	PPFI	82	
Sprayer	1	1,600	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Corn planter	1	6,900	PPFI	82	
Windrower	1	12,000	PPFI	82	
Randem rakes (set)	1	5,000	PPFI	82	
Baler (heavy duty)	1	8,500	T	83	
Automatic (55 bale-PTO wagon)	1	11,000	AC	83	
Forage wagon	3	6,000	T	83	
Forage harvester (med. duty)	1	14,000	T	83	
Forage blower	1	3,000	T	83	
Pickup truck (3/4 ton)	1	6,200	CAP	80	
Total		176,400			
Per Cow		1,176			

Table C7. Crop Machinery and Equipment (Grow All Feeds); Herd Size = 300 Cows

Equipment	No.	Price each ($)	Source	Yr	Make
60 hp tractor	1	18,600	OG	82	JD 2440
130 hp tractor	1	38,400	OG	82	JD 4440
150 hp tractor	1	46,300	OG	82	JD 4640
Plow (7 bottom)	1	9,480	PPFI	82	
Disk harrow (16 ft)	1	7,560	PPFI	82	
Sprayer	1	1,600	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Planter (8 row)	1	13,000	EST		
Cultivator (8 row)	1	4,480	PPFI	82	
Gravity box	4	1,600	PPFI	82	
Combine	1	49,000	PPFI	82	
Windrower (14 ft SP)	1	19,000	OG	82	JD 2320
Tandem rakes (set 18 ft)	1	5,000	T	83	
Baler (heavy duty)	1	8,500	T	83	
Automatic (104 bale - PTO wagon)	1	18,000	AC	83	
Forage blower	1	3,000	T	83	
Forage wagon	4	6,000	T	83	
Forage harvester (SP)	1	40,000	OG	82	NI 767 Uni
Pickup truck (3/4 ton)	1	6,200	PPFI	82	
Total		323,520			
Per Cow		1,078			

Table C8. Crop Machinery and Equipment (Grow Forages Only); Herd Size = 300 Cows

Equipment	No.	Price each($)	Source	Yr	Make
60 hp tractor	1	18,600	OG	82	JD 2440
130 hp tractor	1	38,400	OG	82	JD 4440
110 hp tractor	1	34,400	OG	82	JD 4240
Plow (5 bottom)	1	6,700	PPFI	82	
Disk harrow (13 ft)	1	5,100	PPFI	82	
Sprayer	1	1,600	PPFI	82	
Grain drill	1	5,000	PPFI	82	
Corn planter	1	6,900	PPFI	82	
Windrower (14 ft, SP)	1	19,000	OG	82	JD 2320
Tandem rakes (set 18 ft)	1	5,000	T	83	
Baler (heavy duty)	1	8,500	T	83	
Automatic (104 bale - PTO wagon)	1	18,000	AC	83	
Forage wagon	4	6,000	T	83	
Blower	1	3,000	T	83	
Forage harvester	1	40,000	OG	82	NI 767 Uni
Pickup truck	1	6,200	PPFI	82	
Total		240,400			
Per Cow		801			

APPENDIX D

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CROP LABOR ESTIMATES

Table D2 through D15 contain estimated hours of labor for corn, corn silage, hay and haylage for various herd sizes specified in the model and corresponding crop acreages. Specific tasks to be performed and the labor requirements to perform them are enumerated based on estimates from Table D1 considering the machinery complements estimated in Table C1 through C8. Some labor requirements were approximated when estimates were unavailable (e.g. transporting and ensiling labor).

These estimates were used to derive linear approximations for crop labor based on the number of acres grown and the specific crop in question. They are summarized in Table D16 and can be compared with Telfarm labor requirements in Table D17 and D18. Labor estimates differ most markedly from Telfarm estimates relative to hay and diverge substantially as crop acreages increase for all crops.

Table D1. Machinery Capacities, Acres/Hour for Selected Farming Operations[a]

Machine	Field efficiency %	Width inches	Speed mi/hr	Acres/ hr
Tillage				
Moldboard Plow: 3 bottom	80	42	4.5	1.51
5 bottom	80	80	4.5	2.88
7 bottom	80	112	4.5	4.03
Tandem Disk Harrow: 8 ft	85	96	4.5	1.49
12 ft	85	144	4.5	2.24
Row Crop Cultivator: 4 row, 40 in	80	160	3.5	4.48
8 row, 30 in	80	240	3.5	6.72
Planting				
Conventional Tillage: 4 row, 40 in	60	160	3.5	3.36
6 row, 30 in	55	180	4.5	4.46
8 row, 30 in	55	240	4.5	5.94
Grain Drill: 17 hole, 7 in	70	119	4.0	3.33
23 hole, 8 in	70	184	4.0	5.15
Harvesting				
Corn picker: 1 row, 30 in	70	30	3.0	.63
3 row, 30 in	65	90	2.5	1.46
Combine: self-propelled				
4 row, 30 in	65	120	2.5	1.95
6 row, 30 in	65	180	2.5	2.93
Mower-conditioner:				
9 ft, pull type	75	108	4.5	3.65
12 ft, self-propelled	75	144	4.5	4.86
Side Delivery Rake: 7 ft	80	84	4.5	3.02
18 ft	80	216	4.5	7.78
Baler, bales dropped: 7 ft windrow	75	84	3.5	2.21
9 ft windrow	75	108	3.5	2.84
Baler, bale thrower: 7 ft windrow	65	84	3.5	1.91
9 ft windrow	65	108	3.5	2.46
Forage harvester - Haylage:				
7 ft windrow	65	84	2.0	1.09
9 ft windrow	65	108	2.0	1.40
12 ft windrow	60	144	2.0	1.73
- Corn Silage				
2 row, 30 in	60	60	2.5	.90
4 row, 30 in	55	120	2.5	1.65
Miscellaneous				
Boom type sprayer: 21 ft	65	252	6.5	10.65

[a]Source: White, 1978.

Table D2. Corn Grain Labor: 40 Cows, 42 Acres Corn

Item	Field efficiency	Calculation	Hours
Plow, 3 bottom	80	42 acres ÷ 1.51 acres/hr	27.8
Disk, 8 ft, 2 times	85	(42 acres ÷ 3.67 acres/hr)*2	22.9
Plant, 4 row conventional	60	42 acres ÷ 3.0 acres/hr	14.0
Spray, 21 ft boom	65	42 acres ÷ 10.65 acres/hr	3.9
Cultivate, 4 row	80	42 acres ÷ 3.36 acres/hr	12.5
Picker, 2 row, 30 in	65	42 acres ÷ 1.0 acres/hr	42.0
Transport and ensile	--	42 acres ÷ 1.0 acres/hr	42.0
		Total hr	165.1
		Hr/acre	3.9

Table D3. Corn Grain Labor: 75 Cows, 79 Acres Corn

Item	Field efficiency	Calculation	Hours
Plow, 4 bottom	80	79 acres ÷ 2.19 acres/hr	36.0
Disk, 10 ft,2 times	85	(79 acres ÷ 4.59 acres/hr)*2	34.4
Plant, 4 row conventional	60	79 acres ÷ 3.0 acres/hr	26.3
Spray, 21 ft boom	65	79 acres ÷ 10.65 acres/hr	7.4
Cultivate, 4 row	80	79 acres ÷ 3.36 acres/hr	23.5
Picker, 2 row, 30 in	65	79 acres ÷ 1.0 acres/hr	79.0
Transport and ensile	--	79 acres ÷ 1.0 acres/hr	79.0
		Total hr	285.7
		Hr/acre	3.6

Table D4. Corn Grain Labor: 150 Cows, 158 Acres Corn

Item	Field efficiency	Calculation	Hours
Plow, 5 bottom	80	158 acres ÷ 2.88 acres/hr	54.9
Disk, 12 ft	85	(158 acres ÷ 5.51 acres/hr)*2	57.4
Plant, 4 row conventional	60	158 acres ÷ 3.0 acres/hr	52.7
Spray, 21 ft boom	65	158 acres ÷ 10.65 acres/hr	14.8
Cultivate, 4 row	80	158 acres ÷ 3.36 acres/hr	47.0
Combine 4 row, 30 in	65	158 acres ÷ 1.95 acres/hr	81.0
Transport and ensile	--	158 acres ÷ 1.95 acres/hr	81.0
		Total hr	388.8
		Hr/acre	2.5

Table D5. Corn Grain Labor: 300 Cows, 315 Acres Corn

Item	Field efficiency	Calculation	Hours
Plow, 7 bottom	80	315 acres ÷ 4.03 acres/hr	78.2
Disk, 16 ft	85	(315 acres ÷ 7.30 acres/hr)*2	86.3
Plant, 8 row conventional	60	315 acres ÷ 5.94 acres/hr	53.0
Spray, 21 ft boom	65	315 acres ÷ 10.65 acres/hr	29.6
Cultivate, 8 row	80	315 acres ÷ 6.72 acres/hr	46.9
Combine 4 row, 30 in	65	315 acres ÷ 1.95 acres/hr	161.5
Transport and ensile	--	315 acres ÷ 1.95 acres/hr	161.5
		Total hr	617.0
		Hr/acre	1.96

Table D6. Corn Silage Labor: 40 Cows, 24 Acres Corn Silage

Item	Field efficiency	Calculation	Hours
Plow, 3 bottom	80	24 acres ÷ 1.51 acres/hr	15.9
Disk, 8 ft, 2 times	85	(24 acres ÷ 1.49 acres/hr)*2	32.2
Plant, 4 row conventional	60	24 acres ÷ 3.0 acres/hr	8.0
Spray, 21 ft boom	65	24 acres ÷ 10.65 acres/hr	2.3
Cultivate, 4 row	80	24 acres ÷ 3.36 acres/hr	7.1
Forage harvester, 1 row, 30 in	60	24 acres ÷ .59 acres/hr	40.7
Transport and ensile	--	24 acres ÷ .59 acres/hr	40.7
		Total hr	146.9
		Hr/acre	6.1

Table D7. Corn Silage Labor: 75 Cows, 45 Acres Corn Silage

Item	Field efficiency	Calculation	Hours
Plow, 4 bottom	80	45 acres ÷ 2.19 acres/hr	20.5
Disk, 10 ft, 2 times	85	(45 acres ÷ 1.86 acres/hr)*2	48.4
Plant, 4 row conventional	60	45 acres ÷ 3.0 acres/hr	15.0
Spray, 21 ft boom	65	45 acres ÷ 10.65 acres/hr	4.2
Cultivate, 4 row	80	45 acres ÷ 3.36 acres/hr	13.4
Forage harvester, 2 row, 30 in	60	45 acres ÷ .9 acres/hr	50.0
Transport and ensile, 2 men	--	(45 acres ÷ .9 acres/hr)*2 men	100.0
		Total hr	251.5
		Hr/acre	5.6

Table D8. Corn Silage Labor: 150 Cows, 90 Acres Corn Silage

Item	Field efficiency	Calculation	Hours
Plow, 5 bottom	80	90 acres ÷ 2.88 acres/hr	31.3
Disk, 12 ft, 2 times	85	(90 acres ÷ 5.51 acres/hr)*2	65.3
Plant, 4 row conventional	60	90 acres ÷ 3.0 acres/hr	30.0
Spray, 21 ft boom	65	90 acres ÷ 10.65 acres/hr	8.5
Cultivate, 4 row	80	90 acres ÷ 3.36 acres/hr	26.8
Forage harvester,med. duty	65	90 acres ÷ 1.25 acres/hr	72.0
Transport and ensile,2 men	--	(90 acres ÷ 1.25 acres/hr)*2 men	144.0
		Total hr	449.9
		Hr/acre	5.0

Table D9. Corn Silage Labor: 300 Cows, 180 Acres Corn Silage

Item	Field efficiency	Calculation	Hours
Plow, 7 bottom	80	180 acres ÷ 4.03 acres/hr	44.6
Disk, 16 ft, 2 times	85	(180 acres ÷ 7.30 acres/hr)*2	49.3
Plant, 8 row conventional	60	180 acres ÷ 5.94 acres/hr	30.3
Spray, 21 ft boom	65	180 acres ÷ 10.65 acres/hr	16.9
Cultivate, 8 row	80	180 acres ÷ 6.72 acres/hr	26.8
Forage harvester, self-propelled	65	180 acres ÷ 1.65 acres/hr	109.1
Transport and ensile,3 men	--	(180 acres ÷ 1.65 acres/hr)* 3 men	327.3
		Total hr	604.2
		Hr/acre	3.4

Table D10. Haylage Labor: 75 Cows, 71.1 Acres Haylage (11.9 Acres New Crop, 59.2 Established)[a]

Item	Field efficiency	Calculations	Hours
Plow,4 bottom,new crop	80	11.9 acres ÷ 2.19 acres/hr	5.4
Disk,10 ft,new crop,2 times	85	(11.9 acres ÷ 4.59 acres/hr)*2	5.2
Grain drilled, new crop	60	11.9 acres ÷ 3.33 acres/hr	3.6
Spray,21 ft boom,weeds,new crop	65	11.9 acres ÷ 10.65 acres/hr	1.1
Spray,21 ft boom,insects, all acreage	65	71.1 acres ÷ 10.65 acres/hr	6.7
Mower conditioner,9 ft, 1 time, new crop	75	11.9 acres ÷ 3.65 acres/hr	3.3
Mower conditioner,9 ft,3 times,established	75	(59.2 acres ÷ 3.65 acres/hr)*3	48.7
Rake,18 ft,2 times,new crop	80	11.9 acres ÷ 3.88 acres/hr	3.1
Rake,18 ft, 6 times,estab.	80	(59.2 acres ÷ 3.88 acres/hr)*6	91.5
Forage harvester,9 ft,new crop	65	11.9 acres ÷ 1.75 acres/hr	6.8
Forage harvester,9 ft,estab. 3 times	65	(59.2 ÷ 1.75 acres/hr)*3	101.5
Transport and ensile,new crop, 2 men	--	(11.9 acres ÷ 1.75 acres/hr) *2	13.6
Transport and ensile, estab.,3 times,2 men	--	(59.2 ÷ 1.75 acres/hr)*6	203.0
		Total hr	493.5
		Hr/acre	6.9

[a]Assumes aflalfa is re-seeded at the end of every 5th year and the new crop is 16.7% the total acres.

Table D11. Haylage Labor: 150 Cows, 142.2 Acres Haylage (23.7 Acres New Crop, 118.5 Acres Established)[a]

Item	Field efficiency	Calculations	Hours
Plow, 5 bottom,new crop	80	23.7 acres ÷ 2.88 acres/hr	8.2
Disk,12 ft, 2 times	85	(23.7 acres ÷ 5.51 acres/hr)*2	8.6
Grain drill, new crop	60	23.7 acres ÷ 3.31 acres/hr	7.2
Spray, 21 ft boom,weeds, new crop	65	23.7 acres ÷ 10.65 acres/hr	2.2
Spray,21 ft boom,insects, all hay	65	142.2 acres ÷ 10.65 acres/hr	13.4
Mower conditioner,9 ft,new crop	75	23.7 acres ÷ 3.88 acres/hr	6.1
Mower conditioner,9 ft,estab. 3 times	75	(118.5 acres ÷ 3.88 acres/hr) *3	91.6
Rake,18 ft,2 times,new crop	80	(23.7 acres ÷ 7.78 acres/hr)*2	6.1
Rake,18 ft,6 times,estab.	80	(118.5 acres ÷ 7.78 acres/hr) *6	91.4
Forage harvester,9 ft,new crop	65	23.7 acres ÷ 2.5 acres/hr	9.5
Forage harvester,9 ft,estab. 3 times	--	(118.5 acres ÷ 2.5 acres/hr) *3	142.2
Transport and ensile,new crop, 3 men	--	(23.7 acres ÷ 2.5 acres/hr)*3	28.4
Transport and ensile,estab. 3 times, 3 men	--	(118.5 acres ÷ 2.5 acres/hr) *9	426.6
		Total hr	841.5
		Hr/acre	5.9

[a]Assumes alfalfa is re-seeded at the end of every 5th year and the new crop is 16.7% of the total acres.

