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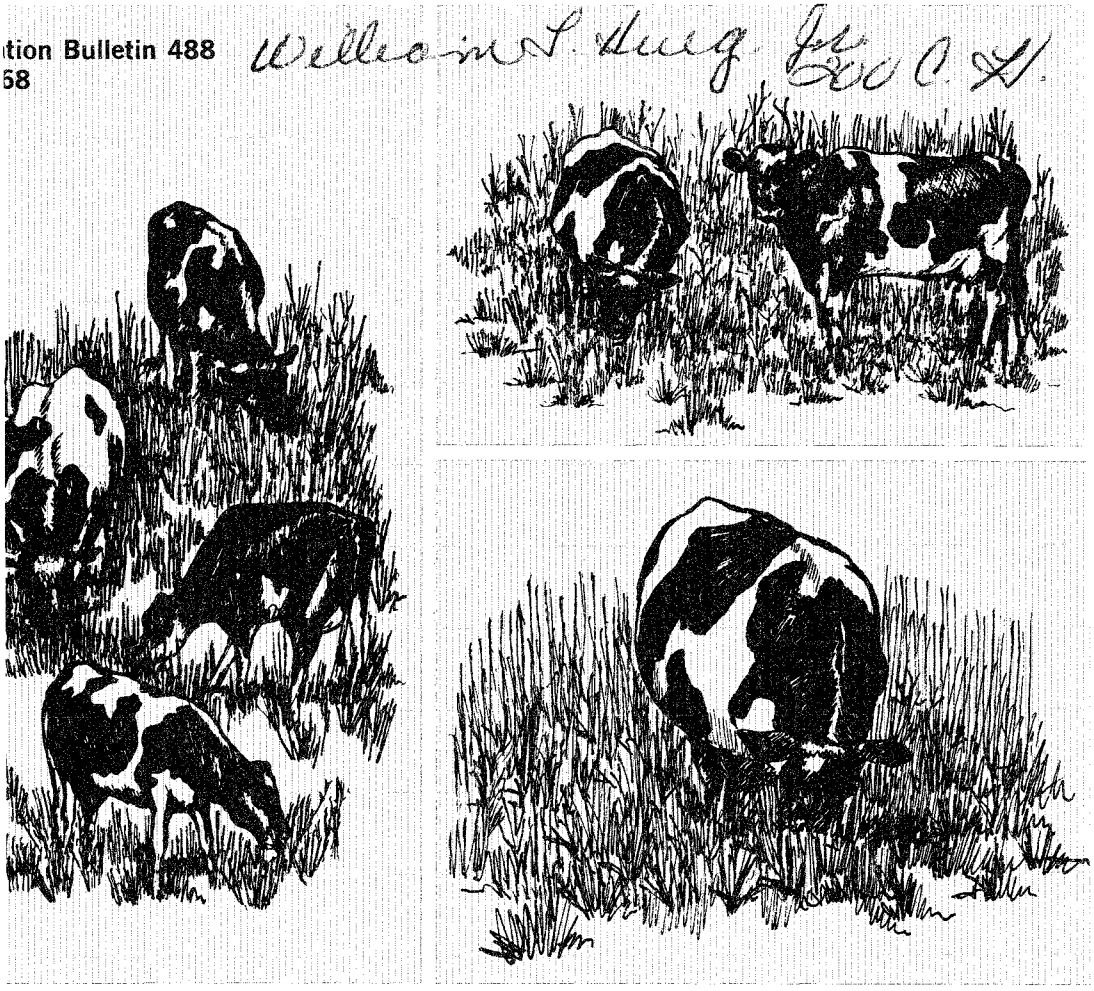

Economies of Size in MINNESOTA DAIRY FARMING

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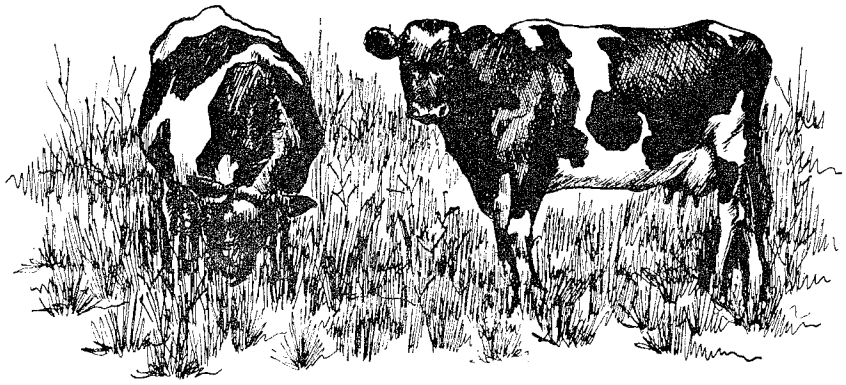

