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FEED PROCUREMENT METHODS FOR SOUTHEASTERN MINNESOTA DAIRY FARMS: A COMPARISON USING LP ANALYSIS

by

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INTRODUCTION

How does the choice of feed procurement for Minnesota dairy farms affect their costs and returns? The answer to this question is significant not only for the dairy farmers, but it may partially explain Minnesota's declining relative share of the national dairy industry. Industry leaders in the state are very concerned about this trend. It means the loss of businesses, jobs, income, and economic base in many communities.

In this paper, we attempt to answer the preceding question relating to feed procurement strategies. The principal objective is to determine the financial impacts of changing feed procurement strategies for a specified southeastern Minnesota dairy farm. Growing all feed for the dairy herd on the farm itself, currently the most prominent mode of procurement, is compared to: (1) producing all forage and purchasing all concentrate feeds from others, and (2) purchasing all feeds from others. The effect of herd size on the comparisons is considered to determine if size has a bearing on the chosen method of feed procurement.

Two related issues are also examined. One is the problem of manure handling if crop production is discontinued and cropland is sold or rented. The impact of the current federal feedgrain program on milk production costs is also considered. It's been hypothesized by some policy analysts that this government program influences a dairy farmers' decision to grow or purchase feeds.

BACKGROUND

Minnesota's milk industry has declined absolutely and relatively since the early 1980's. In terms of share of national milk production, Minnesota accounted for 7.4 percent of U.S. output in 1980. That year, the state ranked fourth in the nation. By 1991, however, Minnesota's share had fallen to 6.6 percent and Pennsylvania had taken over its place in the national standings. In absolute terms, Minnesota's total milk production also fell during this time period. After peaking at 10.9 billion pounds in 1983, output reached only 9.8 billion pounds in 1991. The drop was characterized by a dramatic 24 percent loss in cow numbers [25].

While Minnesota was losing share in the national dairy industry, other states were gaining. California, for example, increased its share of national milk production from 8.1 percent in 1970 to 14.5 percent in 1991. Both cow numbers and milk production increased significantly from 1983 and 1991, cow numbers rose 22 percent and output of milk jumped 46 percent [25]. But, production in several southern and western states also grew significantly. Based on the average of all herds, Minnesota's dairy industry is also at a disadvantage in terms of production per cow. In 1980, Minnesota herds averaged 11,060 pounds per cow. At the same time, productivity averaged 13,750 pounds in Arizona, 13,380 pounds in New Mexico and 14,640 pounds in Washington. By 1991, Minnesota herds had improved to 14,310 pounds, but herds had increased to 18,030 pounds in Arizona, 20,390 pounds in New Mexico and 18,810 pounds in Washington. Productivity improved in all states, but Minnesota remained well below these select states.

Nearly all dairy farmers in Minnesota own or rent land for dairy feed production. A 1988 "Minnesota Dairy Farm Survey" [12] reported that the average Minnesota dairy farmer owned 277 acres, and many also rented land. More than two-thirds of this land was tillable, thus allowing many farmers to produce all of their herd's forage and grain requirements. In fact, 74 percent of these farms did not purchase any forages, and 55 percent required no grain purchases. Some farmers purchased some feed to supplement home production. Very few purchased 100 percent of their feeds.

There are a number of factors that may account for shifting of milk production among national dairy regions. In many southern states, for example, farmers usually receive higher prices for their milk and have lower investment costs. Management practices also differ. In Minnesota, as in other northern states, the majority of farmers milk relatively small dairy herds, use traditional stall type housing, and grow most of their own feed. In contrast, farmers in several southern and western states milk large dairy herds, use newer parlor type milking systems and purchase most feeds.

Researchers have explored many of these interregional changes and their causes. Some have analyzed differences in milk prices and investment costs (eg. Buxton et al.)[1],[2], while others have studied economies of size and type of milking system [4]. To-date, however, very few have considered differences in feed procurement methods and their impacts on milk production costs. Buxton and other researchers have postulated that the additional responsibilities associated with crop production could prevent Minnesota farmers from applying the economically best management practices to their herds and may at least partially account for the lower productivity [2, pg 22]. What if northern farmers changed feed procurement practices and, instead, purchased all necessary feeds? Could they reduce costs, increase profits and contribute to maintaining their current share of the national dairy market?

METHODOLOGY

The LP Model

This study employs the technique of "linear programming" (LP) and uses some associated capital budgeting techniques to evaluate impacts of alternative feed acquisition strategies on dairy farms. The linear programming technique can be used for complex planning problem analysis. It is basically a mathematical tool for working out problems with three basic characteristics. First, the problem must have a specific quantifiable objective to maximize or minimize. Second, there must be quantifiable constraints on a number of the available resources, commodities or markets. Finally, there must be a range of possible activities from which the farmer can choose [13]. The result of a linear program is an "optimum solution" that satisfies all of the conditions of the problem and meets the given objective [10]. It is appropriate for this problem, that the determination of the minimum costs for the various feed procurement strategies.

The basic computerized LP model used in this study was initially developed by Fuller et al. The algorithm is called SMALLP [14]. Subsequent modifications to the model were made by Dornbush and then by Helming [4],[13],[14]. Dornbush used the basic model to derive economies of size curves for a typical southeastern Minnesota dairy farm situation. He modelled the dairy farm as a set of three interrelated subsystems: dairy enterprises, crop enterprises and support services.

Similar to Dornbush's hypothetical firm approach, our model is based on two case dairy farms in southeastern Minnesota [4]. The dairy enterprise has certain base characteristics. For example, all cows have a 13-month calving interval and weigh an average of 1300 pounds. Replacement heifers and bedding can be raised on the farm or purchased. Manure is spread on cropland and pasture. Labor requirements have fixed and variable components. Fixed labor components depend on the type of milking system used and do not vary with the number of cows; variable components change with the number of cows milked, heifers raised and/or other measures of enterprise size.

The cropping enterprise of each of the farm plans has also given base attributes. Each farm can produce alfalfa, corn and soybeans. Oats can be used to establish alfalfa. Labor requirements are specified for particular cropping activities, including planting, production, harvesting and storage. Necessary labor varies by season of the year.

The model permits detailed specifications of the nutrient requirements of the herd [13]. Because feed costs represent such a large proportion of total costs, it is important to estimate nutrient requirements as closely as possible. The various stages of lactation and gestation are included with different nutrient requirements for each. The four discrete feeding phases are: (1) early lactation, (2) peak dry matter intake, (3) mid-to-late lactation, and (4) dry period [19].

A few changes in the original model were necessary for this study. First, because farms in this study were allowed to rent-out cropland, a rental alternative was included. This was specified at the current rental rate for southeastern Minnesota, which is approximately $65/acre [6].

Second, on the basis of the recommended minimum forage and Neutral Detergent Fiber (NDF) requirements for dairy cattle in "Feeding the Dairy Herd," nutritional requirements were added to the model as constraints. The dry matter intake (DMI) of dairy cattle was set to contain at least 40 percent forage in early lactation and 50 percent in the dry period [19]. Minimum requirements were also placed on the NDF content of the feed so that it varied with the stage of lactation and the daily milk production level [21].