Table D12. Haylage Labor: 300 Cows, 284.4 Acres Haylage (47.5 Acres New Crop, 236.9 Established)[a]

Item	Field efficiency	Calculations	Hours
Plow, 7 bottom,new crop	80	47.5 acres ÷ 4.03 acres/hr	11.8
Disk,16 ft new crop,2 times	85	(47.5 acres ÷ 7.30 acres/hr) *2	13.0
Grain drill,new crop	60	47.5 acres ÷ 3.3 acres/hr	14.4
Spray,21 ft boom,weeds, new crop	65	47.5 acres ÷ 10.65 acres/hr	4.5
Spray,21 ft boom,insects, all acreage	65	284.4 acres ÷ 10.65 acres/hr	26.7
Windrower,14 ft,self-propelled,new crop	75	47.5 acres ÷ 5.67 acres/hr	8.4
Windrower,14 ft,self-propelled,estab.,3 times	75	(236.9 acres ÷ 5.67 acres/hr) *3	125.3
Rake,18 ft,new crop,2 times	80	(47.5 acres ÷ 7.78 acres/hr) *2	12.2
Rake,18 ft,estab.,6 times	80	(236.9 acres ÷ 7.78 acres/hr) *6	182.7
Forage harvester,14 ft,self-propelled,new crop	65	47.5 acres ÷ 3.5 acres/hr	13.6
Forage harvester,14 ft,self-propelled,estab.,3 times	65	(236.9 acres ÷ 3.5 acres/hr) *3	203.0
Transport and ensile,new crop, 3 men	--	(47.5 acres ÷ 3.5 acres/hr) *3	40.7
Transport and ensile,estab. 3 times, 3 men	--	(236.9 acres ÷ 3.5 acres/hr) *9	609.2
		Total hr	1265.5
		Hr/acre	4.4

[a]Assumes alfalfa is re-seeded at the end of every 5th year and the new crop is 16.7% of the total acres.

Table D13. Hay Labor: 40 Cows, 63 Acres Hay (10.5 Acres New Crop, 52.5 Established)[a]

Item	Field efficiency	Calculations	Hours
Plow, 3 bottom,new crop	80	10.5 acres ÷ 1.51 acres/hr	6.9
Disk,8 ft, 2 times,new crop	85	(10.5 acres ÷ 3.67 acres/hr)*2	5.8
Grain drill,new crop	60	10.5 acres ÷ 3.33 acres/hr	3.2
Spray,21 ft boom,weeds,new crop	65	10.5 acres ÷ 10.65 acres/hr	1.0
Spray,21 ft boom,insects, all acreage	65	63 acres ÷ 10.65 acres/hr	5.9
Mower conditioner,9 ft,1 time,new crop	75	10.5 acres ÷ 3.65 acres/hr	2.9
Mower conditioner,3 times estab.	75	(52.5 acres ÷ 3.65 acres/hr) *3	43.1
Rake,9 ft,2 times,new crop	80	(10.5 acres ÷ 3.88 acres/hr) *2	
Rake,9 ft, 6 times, estab.	80	(52.5 acres ÷ 3.88 acres/hr) *6	81.2
Baler thrower,1 time, new crop	65	10.5 acres ÷ 1.91 acres/hr	5.5
Baler thrower,3 times,new crop	65	(52.5 acres ÷ 1.91 acres/hr) *3	82.5
Transported and stored,1 time,new crop,3 men	--	(10.5 acres ÷ 1.91 acres/hr) *3	16.5
Transported and stored,3 times,estab.,3 men	--	(52.5 acres ÷ 1.91 acres/hr) *9	247.4
		Total hr	507.3
		Hr/acre	8.1

[a]Assumes alfalfa is re-seeded at the end of every 5th year and the new crop is 16.7% of the total acres.

Table D14. Hay Labor: 150 Cows, 95 Acres Hay (15.8 Acres New Crop, 79.2 Acres Established)[a]

Item	Field efficiency	Calculations	Hours
Plow,5 bottom,new crop	80	15.8 acres ÷ 2.88 acres/hr	5.5
Disk,12 ft, 2 times	85	(15.8 acres ÷ 5.51 acres/hr)*2	5.7
Grain drill,new crop	60	15.8 acres ÷ 3.33 acres/hr	4.7
Spray,21 ft boom,weeds, new crop	65	15.8 acres ÷ 10.65 acres/hr	1.5
Spray, 21 ft boom,insects all hay	65	95 acres ÷ 10.65 acres/hr	8.9
Mower conditioner,9 ft,new crop	75	15.8 acres ÷ 3.88 acres/hr	4.1
Mower conditioner,9 ft, estab.,3 times	75	(79.2 acres ÷ 3.88 acres/hr) *3	61.2
Rake,18 ft,2 times, new crop	80	(15.8 acres ÷ 7.78 acres/hr) *2	4.1
Rake,18 ft,6 times, estab.	80	(79.2 acres ÷ 7.78 acres/hr) *6	61.1
Baler,bales dropped, 1 time,new crop	75	15.8 acres ÷ 2.21 acres/hr	7.1
Baler,bales dropped, 3 times, estab.	75	(79.2 acres ÷ 2.21 acres/hr) *3	107.5
Transport and store,1 time new crop, 3 men	--	(15.8 acres ÷ 2.21 acres/hr) *3	21.4
Transport and store,3 times estab., 3 men	--	(79.2 acres ÷ 2.21 acres/hr) *9	322.5
		Total hr	615.3
		Hr/acre	6.5

[a]Assumes alfalfa is re-seeded at the end of every 5th year and the new crop is 16.7% of the total acres.

Table D15. Hay Labor: 300 Cows, 190 Acres Hay (31.6 Acres New Crop, 158.4 Established)[a]

Item	Field efficiency	Calculations	Hours
Plow,7 bottom,new crop	80	31.6 acres ÷ 4.03 acres/hr	7.8
Disk,16 ft, new crop,2 times	85	(31.6 acres ÷ 7.30 acres/hr) *2	8.7
Grain drill, new crop	60	31.6 acres ÷ 3.33 acres/hr	9.5
Spray,21 ft boom,weeds, new crop	65	31.6 acres ÷ 10.65 acres/hr	3.0
Spray,21 ft boom,insects, all acreage	65	190 acres ÷ 10.65 acres/hr	17.8
Windrower,14 ft,self-propelled,1 time,new crop	75	31.6 acres ÷ 5.67 acres/hr	5.6
Windrower,14 ft,self-propelled,3 times,estab.	75	(158.4 acres ÷ 5.67 acres/hr) *3	83.3
Rake,18 ft,2 times,new crop	80	(31.6 acres ÷ 7.78 acres/hr) *2	81.2
Rake,18 ft,6 times,estab.	80	(158.4 acres ÷ 7.78 acres/hr) *6	122.2
Baler,bales dropped,9 ft windrow,1 time,new crop	65	31.6 acres ÷ 2.84 acres/hr	11.1
Baler,bales dropped,9 ft windrow,3 times,new crop	65	(158.4 acres ÷ 2.84 acres/hr) *3	167.3
Transport and store,1 time, new crop, 2 men	--	(31.6 acres ÷ 2.84 acres/hr) *3	33.3
Transport and store, 3 times estab.,2 men	--	(158.4 acres ÷ 2.84 acres/hr) *9	502.0
		Total hr	1053.3
		Hr/acre	5.5

[a]Assumes alfalfa is re-seeded at the end of every 5th year and that the new crop is 16.7% of the total acres.

Table D16. Summary of Crop Labor Requirements by Acres and Equations to Predict Crop Labor Requirements[a]

Crop	Acres	Hours/Acre[b]	Equation[c]
Haylage	71	8.6	$Y = 4.6 + 284/X$
	142	7.4	
	284	5.5	
Hay	63	10.1	
	95	8.1	$Y = 5.4 + 250/X$
	190	6.9	
Corn Grain	42	4.9	
	79	4.5	$Y = 2.2 + 125/X$
	158	3.1	
	315	2.5	
Corn Silage	24	7.6	
	45	7.0	$Y = 3.7 + 90/X$
	90	6.3	
	180	4.3	

[a]Based on Tables D2 through D15.
[b]Estimated by multiplying hours of labor/acre estimated in Tables D2 through D15 by 1.25 to allow for breaks, breakdown, etc.
[c]Y = hr of labor acre; X = number of acres

Table D17. Telfarm Equation Estimating Enterprise Labor Requirements[a]

Crop	Equation
Haylage	$Y = 8.47 + 47.88/X$
Hay	$Y = 11.29 + 47.89/X$
Corn Grain	$Y = 5.39 + 57.41/X$
Corn Silage	$Y = 7.39 + 57.41/X$

[a]Source: Schwab et al., 1983.

Table D18. Calculated and Predicted Labor Requirements by Acres

Crop	Acres	Calculated hr (Tables D2-D15)	Predicted (Table D16)	Predicted by Telfarm (Table D17)
Haylage	71	8.6	8.6	9.1
	142	7.4	6.6	8.8
	284	5.5	5.6	8.6
Hay	63	10.1	9.4	12.0
	95	8.1	8.0	11.8
	190	6.9	6.7	11.5
Corn Grain	42	4.9	5.2	6.8
	79	4.5	3.8	6.1
	158	3.1	3.0	5.8
	315	2.5	2.6	5.6
Corn Silage	24	7.6	7.5	9.8
	45	7.0	5.7	8.7
	90	6.3	4.7	8.0
	180	4.3	4.2	7.7

APPENDIX E

DAIRY BUILDINGS AND FACILITIES ESTIMATES

Buildings and facilities and equipment were assembled for herd sizes of 40, 75, 150, 300 and 500 cow herds. The principle source of information used to assemble building costs is: Bath et al., Appendix Table V-J. Cost estimates published there are outdated and therefore inflated by a factor of 1.44 for buildings (Bureau of Industrial Economics, 1983) and 1.65 for other equipment (Economic Research Service, 1983).

Sources of prices used to estimate costs in Tables El through E8 are listed below:

Abbreviation	Source
H	Bath et al., 1978,Appendix Table V-J
CD	Central Dairy Supply, 2810 Canal St., Lansing, Michigan - via phoen conversation, 1982
PPFI	Crop Reporting Board, 1982a,b
CAP	Shaudys, 1980
OG	National Farm Power and Equipment Dealers Association, 1982
AE	Prices obtained from exhibitors at Ag Expo, East Lansing, Michigan - via conversation, 1983
D	DeLaval, Alfa-Laval, Inc., 1983 - via mail correspndence

Table E1. Dairy Buildings and Facilities, Equipment; Herd Size = 40 Cows, Confinement-Stall Barn

Item	Investment cost ($)	Source	Years life	Inflation factor
Buildings and facilities:	71,350			
Confined-stall barn (including gutter and other cement work, ventilation, insulation, milkroom, and hospital area	58,450	H	20	1.44
Youngstock housing (Virginia style barn, hutches for newborn calves	6,000	B	20	----
Manure storage, 6 months	6,900	H	20	1.44
Equipment:	66,250			
Pipeline milking system (including bulk tank, sinks etc.)	20,500	CD	8	----
Gutter cleaner + manure stacker	11,150	H	8	1.65
Manure spreader (150 bu)	2,500	CAP	8	----
Front end loader	3,000	PPFI	8	----
Tractor, 40 hp tractor	14,000	OG	8	----
Pickup truck	6,200	PPFI	8	----
Roller mill	1,300	AE	8	----
Feed cart (59 bu Uebler cart)	4,400	AE	8	----
Miscellaneous equipment[a]	3,200		8	----

[a]Miscellaneous is estimated as 10% of the total equipment cost.

Table E2. Dairy Buildings and Facilities, Equipment; Herd Size = 75 Cows Free-Stall Barn

Item	Investment cost ($)	Source	Years life	Inflation factor
Buildings and facilities:	119,800			
Free-stall barn(including barn structure and concrete, free-stall, water, wiring and plumbing, milk-room and parlor and hospital area	94,400	H	20	1.44
Youngstock housing (Virginia style barn, hutches for newborn calves)	15,000	B	20	----
Manure storage (earthen pit, 6 months)	10,400	H	20	1.44
Equipment:	101,100			
Herringbone parlor milking system (double-4, no mechanization, std. stalls)	23,700	D	8	----
bulk tank and cooling	13,000	CE	8	
Manure agitator pump (trailer)	5,000	PS	8	
Manure spreader	6,800	OG	8	
Front end loader	2,900	PPFI	8	
Tractor (40 hp)	14,000	OG	8	
Tractor (75 hp)	19,000	OG	8	
Pickup truck	6,200	PPFI	8	
Roller mill	1,300	AE	8	
Feeding cart (50 bu, Uebler cart)	4,400	AE	8	
Miscellaneous	4,800	--	8	

Table E3. Dairy Buildings and Facilities, Equipment; Herd Size = 150 Cows, Free-Stall Barn

Item	Investment cost ($)	Source	Years life	Inflation factor
Buildings and Facilities:	202,850			
Free-stall barn (including barn structure and concrete, free stalls, water wiring and plumbing, milk-room and parlor and hospital area)	154,350	H	20	1.44
Youngstock housing (Virginia style barn, hutches for new-born calves	30,000	B	20	----
Manure storage (earthen pit, 6 months)	18,500	H	20	1.44
Equipment:	136,950			
Herringbone parlor milking system (double-4, including HD stalls, no mechanization)	26,300	D	8	----
Bulk tank and cooling	18,650	H	8	1.65
Manure agitator pump (trailer)	5,000	PS	8	----
Manure spreader, liquid	10,100	H	8	1.44
Front end loader	2,900	PPFI	8	----
Tractor (40 hp)	14,000	OG	8	----
Tractor (90 hp)	30,000	OG	8	----
Pickup truck	6,200	PPFI	8	----
Roller mill	1,300	AE	8	----
Mixer wagon	16,000	H	8	1.44
Miscellaneous	6,500	-	8	----

Table E4. Dairy Buildings and Facilities, Equipment; Herd Size = 300 Cows, Free-Stall Barn

Item	Investment cost ($)	Source	Years life	Inflation factor
Buildings and facilities:	368,700			
Free-stall barn (including barn structure and concrete, free stalls, water wiring and plumbing, milk-room and parlor and hospital area)	274,000	H	20	1.44
Youngstock housing (Virginia style barn, hutches for newborn calves)	60,000	B	20	----
Manure storage (earthen pit, 6 months)	34,700	H	20	1.44
Equipment:	205,450			
Herringbone parlor milking system (double-8, with detachers, power gates)	60,250	D	8	----
Bulk tank and cooling	30,000	H	8	1.65
Manure agitator pump (trailer)	5,000	PS	8	----
Manure spreader, liquid	12,000	H	8	1.44
Front end loader	2,900	PPFI	8	----
2 tractors (40 hp)	28,000	OG	8	----
Tractor (90 hp)	30,000	OG	8	----
Pickup truck	6,200	PPFI	8	----
Roller mill	1,300	AE	8	----
Mixer wagon	20,000	H	8	1.44
Miscellaneous	9,800	-	8	----

Table E5. Dairy Buildings and Facilities, Equipment; Herd Size = 500 Cows, Free-Stall Barn

Item	Investment cost ($)	Source	Years life	Inflation factor
Buildings and facilities:	590,300			
Free-stall barn (including barn structure and concrete free stalls, water, wiring and plumbing, milkroom and parlor and hospital area)	434,000	H	20	1.44
Youngstock housing (Virginia style barn, hutches for newborn calves)	100,000	B	20	1.44
Manure storage (earthen pit, 6 months)	56,300	H	20	1.44
Equipment:	221,400			
Herringbone parlor milking system (double-8, with detachers, power gate)	60,250	D	8	----
Bulk tank and cooling	45,200	H	8	1.65
Manure agitator pump (trailer)	5,000	-	8	----
Manure spreader, liquid	12,000	-	8	----
Front end loader	2,900	-	8	----
2 tractors (40 hp)	28,000	OG	8	----
Tractor (90 hp)	30,000	OG	8	----
Pickup truck	6,200	PPFI	8	----
Roller mill	1,300	AE	8	----
Mixer wagon	20,000	H	8	1.44
Miscellaneous	10,550	-	8	----

APPENDIX F

THE DAIRY INVESTMENT MODEL

THE DAIRY INVESTMENT MODEL

F1. Orientation

This contains the template of the investment program for use with the MICROSOFT MULTIPLAN electronic worksheet and was developed to evaluate the three strategies described in this thesis. The program name is DRYINV.MP and can be accessed by this name. A brief description of each component of the model and the formulas comprising each component are presented in the following pages. The user should be familiar with MULTIPLAN to operate the program. All cells containing text and formulas are locked except those containing the values for rows 13:17 column 3. These are values for the following variables:

Location	Description	Acronym	Value
R13C3	soil management group	SMG	enter either 2.5,3 or 4
R14C3	milk production level of the herd(thousand lb)	MP	enter either 13,15,17 or 19
R15C3	price of land ($/acre)	PLND	enter price
R16C3	price of milk ($/cwt)	PMLK	enter price
R17C3	price of shelled corn($/bu)	PSCORN	enter price

Values of other variables are default values; they can be changed by simply unlocking the cell containing the value to change, and then making the change. Variables described as endogenous variables should be changed with caution as their values are estimated by formulas.