Summary and Conclusions

The approach in this study was to construct or synthesize on paper farm situations to estimate economies of size in dairy farming. The relationship between farm size and unit cost was identified by the longrun unit cost (LRUC) curve.

Sixty farm situations were synthesized from five alternative housing arrangements, five alternative milking facilities, two alternative feeding rations, three size complements of field machinery, and four supplies of labor. For example, one farm was comprised of a loose housing loafing barn, a double-4 herringbone milking parlor, baled hay ration, a small complement of field machinery, and two full-time men. Labor requirements and investment expenditures for various size farms were estimated for the dairy technologies considered.

Estimating the minimum cost of producing several levels of gross income in each of 60 farm situations provided several points on the 60 corresponding shortrun unit cost (SRUC) curves. The LRUC curve was drawn tangent to the lowest SRUC curves representing the least-cost farm situations.

Results showed that there were substantial economies of size in dairy farming. The LRUC curve fell rapidly as the level of output was increased up to the largest two-man dairy farm. For the high levels of output on three- and four-man farms, the curve continued to fall, but at a much slower rate, and became almost flat. Net returns increased for high output levels up to the largest four-man farm with 130 milk cows and 765 acres of land.

These results indicate that large dairy farms have considerable cost advantages. As long as maximum net return is a primary motive, dairy farms will move toward four-man units.[1]

[1] Results of this study do not imply what happens to unit cost on larger than four-man farms.

Two important conclusions are implied by this study. First, lower unit costs and higher net returns favor loose housing arrangements with milking parlors over conventional stanchion barns. Second, lower unit cost and higher net returns provide strong incentives to build facilities for no smaller than a two-man dairy farm. The relatively high fixed costs of a milking parlor can be spread over more units of output. The labor-efficient technologies can be more fully utilized on a two-man farm than on a one-man farm. The combined effect of a lower unit cost and larger volume of output on a two-man farm increases net returns to the operator to almost $12,000—about $8,000 higher than the optimal one-man farm.

Implications for Future Adjustments in Minnesota Dairy Farming

A dairy farm with 130 milk cows (a four-man farm) or even 80 milk cows (a two-man farm) is substantially larger than the average Minnesota farm, with a dairy herd of about 22 milk cows. Therefore, the results of this study suggest major adjustments in the future for the Minnesota dairy industry. These adjustments toward fewer and larger dairy farms have been occurring at a rapid rate. This study suggests that the adjustments will continue in the future, but for the following reasons the adjustments probably will be slower than expected.

Existing Dairy Facilities

The LRUC curve is essentially a longrun planning curve. It suggests the size of farms and types of technologies that are the most efficient when built new. Many of the stanchion barns now on most Minnesota dairy farms have depreciated and have few, if any, alternative uses. Probably the best alternative use for a stanchion barn is for replacement stock when new loose housing and milking facilities are constructed.[2]

A dairy farmer may have a higher net return for a number of years by operating his existing dairy farm than by investing large sums in a new technology. This may be particularly true for older operators who could utilize facilities that have depreciated.

Investment Expenditures

Constructing a one-man farm with loose housing and milking parlor requires almost $29,000 more total investment than the optimal one-man farm with stanchion barn facilities. The optimal two-man farm requires about $115,000 more total investment than the one-man farm with the same type of dairy facilities. Similarly, the optimal three-man farm requires $62,000 more total investment than the two-man farm, and the

[2] Apparently this is the case on many Minnesota farms where operators have built new loose housing and milking parlor facilities and increased herd size.

optimal four-man farm requires $69,000 more than the optimal three-man farm. The difficulty of acquiring this amount of capital would be restrictive to many Minnesota dairy farm operators. The owner of a one-man farm may be able to get control of sufficient capital to set up a two-man operation but not a three- or four-man operation.