In addition, the minimum net energy and crude protein requirements for each stage of lactation were slightly modified based on guidelines found in "Feeding the Dairy Herd" [19]. Those used by Helming seemed unnecessarily high during the early stages of lactation. To be consistent with changed requirements for milking animals, the nutritional requirements of replacement heifers were modified to reflect recommendations from these sources. These changes to the model are shown in Appendix Tables 1 and 2.

To study the effects of the federal feedgrain program, the prices and set-asides of the current federal price support program (1992) were assumed.

The problem of manure handling if no cropland is available for disposal was evaluated with separate computer programs. First, quantities of manure produced under each farm plan were determined using the Manure Estimator for New Systems (MENS) [18]. Then, the Manure Application Program (MAP), another LP model, was used to identify uses of manure and possible disposal alternatives for excess amounts [17].

Estimation Procedures

With the Dornbush/Helming model as a base, nine model dairy farm plans were developed to represent Minnesota dairy herds that would be classified as small, medium and large, respectively. Each of these was evaluated for three different feed procurement methods; growing all feed except mineral supplements, growing only forages and purchasing grain concentrates and minerals, or purchasing all feeds. This yielded nine farm plan alternatives.

The optimal solutions to each farm specification involved several steps. First, the SMALLP model generates the maximum gross margin between annual gross farm sales and the directly related or variable cash expenses for each farm specification, an optimal solution. The solution is based on an arbitrary milk price. That price does not affect the solution given our alternatives. Second, because the solutions include levels of variable farm input use, expense and farm product sales and because these farms have other income sources besides milk sales, such as cattle and crops, these other revenues are deducted from the total of direct or variable cash costs to approximate the net total variable cash costs that must be covered by returns from milk sales.

Third, the annual charge for associated capital inputs and a predetermined return to operator labor are also calculated for each farm situation. These two components represent, essentially, the annual overhead costs of milk production. Total annual costs of milk production are simply the sum of the annual variable cash costs of milk production that are derived from the LP solutions and the annual overhead costs of production (including operator income).

To calculate the minimum required milk price, the gross annual cost of milk production, (the total of all costs less receipts from other than milk sales) is divided by the volume of milk produced to give the required price per hundredweight. A lower minimum milk price indicates a more economically efficient plan. In summary from the calculations are as follows:

Minimum Required Milk Price = (Net Variable Cash Costs + Annual Fixed Overhead Costs + Imputed Operator Income) / Volume of Milk Produced

Herd and Farm Size Specifications and Associated Characteristics

Farm sizes are specified according to size of the milking herd, acres of cropland, and the number of families operating the farm. A small farm is a one family farm milking 40 head of cattle. A medium-size farm is a two family farm milking 100 head, and a large size farm is a two family farm milking 200 head. The model farm characteristics with identifying symbols are listed in Table 1. Farms in plans SGA, MGA and LGA may produce alfalfa, alfalfa haylage, corn, corn silage, soybeans, oats grain and oatlage. Farms in plans SGF, MGF and LGF cannot produce corn or soybeans, and those in plans SBA, MBA, and LBA may not grow any of their own feed, i.e., they must lease or sell their cropland.

Cows produce an average of 18,000 pounds of milk containing 3.6 percent milkfat. They are on a 13-month calving cycle and all bull calves are sold immediately; no steers are raised. Heifer calves may be sold at birth or replacement heifers can be raised. They can also be purchased and/or sold as springers.

Table 1: BASIC CHARACTERISTICS OF THE DIFFERENT SIZE FARM PLANS *

	Small	**Medium**	**Large**
No. of Families	1	2	2
Herd Size	40	100	200
Milking System	Tie stall	Parlor	Parlor
Acres of Land	183	183	183
Feed Procurement Method:		Identifying Symbol	
Grow All	SGA	MGA	LGA
Grow Only Forage	SGF	MGF	LGF
Buy All	SBA	MBA	LBA

* Note that farm size varies with herd size, not land area.

Milking and housing facilities vary in size and type. Both tie stalls and parlor systems are analyzed [4]. The "small" farms use a tie stall system with one milker operating 3 pipeline units. The "medium" and "large" farms use a double 8 herringbone parlor system with automatic detachers, a crowd gate, and feed bowl covers (full mechanization). The parlor has one milker unit per stall.

Initially, all the farms own 183 acres of land, of which 160 acres are tillable regardless of herd size. A total of 137 acres are considered suitable for corn or alfalfa production, and a maximum of 76 acres are available for row crops. Twenty-three acres are kept in permanent pasture. Cropland may be rented-out to others, but pasture land can not be. The land is valued at $1,099/acre; the average value of farmland in southeastern Minnesota in 1991 [20]. Each of these farms has the choice of renting-out or selling their cropland. Renting only is considered for the short-term and selling is examined for the long-term.

The total operator labor available depends on the number of families. Dornbush assumed that one member from each family acted as the principle operator and worked full-time on the farm. Other family members also provided additional labor. In total, each family provides 65 hours per week. Total regular labor hours available for the small, one-family farm is estimated at 3,710 hours; the medium and large, two-family farms have 6,900 hours available [4, pg 76]. The farms may hire additional outside labor as needed at $8.00/hr.

Prices and Costs of Inputs

The price data used for the LP model were 1992 prices for both sales and purchased inputs. Other price and cost data were updated using information from several sources. The revised prices for crop inputs, feed purchases and sales, livestock purchases and sales, and milk sales are shown in Table 2.

Table 2. PRICES PAID FOR FARM INPUTS AND RECEIVED FOR PRODUCTS SOLD

	Purchase Price	Sale Price*
Nitrogen/cwt (row)	22.00	
Phosphate/cwt (row)	24.00	
Potash/cwt (row)	13.00	
Shelled Corn/bu	2.45	
HMSC/bu	1.85	1.75
Ear Corn/bu	2.10	
HMEC/bu	1.95	
Alfalfa Hay/ton	70	50
Oats/bu		1.45
Soybeans/bu		5.60
Soybean Meal/cwt	9.00	
Bedding	40	
Milk/cwt		11.00
Replacement Head	900	850
Heifer Calf		125
Bull Calf		90

Source: [3],[4],[5],[15],[24]
*Both Purchase and Sale Prices include hauling charges to the "farm gate."

The machinery requirements for each farm depends on crop production. In reality, there are numerous combinations of machinery and equipment available to dairy farmers. Although farmers may prefer to use other equipment, the machinery complement used in this study is the same as that used by Dornbush and Helming. Since the base model was fashioned after case farms in southeastern Minnesota, it represents observable real farm situations. For our analysis, estimates are first made for farms with new machinery and milking facilities. Subsequently machinery and equipment prices are reduced to reflect the practices of buying used machinery and remodeling of facilities. These estimates are made with these components being obtained at one-half the new price.

The investment and operating costs of the machinery from Dornbush and Helming were updated using information from several sources [8],[9],[15]. The revised machinery acquisition costs are listed in Table 3. Operating costs for this equipment were those developed by Dornbush, adjusted to reflect 1991 pricing conditions.