Section IA is typically the only section where users will enter values. Every time the value of a cell (e.g. variable) is changed the entire worksheet is re-estimated based on the new value entered.

It is a good idea to define: Options recalc as "no" (see users manual for Microsoft:Multiplan) which will allow the user to change all the values he/she desires without having to wait for the program to re-estimate for each individual change. When all values have been changed to those desired, simply press the exclamation character (!) and the worksheet will be re-estimated based on all the new values entered.

F2. INTRODUCTION

DAIRY INVESTMENT ANALYSIS PROGRAM

This program is designed to allow the user to investigate the profitability of three alternative strategies of securing feeds on dairy farms in Southern Michigan and other similar areas. The strategies include: 1) growing forages and grain (GFG); 2) growing forages (GF) or 3) purchasing all feed (PR). The strategies are examined across herd sizes of 40, 75, 150 and 300 cows for farms GFG and GF and 40, 75, 150, 300 and 500 cows for farms PR. The model assumes: 1) farms GFG or GF just have enough land to grow the appropriate amounts of alfalfa and corn silage; 2) farms GFG have additional land to grow corn needed; 3) 60% of the forage dry matter is alfalfa and 40% is corn silage, across all feeding strategies.

The user specifies the economic conditions and prices and production factors within the bounds of the program by setting the values of the exogenous variables in component IA. This allows the user to examine profitability across all three strategies and each herd size within each strategy for any given set of conditions.

Component I (A-D) sets the stage in terms of economic conditions and prices and production factors. This includes selecting the soil management group (2.5, 3 or 4) which selects which crop yields/acre to use to estimate the amount of land needed and the crop budget expenses for farms which GF or GFG. The level of milk production: (13,15,17 or 19)000 lb specified, selects which ration (quantities of each feed needed/cow and replacement/year) to use to estimate quantities of feeds needed/herd/year.

Components II through IX estimate the various inputs and expenses incurred by herd sizes, noting differences across strategies where they exist.

Component X estimates incomes across herd sizes and possible adjustments to income taking into account: 1) the value of manure produced; 2) soybean meal savings on farms GFG or GF which grow haylage and 3) savings in the annual use charge on machinery which is common to the dairy and cropping enterprises for farms GFG or GF.

Components XI and XII estimate the total feed cost and total annual costs across herd sizes by feeding strategy by summing up relevant component costs in III through IX.

Component XIII (A-C) estimates profit (in terms of total profit/farm) by summing relevant incomes - total costs, for each herd size within each strategy. Total investments are estimated by summing the appropriate investment component costs within each herd size and strategy.

Component XIV estimates the intercepts, slopes and coefficients of determination regressing profit, number of cows and number of laborers on total investment across herd sizes for each strategy.

Component XV summarizes profits, rates of return on investment, numbers of laborers and number of cows for levels of investment of: $.5, 1.0, 1.5, 2.0 and 2.5 million for each strategy.

This model is useful in projecting long-term profit expectations. It does not consider within year or across years price or yield variations, income taxes, method or detail of financing or yearly cash flows necessary to keep the business solvent. Real interest rates are used and the model assumes that incomes and expenses inflate at the same rate.

Profit is defined as total income-total expense. The model charges interest against all capital investments. All labor (including that which may be family or operator/owner) is considered as an expense. Since returns to capital and labor are already accounted for in expenses, profit is essentially management income.

F3. OUTLINE OF THE INVESTMENT MODEL

I. IA. INPUTS: The value of the variables described here are used to estimate the costs and returns and total investment budgeted in sections II-XIII.

The user can specify values for the following exogenous (EX) variables:

Variable	Variable Name (acronym)	Value (default)
Soil management group (2.5,3 or 4)	SMG	3
Milk production (thousand lb) (13,15,17 or 19)	MP	15
Price of land ($/acre)	PLND	1100
Price of milk ($/cwt)	PMLK	12
Purchase price of shelled corn($/bu)	PSCORN	2.70
Interest rate (decimal)	INTRT	.04
Property tax charge(decimal)	PTXRT	.02
Property insurance charge(decimal)	INSRT	.01
Land value growth rate (decimal)	LNDGRWTHRT	.01
Price of nitrogen ($/lb)	PN	.16
Price of phosphorus ($/lb)	PP	.20
Price of potassium ($/lb)	PK	.12
Price of dicalcium phosphate($/lb)	PDCL	.19
Price of limestone ($/lb)	PLMSTN	.05
Price of salt ($/lb)	PSLT	.07
Price of labor ($/hr)	PLBR	6.00
Price of fuel ($/gal)	PFL	1.10

Values of the following exogenous variables should not be changed:

Herd size 1 (# cows)	HSZ 1	40
Herd size 2 (# cows)	HSZ 2	75
Herd size 3 (# cows)	HSZ 3	150
Herd size 4 (# cows)	HSZ 4	300
Herd size 5 (# cows)	HSZ 5	500
Investment size 1 ($)	INV 1	500,000
Investment size 2 ($)	INV 2	1,000,000
Investment size 3 ($)	INV 3	1,500,000
Investment size 4 ($)	INV 4	2,000,000
Investment size 5 ($)	INV 5	2,500,000

Values of the following endogenous (EN) variables are estimated by formulas:

Variable	Variable Name (acronym)	Contingent upon
Price of milking cows ($/cow)	PCWS	MP,PMLK
Price of cull cows ($/cwt)	PCLLCW	PMLK
Price of cull heifers ($/cwt)	PCLLHFR	PCLLCW
Price of heifers ($/heifer)	PHFRS	MP,PMLK
Price of deacon calves($/cwt)	PDCNCLVS	PCLLCWS
Price of alfalfa hay ($/ton)	PALFHY	PSCORN
Price of corn silage($/ton)	PCSLG	PSCORN,PP,PK
Price of soybean meal ($/lb)	PSYML	PALFHY
Capital charge for machinery(decimal)	CPTMCH	INTRT
Capital charge for buildings and facilities (decimal)	CPTBLDG	INTRT

IB:CROP BUDGETS: Estimates costs/acre for corn, corn silage, alfalfa hay, alfalfa haylage are based on crop yields/acre which are determined based on the soil management group specified in IA. These yields by management group are contained in ID.

IC:RATIONS: This is a table containing the amount of shelled corn (bu), corn silage (tons), alfalfa hay (tons), soybean meal (lb), dicalcium phosphate (lb), salt (lb) and limestone (lb) needed/cow and replacement for levels of production of 13, 15, 17 or 19,000 lb of milk and considers amounts of feeds wasted.

ID:CROP YIELDS: This is a table containing the yields/acre of: corn, corn silage, alfalfa hay and alfalfa haylage for land in soil management groups 2.5, 3 or 4.

II. FEED QUANTITIES: This component estimates the total amount of feed needed for herd sizes of 40, 75, 150, 300 and 500 cows and includes amounts needed by replacements. This is estimated using the amounts of feed needed/cow and replacement according to level of milk produced (IC) and the number of cows.

III. FEED STORAGE FACILITIES: Estimates the investments in feed storage facilities for corn, corn silage, alfalfa hay and haylage and the annual costs associated with these facilities for each herd size within each strategy.

IV. PURCHASED FEED: Estimates the value of purchased feeds for each herd size within each category.

V. CROPLAND: Estimates the total acres of crops needed to supply feed needs for each herd size for the strategy of GFG and GF. The total investment in land for crop production and annualized costs/acre for land are estimated. Annual costs include an interest charge and considers the rate of growth of land values.

VI. CROP MACHINERY: Estimates the total investment and annualized costs for crop machinery for each herd size for farms GFG or GF.

VII. CROP EXPENSES: A) Estimates the annual crop expenses for each herd size for the strategies GFG and GF. Estimated by multiplying the number of acres of each crop by the budgeted crop expenses/acre from IB. B) Labor required for each crop is estimated based on the number of acres grown. C) The cost of labor is estimated by multiplying number of hours of labor by the price paid/hr.

VIII. DAIRY FACILITIES: Estimates the investments and annualized costs of investments in buildings and facilities, equipment and land for facilities for each herd size within each strategy.

IX. LIVESTOCK EXPENSES: A) Estimates the livestock care expenses (building repairs, equipment repairs, livestock supplies, breeding fees, vet and medicine, fuel, insurance, utilities, marketing and other cash expenses) associated with the dairy for each herd size within each strategy. B) Estimates the labor requirements and costs considering the effect of herd size and technology on hours of labor/cow. C) Estimates the investment in dairy cows and the annualized charge of capital invested in dairy cows considering cows as assets with an infinite life.

X. INCOME: A) Estimates income from the sale of milk, deacon calves, cull cows, cull heifers, and excess replacement heifers for each herd size within each strategy. B) The value of manure as a savings in fertilizer cost is estimated for the strategies of GFG and GF. The savings in soybean meal costs due to higher quality forages is estimated for the strategies of GFG and GF. C) Estimates the investment savings in machinery due to the complementarity of some of the crop machinery and dairy equipment. The savings in annualized costs of this machinery is estimated.

XI. TOTAL FEED COST: Estimates total feed costs considering purchased feed costs (IV) and annual feed storage costs (III) for each herd size within each strategy. Soybean meal savings (X) and annual crop expenses and labor (VII), land (V) and machinery (VI) are considered for GFG and GF. Savings in annualized crop machinery expenses (X) are accounted for. Interest is charged against purchased feed and crop expenses.

XII. TOTAL ANNUAL COST: Estimates total annual expenses for each herd size within each strategy considering total feed cost (XI), and all livestock expenses including livestock and expenses, livestock labor, annual use cost of capital invested in livestock (IX). It also accounts for annualized costs attributed to dairy buildings and facilities, equipment and land for dairy facilities (VIII).

XIII. PROFIT: 1) Estimates total profit for each herd size within each strategy. Profit is estimated considering: Income (X) total annual costs (XII) and the savings in fertilizer expense including interest (X) for farms GF and GFG. Farms PR are assumed to recover 25% of the value of manure produced, by selling it. 2) Estimates total investments for each herd size within each strategy considering investments in: feed storage facilities (III), dairy buildings and facilities (VIII), land for dairy facilities (VIII), dairy equipment (VIII) and livestock (VIII). For farms GFG and GF investments in: crop land (V), crop machinery (VI), savings in investments in machinery due to the complementarity of the cropping and dairy enterprises (X) are accounted for. 3) Estimates the rate of return on investment (RROI). 4) Estimates the number of laborers and 5) Estimates the adjusted cost/cwt of milk produced. 6) Calculates the linear regression estimate of profit based on the total investment, for each herd size within each strategy. This value can be compared to the profit estimated above to examine how well the regression estimate tracks the budgeted value of profit.

XIV. REGRESSION: Estimates the intercepts, slopes and coefficients of determination by regressing profit, number of cows and number of laborers on total investment across herd sizes for each strategy as summarized in XIII.

XV. SUMMARY. Summarizes in tabular form the profit, rate of return on investment (RROI), number of cows and numbers of laborers for each strategy, considering levels of investment of: $.5, 1.0, 2.0, and 2.5 million. The slopes (b), intercepts (a) and coefficients of determination (R2) for the regression estimating profit/dollar invested are listed for each strategy. The footnotes contain the maximum numbers of dollars actually budgeted in the analysis. Investment sizes greater than these are extrapolations.

DAIRY INVESTMENT ANALYSIS PROGRAM BY J. HLUBIK

IA INPUTS: SET PRODUCTION FACTORS AND ECONOMIC CONDITIONS AND
-- PRICES TO PROPOSED VALUES

VARIABLE NAME	VALUE	VARIABLE NAME	VALUE	VARIABLE NAME	VALUE	VARIABLE NAME	VALUE
SMC	3	PALFHY	75.00	CPTMCH	0.121	INV1	500000.00
MP	15	PCSLG	18.31	CPTBLDG	0.074	INV2	1000000.00
PLND	1100	PSYML	0.12			INV3	1500000.00
PMLK	12.00	PLMSTN	0.05	PN	0.16	INV4	2000000.00
PSCORN	2.70	PDCL	0.19	PP	0.20	INV5	2500000.00
		PSLT	0.07	PK	0.12		
INTRT	0.040						
PTXRT	0.020	PCWS	1088.35	HSZ1	40		
INSRT	0.010	PCLLCW	39.47	HSZ2	75		
LNDGRWTHRT	0.010	PCLLHFR	51.46	HSZ3	150		
PFL	1.10	PHFRS	960.85	HSZ4	300		
PLBR	6.00	PDCNCLVS	65.06	HSZ5	500		
				CLLS	25.00		

IB CROP BUDGETS:

--	BSCORN	BCSLG	BALFHY	BALFHYLG
SDS	18.08	18.34	5.00	5.00
WS	11.20	11.20	1.75	1.75
INSCT	2.00	2.00	5.00	5.00
N	21.33	23.77	0.00	0.00
P	10.68	13.31	8.56	9.32
K	9.00	15.86	21.60	23.70
LMSTN	4.75	4.54	11.80	12.96
UTLTS	2.56	5.19	0.00	0.00
TRCK	11.03	14.92	5.88	3.56
FL	12.43	12.57	7.96	21.89
RPRS	13.60	18.20	20.58	24.63
OTHR	0.00	0.00	9.40	3.00
	BSCORNT	BCSLGT	BALFHYT	BALFHYLGT
TTL	116.65	139.92	97.53	110.80

IC RATIONS:

-- MILKPROD	NO	SCORN	CSLG	ALFHY	SYML	SLT	DCL
13	1	87.0	10.1	6.5	535.0	95.0	100.0
15	2	110.0	9.6	6.2	1011.0	95.0	100.0
17	3	134.0	8.9	5.8	1529.0	95.0	100.0
19	4	157.0	8.3	5.6	2020.0	95.0	100.0

1	2	3	4	5	6	7

ID CROP YIELDS:

--

SMGRNO	YSCORN	YCSLG	YALFHY	YALFHYLG
1	114.0	15.5	5.0	8.7
2.5	120.0	16.8	4.6	9.0
3	105.0	15.3	4.0	7.9
4	86.0	13.2	3.5	6.9

II FEED QUANTITIES :

--

QUANTITY	HERD SIZE 40	75	150	300	500
QSCORN	4400	8250	16500	33000	55000
QCSLG	384	720	1440	2880	4800
QALFHYGF	248	186	372	744	0
QALFHYLGGF	0	485.46	970.92	1941.84	0
QALFHYPR	248	465	930	1860	3100
QSYML	40440	75825	151650	303300	505500
QDCL	4000	7500	15000	30000	50000
QSLT	3800	7125	14250	28500	47500
QLMSTN	0	0	0	0	0

III FEED STORAGE FACILITIES:

	HERD SIZE 40	75	150	300	500
STOSCORN	9328.00	18983.50	26425.00	41308.00	61152.00
STOCSLG	21905.60	26420.00	40280.00	68000.00	104960.00
STOALFHYGF	10850.00	8137.50	16275.00	32550.00	
STOALFHYPR	6200.00	11625.00	23250.00	46500.00	77500.00
STOALFHYLG	0.00	24268.05	35618.11	58318.22	
STOTINVGF	42083.60	77809.05	118598.11	200176.22	
STOANNGF	3727.84	6892.46	10505.63	17731.96	
STOTINVPR	37433.60	57028.50	89955.00	155808.00	243612.00
STOTANNPR	3315.93	5051.68	7968.37	13801.75	21579.58

IV PURCHASED FEED:

--

	HERD SIZE 40	75	150	300	500
PRFDGFG	5681.05	10651.97	21303.93	42607.86	71013.11
PRFDGF	16681.05	31276.97	62553.93	125107.86	208513.11
PRFDPR	42310.76	79332.67	158665.34	317330.69	528884.48

1 2 3 4 5 6 7

V CROP LAND:

ACRES	40	75	150	300
	HERD SIZE			
ASCORN	41.90	78.57	157.14	314.29
ACSLG	25.10	47.06	94.12	188.24
AALFHY	62.00	107.95	215.90	431.80
AGFT	91.45	162.76	325.52	651.04
AGFGT	140.03	253.40	506.80	1013.59
LNDINVGFG	154028.15	278737.72	557475.44	1114950.87
LNDANNGFG	7701.41	13936.89	27873.77	55747.54
LNDINVGF	100598.24	179035.92	358071.84	716143.69
LNDANNGF	5029.91	8951.80	17903.59	35807.18

VI CROP MACHINERY:

	HERD SIZE 40	75	150	300
MCHCRPINVGFG	145720.00	161400.00	229800.00	323400.00
MCHCRPANNGFG	19875.61	22014.29	31343.77	44110.43
MCHCRPINVGF	129720.00	143025.00	198300.00	240300.00
MCHCRPANNGF	16525.79	18220.79	25262.60	30613.23

VII CROP EXPENSES:

	HERD SIZE 40	75	150	300
CRPEXPGF	9558.23	17914.74	35829.49	71658.98
CRPEXPGFG	14446.53	27080.32	54160.64	108321.29
LBRSCORN	217.19	297.86	470.71	816.43
LBRCSLG	182.86	264.12	438.24	786.47
LBRALFHY	584.80	366.49	622.98	1135.96
LBRALFHYLG	0.00	367.14	645.22	1201.39
LBRTGF	767.66	997.75	1706.44	3123.82
LBRTGFG	984.85	1295.61	2177.16	3940.25
LBRCSTGF	4605.98	5986.51	10238.64	18742.91
LBRCSTGFG	5909.12	7773.65	13062.93	23641.49

VIII DAIRY FACILITIES:

	HERD SIZE 40	75	150	300	500
DBLDGINV	71360.00	119775.00	202800.00	368700.00	590500.00
DBLDGANN	6321.19	10609.88	17964.38	32660.09	52307.52
DLNDINV	2200	3575	8250	16500	27500
DLNDANN	110	178.75	412.5	825	1375
DEQINV	66240.00	101100.00	136950.00	205500.00	221500.00
DEQANN	9233.58	14092.92	19090.26	28645.85	30876.19

IX LIVESTOCK EXPENSES:

	HERD SIZE 40	75	150	300	500
LVSTCKEXP	15712.00	29460.00	58920.00	117840.00	196400.00
LBRLVSTCK	2920.00	4180.00	6880.00	12280.00	19480.00
LBRCSTLVSTCK	17520.00	25080.00	41280.00	73680.00	116880.00
LVSTCKINV	43534.00	81626.25	163252.50	326505.00	544175.00
LVSTCKANN	1741.36	3265.05	6530.10	13060.20	21767.00

X INCOME:

	HERD SIZE 40	75	150	300	500
INCM	81769.69	153318.17	306636.34	613272.68	1022121.14
MNRSVNGS	2352.00	4410.00	8820.00	17640.00	29400.00
MNRSVNGSGF	1872.00	3510.00	7020.00	14040.00	
SYMLSVNGS	460.44	863.33	1726.65	3453.30	
MCHSVNGSINV	20000.00	45200.00	50200.00	50200.00	
MCHSVNGSANN	2967.92	6707.49	7449.47	7449.47	

XI TOTAL FEED COST:

	HERD SIZE 40	75	150	300	500
FDCSTTGFG	55790.50	84869.89	154274.05	287932.05	
FDCSTTGF	54699.97	85992.77	158775.64	296350.36	
FDCSTTPR	46472.91	85971.01	169807.02	337479.05	561041.74

XII TOTAL ANNUAL COST:

	HERD SIZE 40	75	150	300	500
TTLANNCSTSGF	104944.68	164202.74	294746.56	550918.45	
TTLANNCSTSGF	103854.15	165325.62	299248.14	559336.77	
TTLANNCSTPR	97111.04	168657.61	314004.27	604190.19	980647.45

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
XIII PROFIT:							XIV	REGRESSION ESTIMATION						
----			HERD SIZE				---							
		40	75	150	300	500	SUM	(SUMX2)	AVG	SUMXY	SLOPE	INTERCEPT	R2	
XIIIA GROW FORAGES AND GRAIN														
	PRFTGFG	-20775.95	-6386.37	20886.19	80347.03		74070.899	7364303926	18517.725	1.189E+11	0.0503694	-46414.12	0.9994337	PROFIT
	INVGFG	505165.75	778823.02	1366926.05	2505532.09		5156446.9	9.00794E+12	1289111.7					INVESTMENT
	RROIGFG	-0.113	3.180	5.528	7.207									
	LBRGFG	1.30	1.83	3.02	5.41		11.552622	43.37318472	2.8881554	4860026.9	2.059E-06	0.2342311	0.9998034	LABOR
	CSTCWTMLK	16.14	13.08	11.50	10.59		565	119725	141.25	306968765	0.00013	-26.37703	0.9999326	HERD SIZE
	LNRAPPRXGFG	-20969.20	-7185.23	22437.19	79788.14									
XIIIB GROW FORAGES														
	PRFTGF	-20175.02	-8427.25	14548.60	68256.71		54203.041	5348690734	13550.76	8.262E+10	0.0556968	-45712.46	0.9972909	PROFIT
	INVGF	435735.84	660746.23	1136022.45	2023624.91		4256129.4	6.01206E+12	1064032.4					INVESTMENT
	RROIGF	-0.630	2.725	5.261	7.373									
	LBRGF	1.23	1.73	2.66	5.13		10.951891	39.04584184	2.7379729	3664822.6	2.471E-06	0.1092155	0.9993718	LABOR
	CSTCWTMLKGF	15.95	13.18	11.71	10.79		565	119725	141.25	243297960	0.000164	-33.2663	0.9996379	HERD SIZE
	LNRAPPRXGF	-21443.36	-8911.00	17560.38	66997.01									
XIIIC PURCHASE ALL FEEDS														
	PRFTPR	-14753.35	-14236.94	-5162.92	13492.49	48823.69	28162.965	3012807378	5632.5929	6.051E+10	0.0457659	-29930.95	0.9702988	PROFIT
	INVPR	220767.60	363104.75	601207.50	1073013.00	1627287.00	3885379.9	4.34145E+12	777075.97					INVESTMENT
	RROIPR	-2.683	0.079	3.141	5.257	7.000								
	LBRPR	0.97	1.39	2.29	4.09	6.49	15.246667	67.06688889	3.0493333	5210474.1	3.941E-06	-0.012895	0.9979697	LABOR
	CSTCWTMLKPR	14.76	13.50	12.40	11.84	11.47	1065	369725	213	434206177	0.0003284	-42.18567	0.9979697	HERD SIZE
	LNRAPPRXPR	-19827.34	-13313.15	-2416.18	19176.40	44543.23								

XV

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TABLE 5.2 CHANGES IN PROFITABILITY BY LEVEL OF INVESTMENT ACCORDING TO STRATEGY

Milk production (lb)= 15000
Corn Price ($/bu) = 2.70 Milk/feed ratio= 1.50
Milk Price ($/cwt) = 12.00

STRATEGY:	LEVEL OF INVESTMENT ($ million) 0.5	1	1.5	2	2.5	regression: profit by $invested	
GFG							
$PROFIT	-21229	3955	29140	54325	79509	a=	-46414
RROI(%)	-0.25	4.40	5.94	6.72	7.18	b=	0.050
COWS(#)	38.64	103.66	168.67	233.69	298.71	R2=	0.999
LBR(#)	1.26	2.29	3.32	4.35	5.38		
GF							
						a=	-45712
$PROFIT	-17864	9984	37833	65681	93530	b=	0.056
RROI(%)	0.43	5.00	6.52	7.28	7.74	R2=	0.997
COWS(#)	48.74	130.75	212.75	294.76	376.77		
LBR(#)	1.34	2.58	3.82	5.05	6.29		
PR							
						a=	-29931
$PROFIT	-7048	15835	38718	61601	84484	b=	0.046
RROI(%)	2.59	5.58	6.58	7.08	7.38	R2=	0.970
COWS(#)	122.01	286.21	450.40	614.60	778.79		
LBR(#)	1.96	3.93	5.90	7.87	9.84		

Returns to levels of investment beyond $ 2505532 are extrapolated for the strategy GFG
Returns to levels of investment beyond $ 2023625 are extrapolated for the strategy GF
Returns to levels of investment beyond $ 1627287 are extrapolated for the strategy PR

Soil management group = 3
Price of land ($/acre) = 1100
Price of hay ($/ton) = 75.00
Price of corn silage ($/ton)= 18.31
Price of soybean meal ($/lb)= 0.115
Price of dairy cows ($/cow)=1088.35
Price of cull cows ($/cwt)= 39.47
Price of hfrs ($/heifer)= 960.85
Price of cull hfrs ($/cwt)= 51.46
Price of cull clvs ($/cwt)= 65.06

F5. FORMULAS, VALUES AND THEIR EXPLANATION

IA: INPUTS: Set Production Factors and Economic Conditions And Prices to Proposed Values. This component allows the user to select which soil management group (2.5, 3 or 4) and level of milk production (13,15,17 or 19 thousand lb) to consider. In addition, the user can set values for the price of land, milk and corn. Other exogenous (EX) variables can be changed as well. Endogenous (EN) variables are estimated by formulas. They should be changed with caution.

Variable Name	Refers to Row:Col	Variable (units); notes	Type	See Thesis Section	Contingent Model Components
SMG	R13C3	Soil management group (2.5,3,or 4); determines which set of crop yields in (ID) to use to estimate the no. of acres of each crop required to supply feed on farms GFG or GF	EX	4.1.3.C	ID
MP	R14C3	Rolling herd average milk production/cow (13,15,17 or 19 thousand lb); determines which set of ration quantities to use to estimate annual feed quantities needed for cows and replacements	EX	4.1.1	II
		Used to estimate: PCWS and PHFRS		4.4.3	IA
		livestock expenses		4.2.2	IX
		milk income		4.3.1	X
					XV
PLND	R15C3	Purchase price of land ($/acre) should reflect the value of land for crop production and be different for each SMG	EX	4.1.3A Appendix A	
		Used to estimate: cropland		4.1.3	V
		land for dairy facilities		4.2.1	IX
					XV

Variable Name	Refers to Row:Col	Variable (units); notes	Type	See Thesis Section	Contingent Model Components
PMLK	R16C3	Price received at the farm($/cwt) sold	EX	4.3.1	
		Used to estimate: PCWS,PHFRS		4.4.3	IA
		milk income		4.3.1	X
		milk/feed price ratio		4.4.2	XV
PSCORN	R17C3	Purchase price of shelled corn ($/bu); should reflect market value	EX	4.4.4	
		Used to estimate: PCSLG,PALFHY		4.4.4	IA
		purchased feed costs		4.1.7	IV
		milk/feed price ratio		4.4.2	XV
INTRT	R19C3	Real interest rate(decimal);applied against investments and operating expenses such as feed purchases and crop expenses	EX	4.4.5	
		Used to estimate: CPTMCH			IA
		CPTBLDG			IA
		annual land charge			V
		total feed cost			XI
		total annual cost			XII
		profit			XIII
		annual livestock expenses			IX
PTXRT	R20C3	Property tax charge(decimal);charged against:	EX	4.1.3B	
		Value of crop land			V
		Feed storage facilities(avg. value)			III
		Dairy facilities(avg. value)			VIII
INSRT	R21C3	Property insurance charge(decimal);charged against:	EX	4.1.5 Table 4.12	
		Value of crop machinery(avg. value)			VI
		Value of feed storage facilities(avg. value)			III
		Dairy facilities(avg. value)			VIII
LNDGRWTHRT	R22C3	Land value growth rate(decimal);credited to the annual land expense	EX	4.1.3B	
		For crop land		4.1.3B	
		For land for dairy facilities		4.2.1	VIII

Variable Name	Refers to Row:Col	Variable (units); notes	Type	See Thesis Section	Contingent Model Components
PFL	R23C3	Purchase price for fuel and lubrication	EX	4.4	
		used to estimate fuel expenses for crop			
		budgets		4.1.4	IB
PLBR	R24C3	Purchase price of labor($/hr) used to	EX	4.4	
		estimate: labor for cropping		4.1.6	VII
		livestock labor		4.2.2	IX
PALFHY	R13C5	Purchase price of alfalfa hay ($/ton);cal-	EN	4.4.4B	
		culated based on the price of corn			
		Used to estimate:purchase price of soybean			
		meal		4.4.4B	IA
		purchased feed costs		4.1.7	IV
		milk/feed price ratio		4.4.2	XV
PCSLG	R14C5	Purchase price of 35% dry matter corn sil-	EN	4.4.4C	
		age ($/ton);calculated based on the prices			
		of PSCORN,PP,PK,PLMSTN			
		Used to estimate:purchased feed costs		4.1.7	IV
					XV
PSYML	R15C5	Purchase price of soybean meal ($/lb);	EN	4.4.4B	
		Calculated based on the price of ALFHY			
		Used to estimate: purchased feed costs		4.1.7	IV
		soybean meal savings		4.3.5	X
		milk/feed price ratio		4.4.2	XV
PLMSTN	R17C5	Purchase prices of limestone,dicalcium	EX	4.1.7	
		phosphate, and salt ($/lb)			
		Used to estimate: purchased feed costs			IV
		PDCL used to estimate PCSLG		4.4.4C	IA
		PLMSTN used to estimate crop budgets			IB
PCWS	R20C5	Purchase price of dairy cows ($/cow);this	EN		
		is calculated based on MP and PMLK			
		Used to estimate: livestock expenses		4.2.2	IX
					XV

Variable Name	Refers to Row:Col	Variable (units); notes	Type	See Thesis Section	Contingent Model Components
PCLLCW	R21C5	Sale price of cull cows($/cwt); this is calculated based on PMLK Used to estimate: income cost/cwt milk	EN	4.4.3 4.3.2	 X XIII XV
PCLLHFR	R22C5	Sale price of cull heifers($/cwt);this is calculated based on PCLLCW Used to estimate: income cost/cwt milk	EN	4.3.3 4.3.3	 X XIII XV
PHFRS	R23C5	Sale price of excess replacement heifers ($/heifer); this is calculated based on MP,PMLK and CLLS Used to estimate: income cost/cwt milk	EN	4.3.3 4.3.3	 X XIII XV
PDCNCLVS	R24C5	Sale price of deacon calves($/cwt);this is calculated based on PCLLCW Used to estimate: income cost/cwt milk	EN	4.3.3 4.3.3	 X XIII XV
CPTMCH CPTBLDG	R13C7 R14C7	Capitalization formula to use to estimate the interest and depreciation charge on durable assets with a fixed life(decimal); based on INTRT. CPTMCH is calculated based on assets with a life of 8 yrs and a salvage value of 25%. CPTMCH is used to estimate the annual use cost of capital for investments in crop machinery and dairy equipment and savings in equipment CPTBLDG is calculated based on assets with a life of 20 yrs and a salvage value of 0. It is used to estimate the annual use cost of capital for investments in feed storage facilities and dairy buildings and facilities	EN	4.1.5 4.1.2 4.2.1	 VI,VIII,X III,VIII

Variable Name	Refers to Row:Col	Variable (units); notes	Type	See Thesis Section	Contingent Model Components
PN	R16C7	Prices of nitrogen,phosphorus,and potassium ($/lb);	EX	4.4	
		Used to estimate:cash crop budgets		4.1.4	IB
		PCSLG		4.4.4C	IA
		fertilizer value of manure		4.3.4	X
HSZ 1	R20C7	Herd sizes(no. cows); the model assumes replacements are raised	EX		
HSZ 2	R21C7	Used to estimate and summarize by herd sizes model components II-XIII			
HSZ 3	R22C7				
HSZ 4	R23C7				
HSZ 5	R24C7				II-XV
		Used in section XIV to estimate a regression to estimate the number of cows for a given level of investment for the summary table in XV			
		DO NOT CHANGE THESE CELLS			
CLLS	R25C5	Percent of the herd culled annually(20 to 35%)	EX	4.3.2 4.3.3	X
INV 1	R13C9	Investment levels;used to summarize profitability by levels of investment for each strategy;used in section XV of the model	EX		XV
INV 2	R14C9				
INV 3	R15C9				
INV 4	R16C9				
INV 5	R17C9				
		DO NOT CHANGE THESE CELLS			