Initial adjustments on Minnesota dairy farms probably will be towards two-man farms that may be intermediate steps to larger farms. Some two-man farms are designed and constructed to allow for further expansion at a later date.[3]

Land Acquisition

In this study, much of the higher total investment on larger farms was for land. The ability of dairy farmers to obtain land in large contiguous units will hinder the movement towards four-man operations with 765 acres of land or even two-man operations with 465 acres.

Labor Supply and Management

One of the more important problems hindering the organization of larger farms is the availability of labor. Some two-man farms involve a father and son or two brothers, while relatively few involve an owner-operator with a full-time hired man. Employer-employee relationships, which are nonexistent on one-man farms except for seasonal labor, become extremely important. Management skills must include the ability to recruit, train, and hold good hired labor. The availability of a suitably trained labor force in an economy with good employment alternatives will be a major problem in organizing large dairy farms that depend on full-time hired men.

Other Factors

Two other factors that act as barriers to firm growth are the implications of a progressive income tax and a declining need for incomes above a given level. Both dampen the incentives to attain higher levels of gross income and net returns associated with a large dairy farm.

Little is known about the relationship between farm size and certain input prices such as those for fertilizer, seed, and protein feed supplements. Because of volume buying, large farm operators may be able to obtain these inputs at significantly lower cost than the small operator can.

Other farm organizational opportunities not studied here may become realistic for three- and four-man farms. For example, cow replacements and/or feed may be purchased and the labor saved could be used to expand the milking herd size. Such specialization would enable a more efficient use of housing and milking facilities and permit other farm operators to specialize in raising dairy heifers or feed.

[3] It is usually much easier to expand a loose housing with milking parlor arrangement than the traditional stanchion barns.

Economies of Size in Minnesota Dairy Farming

Boyd M. Buxton and Harald R. Jensen*

Recent changes in Minnesota dairy farming have included a rapid shift towards fewer and larger dairy herds. From 1960 to 1966 the reported number of farms with milk cows declined more than 28 percent—by 23,800.[4] For the same period the reported number of farms with less than 20 cows decreased 41 percent while the reported number with more than 30 cows increased 66 percent. This shift in number and size of dairy herds demonstrates a need for further information on how changes in farm size influence unit production costs and dairy farm profitability. Such information will help in understanding the nature of tomorrow's dairy farm.

The change in number and size of farms is closely related to new developments in dairy technology. The size of the dairy herd usually must be increased to fully utilize new housing, milking, and feeding facilities that typically require large investment expenditures.

Several alternative housing, milking, and feeding technologies were considered when estimating the effect of herd size on production cost. However, this bulletin concerns only those technologies showing the lowest unit production costs. A second bulletin will be published containing a comparison of the efficiency and profitability of these least-cost technologies with alternative dairy technologies.

The objectives of this study were to estimate (1) production costs and profitability of various size dairy farms, (2) total investment requirements for various size dairy farms, and (3) how the cost per dollar of gross income produced on dairy farms is influenced by changes in the price of milk, special crop rotation restrictions, and increased salaries for full-time hired help.

Economies of Size and Estimating Procedures

The purpose of economies of size studies is to estimate the relationship between farm size and per unit production cost. When economies of size exist, the per unit production cost is lower on large farms than it is on smaller farms. When diseconomies of size exist, per unit production cost is higher on large farms than on smaller ones.

The trend toward fewer and larger dairy farms suggests that large farms have the same or lower per unit production cost and higher returns to the operator's labor and management than smaller farms.

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[4] *Minnesota Agricultural Statistics*, State and Federal Crop and Livestock Rept. Serv., Minnesota Department of Agriculture, Mar. 1966, p. 95.

Average production cost may be lower on large farms for one or more of the following reasons.

1. Large farms may more fully utilize new technology. For example, a new milking parlor represents a relatively large investment expenditure, and a large herd can more fully utilize this particular technology than a small herd.
2. Large farm operators may be able to build or purchase a more efficient size building or machine. For example, cost per cow for housing facilities may be lower when a new barn is constructed for a large herd than for a small one.
3. Labor requirements per unit of product may be lower on large farms. For example, the labor required to clean milking equipment does not depend on the number of cows milked. Therefore, the larger the herd the lower is the cleaning labor per cow.
4. Large farm operators may be able to obtain quantity discounts on purchased inputs such as feed supplements and/or fertilizer.