Feed storage facilities depend on the crops produced on the farm. All farms have grain bins and/or corn cribs for storage of ear corn and purchased grains. All can select either upright or horizontal silos. The upright silos are concrete and come equipped with an unloader. Horizontal silos are concrete bunkers. All storage facilities may be filled more than once a year. Storage investments vary with feed production and purchases, and estimates are based on information from two sources [11],[23].

Although raised replacement heifers are kept on pasture during the pasture season, all farms have shelter and facilities for these heifers. Each farm also has a machine storage shed sized according to the machinery complement. Building investment costs are estimated by multiplying Dornbush's original data by an inflationary factor ("index for prices paid by farmers for building & fencing" in [24]).

The investment costs for milking facilities include a manure spreader and other solid waste handling equipment. Waste can be disposed of on pasture land or used in crop production.

Annual overhead costs are calculated using a set of "annual charge rates." These rates cover depreciation, interest, repairs, taxes and insurance. They are specified according to investment costs. The useful life specified for each group of investments and the total annual charge rates are shown in Table 4. The annual overhead charge for depreciation, repairs, taxes and insurance are based on information from (Buxton) [2]. For the interest rate, it is assumed that funds for any building and facility investments will be either borrowed or provided by the owner(s). In either case there is an interest charge. We have used a "borrowed funds" rate. It reflects either the cost of borrowed funds or, if investments are made with funds from the operator, it reflects the "opportunity" cost of these funds. The interest charge for other assets is the "real" interest rate, noted at the bottom of Table 4. The total investment and annual charge rates for the various facilities and equipment are presented in Table 5.

Table 3. INITIAL OR NEW MACHINERY COSTS AT 1992 PRICES

Machine	Tractor HP	Cost Per Unit
Tractor	40	15,485
Tractor	75	24,550
Tractor	140	53,610
MB Plow 5-16	100	8,415
Chisel Plow 15'	120	4,650
Field Cultivator 18'	100	4,275
Disk 16'	75	6,160
Springtooth Drag 48'	75	2,755
Corn Planter 6-30	60	11,325
Grain Drill PW 14'	40	9,845
Cultivator 6-30	60	3,500
Sprayer 30'	40	3,350
Picker-Sheller 2-row	60	16,730
Shredder (stk chop) 12'	60	6,640
Gravity Box 185 bu. (2 units)	60	1,585
Corn Roller Mill	60	12,190
Forage Harvester 2-row	100	15,720
2-row Corn Head		4,635
7-ft Hay Head		3,090
Forage Wagon 16' (3 units)	40	6,875
Forage Blower Large	75	4,025
Swather-Conditioner 12'		31,690
Rake (hyd)	40	3,240
Baler PTO (Twine)	40	8,920
Hay Wagon (2 units)	40	2,075
Round Baler 1000 lb	60	10,750
Round Bale Wagon	60	8,970
8" 48' Grain Auger	40	3,105
Corn Elevator PTO 52'	40	5,261
Bale Conveyor w/Motors		3,404
Mixer Wagon 175 bu.	40	11,658
Loader	75	3,800
Standby Generator	75	3,500
Pickup 3/4 ton, 4 wd		22,000
Tools, Miscellaneous		15,000

Source: [9],[15]

Table 4. ANNUAL CHARGE RATES FOR DAIRY EQUIPMENT AND FACILITIES

	Wt'd Avg Useful Life	Deprec.	Interest	Repairs	Taxes[a/]	Ins.	Total
Land	-	-	4.5%	-	1.5%	-	6.0%
Milking Facilities	17	5.9%	9.2%	2.6%	0.7%	1.5%	20.0%
Heifer Facilities	17	5.9%	9.2%	2.6%	0.7%	1.5%	20.0%
Feed Storage	16	6.3%	9.2%	2.0%	1.0%	1.5%	20.0%
Machinery[b/]	10	10.0%	9.2%	-	-	2.0%	21.2%
Machine Storage	20	5.0%	9.2%	2.0%	0.7%	1.5%	18.5%
Tools, Misc.	8	12.5%	4.5%	0.0%	-	1.5%	18.5%
Cow Cost[c/]	-	-	4.5%	-	-	0.0%	4.5%
Young Stock[c/]	-	-	4.5%	-	-	0.0%	4.5%
Borrowed Funds	9.2%	Inflation	4.0%				
Yield on T-bonds	8.5%	"Real"	4.5%				

Source: [2],[26]

a/ No personal property taxes in Minnesota.

b/ Machinery repairs costs included in operating costs as a use cost.

c/ Livestock insurance costs are included in direct costs.

Table 5. TOTAL INVESTMENT NEW COSTS FOR FACILITIES AND EQUIPMENT & ANNUAL OVERHEAD CHARGE

	Annual Charge Rate	Small Farm Grow All feed	Small Farm Grow Forage	Small Farm Buy All feed	Medium Farm Grow All feed	Medium Farm Grow Forage	Medium Farm Buy All feed	Large Farm Grow All feed	Large Farm Grow Forage	Large Farm Buy All feed
Total Investment Costs:						Dollars				
Land	6.0%	201,117	201,117	201,117	201,117	201,117	201,117	201,117	201,117	201,117
Milking Facilities[a/]	20.0%	109,334	109,334	109,334	229,905	229,905	229,905	351,983	351,983	351,983
Heifer Facilities[a/b/]	20.0%	1,447	1,809	2,532	16,280	16,280	16,280	6,150	7,597	6,512
Feed Storage	20.0%	29,892	16,638	19,060	91,191	72,199	52,123	100,430	81,690	88,468
Machinery	21.2%	287,075	231,295	78,000	315,349	268,499	89,658	331,823	288,143	89,658
Machine Storage[a/c/]	18.5%	28,000	22,560	7,608	30,758	26,189	8,745	32,365	28,105	8,745
Tools & Miscellaneous	18.5%	12,977	10,456	3,526	14,255	12,137	4,053	15,000	13,025	4,053
Cow Cost[d/]	4.5%	49,000	49,000	49,000	122,500	122,500	122,500	245,000	245,000	245,000
Young Stock[e/b/]	4.5%	1,800	2,250	3,150	20,250	20,250	20,250	7,650	9,450	8,100
Total Investment Costs		**720,642**	**644,458**	**473,327**	**1,041,605**	**969,076**	**744,631**	**1,291,518**	**1,226,110**	**1,003,635**
Annual Fixed Overhead Cost		110,928	95,072	59,195	161,147	146,180	99,527	194,258	180,467	134,224

Source: [4],[13],[23],[24].

a/ Building Costs estimated using Dornbush and Index of Prices Paid by Farmers for Building & Fencing.
b/ Heifer facilities and youngstock value for Raised replacements only.
c/ Machine Storage and Miscellaneous vary with Machinery investment.
d/ Cow costs based on value of $1,225/cow.
e/ Estimated value of heifers on hand at half their mature value ($900/hd).