	1	2	3	4	5	6	7	8	9
10		"VARIABLE"		"VARIABLE"		"VARIABLE"		"VARIABLE"	
11		"NAME"	"VALUE"	"NAME"	"VALUE"	"NAME"	"VALUE"	"NAME"	"VALUE"
12		"------------"	"------------"	"------------"	"------------"	"------------"	"------------"	"------------"	"------------"
13		"SMG"	3	"PALPHY"	21+20*PSCORN	"CPTMCH"	(INTRT/(1-(1/(1+INTR? 8)))*0.75+0.25*INTRT	"INV1" "INV2"	500000 1000000
14		"MP"	15	"PCSLG"	((PSCORN-0.3)*INDEX(YSC ORN,SMG)+10.83+18.6*PP+ 80.5*PK+77.6*PLMSTN)/IN DEX(YCSLG,SMG)	"CPTBLDG"	INTRT/(1-(1/(1+INTRT? 0))	"INV3" "INV4" "INV5"	1500000 2000000 2500000
15		"PLND"	1100	"PSYML"	(24.72+2.74*PALPHY)/200 0				
16		"PMLK"	12	"PLMSTN"	0.05	"PN"	0.16		
17		"PSCORN"	2.7	"PDCL"	0.19	"PP"	0.2		
18				"PSLT"	0.07	"PK"	0.12		
19		"INTRT"	0.04						
20		"PTXRT"	0.02	"PCWS"	(MP-13)*85-260.77+98.26 *PMLK	"HSZ1"	40		
21		"INSRT"	0.01	"PCLLCW"	2.63+3.07*PMLK	"HSZ2"	75		
22		"LNDGRWTHRT"	0.01	"PCLLHFR"	2.91+1.23*PCLLCW	"HSZ3"	150		
23		"PFL"	1.1	"PHFRS"	(0.9*MP-13)*85-260.77+9 8.26*PMLK	"HSZ4"	300		
24		"PLBR"	6	"PDCNCLVS"	-5.99+1.8*PCLLCW	"HSZ5"	500		
25						"CLLS"	25		

IB:CROP BUDGETS: This subcomponent estimates selected crop cash expenses (crop budgets)/acre for corn, corn silage, alfalfa hay and haylage. The following is a list of abbreviations of expenses and the item each represents; SDS = seeds, WS = weed spray, INSCT = insecticides, N = nitrogen, P = phosphorus, K = potassium, LMSTN = limestone, UTLTS = utilities, TRCK = trucking, FL = fuel, RPRS = repairs, OTHR = other and TTL refers to the total expense. BSCORN, BCSLG, BALFHY and BALFHYLG and alfalfa haylage are abbreviations for shelled corn budget, corn silage budget, alfalfa hay budget and alfalfa haylage budget, respectively. The variables BSCORNT, BCSLGT, BALFHYT and BALFHYLGT contain the total cash expense for each crop which is contained in the cell immediately below the variable name. Many of the crop expenses are linear approximations based on the yield/acre for that particular crop which is determined by the soil management group selected in (IA) and expected crop yields in (ID). The formulas or constant values for each particular expense item are listed below. These were estimated in Table 4.11.

Here is an example how part of one of the formulas works:

INDEX (YSCORN, SMG)

INDEX is a multiplan command used to locate a particular value in an array or table. The array is indicated by the first value in the parenthesis and the ordinal position of the particular value by the second number in the parenthesis. In this instance the instruction is to look up the value of the array YSCORN corresponding to the number indicated by SMG. If SMG were set to 3 in (IA) then the 3rd value of the array YSCORN (i.e. 105) would have been selected (see section ID of the model).

Another example indicates how the SUM command operates:

SUM (R(-14)C:R(-3)C directs the summation of values 14 rows above the present cell (in the same column) down to and including values 3 rows above the present cell.

	1	2	3	4	5	6
28	"--"		"BSCORN"	"BCSLG"	"BALFHY"	"BALFHYLG"
29		"SDS"	(8.16+0.06*INDEX(YSCORN,SMG))*1.25	(6.5+0.534*INDEX(YCSLG,SMG))*1.25	5	5
30		"WS"	11.2	11.2	1.75	1.75
31		"INSCT"	2	2	5	5
32		"N"	(17.2+1.106*INDEX(YSCORN,SMG))*PN	(6.3+9.3*INDEX(YCSLG,SMG))*PN	0	0
33		"P"	(10.45+0.409*INDEX(YSCORN,SMG))*PP	(4.35*INDEX(YCSLG,SMG)*PP)	10.7*INDEX(YALFHY,SMG)*PP	5.9*INDEX(YALFHYLG,SMG)*PP
34		"K"	75*PK	8.64*INDEX(YCSLG,SMG)*PK	45*INDEX(YALFHY,SMG)*PK	25*INDEX(YALFHYLG,SMG)*PK
35		"LMSTN"	95*PLMSTN	5.94*INDEX(YCSLG,SMG)*PLMSTN	59*INDEX(YALFHY,SMG)*PLMSTN	32.8*INDEX(YALFHYLG,SMG)*PLMSTN
36		"UTLTS"	0.041+0.024*INDEX(YSCORN,SMG)	0.339*INDEX(YCSLG,SMG)	0	0
37		"TRCK"	0.105*INDEX(YSCORN,SMG)	-1.6+1.08*INDEX(YCSLG,SMG)	1.47*INDEX(YALFHY,SMG)	0.45*INDEX(YALFHYLG,SMG)
38		"FL"	11.3*PFL	6.92+0.336*INDEX(YCSLG,SMG)*PFL	6.02+0.44*INDEX(YALFHY,SMG)*PFL	19.9*PFL
39		"RPRS"	13.6	18.2	12.94+1.91*INDEX(YALFHY,SMG)	18.9+0.725*INDEX(YALFHYLG,SMG)
40		"OTHR"	0	0	2.35*INDEX(YALFHY,SMG)	3
41		"-----------------------------------"	"------------------------------"	"------------------------------"	"------------------------------"	"------------------------------"
42			"BSCORNT"	"BCSLGT"	"BALFHYT"	"BALFHYLGT"
43		"TTL"	SUM(R[-14]C:R[-3]C)	SUM(R[-14]C:R[-3]C)	SUM(R[-14]C:R[-3]C)	SUM(R[-14]C:R[-3]C)

IC:RATIONS: This table contains amounts of feeds consumed/cow and replacement/year by level of milk production considering feeding and storage losses of feeds (see Table 4.4). The forage component on a dry matter basis is assumed to be 60% alfalfa (as either hay or hay and haylage) and 40% corn silage. See thesis section 4.1.1 for details. The appropriate ration (quantities of each feed) is selected based on the level of milk production (MP) specified in (IA) and is used when estimating quantities of feeds needed/herd/year for the various sizes of herds in component II. Beware that changing values in this table will change the number of acres of crops for farms GFG or GF and thus may make the crop machinery component (VI) inaccurate.

The array variables: SCORN, CSLG, ALFHY, SYML, DCL, SLT and LMSTN refer to the bushels of shelled corn, tons of 35% dry matter corn silage, tons of air dry alfalfa hay equivalent, lb of soybean meal, lb of dicalcium phosphate, lb salt and lb of limestone that are needed for each level of milk production.

The array variable MILKPROD contains the values corresponding to the possible milk production levels.

The array variables NO contains the ordinal numbers (subscripts) for indexing (retrieving) appropriate values from the array variables above based on the level of milk production specified in IA.

	1	2	3	4	5	6	7	8	9
48	--	MILKPROD	NO	SCORN	CSLG	ALFHY	SYML	SLT	DCL
49		13	1	87.0	10.1	6.5	535.0	95.0	100.0
50		15	2	110.0	9.6	6.2	1011.0	95.0	100.0
51		17	3	134.0	8.9	5.8	1529.0	95.0	100.0
52		19	4	157.0	8.3	5.6	2020.0	95.0	100.0

ID:CROP YIELDS: This table contains the expected crop yields/acre for corn, corn silage and alfalfa hay and haylage by soil management group. Yields for haylage are assumed to be 10% greater on a dry matter basis than the same crop harvested as hay. See thesis section 4.1.3C and Table 4.10 for details. The appropriate yields/acre for each crop are selected based on the soil management group number specified in (IA) and is used in (V) where acres of crops needed are estimated for farms GF and GFG. Beware that changing values in this table will change the number of acres of crops for farms GFG or GF and may make the crop machinery component (VI) inaccurate.

The array variables YSCORN, YCSLG, YALFHY and YALFHYLG refer to the bushesl/acre of shelled corn, tons of 35% dry matter corn silage, tons of air dry alfalfa hay and tons of 50% dry matter alfalfa haylage produced.

The array variable SMGNO contains the value corresponding to the possible soil management group numbers. These same values can be used as the ordinal numbers (subscripts) for indexing (retrieving) appropriate values from the array variables above based on the soil management group specified in IA.

	1	2	3	4	5	6	7
56 --			SMGRNO	YSCORN	YCSLG	YALFHY	YALFHYLG
57			1	114.0	15.5	5.0	8.7
58			2.5	120.0	16.8	4.6	9.0
59			3	105.0	15.3	4.0	7.9
60			4	86.0	13.2	3.5	6.9

II:FEED QUANTITIES: The amounts of feeds needed/herd/year for the various herd sizes are determined by multiplying the quantity of each feed needed/cow and replacement from (IB) by the herd sizes. Feed quantities which differ according to strategy are suffixed by: GF for the strategies GF or GFG, or PR for the strategy PR. Farms which GF or GFG feed alfalfa haylage and hay for herd sizes 75, 150, and 300. Farms PR, feed hay and no haylage. Haylage is estimated as: 60% alfalfa hay dry matter * (87% dry matter/lb hay)/(50% dry matter/lb of haylage) = 1.044 * quantity of alfalfa hay. See thesis section 4.1.1.

QSCORN, QCSLG, QSYML, QDCL, QSLT and QLMSTN are array variables referring to the quantities of shelled corn, corn silage, soybean meal, dicalcium phosphate, salt and limestone needed for each herd size.

QALFHYGF and QALFHYLGGF are array variables which refer to quantities of alfalfa hay and haylage needed for each herd size for the strategies GFG or GF. QALFHYPR is an array variable which refers to quantities of alfalfa hay for each herd size for the strategy PR.

The formulas or constants used to calculate these quantities are located below. Here is an example of how part of the one of the formulas works:

INDEX (SCORN, LOOKUP (MP,MILKPROD:NO))

LOOKUP (N, table) is a multiplan command which directs a search in the first col. (or row) of a table for a value equal to the value of N. The search then returns the value from the last col. (or row) which corresponds to the position in the col. (or row) held by N.

In this instance LOOKUP (MP, MILKPROD:NO) directs a search in component IC in table: MILKPROD:NO for a value = MP, it then returns the corresponding value of the array NO (see IB). Thus, if MP were set to 15 in (IA), then the computer would have searched for a value in MILKPROD = 15 and returned the corresponding value of 2 from NO.

The purpose of the LOOKUP was to provide a subscript to indicate the ordinal position of the value of the array SCORN that was being searched for by the INDEX command.

	2	3	4	5	6	7
65				"HERD SIZE"		
66		"------------"	"------------"	"------------"	"------------"	"------------"
67		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
68	"QUANTITY"	"------------"	"------------"	"------------"	"------------"	"------------"
69	"QSCORN"	INDEX(SCORN,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(SCORN,LOOKUP(MP,MILKPROD:NO))*HSZ2	INDEX(SCORN,LOOKUP(MP,MILKPROD:NO))*HSZ3	INDEX(SCORN,LOOKUP(MP,MILKPROD:NO))*HSZ4	INDEX(SCORN,LOOKUP(MP,MILKPROD:NO))*HSZ5
70	"QCSLG"	INDEX(CSLG,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(CSLG,LOOKUP(MP,MILKPROD:NO))*HSZ2	INDEX(CSLG,LOOKUP(MP,MILKPROD:NO))*HSZ3	INDEX(CSLG,LOOKUP(MP,MILKPROD:NO))*HSZ4	INDEX(CSLG,LOOKUP(MP,MILKPROD:NO))*HSZ5
71	"QALFHYGF"	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*0.4*HSZ2	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*0.4*HSZ3	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*0.4*HSZ4	0
72	"QALFHYLGGF"	0	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*1.044*HSZ2	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*1.044*HSZ3	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*1.044*HSZ4	0
73	"QALFHYPR"	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*HSZ2	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*HSZ3	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*HSZ4	INDEX(ALFHY,LOOKUP(MP,MILKPROD:NO))*HSZ5
74	"QSYML"	INDEX(SYML,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(SYML,LOOKUP(MP,MILKPROD:NO))*HSZ2	INDEX(SYML,LOOKUP(MP,MILKPROD:NO))*HSZ3	INDEX(SYML,LOOKUP(MP,MILKPROD:NO))*HSZ4	INDEX(SYML,LOOKUP(MP,MILKPROD:NO))*HSZ5
75	"QDCL"	INDEX(DCL,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(DCL,LOOKUP(MP,MILKPROD:NO))*HSZ2	INDEX(DCL,LOOKUP(MP,MILKPROD:NO))*HSZ3	INDEX(DCL,LOOKUP(MP,MILKPROD:NO))*HSZ4	INDEX(DCL,LOOKUP(MP,MILKPROD:NO))*HSZ5
76	"QSLT"	INDEX(SLT,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(SLT,LOOKUP(MP,MILKPROD:NO))*HSZ2	INDEX(SLT,LOOKUP(MP,MILKPROD:NO))*HSZ3	INDEX(SLT,LOOKUP(MP,MILKPROD:NO))*HSZ4	INDEX(SLT,LOOKUP(MP,MILKPROD:NO))*HSZ5
77	"QLMSTN"	INDEX(LMSTN,LOOKUP(MP,MILKPROD:NO))*HSZ1	INDEX(LMSTN,LOOKUP(MP,MILKPROD:NO))*HSZ2	INDEX(LMSTN,LOOKUP(MP,MILKPROD:NO))*HSZ3	INDEX(LMSTN,LOOKUP(MP,MILKPROD:NO))*HSZ4	INDEX(LMSTN,LOOKUP(MP,MILKPROD:NO))*HSZ5

III: FEED STORAGE FACILITIES: This component estimates the dollars invested and annual use charge for feed storage facilities. The storage investment for each of the feeds is estimated across herd sizes and then the appropriate components are assembled according to the storage needs for each particular strategy. It is assumed that shelled corn is stored as high moisture shelled corn in upright cement stave silos for all herd sizes. All but the smallest herd size are equipped with unloaders. Corn silage is stored in bunkers except for the smallest herd size where it is stored in an upright cement stave silo with a top unloader. Hay is stored in a pole barn. Haylage is stored in upright cement stave silos. Linear equations are used to estimate the costs of feed storage facilities depending on the quantity of each feed to be stored. It is assumed that 70% of the total hay equivalent required will be stored on farms GF or GFG and that 40% will be stored on farms PR. For details see thesis section 4.1.2. Annual use charges are derived by multiplying the total investment in feed storage facilities by the annual use charge on capital (CPTBLDG) + (multiplying the average investment by the charge for property taxes and insurance).

STOSCORN, STOCSLG, STOALFHYGF, STOALFHYPR, STOALFHYLG are array variables referring to feed storage facilities investments for shelled corn, corn silage, alfalfa for GF and GFG, alfalfa hay for PR and alfalfa haylage for GF or GFG.

STOINVGF, STOANNGF refer to the total feed storage investments and annual use costs for farms GF or GFG.

STOINVPR, STOANNPR refer to the total feed storage investments and annual use costs for farms PR.