Economies of size can exist even when farmers are able to use different amounts of land, labor, and types of dairy housing, milking, and feeding technologies. One necessity, of course, is a period long enough for farmers to vary the amounts and types of all resources used on the farm; that is, to build any size and type of dairy operation that will allow a minimum per unit production cost at each output level. A curve showing the relationship between per unit production cost and the size of dairy farm when all resources can be varied is called a longrun unit cost (LRUC) curve. Such a curve is shown in figure 1. This curve shows

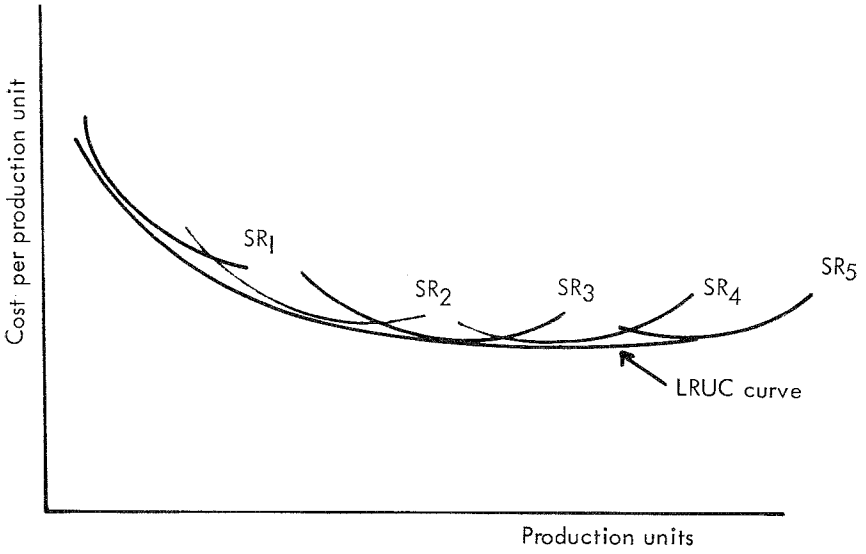

Figure 1. Graphic illustration of derivation of longrun unit cost (LRUC) curve from several shortrun unit cost (SRUC) curves.

the change in the minimum per unit output cost as the dairy farm is constructed for increasingly larger output levels.

A curve that falls as the size of farm increases indicates that economies of size exist. A curve that rises as the size of farm increases indicates that diseconomies of size exist.

In a short period, one or more resources such as labor or a milking parlor may be fixed on a given dairy farm. An objective of the farm operator in a short period is to combine the quantity of resources he can vary with the resources he cannot vary to maximize net returns. A curve showing the relationship between cost per unit of product produced and the level of production when at least one resource is fixed is called a shortrun unit cost (SRUC) curve. Five such curves are shown in figure 1 (SR_1-SR_5).

The technique used to measure economies of size in this study was to synthesize a number of dairy farm situations based on different combinations of housing, milking and feeding facilities, full-time labor, and field machinery. These different combinations produced synthetic farm situations of different characteristics and sizes. These situations were synthesized as complete dairy farms with all component parts selected to be consistent with one another. Labor requirements and costs associated with the housing, milking and feeding facilities, and field machinery were estimated independently. Total labor use and cost for each synthetic farm situation are the sum of the labor use and the cost of each farm component.

With the labor, machinery, and milking facilities fixed, the minimum unit cost was estimated for several production levels. From these estimates, the relationship between per unit production costs and production level was derived for each farm situation. This relationship identifies the SRUC curve for a farm that has some fixed quantity of resources. This procedure was used to estimate the relationship between per unit production cost and output level (SRUC curve) for 60 synthetic farm situations representing alternative technologies and farm sizes.

The LRUC curve was determined by identifying the synthetic farm situations with the minimum per unit production cost for each output level. The procedure is illustrated in figure 1. The five SRUC curves labeled SR_1 to SR_5 illustrate the relationship between per unit production cost and production level on five of the 60 farms. The LRUC curve is drawn tangent to the lowest of the 60 SRUC curves.

Basic Assumptions About Synthetic Farm Situations

Construction of the synthetic farm situations required certain assumptions about crop and livestock alternatives and about depreciation rates for buildings and equipment. These assumptions are outlined below.