The annual operator labor component is assumed fixed at $32,500 per family. We considered it be a rather conservative estimate of an acceptable per family labor income and one that is consistent with returns in many other activities in the economy.

EMPIRICAL RESULTS

Comparisons of Feed Procurement Methods for Given Herd Sizes

The resource uses, costs of variable inputs and annual fixed investment costs were generated using the LP model and associated capital budgeting procedures for the three dairy herd sizes.

Results for Small Dairy Herds: The land use and feed purchase requirements for all farm plans are shown in Table 6. For the small farm that grows all feed, SGA, the optimum farm plan results in 66 acres of cropland being rented-out. The farmer produces corn, soybeans, corn silage, alfalfa and oats. The only feed purchased is soybean meal, 472 cwt., at a cost of $4,251 (Table 6).

Feed purchases increase and land use decreases under the plan allowing only for the production of forages (SGF). In this plan, all of the necessary hay is raised on the farm. However, corn, soybean meal and bedding are all purchased, costing a total of $10,742. Nearly 115 acres of cropland is rented-out to others, generating rental income of $7,464.

In plan SBA, where all feeds are purchased, 160 acres of cropland are rented out with rental income of $10,400. Feed purchases, though, total $24,419. Slightly more than 120 tons of alfalfa hay is purchased under this plan.

Some additional hired labor is necessary on all three of the small farm plans, but the number of hours required drops as feed production falls. Under plan SGA, the farmer hires outside help for 506 hours. This need drops to 62 hours under plan SBA where all feed is purchased. Note that the additional family labor that is made available with SBA reduces the need for hired non-family labor.

Total variable cash costs of the farm increase from $27,741 to $34,244 when all feed is purchased, Table 7. Firm gross margins decline as feed production drops and feed purchases rise. The contribution to overhead, as calculated by the LP model, ranges from $69,846 for plan SGA to $56,816 for plan SBA. On an annual basis, the increase in land rental income and the savings gained by reducing hired labor and crop production costs are not as great as the increases in feed purchase costs.

Table 6. USE OF LAND AND FEEDS PURCHASED IN ALTERNATIVE FARM PLANS

	Small Farm			Medium Farm			Large Farm		
	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed
Land Use (acres):									
Perm. Pasture - used	16	17	23	23	23	23	23	23	23
Perm. Pasture - unused	7	6							
Cropland Rented	66	115	160		23	160		23	160
HMSC Corn/Corn									
HMSC Corn/Soybeans	14								
HMSC Corn/Alfalfa	4								
EC Corn/Corn									
EC Corn/Soybeans	33								
EC Corn/Alfalfa									
Corn Silage Corn/Corn							9		
Corn Silage Corn/Soybeans	25			55			46		
Corn Silage Corn/Alfalfa				21			21		
Est. Alfalfa w/Oatgrain	4	11							
Est. Alfalfa w/Oatlage				21	34		21	34	
Est. Alfalfa w/Herbicide									
Full Alfalfa	13	34	—	63	103	—	63	103	—
Total acres	183	183	183	183	183	183	183	183	183
Purchased Feed & Bedding:									
Shell Corn (bu.)				6,047					
Ear Corn (bu.)		3,314	4,453	402	11,776	15,396	14,774	22,230	23,555
Alfalfa Hay (tons)			120			336		27	605
Soybean Meal (cwts.)	472	303	509	774	782	1,680	2,598	2,649	2,720
Bedding (tons)		27	52	126	126	126	166	171	182
Total Labor Hired:									
Hours	506	151	62	263	151	0	753	658	97

Table 7. ANNUAL RECEIPTS AND VARIABLE CASH EXPENSES FOR SELECTED MINNESOTA DAIRY FARMS

	Small Farm			Medium Farm			Large Farm		
	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed
					Dollars				
CASH RECEIPTS:									
Milk Sold	77,743	77,743	77,743	194,357	194,357	194,357	388,714	388,714	388,714
Bull Calves Sold	1,579	1,594	1,696	5,273	5,273	5,273	7,788	7,949	8,301
Heifer Calves Sold	1,556	1,514	1,222	101	101	101	8,088	7,628	6,622
Replacements Sold	0	0	0	12,277	12,277	12,277	0	0	0
Com Sold	3,372	0	0	0	0	0	0	0	0
Soybeans Sold	9,024	0	0	6,950	0	0	5,796	0	0
Oats Grain Sold	0	0	0	0	0	0	0	0	0
Cropland Rented	4,313	7,464	10,400	0	1,495	10,400	0	1,495	10,400
Total Cash Receipts	97,587	88,315	91,061	218,959	213,504	222,409	410,386	405,786	414,037
CASH EXPENSES:									
Cattle:									
Cows	4,167	4,167	4,167	10,417	10,417	10,417	20,834	20,834	20,834
Replacement Heifers	297	326	528	3,361	3,361	3,361	1,270	1,588	2,284
Replacements Bought	7,270	6,926	4,519	0	0	0	38,886	35,100	26,816
Crop Production									
Com	1,934	0	0	0	0	0	0	0	0
Com Silage	1,681	0	0	8,544	0	0	8,776	0	0
Alfalfa Hay + Haylage	792	2,580	0	2,429	4,483	0	2,806	4,576	0
Oatlage	0	0	0	2,150	3,507	0	2,150	3,507	0
Oats Grain	497	1,273	0	0	0	0	0	0	0
Soybeans	2,572	0	0	0	0	0	0	0	0
Com Stalks	156	0	0	0	0	0	0	0	0
Pasture	79	87	115	115	115	115	115	115	115
Purchased Feed									
Soybean Meal	4,251	2,723	4,585	6,965	7,039	15,119	23,380	23,837	24,479
Com	0	6,959	9,352	12,346	24,730	32,332	31,026	46,684	49,465
Bedding	0	1,060	2,084	5,036	5,036	5,036	6,639	6,840	7,278
Alfalfa Hay	0	0	8,397	0	0	23,530	0	1,873	42,365
Hired Labor	4,045	1,209	497	2,105	1,204	0	6,025	5,266	774
Total Variable Cash Expenses	27,741	27,309	34,244	53,468	59,892	89,909	141,908	150,220	174,410
Total Variable Costs Minus Non Milk Income	7,897	16,737	20,926	28,867	40,745	61,857	120,235	133,147	149,087
Cash Available for Fixed Overhead Cost of Milk	69,846	61,006	56,816	165,490	153,611	132,500	268,479	255,566	239,626

Beyond a one-year horizon where disinvestment in machinery and equipment can occur, there are significant financial benefits to be gained by reducing crop production. Using the investment costs and annual charge rates developed previously, the minimum milk price required to cover all costs ranges from $21.41/cwt for plan SGA to $15.94/cwt for plan SBA Table 8. The minimum required milk price for plan SGF is $20.42/cwt. All of these are somewhat higher than current market prices, but it is clear that the funds needed to cover both operating and ownership costs fall as crop production declines. Although annual variable costs are higher when feed purchases increase, fixed costs are lower. This is due to significant reductions in machinery and feed storage investments.