	2	3	4	5	6	7
82			"HERD SIZE"			
83		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
84		"------------"	"------------"	"------------"	"------------"	"------------"
85	"STOSCORN"	2.12*QSCORN	11542+0.902*QSCORN	11542+0.902*QSCORN	11542+0.902*QSCORN	11542+0.902*QSCORN
86	"STOCSLG"	12920+23.4*QCSLG	12560+55*(QCSLG*0.35)	12560+55*(QCSLG*0.35)	12560+55*(QCSLG*0.35)	12560+55*(QCSLG*0.35)
87	"STOALFHYGF"	62.5*QALFHYGF*0.7	62.5*QALFHYGF*0.7	62.5*QALFHYGF*0.7	62.5*QALFHYGF*0.7	
88	"STOALFHYPR"	62.5*QALFHYPR*0.4	62.5*QALFHYPR*0.4	62.5*QALFHYPR*0.4	62.5*QALFHYPR*0.4	62.5*QALFHYPR*0.4
89	"STOALFHYLG"	0	12918+33.4*QALFHYLGGF*0.7	12918+33.4*QALFHYLGGF*0.7	12918+33.4*QALFHYLGGF*0.7	
90	"-------------------------------"	"-------------------------------"	"-------------------------------"	"-------------------------------"	"-------------------------------"	"-------------------------------"
91	"STOTINVGF"	R[-6]C+R[-5]C+R[-4]C+R[-2]C	R[-6]C+R[-5]C+R[-4]C+R[-2]C	R[-6]C+R[-5]C+R[-4]C+R[-2]C	R[-6]C+R[-5]C+R[-4]C+R[-2]C	
92	"STOANNGF"	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	
93	"STOTINVPR"	R[-8]C+R[-7]C+R[-5]C	R[-8]C+R[-7]C+R[-5]C	R[-8]C+R[-7]C+R[-5]C	R[-8]C+R[-7]C+R[-5]C	R[-8]C+R[-7]C+R[-5]C
94	"STOTANNPR"	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*0.5*(PTXRT+INSRT)

<u>IV</u>:PURCHASED FEED: This component estimates the cost of purchased feed for each herd size within each strategy. It is estimated by multiplying the quantities of each feed purchased by the approximate price from component (IA). The feeds purchased depend on the feeding strategy. See thesis section 4.1.7.

PRFDGFG, PRFDGF and PRFDFR refer to the array variables containing the cost of purchased feeds on farms which GFG, GF or PR respectively.

	2	3	4	5	6	7
99			"HERD SIZE"			
100		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
101		"------------"	"------------"	"------------"	"------------"	"------------"
102	"PRFDGFG"	QSYML*PSYML+QSLT*PSLT+Q DCL*PDCL+QLMSTN*PLMSTN	QSYML*PSYML+QSLT*PSLT+Q DCL*PDCL+QLMSTN*PLMSTN	QSYML*PSYML+QSLT*PSLT+Q DCL*PDCL+QLMSTN*PLMSTN	QSYML*PSYML+QSLT*PSLT+Q DCL*PDCL+QLMSTN*PLMSTN	QSYML*PSYML+QSLT*PSLT+Q DCL*PDCL+QLMSTN*PLMSTN
103	"PRFDGF"	R[-1]C+QSCORN*(PSCORN-O .2)	R[-1]C+QSCORN*(PSCORN-O .2)	R[-1]C+QSCORN*(PSCORN-O .2)	R[-1]C+QSCORN*(PSCORN-O .2)	R[-1]C+QSCORN*(PSCORN-O .2)
104	"PRFDPR"	R[-1]C+QCSLG*PCSLG+QALF HYPR*PALFHY	R[-1]C+QCSLG*PCSLG+QALF HYPR*PALFHY	R[-1]C+QCSLG*PCSLG+QALF HYPR*PALFHY	R[-1]C+QCSLG*PCSLG+QALF HYPR*PALFHY	R[-1]C+QCSLG*PCSLG+QALF HYPR*PALFHY

V:CROP LAND: This component estimates the acres of land required to supply alfalfa and corn silage on farms GF as well as corn on farms GFG. Acres of each crop needed are calculated by dividing the quantity needed for a particular herd size (from component II) by the expected yield/acre (ID) for each crop; this is then multiplied by 1.05 to account for headlands and wasted acreage. The total acres necessary to GF or GFG is estimated by summing the acreages of the crops needed according to the strategy. The total investment in land is estimated by multiplying the number of acres needed by the price of land (PLND, component IA). The annual use cost is established by multiplying the investment value by the interest rate - growth rate in land value + property tax charge. See thesis section 4.1.3 for details.

ASCORN, ACSLG, AALFHY are array variables referring to the acres of corn, corn silage and alfalfa (both for hay and haylage) required to supply the quantities of these feeds needed for each herd size.

AGFT and AGFGT are array variables referring to the total acres needed for cropping for each herd size for the strategies GF and GFG.

LNDINVGFG, LNDANNGFG, LNDINVGF and LNDANNGF are array variables which refer to the total investment and annual use cost for farms GFG and GF respectively.

	2	3	4	5	6
109				"HERD SIZE"	
110		"------------"	"------------"	"------------"	"------------"
111		HSZ1	HSZ2	HSZ3	HSZ4
112	"ACRES"	"-----------------------------------"	"-----------------------------------"	"-----------------------------------"	"-----------------------------------"
113	"ASCORN"	QSCORN/INDEX(YSCORN,INT(SMG))	QSCORN/INDEX(YSCORN,INT(SMG))	QSCORN/INDEX(YSCORN,INT(SMG))	QSCORN/INDEX(YSCORN,INT(SMG))
114	"ACSLG"	QCSLG/INDEX(YCSLG,INT(SMG))	QCSLG/INDEX(YCSLG,INT(SMG))	QCSLG/INDEX(YCSLG,INT(SMG))	QCSLG/INDEX(YCSLG,INT(SMG))
115	"AALFHY"	QALFHYGF/INDEX(YALFHY,INT(SMG))	QALFHYGF/INDEX(YALFHY,INT(SMG))+QALFHYLGGF/INDEX(YALFHYLG,INT(SMG))	QALFHYGF/INDEX(YALFHY,INT(SMG))+QALFHYLGGF/INDEX(YALFHYLG,INT(SMG))	QALFHYGF/INDEX(YALFHY,INT(SMG))+QALFHYLGGF/INDEX(YALFHYLG,INT(SMG))
116	"-------------------------------------"	"-------------------------------------"	"-------------------------------------"	"-------------------------------------"	"-------------------------------------"
117	"AGFT"	(R[-3]C+R[-2]C)*1.05	(R[-3]C+R[-2]C)*1.05	(R[-3]C+R[-2]C)*1.05	(R[-3]C+R[-2]C)*1.05
118	"AGFGT"	(R[-1]C-R[-5]C)*1.05	(R[-1]C+R[-5]C)*1.05	(R[-1]C+R[-5]C)*1.05	(R[-1]C+R[-5]C)*1.05
119	"---"	"---"	"---"	"---"	"---"
120	"LNDINVGFG"	R[-2]C*PLND	R[-2]C*PLND	R[-2]C*PLND	R[-2]C*PLND
121	"LNDANNGFG"	PLND*AGFGT*(INTRT+PTXRT-LNDGRWTHRT)	PLND*AGFGT*(INTRT+PTXRT-LNDGRWTHRT)	PLND*AGFGT*(INTRT+PTXRT-LNDGRWTHRT)	PLND*AGFGT*(INTRT+PTXRT-LNDGRWTHRT)
122	"LNDINVGF"	R[-5]C*PLND	R[-5]C*PLND	R[-5]C*PLND	R[-5]C*PLND
123	"LNDANNGF"	PLND*AGFT*(INTRT+PTXRT-LNDGRWTHRT)	PLND*AGFT*(INTRT+PTXRT-LNDGRWTHRT)	PLND*AGFT*(INTRT+PTXRT-LNDGRWTHRT)	PLND*AGFT*(INTRT+PTXRT-LNDGRWTHRT)

VI:CROP MACHINERY: This component estimates the total crop machinery investment and annual use charge for farms GFG or GF. Investments are derived by multiplying the crop machinery investments/cow (Table 4.12) by the appropriate herd size. See thesis section 4.1.5. The annual use charge for machinery is calculated by multiplying the machinery investment by the annual use charge for capital (CPTMCH) for machinery estimated in (IA) + the average value of the investment (.6 * investment cost) multiplied by (insurance + machinery storage charge).

MCHCRPINVGFG, MCHCRPANN, MCHCRPINVGF and MCHCRPANNGF are array variables referring to the machinery investment and annual cost for farms GFG and GF respectively.

	2	3	4	5	6
128			"HERD SIZE"		
129		HSZ1	HSZ2	HSZ3	HSZ4
130		"------------"	"------------"	"------------"	"------------"
131	"MCHCRPINVGFG"	3643*HSZ1	2152*HSZ2	1532*HSZ3	1078*HSZ4
132	"MCHCRPANNGFG"	R[-1]C*CPTMCH+R[-1]C*0.6*(INSRT+0.015)	R[-1]C*CPTMCH+R[-1]C*0.6*(INSRT+0.015)	R[-1]C*CPTMCH+R[-1]C*0.6*(INSRT+0.015)	R[-1]C*CPTMCH+R[-1]C*0.6*(INSRT+0.015)
133	"MCHCRPINVGF"	3243*HSZ1	1907*HSZ2	1322*HSZ3	801*HSZ4
134	"MCHCRPANNGF"	R[-1]C*CPTMCH+R[-1]C*0.6*INSRT	R[-1]C*CPTMCH+R[-1]C*0.6*INSRT	R[-1]C*CPTMCH+R[-1]C*0.6*INSRT	R[-1]C*CPTMCH+R[-1]C*0.6*INSRT

VII:CROP EXPENSES AND LABOR: This component estimates the cash crop expenses for farms which GFG or GF, by multiplying acres of each feed by the crop budget expense estimated in (IB). Total hours of labor for each crop are estimated across herd sizes using linear relationships dependent upon the number of acres of each crop grown. See thesis section 4.1.4 and 4.1.6. The total hours of labor are then estimated for each strategy of GFG or GF by summing the appropriate labor hours for each crop. The cost of labor is estimated by multiplying the total hours of labor by the cost of labor (PLBR) from component (IA).

CRPEXPGF and CRPEXPGFG are array variables referring to the cash crop expenses for farmers GF or GFG across herd sizes. Since alfalfa haylage is assumed to yield 10% greater yield than hay, and 60% of the hay crop is harvested as haylage, .6 * 1.03 ≈ .56 of the total acres of hay crop is harvested as haylage and .44 is harvested as hay.

LBRSCORN, LBRCSLG, LBRALFHY and LBRHYLG are array variables referring to the hours of labor required for each particular crop (i.e. corn, corn silage, alfalfa hay and haylage).

LBRTGF and LBRTGFG are array variables which refer to the total hours of labor required to GF or GFG for each herd size.

LBRCSTGF and LBRCSTGFG are array variables referring to the total labor cost to GF or GFG for each herd size.

	2	3	4	5	6
139			"HERD SIZE"		
140		HSZ1	HSZ2	HSZ3	HSZ4
141		"------------"	"------------"	"------------"	"------------"
142	"CRPEXPGF"	ACSLG*BCSLGT+AALFHY*BALFHYT	ACSLG*BCSLGT+AALFHY*0.44*BALFHYT+AALFHY*0.56*BALFHYLGT	ACSLG*BCSLGT+AALFHY*0.44*BALFHYT+AALFHY*0.56*BALFHYLGT	ACSLG*BCSLGT+AALFHY*0.44*BALFHYT+AALFHY*0.56*BALFHYLGT
143	"CRPEXPGFG"	R[-1]C+ASCORN*BSCORNT	R[-1]C+ASCORN*BSCORNT	R[-1]C+ASCORN*BSCORNT	R[-1]C+ASCORN*BSCORNT
144					
145	"LBRSCORN"	(2.2+125/ASCORN)*ASCORN	(2.2+125/ASCORN)*ASCORN	(2.2+125/ASCORN)*ASCORN	(2.2+125/ASCORN)*ASCORN
146	"LBRCSLG"	(3.7+90/ACSLG)*ACSLG	(3.7+90/ACSLG)*ACSLG	(3.7+90/ACSLG)*ACSLG	(3.7+90/ACSLG)*ACSLG
147	"LBRALFHY"	(5.4+250/AALFHY)*AALFHY	(5.4+250/AALFHY)*AALFHY*0.44	(5.4+250/AALFHY)*AALFHY*0.44	(5.4+250/AALFHY)*AALFHY*0.44
148	"LBRALFHYLG"	0	(4.6+284/AALFHY*0.56)*AALFHY*0.56	(4.6+284/AALFHY*0.56)*AALFHY*0.56	(4.6+284/AALFHY*0.56)*AALFHY*0.56
149					
150	"LBRTGF"	SUM(R[-4]C:R[-2]C)	SUM(R[-4]C:R[-2]C)	SUM(R[-4]C:R[-2]C)	SUM(R[-4]C:R[-2]C)
151	"LBRTGFG"	R[-1]C+R[-6]C	R[-1]C+R[-6]C	R[-1]C+R[-6]C	R[-1]C+R[-6]C
152					
153	"LBRCSTGF"	R[-3]C*PLBR	R[-3]C*PLBR	R[-3]C*PLBR	R[-3]C*PLBR
154	"LBRCSTGFG"	R[-3]C*PLBR	R[-3]C*PLBR	R[-3]C*PLBR	R[-3]C*PLBR

VIII:DAIRY FACILITIES: This component estimates the investment and annual use cost of dairy buildings and facilities, land for facilities and dairy equipment. Investments are based on Table 4.14. These are described in thesis section 4.2.1. The smallest herd size is assumed to be housed in a confined-stall barn with a pipeline milking facility. Manure is handled via a stacker-storage system. All other herd sizes are housed in free-stall barns and milked in a herring-bone parlor. Manure is stored in a holding pond with 6 months storage. Annual use charges on buildings and facilities are estimated by multiplying the investment by the annual use cost of capital (CPTBLDG) from (IA) + the average investment multiplied by the (property tax + insurance charges). The annual use of land for facilities is estimated as the investment in land multiplied by the (interest rate + property tax - land value growth rate). Annual use charges on dairy equipment are found by multiplying the investment by the appropriate annual use cost of capital (CPTMCH) from (IA) +(the average investment multiplied by the (property tax + insurance charges)).

DBLDGINV and DBLDGANN, DLNDINV, DLNDANN and DEQINV and DEQANN are array variables referring to the investment and annual use costs for dairy buildings and facilities, land for facilities and dairy equipment respectively.

	2	3	4	5	6	7
159			"HERD SIZE"			
160		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
161		"------------"	"------------"	"------------"	"------------"	"------------"
162	"DBLDGINV"	1784*HSZ1	1597*HSZ2	1352*HSZ3	1229*300	1181*HSZ5
163	"DBLDGANN"	R[-1]C*CPTBLDG+R[-1]C*O .5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*O .5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*O .5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*O .5*(PTXRT+INSRT)	R[-1]C*CPTBLDG+R[-1]C*O .5*(PTXRT+INSRT)
164	"DLNDINV"	2*PLND	3.25*PLND	7.5*PLND	15*PLND	25*PLND
165	"DLNDANN"	DLNDINV*(INTRT+PTXRT-LN DGRWTHRT)	DLNDINV*(INTRT+PTXRT-LN DGRWTHRT)	DLNDINV*(INTRT+PTXRT-LN DGRWTHRT)	DLNDINV*(INTRT+PTXRT-LN DGRWTHRT)	DLNDINV*(INTRT+PTXRT-LN DGRWTHRT)
166	"DEQINV"	1656*HSZ1	1348*HSZ2	913*HSZ3	685*HSZ4	443*HSZ5
167	"DEQANN"	R[-1]C*CPTMCH+R[-1]C*O. 6*(PTXRT+INSRT)	R[-1]C*CPTMCH+R[-1]C*O. 6*(PTXRT+INSRT)	R[-1]C*CPTMCH+R[-1]C*O. 6*(PTXRT+INSRT)	R[-1]C*CPTMCH+R[-1]C*O. 6*(PTXRT+INSRT)	R[-1]C*CPTMCH+R[-1]C*O. 6*(PTXRT+INSRT)

IX: LIVESTOCK EXPENSES, LABOR AND INVESTMENT: Livestock cash expenses are estimated using linear equations developed in section 4.2.2 of the thesis and depend upon the level of milk production (MP from component IA) and the herd size. Livestock labor requirements are also estimated using linear equations derived in Table 4.16 of the thesis and are dependent upon herd sizes. The cost of labor is estimated as the price of labor (PLBR) from component (IA) multiplied by the hours of labor. Livestock investment is calculated by multiplying the price of cows (PCWS) from component (IA) by the herd size. The annual use charge on livestock is estimated on the investment cost multiplied by the interest rate (INTRT) from component (IA).