1. The synthetic dairy farms were constructed with the possibility of being organized as multi-enterprise farms with alternatives of producing milk, hogs, corn grain, and soybeans for sale. Because more than

Table 1. Composition of the dairy herd at a given time as a percent of adult cows

Replacement	Age of animal	Number per adult cow at any point in time
Calves	0-2 weeks	0.035
Calves	2-4 weeks	0.017
Calves	4 weeks-2 months	0.275
Calves	2-12 months	0.275
Heifers	12-24 months	0.250
Heifers	24-28 months	0.080
Dry cows	Adult	0.125
Milk cows	Adult	0.875

one product could be sold from a farm, output was measured in dollars of gross income.

2. At least 60 percent of the output or total gross income had to be generated by the dairy enterprise in the form of milk receipts and sale of calves and cull cows.

3. All building and equipment facilities were built new to the exact specification of the dairy herd.

4. All replacement stock was raised on the farm and cows were held in the milking herd for an average of 4 years. Table 1 summarizes the number of replacements per adult cow by age groups at any given point in time.

5. Half of a 90 percent calf crop was assumed to be bulls, which were sold within 2 weeks of birth. Heifers were culled at 4 weeks and 12 months of age, leaving one replacement for every four adult cows in the herd.

6. Crop yields, production costs, cultural practices, and crop alternatives were based on those for 15 southeastern Minnesota counties. Crop yields were adjusted to approximate 1968 yields.

7. Input and product prices were assumed constant for all size dairy farms and input prices were estimated to approximate 1968 prices. In the first section, a milk price of $3.20 per hundredweight (cwt.) was assumed. A $3.65 milk price was assumed in a later section.

8. Because of rapid technological change and obsolescence, it was assumed that machinery, buildings, milking stalls, and equipment had to be paid for in at least 15 years.

9. Yields and livestock production reflect above average management. A constant management requirement was assumed for full-time and seasonal hired labor.

10. This study disregarded existing organizations and assumed that the operator was starting a new farm business for which he could gain control of the necessary resources. Land and capital were not assumed to be limiting factors of dairy farm size.

11. Because output was measured in dollars of gross income, the unit cost curves were influenced by product prices. An increase in the price of milk, for example, would cause a downward shift in the unit cost curve. Costs per physical unit of output would remain the same, but an increase in gross income due to higher prices would lower the cost of each dollar of gross income. A fall in prices, on the other hand, would cause the unit cost curve to shift upward.

Estimated Economies of Size

The results of the analysis are presented in two sections. The first section contains a detailed discussion of the individual farm situations exhibiting the lowest production costs. The second section describes the derivation on the LRUC curve that illustrates how cost per dollar of gross income produced changes as the size of a dairy farm increases.

Least-Cost Farm Situations

Sixty separate dairy farm situations, each representing a combination of labor, field machinery, dairy housing, and milking and feeding facilities, were used to estimate economies of size in dairy farming. These farm situations are summarized in appendix table A-1. Of the sixty farm situations, the five showing the lowest production costs are outlined in table 2.

This section describes in detail the least-cost farm organizations, total investments, net returns, and minimum unit costs for selected gross income levels on each of the five dairy farm situations. The minimum unit costs of producing several gross income levels establish several points on a farm's SRUC curve.

Table 2. Amount of full-time labor, type of dairy technology, and size group of field machinery for five dairy farm situations

Item	Farm situation number*				
	18721	15121	25123	36323	46323
Labor	One-man	One-man	Two-man	Three-man	Four-man
Housing	Stanchion	Loafing shed	Loafing shed	Loafing shed (herd divided)	Loafing shed (herd divided)
Milking	3-unit pipeline	Double-4 herringbone	Double-4 herringbone	Double-8 herringbone	Double-8 herringbone
Feeding	Baled hay	Baled hay	Baled hay	Baled hay	Baled hay
Machinery group†	I	I	III	III	III

* The situation number identifies the labor, housing, milking, feeding, and machinery used on the farm.

† Machine group I is the smallest set of field machinery; group III is the largest. For a listing of machine items, see appendix table A-10.