When the farms sell off "excess" cropland, the minimum required milk price does not change significantly. Selling the land reduces land investment costs and lowers annual overhead, but the minimum required milk price declines by only 1-3 cents/cwt for each of the plans. Of course, selling the land also decreases the farm asset base including area to spread manure and reduces the total farm assets.

Results for Medium-size Herds: All medium farms raise 45 head of replacement heifers and fully utilize all pasture land, regardless of the feed acquisition strategy. Other than this, patterns of land use and feed purchases and costs on medium-size farms are very different.

In the plan allowing for all feed production (MGA), all cropland is used by the farmer (Table 6). Corn silage, soybeans, alfalfa and oatlage are grown on the farm. Still, there is not enough land available to meet the cattle's nutritional needs and grain has to be purchased from others. Feed purchases total $24,347 (Table 7). The farmers also hire 263 hours of additional labor, costing $2,100.

Feed purchases increase to $36,805 when no grains are produced on the farm (MGF). In this plan, ear corn, soybean meal and bedding are purchased in even greater quantities than in plan MGA. All hay is produced on the farm. Twenty-three acres of cropland are rented out, thus providing $1,500 in land rental income. Only 151 hours of additional labor are needed; all of this is required during the April-May and June-August time periods (Table 6).

In plan MBA all cropland is rented out, but feed purchases increase to $76,016. This is nearly double the purchase costs in plan MGA. However, the cropland does generate $10,400 in rental income and no additional hired labor is necessary. In fact, approximately 1,715 hours of

Table 8. TOTAL MILK PRODUCTION COSTS & MINIMUM MILK PRICE REQUIRED TO COVER ALL COSTS

	Small Farm			Medium Farm			Large Farm		
	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed
					(dollars)				
Total Investment Costs	720,642	644,458	473,327	1,041,605	969,076	744,631	1,291,518	1,226,110	1,003,635
Annual Costs of Milk Production:									
Fixed Overhead Cost	110,928	95,072	59,195	161,147	146,180	99,527	194,258	180,467	134,224
Variable Cash Costs	7,897	16,737	20,926	28,867	40,745	61,857	120,235	133,147	149,087
Annual Operator Labor Charge	32,500	32,500	32,500	65,000	65,000	65,000	65,000	65,000	65,000
Total Annual Cost	**151,326**	**144,308**	**112,621**	**255,014**	**251,925**	**226,385**	**379,493**	**348,311**	**348,331**
Cwt. Milk Produced	7,068	7,068	7,068	17,669	17,669	17,669	35,338	35,338	35,338
Required Milk Price ($/Cwt.)	**21.41**	**20.42**	**15.94**	**14.43**	**14.26**	**12.81**	**10.74**	**10.71**	**9.86**

available family labor is not used over the course of the year. Under this plan, the farmers could increase their herd size by 23 head without hiring additional outside labor. Even more cattle could be added if time was not so constrained during the spring time period.

The gross margin of plan MGA is $165,490. It declines to $153,611 under plan MGF and $132,500 under plan MBA (Table 7). Increases in feed purchases lead to significant declines in annual gross margins.

However, investment and annual overhead costs also drop as feed purchases increase and crop production falls. Because of this, the minimum milk price required to cover all costs is lowest for the farm that buys all feeds. In plan MBA, the minimum price is $12.81/cwt. It increases to $14.26/cwt for plan MGF and $14.43/cwt for plan MGA. These prices do not change for any of the plans when the farms are allowed to sell off excess cropland.

Results for Large-size Herds: Land use patterns on large-size farms are nearly identical to those of the medium-size farms (Table 6). All of the larger farms fully utilize pasture land, though they raise fewer replacement heifers than medium farms. Under plan LGA all cropland is used for the production of corn silage, soybeans, alfalfa and oatlage. Still, the farmers in this plan purchase $61,046 worth of corn, soybean meal and bedding. It is readily apparent that a 200 head dairy herd requires significantly more than 160 acres of cropland for its feed needs.

Under plan LGF, 260 dry matter tons (DMT) of hay, 235 DMT of hay silage and 60 DMT of oatlage is produced on the farm. This is not enough forage to meet all feed requirements, however. Surprisingly, 23 acres of cropland are rented out and the farmers purchase an additional 27 tons of alfalfa hay rather than increase hay production on the farm. This, combined with the corn, meal and bedding purchases brings total feed purchases to $79,234.

As one would expect, total feed purchases are largest under plan LGA (Table 8). Corn, soybean meal, bedding and hay purchases total $123,587 in this plan. All cropland is rented out.

Although the need for additional hired labor declines as crop production falls, all of the large farms require some non-family labor. In plan LGA, 753 hired labor hours are needed, enough to employ someone all year slightly less than half-time. Under LGF, a total of 658 additional labor hours are necessary; however, the majority of this (469 hours) is required during the summer months when alfalfa hay is harvested. The need for extra labor drops to 97 hours under plan LBA, all of this is needed in the early spring and late fall.

Firm gross margins for the large farms range from $268,479 for farm LGA to $239,626 for plan LBA (Table 7). Although the need for hired labor falls as crop production declines and land rental generates some income, the annual increase in feed purchase costs far outweigh these benefits.

The minimum milk price required to cover all costs is nearly equal for the LGA and LGF plans. Under LGA, the price is $10.74/cwt and in plan LGF it is $10.71/cwt. The minimum price falls to $9.86/cwt under plan LBA. All of these are substantially under, about $12,000 per hundredweight, current market prices. When the farms are allowed to sell off their excess cropland, the minimum required milk prices do not change.

Comparisons Between Herd Sizes

Firm gross margins increase significantly as the size of the farm (or herd) increases; this makes sense, since larger herds mean larger milk sales and more income. Investment costs also increase tremendously as farm size rises, however. Total investment costs range from a low of $505,827 for plan SBA to $1,356,518 for plan LGA. Differences are due to variations in milking facilities, feed storage, machinery and the value of stock on hand.

Despite the larger investments and higher associated annual overhead costs, the minimum required milk price for larger farms is lower than that for smaller farms. Based on the model assumptions, small farms require minimum milk prices of $16 to $21/cwt, medium farms require $13 to $14/cwt and large farms need $10 to $11/cwt. The minimum price ranges from a low of $9.86/cwt under plan LBA to a high of $21.41/cwt under plan SGA. This is a difference of $11.55/cwt. Thus, there are substantial economies of herd size on dairy farms.

Although there is a wide variation in the minimum required milk price, the pattern for each of the three sizes is similar. The less feed produced on the farm, the lower the milk price required to cover all costs.

Impacts of Utilizing Used Machinery, Equipment, and Remodelling of Milkhouse

The purchase of used equipment and remodelling of existing facilities with labor input by the owner-operator is a frequent strategy in adopting new technology on dairy farms. This can substantially reduce total investment costs, debt servicing, depreciation charges, and annual average costs of milk production. The reduction of initial investment costs will vary according to age of used equipment, the current market conditions for used equipment, and the amount of labor input for remodelling that is supplied by the owners. For purposes of our analysis, we assumed that used equipment and remodelling of facilities with owner-operator labor could reduce total investment in equipment and milking facilities by 50 percent.