LVSTCKEXP, LBRLVSTCK, LBRCSTLVSTCK, LVSTCKINV and LVSTCKANN refer to the array variables: livestock cash expense, livestock labor, livestock labor cost, livestock investment and livestock annual use cost of capital.

	2	3	4	5	6	7
173			"HERD SIZE"			
174		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
175		"------------"	"------------"	"------------"	"------------"	"------------"
176	"LVSTCKEXP"	(-36.2+28.6*MP)*HSZ1	(-36.2+28.6*MP)*HSZ2	(-36.2+28.6*MP)*HSZ3	(-36.2+28.6*MP)*HSZ4	(-36.2+28.6*MP)*HSZ5
177	"LBRLVSTCK"	(36+1480/HSZ1)*HSZ1	(36+1480/HSZ2)*HSZ2	(36+1480/HSZ3)*HSZ3	(36+1480/HSZ4)*HSZ4	(36+1480/HSZ5)*HSZ5
178	"LBRCSTLVSTCK"	R[-1]C*PLBR	R[-1]C*PLBR	R[-1]C*PLBR	R[-1]C*PLBR	R[-1]C*PLBR
179						
180	"LVSTCKINV"	PCWS*HSZ1	PCWS*HSZ2	PCWS*HSZ3	PCWS*HSZ4	PCWS*HSZ5
181	"LVSTCKANN"	R[-1]C*INTRT	R[-1]C*INTRT	R[-1]C*INTRT	R[-1]C*INTRT	R[-1]C*INTRT

X:INCOME: This component estimates the income (INCME) generated/cow as:

1) sale of milk = milk production * fraction of that produced which is sold * 10 * price of milk + MP * 9.5* PMLK (see thesis section 4.3.1).
2) sale of deacon calves = deacon calf sales/cow (cwt) * price/cwt of deacon calves + .44* PDCNCLVS (see thesis section 4.3.3).
3) sale of cull heifers = cull heifers sales/cow (cwt) * price/cwt of cull heifers + 1.4* PCLLHFR (see thesis section 4.3.3).
4) sale of cull cows = cull cow sales/cow (cwt) * price/cwt of cull cows + 3.24* PCLLCW (see thesis section 4.3.2).
5) sale of excess replacement heifers = the number of excess heifers for sale * price of replacement heifers (36-CLLS) % * PHFRS (see thesis section 4.3.3).

Prices are derived from component (IA). Income/cow is multiplied by herd size to estimate income for each herd size.

Savings in fertilizer costs are estimated based on the value of manure as a fertilizer considering the amount and price of N, P and K. These are estimated differently for farms GFG vs. GF. The savings estimated here is applied in XIII. (see thesis section 4.3.4).

Savings in machinery investments and savings in the annual use costs of machinery are estimated to be applied to farm GFG and GF in XI and XII.

INCM, MNRSVNGS, MNRSVNGSGF, SYMLSVNGS, MCHSVNGSINV and MCHSVNGS are array variables referring to: income, savings in fertilizer costs by using manure for farms GFG, savings in fertilizer costs for farms GF, soybean meal savings for farms GFG or GF, and savings in investment and annual use costs of machinery for farms GF or GFG.

	2	3	4	5	6	7
186			"HERD SIZE"			
187		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
188		"------------"	"------------"	"------------"	"------------"	"------------"
189	"INCM"	(MP*9.5*PMLK+0.44*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ1	(MP*9.5*PMLK+0.44*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ2	(MP*9.5*PMLK+0.44*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ3	(MP*9.5*PMLK+0.44*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ4	(MP*9.5*PMLK+0.44*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ5
190	"MNRSVNGS"	(150*PN+54*PP+200*PK)*HSZ1	(150*PN+54*PP+200*PK)*HSZ2	(150*PN+54*PP+200*PK)*HSZ3	(150*PN+54*PP+200*PK)*HSZ4	(150*PN+54*PP+200*PK)*HSZ5
191	"MNRSVNGSGF"	(75*PN+54*PP+200*PK)*HSZ1	(75*PN+54*PP+200*PK)*HSZ2	(75*PN+54*PP+200*PK)*HSZ3	(75*PN+54*PP+200*PK)*HSZ4	
192	"SYMLSVNGS"	100*PSYML*HSZ1	100*PSYML*HSZ2	100*PSYML*HSZ3	100*PSYML*HSZ4	
193	"MCHSVNGSINV"	20000	45200	50200	50200	
194	"MCHSVNGSANN"	R[-1]C*CPTMCH+R[-1]C*0.6*(PTXRT+INSRT+0.015)	R[-1]C*CPTMCH+R[-1]C*0.6*(PTXRT+INSRT+0.015)	R[-1]C*CPTMCH+R[-1]C*0.6*(PTXRT+INSRT+0.015)	R[-1]C*CPTMCH+R[-1]C*0.6*(PTXRT+INSRT+0.015)	

XI: TOTAL FEED COST: This component estimates total feed costs for farms of all three feeding strategies across all herd sizes. The feed cost for farms GFG or GF are denoted by the variable names FDCSTTGFG and FDCSTGF and are estimated as:

(Purchase feed cost - soybean meal savings + cash crop expenses) * (1 + interest rate * .5) + feed storage annual cost + crop labor cost + annual land use cost + (crop machinery annual cost - machinery savings annual use cost * .5)).

Only 1/2 of the machinery savings annual use cost is applied to the cropping program. The other 1/2 is attributed to the dairy.

FDCSTPR refers to the feed cost for farms purchasing all feeds and is estimated as:

Purchased feed cost * (1 + interest rate * .5) + feed storage cost

	2	3	4	5	6	7
199			"HERD SIZE"			
200		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
201		"------------"	"------------"	"------------"	"------------"	"------------"
202	"FDCSTTGFG"	((PRFDGFG-SYMLSVNGS+CRPEXPGFG)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGFG+LNDANNGFG+MCHCRPANNGFG-MCHSVNGSANN*0.5)	((PRFDGFG-SYMLSVNGS+CRPEXPGFG)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGFG+LNDANNGFG+MCHCRPANNGFG-MCHSVNGSANN*0.5)	((PRFDGFG-SYMLSVNGS+CRPEXPGFG)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGFG+LNDANNGFG+MCHCRPANNGFG-MCHSVNGSANN*0.5)	((PRFDGFG-SYMLSVNGS+CRPEXPGFG)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGFG+LNDANNGFG+MCHCRPANNGFG-MCHSVNGSANN*0.5)	
203	"FDCSTTGF"	((PRFDGF-SYMLSVNGS+CRPEXPGF)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGF+LNDANNGF+MCHCRPANNGF-MCHSVNGSANN*0.5)	((PRFDGF-SYMLSVNGS+CRPEXPGF)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGF+LNDANNGF+MCHCRPANNGF-MCHSVNGSANN*0.5)	((PRFDGF-SYMLSVNGS+CRPEXPGF)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGF+LNDANNGF+MCHCRPANNGF-MCHSVNGSANN*0.5)	((PRFDGF-SYMLSVNGS+CRPEXPGF)*(1+(INTRT*0.5))+STOANNGF+LBRCSTGF+LNDANNGF+MCHCRPANNGF-MCHSVNGSANN*0.5)	
204	"FDCSTTPR"	PRFDPR*(1+(INTRT*0.5))+STOTANNPR	PRFDPR*(1+(INTRT*0.5))+STOTANNPR	PRFDPR*(1+(INTRT*0.5))+STOTANNPR	PRFDPR*(1+(INTRT*0.5))+STOTANNPR	PRFDPR*(1+(INTRT*0.5))+STOTANNPR

XII: TOTAL ANNUAL COST: This component estimates the total annual cost for farms of all three feeding strategies across all herd sizes. TTLANNCSTSGFG, TTLANNCSTSGF and TTLANNCSTPR refer to the array variables estimating total annual costs for farms GFG, GF and PR. Total annual costs include: total feed cost estimated in (XI) + dairy building and facilities annual use cost + dairy equipment annual use cost + livestock cash expense + livestock labor cost + livestock annual use cost - (machinery savings annual use cost * .5).[1]

	2	3	4	5	6	7
209			"HERD SIZE"			
210		HSZ1	HSZ2	HSZ3	HSZ4	HSZ5
211		"------------"	"------------"	"------------"	"------------"	"------------"
212	"TTLANNCSTSGFG"	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	
213	"TTLANNCSTSGF"	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN-MCHS VNGSANN*0.5	
214	"TTLANNCSTPR"	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN	R[-10]C+DBLDGANN+DEQANN +DLNDANN+LVSTCKEXP+LBRC STLVSTCK+LVSTCKANN

[1]This is a reduction in annual costs to be applied to farms GF or GFG and is based on the machinery cost common to both the dairy and cropping enterprise. Since half of this savings was included in estimating feed costs for farms GF or GFG, the other half (attributable to the dairy enterprise), is included here.

XIII:PROFIT: Total farm profit for each herd size within each strategy is estimated in this component. Profit is actually dollar returns to management as labor and capital have already been accounted for. The array variables PRFTGFG and PRFTGF refer to total annual farm profit for farms GFG or GF. It is estimated as: income - total annual costs + savings in fertilizer cost due to use of manure,including interest on the fertilizer savings. The value of manure for farms growing forages (GF) is based on the value of all of the P and K produced but only half of the value of N as over 1/2 of the manure will be spread on hay crops. PRFTPR is an array variable referring to total annual farm profit for farms PR. It is estimated as: income - total annual cost + .25 * savings in fertilizer cost due to the value of manure. Thus the model assumes that .25 * the value of the manure produced will be retrieved by farms PR through sales to neighboring farmers. See thesis section 4.3.4. Profit is denoted by the variables: PRFTGFG, PRFTGF and PRFTPR for the strategies GFG, GF or PR.

The array variables:INVGFG, INVGF and INVPR refer to total investments in the farms. Total investments include: land + feed storage facilities + crop machinery investments - savings in machinery investments + dairy building and facility investments + dairy equipment + livestock investments for the strategies GFG and GF. Total investments for farms PR include: feed storage + dairy buildings and facilities + dairy equipment + livestock investments.

The array variables: RROIGFG, RROIGF and RROIPR refer to the ratio of: (profit/investment) + INTRT) for the strategies of GFG, GF, PR.

The array variables:LBRGFG, LBRGF and LBRPR refer to the total man equivalents (hrs/2500) for the strategies GFG, GF and PR.

The array variables:CSTCWTMLKGFG, CSTCWTMLKGF and CSTCWTPR refer to the adjusted cost/cwt of milk sold. It is estimated as: (total annual costs - income from the sale of deacon calves, cull heifers, cull cows and excess replacement heifers) * herd size)/(total lb of milk sold/cow * herd size).

The array variables:LNRAPPRXGFG, LNRAPPRXGF and LNRAPPRXPR refer to the estimated profit for each herd size within each strategy. This is based on the regression estimates calculated in XIV and are predictions of profit based on dollars invested.

	2	3	4	5	6
223	"PRFTGFG"	INCM-TTLANNCSTSGFG+(MNRSVNGS*(1+(INTRT*0.5)))	INCM-TTLANNCSTSGFG+(MNRSVNGS*(1+(INTRT*0.5)))	INCM-TTLANNCSTSGFG+(MNRSVNGS*(1+(INTRT*0.5)))	INCM-TTLANNCSTSGFG+(MNRSVNGS*(1+(INTRT*0.5)))
224	"INVGFG"	LNDINVGFG+STOTINVGF+MCHCRPINVGFG-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	LNDINVGFG+STOTINVGF+MCHCRPINVGFG-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	LNDINVGFG+STOTINVGF+MCHCRPINVGFG-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	LNDINVGFG+STOTINVGF+MCHCRPINVGFG-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV
225	"RROIGFG"	((R[-2]C/R[-1]C)+INTRT)*100	((R[-2]C/R[-1]C)+INTRT)*100	((R[-2]C/R[-1]C)+INTRT)*100	((R[-2]C/R[-1]C)+INTRT)*100
226	"LBRGFG"	(LBRLVSTCK+LBRTGFG)/3000	(LBRLVSTCK+LBRTGFG)/3000	(LBRLVSTCK+LBRTGFG)/3000	(LBRLVSTCK+LBRTGFG)/3000
227	"CSTCWTMLK"	(R[-15]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ1)/(MP*9.45*HSZ1)	(R[-15]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ2)/(MP*9.45*HSZ2)	(R[-15]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ3)/(MP*9.45*HSZ3)	(R[-15]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ4)/(MP*9.45*HSZ4)
228	"LNRAPPRXGFG"	INTCPTGFG+SLPGFG*INVGFG	INTCPTGFG+SLPGFG*INVGFG	INTCPTGFG+SLPGFG*INVGFG	INTCPTGFG+SLPGFG*INVGFG

	2	3	4	5	6
231	"PRFTGF"	INCM-TTLANNCSTSGF+MNRSVNGSGF*(1+(INTRT*0.5))	INCM-TTLANNCSTSGF+MNRSVNGSGF*(1+(INTRT*0.5))	INCM-TTLANNCSTSGF+MNRSVNGSGF*(1+(INTRT*0.5))	INCM-TTLANNCSTSGF+MNRSVNGSGF*(1+(INTRT*0.5))
232	"INVGF"	LNDINVGF+STOTINVGF+MCHCRPINVGF-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	LNDINVGF+STOTINVGF+MCHCRPINVGF-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	LNDINVGF+STOTINVGF+MCHCRPINVGF-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	LNDINVGF+STOTINVGF+MCHCRPINVGF-MCHSVNGSINV+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV
233	"RROIGF"	((R[-2]C/R[-1]C)+INTRT)*100	((R[-2]C/R[-1]C)+INTRT)*100	((R[-2]C/R[-1]C)+INTRT)*100	((R[-2]C/R[-1]C)+INTRT)*100
234	"LBRGF"	(LBRTGF+LBRLVSTCK)/3000	(LBRTGF+LBRLVSTCK)/3000	(LBRTGF+LBRLVSTCK)/3000	(LBRTGF+LBRLVSTCK)/3000
235	"CSTCWTMLKGF"	(R[-22]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ1)/(MP*9.45*HSZ1)	(R[-22]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ2)/(MP*9.45*HSZ2)	(R[-22]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ3)/(MP*9.45*HSZ3)	(R[-22]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ4)/(MP*9.45*HSZ4)
236	"LNRAPPRXGF"	INTCPTGF+SLPGF*INVGF	INTCPTGF+SLPGF*INVGF	INTCPTGF+SLPGF*INVGF	INTCPTGF+SLPGF*INVGF

	2	3	4	5	6	7
239	"PRFTPR"	INCM-TTLANNCSTPR+0.25*MNRSVNGS	INCM-TTLANNCSTPR+0.25*MNRSVNGS	INCM-TTLANNCSTPR+0.25*MNRSVNGS	INCM-TTLANNCSTPR+0.25*MNRSVNGS	INCM-TTLANNCSTPR+0.25*MNRSVNGS
240	"INVPR"	STOTINVPR+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	STOTINVPR+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	STOTINVPR+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	STOTINVPR+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV	STOTINVPR+DBLDGINV+DLNDINV+DEQINV+LVSTCKINV
241	"RROIPR"	(R[-2]C/R[-1]C+INTRT)*100	(R[-2]C/R[-1]C+INTRT)*100	(R[-2]C/R[-1]C+INTRT)*100	(R[-2]C/R[-1]C+INTRT)*100	(R[-2]C/R[-1]C+INTRT)*100
242	"LBRPR"	LBRLVSTCK/3000	LBRLVSTCK/3000	LBRLVSTCK/3000	LBRLVSTCK/3000	LBRLVSTCK/3000
243	"CSTCWTMLKPR"	(R[-29]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ1)/(MP*9.45*HSZ1)	(R[-29]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ2)/(MP*9.45*HSZ2)	(R[-29]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ3)/(MP*9.45*HSZ3)	(R[-29]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ4)/(MP*9.45*HSZ4)	(R[-29]C-(0.46*PDCNCLVS+1.4*PCLLHFR+3.24*PCLLCW+(36-CLLS)%*PHFRS)*HSZ5)/(MP*9.45*HSZ5)
244	"LNRAPPRXPR"	INTCPTPR+SLPPR*INVPR	INTCPTPR+SLPPR*INVPR	INTCPTPR+SLPPR*INVPR	INTCPTPR+SLPPR*INVPR	INTCPTPR+SLPPR*INVPR

XIV:REGRESSION: This component estimates the intercepts, slopes and coefficients of determination for the regressions of profit, labor and herd size on dollars invested for each strategy. These regression estimates allow transformation of estimates of profitability and labor based on herd size to be expressed on the basis of discrete levels of investment. These estimates are based on equations derived from: Zar, J.H., 1974, pg. 201-208.