Table 3. Minimum unit costs, net returns, farm organization, and investment for selected gross income levels, farm situation 18721: One-man farm, stanchion barn housing, three-unit pipeline milking system, baled hay ration, machinery group I

Item	Units	Gross income				
		$10,000	$14,000	$18,000	$20,000	$23,000
Percentage of gross income from dairy	Percent	60	60	60	60	60
Total cost	Dollars	11,788	14,429	17,150	18,661	21,139
Net returns	do.	−1,788	−429	850	1,339	1,861
Cost per dollar of gross income	do.	1.1788	1.0300	.9528	.9331	.9191
Farm organization:						
Cows in herd	Number	13	19	24	27	31
Hogs	Litters	0	0	6	0	0
Total land	Acres	78	109	114	156	179
Corn silage	do.	9	13	17	19	22
Corn grain	do.	6	9	26	13	14
Corn for sale	do.	44	62	39	89	102
Oats	do.	4	6	8	9	10
Alfalfa	do.	13	19	24	27	31
Soybeans	do.	0	0	0	0	0
Chopped corn stalks for bedding	do.	8	12	16	17	19
Commercial fertilizer	Cwt.	35	49	10	70	81
Silos	Number	1	1	1	1	1
Hired seasonal labor	Hours	145	204	304	527	965
Jan.-Mar.	do.	0	0	0	0	0
Apr.-May	do.	0	0	0	28	104
June-July	do.	39	56	70	77	148
Aug.	do.	20	28	36	38	45
Sept.	do.	55	76	100	111	128
Oct.-Nov. 15	do.	31	44	98	223	347
Nov. 16-Dec.	do.	0	0	0	0	0
Add to full-time labor	do.	0	0	0	50	193
Full-time hired and operator labor	do.	1,582	2,002	2,439	2,395	2,305
Management of hired labor	do.	29	41	61	105	195
Total investment	Dollars	75,388	89,035	99,521	109,488	119,715
Land	do.	23,364	32,710	34,202	46,728	53,737
Dairy facilities	do.	14,348	16,653	19,011	20,095	21,816
Dairy herd	do.	4,989	6,985	8,981	9,978	11,475
Machinery	do.	32,687	32,687	32,687	32,687	32,687
Hog facilities	do.	0	0	4,640	0	0
Investment/cow in dairy facilities	do.	1,066	833	784	746	704

Farm Situation 18721

This farm situation is a one-man farm with stanchion barn housing and a three-unit pipeline milker. The baled hay feeding program is used and the farm is equipped with the smallest complement of field equipment (machinery group I). The least-cost farm organizations for five levels of gross income are presented in table 3. Cost per dollar of gross income is lower for successively higher levels of gross income up to the near optimal $23,000 output, where unit cost is a minimum of about

91.91 cents. The highest level of gross income ($26,000) cannot be produced with the labor available on this one-man farm.

Net return to the operator's labor and management is relatively low for this farm and, below about $17,000 gross income, net return is negative. Net return is $1,867 at the optimal $23,000 gross income. The relatively high labor requirements for handling the dairy herd in a stanchion barn exhaust the available labor at low gross income levels. Combined with high fixed machinery costs and high investment per cow in dairy facilities ($704 per cow at the $23,000 output level), this results in relatively high unit cost and low net return.

At all levels of gross income, the dairy enterprise accounts for the minimum 60 percent of total gross income (figure 2). The sale of corn for grain accounts for the balance of all gross receipts, except that hogs produce some revenue between the $14,000 and $20,000 gross income levels. At point A (figure 2) the available labor supply from October 1