The impacts on investment are illustrated by comparing the total investment and annual investment charge rows of Tables 8 and 9. Note that Table 9 is calculated for farms that have acquired used equipment and remodelled existing facilities. The impacts on total milk production costs are greatest for farms that are producing all feed, a reduction of approximately 27 percent for small herds and 19 percent for large herds. Nevertheless, the same pattern of reduced production costs emerges as when all equipment and facilities are valued at new prices. That is, purchase of feeds tends to be least cost feed acquisition strategy on a per hundredweight milk costs basis. The minimum required milk price is below $9.00 per hundredweight for all large herds, Table 9. Interestingly, for medium-sized herds, growing all feed is a lower cost strategy than growing only forage, but the total required cost is still greater than for purchase of all feeds, $11.24 vs. $10.97 per hundredweight.

The analysis with used equipment and remodelling indicates how small dairy herds are able to compete, even with a full machinery complement. Note that the costs for small herds are reduced from $2.72 to $4.85 per hundredweight with used crop equipment and remodelling of milking facilities. Additional reductions are possible by remodelling of other farm buildings and equipment.

Manure Production/Use

Manure is one of the primary byproducts of livestock farms and dairy farms produce sizable amounts. An average milking cow weighing 1,400 pounds, can generate as much as 20-21 tons of solid manure per year [18]. Most Minnesota dairy farmers currently dispose of manure by spreading it on their cropland as fertilizer. Sometimes, however, even when using "improved" manure handling practices, dairy farms still have large excess amounts of manure [16, pg 19]. If dairy farmers were to purchase all their feeds and rent or sell their cropland, manure disposal could become an even greater problem.

Dairy farm manure is usually used as a fertilizer. It contains several plant nutrients, which are valuable for crop production. When applied properly and in the correct amounts, manure greatly aids crop production. However, excessive amounts can cause environmental harm. Because it contains large amounts of nitrogen, for example, excesses can leach into groundwater supplies and elevate nitrate levels in drinking water. Our major consideration is excess nitrogen, but we also consider the phosphate and potash that are available in the manure.

Table 9. TOTAL MILK PRODUCTION COSTS & MINIMUM MILK PRICE REQUIRED TO COVER ALL COSTS WITH UPDATED MILKING FACILITIES AND USED EQUIPMENT

	Small Farm			Medium Farm			Large Farm		
	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed	Grow All feed	Grow Forage	Buy All feed
					(dollars)				
Total Investment Costs	522,438	474,144	370,660	768,978	719,874	584,849	949,615	906,047	782,815
Annual Costs of Milk Production:									
Fixed Overhead Cost	69,565	59,621	39,993	104,730	94,728	67,033	123,886	114,725	89,522
Variable Cash Costs	7,897	16,737	20,926	28,867	40,745	61,857	120,235	133,147	149,087
Annual Operator Labor Charge	32,500	32,500	32,500	65,000	65,000	65,000	65,000	65,000	65,000
Total Annual Cost	**109,962**	**108,858**	**93,419**	**198,597**	**200,473**	**193,890**	**309,121**	**312,872**	**303,609**
Cwt. Milk Produced	7,068	7,068	7,068	17,669	17,669	17,669	35,338	35,338	35,338
Required Milk Price ($/Cwt.)	**15.56**	**15.40**	**13.22**	**11.24**	**11.35**	**10.97**	**8.75**	**8.85**	**8.59**

Although the amount of manure produced under each farm plan depends not only on the size of the milking herd and on the number of replacement heifers raised, we have assumed heifers are kept on pasture during the pasture season and very little waste is collected from these animals. Thus, only the manure produced by the dairy cows is considered in the following calculations. The amount of solid manure produced by the cows is summarized in Table 10 below.

Table 10. MANURE PRODUCTION AND USE UNDER VARIOUS FARM PLANS (tons) #

	SGA	SGF	SB	MGA	MGF	MBA	LGA	LGF	LBA
Solid Manure:									
Produced	840	840	840	2099	2099	2099	4198	4198	4198
Used for Crops *	840	746	0	1948	2099	0	2350	2274	0
Excess	0	94	840	151	0	2099	1848	1924	4198
Value of Manure in Crop Production($)	1386	1099	0	2993	3348	0	3392	3348	0

Assumes only manure from dairy cows is collected.
* Assumes nutrient content per ton solid manure is 7 lbs N, 4 lbs P_2O_5, and 8 lbs K_2O.

Manure production on the small farms totals 840 tons per year. Under plan SGA, practically all of this is used for crop production. In plan SGF, however, only 746 tons is used on crops; there is an excess of 94 tons. All 840 tons are left unused in plan SBA.

The dairy cattle on the medium-size farms produce 2,099 tons of solid manure per year. Only plan MGF is able to use all of this waste for crop production. Under plan MGA, most of the manure is utilized but there remains an excess of 151 tons. None is used in plan MBA.

Large farms produce some 4,198 tons per year. Under the given situation, none of these farms are able to use all of the manure they produce. Plans LGA and LGF spread approximately 55 percent on cropland, but still have "excesses" of 1,848 and 1,924 tons, respectively. Obviously, plan LBA does not have any cropland for manure disposal.

Because of the available nutrients in the manure, all of the farms that are allowed to produce crops are able to use it as fertilizer. None of these farms have to purchase commercial fertilizers for their given crop production plans. Using the assumed prices for nitrogen, phosphate and potash, the manure used for crop production ranges in value from $1,099 for plan SGF to $3,392 for plan LGA. Thus, the use of manure reduces crop production costs.

The farms with large amounts of excess manure must find some way to dispose of it properly, without adversely affecting the environment. The farm in plan SGF could spread its excess on pasture land. The others, however, would have more difficulty disposing of it. The SBA farmer would have to find other farmers with either 150 acres in corn production, or 120 acres in soybean production who would accept the manure. These acreages would allow the SBA farmer to safely dispose of all nitrogen in the excess manure. The number of corn or soybean acres needed for excess manure under the other alternative farm plans is shown in Table 11.

Table 11. ACRES OF LAND NEEDED FOR EXCESS MANURE UNDER VARIOUS PLANS

	SGF	**SBA**	**MGA**	**MBA**	**LGA**	**LGF**	**LBA**
				Acres			
Corn	15	150	30	450	370	285	840
Soybeans	13	120	20	280	250	260	560

If farms in plans SBA, MBA and LBA invested in a liquid manure system in order to increase storage capacity and reduce the number of times waste has to be removed, the minimum required milk price would increase. These systems require a larger investment base and more energy than the solid manure system and it would significantly add to annual overhead and operating costs. We have calculated that the minimum milk price increases by $1.69/cwt for SBA, $1.40/cwt for MBA and $1.00/cwt for LBA (Table 12).