The column SUM refers to the sums of the values of profit, investment, labor or herd size for the herd sizes budgeted for each particular strategy.

The column SUM X2 refers to the sum of the squared values of profit, investment, labor or herd size for the herd sizes budgeted for each particular strategy.

The column AVG refers to the mean values of profit, investment, labor or herd size for the herd sizes budgeted for each particular strategy.

The column SUMXY refers to the sum of the cross products of deviation from the mean for values of: (profit * investment), (herd size * investment) or (labor * investment) for the herd sizes budgeted for each particular strategy. It is estimated based on the equation: $\Sigma XY = \Sigma X_i Y_i - (\Sigma X_i) * (\Sigma Y_i)/n$.

The column SLOPE refers to the slopes for the regressions of profit, labor or number of cows on dollars invested for each particular strategy. It is estimated based on the equation:

$$b = \frac{\Sigma X_i Y_i - \Sigma (X_i) * (Y_i)/n}{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{n}}$$

where n = # of values of X

The column INTERCEPT refers to the intercepts for the regressions of profit, labor or number of cows on dollars invested for each particular strategy. It is estimated based on the equation: $a = \bar{Y} - b * \bar{X}$

The column R2 refers to the coefficients of determination for the regressions of profit, labor or number of cows on dollars invested for each particular strategy. It is estimated based on the equation:

$$r^2 = \frac{\text{SS regression}}{\text{SS Total}} = \frac{b * \Sigma XY}{\Sigma Y_i^2 - \frac{(\Sigma Y_i)^2}{n}}$$

INTCPTGFG, INTCPTGF, INTCPTPR refer to the intercept of the regressions of profit by dollars invested calculated in XIV.

SLPGFG, SLPGF, SLPPR refer to the slope of the regressions of profit by dollars invested calculated in XIV.

These predictions should be compared to values for PRFTGFG, PRFTGF and PRFTPR to assess how accurately the regression estimates in XIV track the budgeted values.

	8	9	10	11	12	13	14	
222	"SUM"	"(SUMX2)"	"AVG"	"SUMXY"	"SLOPE"	"INTERCEPT"	"R2"	
223	SUM(RC[-5]:RC[-2])	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2	RC[-2]/4	(RC[-8]*R[+1]C[-8]+RC[-7]*R[+1]C[-7]+RC[-6]*R[+1]C[-6]+RC[-5]*R[+1]C[-5])-((RC[-3]*R[+1]C[-3])/4)	RC[-1]/(R[+1]C[-3]-(R[+1]C[-4]^2/4))	RC[-3]-(RC[-1]*R[+1]C[-3])	RC[-2]*RC[-3]/(RC[-5]-RC[-6]^2/4)	"PROFIT"
224	SUM(RC[-5]:RC[-2])	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2	RC[-2]/4					"INVESTMENT"
225								
226	RC[-5]+RC[-4]+RC[-3]+RC[-2]	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2	RC[-2]/4	(RC[-8]*R[-2]C[-8]+RC[-7]*R[-2]C[-7]+RC[-6]*R[-2]C[-6]+RC[-5]*R[-2]C[-5])-(R[-2]C[-3]*RC[-3]/4)	RC[-1]/(R[-2]C[-3]-(R[-2]C[-4]^2/4))	RC[-3]-RC[-1]*R[-2]C[-3]	RC[-2]*RC[-3]/(RC[-5]-(RC[-6]^2/4))	"LABOR"
227	HSZ1+HSZ2+HSZ3+HSZ4	HSZ1^2+HSZ2^2+HSZ3^2+HSZ4^2	RC[-2]/4	(HSZ1*R[-3]C[-8]+HSZ2*R[-3]C[-7]+HSZ3*R[-3]C[-6]+HSZ4*R[-3]C[-5])-(RC[-3]*R[-3]C[-3]/4)	RC[-1]/(R[-3]C[-3]-(R[-3]C[-4]^2/4))	RC[-3]-RC[-1]*R[-3]C[-3]	RC[-2]*RC[-3]/(RC[-5]-RC[-6]^2/4)	"HERD SIZE"
	8	9	10	11	12	13	14	
231	SUM(RC[-5]:RC[-2])	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2	RC[-2]/4	(RC[-8]*R[+1]C[-8]+RC[-7]*R[+1]C[-7]+RC[-6]*R[+1]C[-6]+RC[-5]*R[+1]C[-5])-((RC[-3]*R[+1]C[-3])/4)	RC[-1]/(R[+1]C[-3]-(R[+1]C[-4]^2/4))	RC[-3]-(RC[-1]*R[+1]C[-3])	RC[-2]*RC[-3]/(RC[-5]-RC[-6]^2/4)	"PROFIT"
232	SUM(RC[-5]:RC[-2])	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2	RC[-2]/4					"INVESTMENT"
233								
234	RC[-5]+RC[-4]+RC[-3]+RC[-2]	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2	RC[-2]/4	(RC[-8]*R[-2]C[-8]+RC[-7]*R[-2]C[-7]+RC[-6]*R[-2]C[-6]+RC[-5]*R[-2]C[-5])-(R[-2]C[-3]*RC[-3]/4)	RC[-1]/(R[-2]C[-3]-(R[-2]C[-4]^2/4))	RC[-3]-RC[-1]*R[-2]C[-3]	RC[-2]*RC[-3]/(RC[-5]-(RC[-6]^2/4))	"LABOR"
235	HSZ1+HSZ2+HSZ3+HSZ4	HSZ1^2+HSZ2^2+HSZ3^2+HSZ4^2	RC[-2]/4	(HSZ1*R[-3]C[-8]+HSZ2*R[-3]C[-7]+HSZ3*R[-3]C[-6]+HSZ4*R[-3]C[-5])-(RC[-3]*R[-3]C[-3]/4)	RC[-1]/(R[-3]C[-3]-(R[-3]C[-4]^2/4))	RC[-3]-RC[-1]*R[-3]C[-3]	RC[-2]*RC[-3]/(RC[-5]-RC[-6]^2/4)	"HERD SIZE"
	8	9	10	11	12	13	14	
239	SUM(RC[-5]:RC[-1])	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2+RC[-2]^2	RC[-2]/5	(RC[-8]*R[+1]C[-8]+RC[-7]*R[+1]C[-7]+RC[-6]*R[+1]C[-6]+RC[-5]*R[+1]C[-5])+RC[-4]*R[+1]C[-4]-((RC[-3]*R[+1]C[-3])/5)	RC[-1]/(R[+1]C[-3]-(R[+1]C[-4]^2/5))	RC[-3]-(RC[-1]*R[+1]C[-3])	RC[-2]*RC[-3]/(RC[-5]-RC[-6]^2/5)	"PROFIT"
240	SUM(RC[-5]:RC[-1])	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2+RC[-2]^2	RC[-2]/5					"INVESTMENT"
241								
242	RC[-5]+RC[-4]+RC[-3]+RC[-2]+RC[-1]	RC[-6]^2+RC[-5]^2+RC[-4]^2+RC[-3]^2+RC[-2]^2	RC[-2]/5	(RC[-8]*R[-2]C[-8]+RC[-7]*R[-2]C[-7]+RC[-6]*R[-2]C[-6]+RC[-5]*R[-2]C[-5]+RC[-4]*R[-2]C[-4])-(R[-2]C[-3]*RC[-3]/5)	RC[-1]/(R[-2]C[-3]-(R[-2]C[-4]^2/5))	RC[-3]-RC[-1]*R[-2]C[-3]	RC[-2]*RC[-3]/(RC[-5]-(RC[-6]^2/5))	"LABOR"
243	HSZ1+HSZ2+HSZ3+HSZ4+HSZ5	HSZ1^2+HSZ2^2+HSZ3^2+HSZ4^2+HSZ5^2	RC[-2]/5	(HSZ1*R[-3]C[-8]+HSZ2*R[-3]C[-7]+HSZ3*R[-3]C[-6]+HSZ4*R[-3]C[-5]+HSZ5*R[-3]C[-4])-(RC[-3]*R[-3]C[-3]/5)	RC[-1]/(R[-3]C[-3]-(R[-3]C[-4]^2/5))	RC[-3]-RC[-1]*R[-3]C[-3]	RC[-2]*RC[-3]/(RC[-5]-RC[-6]^2/5)	"HERD SIZE"

XV:SUMMARY: This component summarizes in tabular form the profit, rate of return on investment (RROI), number of cows and number of laborers for each strategy, considering levels of investment of: $.5, 1.0, 1.5, 2.0 and 2.5 million. The slope (b), intercept (a) and coefficient of determination (R2) for the regression estimating profit/ dollar invested are listed for each strategy. The footnotes contain the maximum number of dollars actually budgeted in the analysis. Investment sizes greater than these are extrapolations. In addition many of the factors describing the specifics of a particular analysis such as level of milk production, price of corn, price of milk, etc. are printed. The approximate milk price/feed cost ratio is printed using a regression equation which relates a weighted average of the price of corn, soybean meal and hay with 16% concentrate (see thesis section 4.4.3).

	11	12	13	14	15	16	17	18	19
1	"XV"								
2	"--"								
3	"TABLE 5.2 CHANGES IN PROFITABILITY B Y LEVEL OF INVESTME NT ACCORDING"								
4	" TO STRA TEGY"								
5									
6		" Milk produc tion (lb)= "			MP*1000				
7		" Corn Price ($/bu) ="			PSCORN	"Milk/feed ratio= "			((PMLK/100)/((PALFH Y-18)*0.000275+PSCO RN*0.00536+PSYML*0. 15))*0.388+0.522
8		" Milk Price ($/cwt) ="			PMLK				
9									
10			"LEVEL OF INVESTMEN T ($ million)"						
11		INV1/1000000	INV2/1000000	INV3/1000000	INV4/1000000	INV5/1000000			
12	"----------"	"----------"	"----------"	"----------"	"----------"	"----------"	"---- ----- -"	"---------- "	"----------"
13	"STRATEGY:"							"regression :"	
14	"GFG"							" profit b y"	
15								" $investe d"	
16	"$PROFIT"	ICPTPFTGFG+SLPPFTGF G*INV1	ICPTPFTGFG+SLPPFTGF G*INV2	ICPTPFTGFG+SLPPFTGF G*INV3	ICPTPFTGFG+SLPPFTGF G*INV4	ICPTPFTGFG+SLPPFT GFG*INV5		"a="	ICPTPFTGFG
17	"RROI(%)"	(R[-1]C/INV1+INTRT) *100	(R[-1]C/INV2+INTRT) *100	(R[-1]C/INV3+INTRT) *100	(R[-1]C/INV4+INTRT) *100	(R[-1]C/INV5+INTR T)*100		"b="	SLPPFTGFG
18	"COWS(#)"	ICPTHSZGFG+SLPHSZGF G*INV1	ICPTHSZGFG+SLPHSZGF G*INV2	ICPTHSZGFG+SLPHSZGF G*INV3	ICPTHSZGFG+SLPHSZGF G*INV4	ICPTHSZGFG+SLPHSZ GFG*INV5		"R2="	RPFTGFG
19	"LBH(#)"	ICPTLBRGFG+SLPLBRGF G*INV1	ICPTLBRGFG+SLPLBRGF G*INV2	ICPTLBRGFG+SLPLBRGF G*INV3	ICPTLBRGFG+SLPLBRGF G*INV4	ICPTLBRGFG+SLPLBR GFG*INV5			
20		"-------------"	"-------------"	"-------------"	"-------------"	"-------------"			
21	"GF"								
22								"a="	ICPTPFTGF
23	"$PROFIT"	ICPTPFTGF+SLPPFTGF* INV1	ICPTPFTGF+SLPPFTGF* INV2	ICPTPFTGF+SLPPFTGF* INV3	ICPTPFTGF+SLPPFTGF* INV4	ICPTPFTGF+SLPPFTG F*INV5		"b="	SLPPFTGF
24	"RROI(%)"	(R[-1]C/INV1+INTRT) *100	(R[-1]C/INV2+INTRT) *100	(R[-1]C/INV3+INTRT) *100	(R[-1]C/INV4+INTRT) *100	(R[-1]C/INV5+INTR T)*100		"R2="	RPFTGF
25	"COWS(#)"	ICPTHSZGF+SLPHSZGF* INV1	ICPTHSZGF+SLPHSZGF* INV2	ICPTHSZGF+SLPHSZGF* INV3	ICPTHSZGF+SLPHSZGF* INV4	ICPTHSZGF+SLPHSZG F*INV5			
26	"LBH(#)"	ICPTLBRGF+SLPLBRGF* INV1	ICPTLBRGF+SLPLBRGF* INV2	ICPTLBRGF+SLPLBRGF* INV3	ICPTLBRGF+SLPLBRGF* INV4	ICPTLBRGF+SLPLBRG F*INV5			
27		"-------------"	"-------------"	"-------------"	"-------------"	"-------------"			

	11	12	13	14	15	16	17	18	19
28	"PR"								
29								"a="	ICPTPFTPR
30	"$PROFIT"	ICPTPFTPR+SLPPFTPR* INV1	ICPTPFTPR+SLPPFTPR* INV2	ICPTPFTPR+SLPPFTPR* INV3	ICPTPFTPR+SLPPFTPR* INV4	ICPTPFTPR+SLPPFTP R*INV5		"b="	SLPPFTPR
31	"RROI(%)"	(R[-1]C/INV1+INTRT) *100	(R[-1]C/INV2+INTRT) *100	(R[-1]C/INV3+INTRT) *100	(R[-1]C/INV4+INTRT) *100	(R[-1]C/INV5+INTR T)*100		"R2="	RPFTPR
32	"COWS(#)"	ICPTHSZPR+SLPHSZPR* INV1	ICPTHSZPR+SLPHSZPR* INV2	ICPTHSZPR+SLPHSZPR* INV3	ICPTHSZPR+SLPHSZPR* INV4	ICPTHSZPR+SLPHSZP R*INV5			
33	"LBR(#)"	ICPTLBRPR+SLPLBRPR* INV1	ICPTLBRPR+SLPLBRPR* INV2	ICPTLBRPR+SLPLBRPR* INV3	ICPTLBRPR+SLPLBRPR* INV4	ICPTLBRPR+SLPLBRP R*INV5			
34		"-------------"	"-------------"	"-------------"	"-------------"	"-------------"			
35	"----------"	"----------"	"----------"	"----------"	"----------"	"----------"	"---- ----- -"	"---------- "	
36	"Returns to levels of investment beyon d $"				INDEX(INVGFG,4)	"are "			
37	" extrapolated for the strategy GFG"								
38	"Returns to levels of investment beyon d $"				INDEX(INVGF,4)	"are"			
39	" extrapolated for the strategy GF"								
40	"Returns to levels of investment beyon d $"				INDEX(INVPR,5)	"are"			
41	" extrapolated for the strategy PR"								
42									
43	"Soil management gr oup ="			SMG	"Price of dairy cow s ($/cow)="				PCWS
44	"Price of land ($/a cre) ="			PLND	"Price of cull cows ($/cwt)="				PCLLCW
45	"Price of hay ($/t on) ="			PALFHY	"Price of hfrs ($/h eifer)="				PHFRS
46	"Price of corn sila ge ($/ton)="			PCSLG	"Price of cull hfrs ($/cwt)="				PCLLHFR
47	"Price of soybean m eal ($/lb)="			PSYML	"Price of cull clvs ($/cwt)="				PDCNCLVS

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