Table 12. EFFECTS OF INVESTING IN A LIQUID MANURE TANK SYSTEM

	SBA	**SBA & Liquid**	**MBA**	**MBA & Liquid**	**LBA**	**LBA & Liquid**
Total Investment	505,827	545,711	809,631	887,750	1,068,636	1,175,635
Fixed Overhead Costs	59,195	67,211	99,527	115,151	134,224	155,624
Variable Cash Costs	20,926	24,874	61,857	70,939	149,087	163,238
Operator Income	32,500	32,500	65,000	65,000	65,000	65,000
Total Costs	112,621	124,585	226,385	251,088	348,311	383,862
Min. Req. Milk Price ($/cwt)	15.94	17.63	12.81	14.21	9.86	10.86

Impacts of the Federal Feedgrain Program

The effect of the federal feedgrain program was also examined. Initially, all crop sale prices used were market prices with no participation in the feedgrain program. Later, plans for farms producing all feeds were also solved with participation in the feedgrain program. In the latter runs, farmers are paid a deficiency payment for corn grown on the farm, based on the average yield for the southeastern Minnesota farm for the years 1981-1985. It is assumed that the farmer has an established corn crop base and that he/she meets all government set-aside requirements each year. The adjusted minimum milk price required to cover all costs was calculated for these `participating' farms.

The `base' yield for farms participating in the program is 120 bushels/acre [22]. The target price is $2.75/bushel, thus giving a deficiency payment of $0.30/bushel (i.e. the difference between the target price and the assumed market price for shelled corn ($2.45)). Finally, the set-aside requirement is 10 percent.

The federal crop programs may play a role in the choice of feed procurement and obstruct changes in states like Minnesota, where crop production often takes place in conjunction with dairy production. Southern Minnesota dairy farmers that produce all of their own feeds may be in the federal feedgrain program. As participants in the program, they must maintain a corn crop base and follow set-aside regulations. In return, the government guarantees them a minimum price, called the `target' price, for their corn.

The effects of participating in the federal corn program varies depending on the size of the farm. Although all three of the farms that grow all feeds benefit from participating in the program, results indicate that the small farm gains the most. Changes in gross margins, total investments and the minimum required milk prices are shown below in Table 13.

When the small farm participates in the program, it receives a total deficiency payment of $1,378. Though corn production declines slightly due to the set-aside requirement, the deficiency payment and reduced variable production costs more than compensate for any loss in income from crop sales. Thus, gross margins increase. Since all other crop production is unchanged, there is no change in feed storage costs, total investment costs or annual overhead. Therefore, the minimum required milk price falls from $21.41/cwt for the base plan to $21.30/cwt for the participating plan, Table 13.

Table 13. EFFECTS OF PARTICIPATING IN THE FEDERAL CORN PROGRAM ON MILK PRODUCTION COSTS

	SGA	SGA & Program	MGA	MGA & Program	LGA	LGA & Program
Def. Payment	0	1,378	0	1,735	0	1,735
Gross Margin	69,845	70,603	165,491	166,243	259,258	259,272
Fixed Overhead Cost	110,928	110,928	161,147	160,582	194,258	194,272
Variable Cash Costs	7,897	7,139	28,867	28,115	120,235	119,447
Annual Operator Income	32,500	32,500	65,000	65,000	65,000	65,000
Total Annual Cost	151,326	150,567	255,014	253,697	379,493	378,719
Min. Req. Milk Price ($/cwt)	21.41	21.30	14.43	14.36	10.74	10.72

Participation by the medium farm also helps improve gross margins. The deficiency payment of $1,735 increases farm receipts. In addition, the set-aside requirement reduces corn silage production and the farm can use slightly smaller silos. This decreases annual overhead costs. These two benefits lower the minimum required milk price from $14.43/cwt for the base plan to $14.36/cwt for the plan incorporating program participation.

Because the land available to all farms is the same, the effects of participating in the corn program affects the large farm very much the same as it does the medium farm. Both sizes produce similar amounts of corn silage. Thus the deficiency payment for the large farm is the same as for the medium farm, or $1,735.

For the large dairy herds, however, deficiency payments represent a smaller amount of total income than it does for the medium farm. Thus, the impact on gross margins is relatively smaller. Necessary feed storage structures for the large farm increase slightly under the participation plan because the farmer raises more heifers. Annual overhead costs are increased. This nearly negates the improvement in margins and the minimum required milk price declines by only $0.01/cwt when the large farm participates in the program.

Hay Price Variations

The effects of hay price changes are also briefly examined. Due in part to the lack of a federal crop program and wide variations in quality, alfalfa hay prices vary considerably. Farms producing their own hay are largely protected from these price swings. Those purchasing hay, however, are not. Therefore, farms in plans SBA, MBA and LBA may experience large swings in gross margins from year to year. Assuming they continue to purchase the same amount of alfalfa hay regardless of the price, the effects of a 20 percent increase and decrease in purchased hay prices from 1992 levels are analyzed.

The effects of a 20 percent increase and decrease in purchased alfalfa hay prices are summarized in Table 14 for farms in plans SBA and LBA. Essentially, an increase in hay prices reduces annual firm gross margins by 3.0 percent for the small farm and 3.5 percent for the medium and large farms. Decreases in hay prices lead to similar percentage improvements in margins.

If the hay price changes were sustained for several years, the minimum required milk price would also change, but by relatively small amounts. Higher hay prices would increase the required milk price by 1.5 percent for the small farm and 2.4 percent for the large farm. Decreases would reduce the required milk price by similar amounts.

Table 14. EFFECTS OF A 20 PERCENT INCREASE OR DECREASE IN PURCHASED ALFALFA HAY PRICES ON MILK PRODUCTION COSTS

	SBA			LBA		
	Base	**+20%**	**-20%**	**Base**	**+20%**	**-20%**
Total Cash Receipts	91,061	91,061	91,061	414,037	414,037	414,037
Total Cash Expenses	34,244	35,924	32,565	174,410	182,883	165,937
Alfalfa Hay Expense	8,397	10,077	6,718	42,365	50,838	33,892
Fixed Overhead Cost	59,195	59,195	59,195	134,224	134,224	248,100
Variable Cash Costs*	7,897	9,577	6,218	149.087	157,560	140,614
Annual Operator Income	32,500	32,500	32,500	65.000	65,000	65,000
Total Annual Cost	112,621	114,301	110,942	348,311	356,784	339,838
% change from Base		1.5%	-1.5%		2.4%	-2.4%
Min. Req. Milk Prc	15.94	16.17	15.70	9.86	10.10	9.62

*Variable Cash Costs are those attributable to milk production, Total Variable Costs minus nonmilk income.

SUMMARY AND CONCLUSIONS

The main objective of this study was to determine the financial impact of changing feed procurement methods on Southeastern Minnesota dairy farms. Three related issues were also examined: 1) the effect of herd size, 2) problems related to manure disposal, and 3) the effect of the federal corn program. This study used a combined LP technique and a capital budgeting approach to assess the impacts of alternative feed procurement strategies for Southeastern Minnesota dairy farms. Three different size farms with different herd sizes were evaluated with three methods of feed procurement. First, they were allowed to produce all feeds on the farm. Second, they were allowed to produce only forages and buy all grains. Third, they were forced to purchase all feeds. All farm models used for the analysis included a per farm family income of $32,500 per year as a cost. Initially, all costs were calculated for new equipment and facility prices.

The analysis indicated that purchase of all feeds for dairy farmers can reduce the real costs of milk production for these dairy farms and thereby reduce the minimum necessary price to cover costs of milk production. The cost savings are achieved by reductions in the equipment for crop production. For any given herd size, the change from total feed production to total feed purchasing actually increases the farm's variable cash costs of milk production, i.e. variable cash costs are shown to be lowest for farms that produced their own feed. However, lower overhead costs more than offset the increase in these variable costs and lead to lower required milk prices for farms that purchase their feeds.

Comparisons of the minimum required milk price for each of the three different farm sizes (i.e. herd sizes) illustrated that there are substantial economies of scale in milk production. The required minimum price ranged from a high of $21.41/cwt for small farms growing all feeds to a low of $9.86/cwt for large farms purchasing all feeds. Whether the farm rented out "excess" cropland or sold it made little difference in the required minimum milk price. In absolute terms, large farms have the lowest cost per unit and lowest minimum required milk price. Although investment costs for small farms are much lower than those for large farms, small farm gross margins are also lower.

These prices are based on the assumption of investment in new facilities and equipment. Actually, there are many farms that use existing assets longer than assumed here or that buy used equipment, and remodel existing facilities with substantial use of owner-operator or family labor. Our analysis shows that this can make major reductions in minimum required milk prices to cover all costs, almost $5.00 per hundredweight for the small dairy herds.

It should be noted that for dairy farms that currently have equipment and facilities for crop production, the current method of feed procurement on Minnesota dairy farms may be the most profitable (on an annual basis), unless disinvestment in these items is possible. If disinvestment in equipment, machinery and land is possible, or, one is considering the initial investment for these farm situations, this analysis indicates that it is more profitable to purchase all feeds rather than grow them on the farm.

The disposal of manure produced under each of the nine dairy farm plans is a significant issue for dairy farms if cropland is to be rented-out or sold. There is very little excess on small and medium farms allowing for crop production. Under these plans, the manure is easily used as fertilizer. For farms buying all feeds, however, there are large excesses which would require the dairy farmer to develop other disposal strategies. They could, for example, spread it on land of neighboring crop producers. This may require additional manure handling equipment. If they must invest in a liquid manure system, rather than the initial solid system assumed in the model, annual operating and overhead costs and the minimum milk price required to cover all costs would increase.

The effect of the federal feedgrain program on milk production costs and returns was also examined. Participation in the federal corn program benefitted farms in all size groups, though small farms gained the most. In relative terms, government deficiency payments improve small farm gross margins more than medium or large farm margins. Thus the minimum required milk price declined for the farms with smaller herds, but with similar cropland acreage. Hay price variations were also briefly discussed; it was shown that price swings for purchased hay can greatly affect gross margins for farms that purchase all feeds. These impacts of the hay price savings may be moderated by producing feed and are one argument against a strategy of buying all feed.

Although every effort was made to be systematic and thorough in this study, the cost and minimum required milk prices in actual situations may be considerably modified by each particular farm situation. For example, this study first assumed that all equipment buildings and facilities are acquired at the current contract rate for new construction or market prices. Remodelling, purchasing of used facilities and/or self-construction could reduce these costs and alter the results. When this was permitted, for example, buying used machinery and remodelling existing facilities, per hundredweight milk production cost may be reduced by as much as $4.85 per hundredweight.

The conclusions could also be altered significantly if other conditions were changed. Two of these involve land and machinery. This model assumed that all farm plans include the same amount of land. In reality, dairy farms vary in land area as much as they do in herd size. The farm plans selected from specified machinery complements. For the given land area and the chosen crop production plans, several pieces of equipment were grossly under-utilized and some of the farms were over-capitalized.

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APPENDIX

Appendix Table 1. NUTRITIONAL REQUIREMENTS OF DAIRY COWS

	Units	Stage of Lactation				
		Early	Peak	Late	Dry	Total
Min. Net Energy	Mcal/lb	0.78	0.78	0.71	0.57	
	CMcal	17.25	20.79	48.53	7.12	93.70
Min. Crude Protein	% DMI	18.0%	17.0%	15.5%	12.0%	
	cwt	3.98	4.53	10.60	1.50	20.61
Min. NDF	% DMI	25.0%	25.0%	28.0%	35.0%	
	cwt	5.53	6.66	19.14	4.38	35.71
Min. Forage	% DMI	40.0%	40.0%	40.0%	50.0%	
	cwt	8.85	10.66	27.34	6.25	53.10
Max. DMI	cwt	22.11	26.65	68.36	12.50	129.63

Source: [13],[19]

Appendix Table 2. NUTRITIONAL REQUIREMENTS OF RAISED REPLACEMENT HEIFERS

Age (months)		3-6	6-12	12-20	20-24	Total
Avg. Weight (lbs)		295	535	900	1196	
No. Days		91	183	243	122	639
Adjustment Factors*		1.16	1.16	1.15	1.08	1.30
Min. TDN	% DMI	69.0%	66.0%	61.0%	61.0%	
	cwt	5.80	17.99	35.13	22.01	80.93
Min. Crude Protein	% DMI	16.0%	12.0%	12.0%	12.0%	
	cwt	1.35	3.27	6.91	4.33	15.86
Min. NDF	% DMI	23.0%	25.0%	25.0%	25.0%	
	cwt	1.93	6.81	14.40	9.02	32.17
Max. DMI	% Wt.	2.7%	2.4%	2.3%	2.3%	
	cwt	8.41	27.26	57.59	36.08	129.34

Source: [13],[19]

* To account for losses due to death - Source: [4], pg 40.

Appendix Table 3. NUTRITIONAL CONTENT OF PLAN RATIONS FOR DAIRY COWS

	Units	SGA	SGF	SBA	MGA	MGF	MBA	LGA	LGF	LBA
Net Energy	CMcal	.72	.72	.75	.72	.73	.75	.74	.75	.75
Crude Protein	% DMI	16	16	16	16	16	16	16	16	16
NDF	% DMI	41	35	32	38	34	32	37	32	32
DMI	cwt	129	129	125	129	129	125	127	125	125
% Grain	% DMI	36	46	58	29	47	58	46	58	58
% Forage	% DMI	64	54	42	71	53	42	54	42	42
Hay in Forage	%	33	100	100	54	100	100	41	90	100

Appendix Table 4. NUTRITIONAL CONTENT OF PLAN RATIONS FOR REPLACEMENT HEIFERS

	Units	SGA	SGF	SBA	MGA	MGF	MBA	LGA	LGF	LBA
TDN	% DMI	63	63	65	64	67	75	63	75	76
Crude Protein	% DMI	12	12	13	13	13	15	12	15	15
NDF	% DMI	56	56	51	56	42	30	58	33	30
DMI	cwt	129	129	124	126	120	107	129	108	106
% Grain	% DMI	29	29	40	0	34	77	4	77	81
% Forage	% DMI	71	71	60	100	66	23	96	23	19