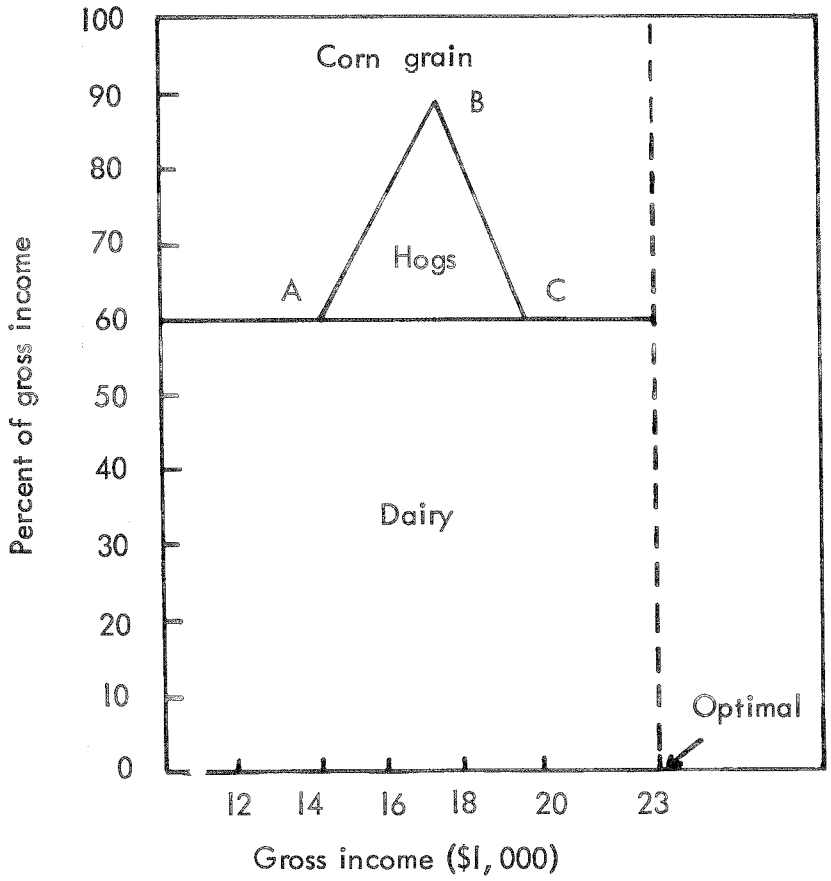

Figure 2. Sources of gross income at various gross income levels, farm situation 18721.

to November 15 is exhausted and, rather than hire labor, hogs are included in the production plan. At point B (figure 2) total labor becomes limited, so further expansion results in reducing hogs in favor of selling corn as a cash crop. Above point C, seasonal labor is hired to add to the total annual labor available (not for a specific labor period)[5], and corn grain accounts for 40 percent of total gross income.

Corn silage, corn grain, and alfalfa hay are raised to meet the feed requirement of the dairy and hog enterprises. A sharp increase in corn grain acres occurs when hogs are included on the farm due to their relatively high concentrate requirement.

Oat straw is insufficient to meet bedding requirements at all gross income levels. At the $23,000 output level, cornstalks are chopped from 19 acres of cornland to provide the remaining bedding requirement.

Total investment at the $23,000 output level is almost $120,000. Of this amount, 47 percent is land, 27 percent is machinery, and 28 percent is dairy facilities and dairy herd.

Farm Situation 15121

This farm situation is a one-man farm with loose housing loafing barn, double-4 herringbone milking parlor, baled hay feeding program, and machinery group I.

The least-cost solutions for five levels of gross income are presented in table 4. Unit costs or costs per dollar of gross income are a minimum of 84.56 cents at $30,000 of gross income. The minimum unit cost is more than 7 cents lower and the optimal output level is $7,000 higher for this one-man farm than for the one-man stanchion barn arrangement. Because labor requirements are lower, one man can handle more cows and a substantially higher level of gross income can be produced than with the stanchion barn arrangement. The higher output level spreads the fixed cost of the field machinery and dairy facilities over more output units, resulting in lower unit cost than for the stanchion barn arrangement. Lower unit costs combined with a higher output volume result in a $2,700 higher net return for this farm than for the stanchion barn arrangement. Net return to the operator's labor and management is estimated at $4,633 at the $30,000 gross income level.

Figure 3 illustrates the relative importance of the alternative enterprises in producing income at all gross income levels between $18,000 and $32,000. At the $18,000 level, full-time labor is not fully employed. Hence, the dairy operation accounts for 88 percent and corn grain for sale accounts for 12 percent of total gross income. At slightly more than $18,000 gross income (point A, figure 3), full-time labor is fully employed. Rather than hire seasonal labor for the dairy enterprise, it is more efficient to increase the proportion of gross income from corn grain. When the dairy enterprise accounts for the minimum 60 percent of gross income at about

[5] Each full-time man can contribute a maximum 300 hours per month and/or a maximum 2,500 hours per year. When the 2,500 hours are used, seasonal labor is hired even though the operator or full-time man may be working less than 300 hours every month during the year.

Table 4. Minimum unit costs, net returns, farm organization, and investments for selected gross income levels, farm situation 15121: One-man farm, loose housing loafing barn, double-4 herringbone milking parlor, baled hay ration, machinery group I

Item	Units	Gross income				
		$18,000	$20,000	$26,000	$30,000	$32,000
Percentage of gross income from dairy	Percent	88	73	60	60	60
Total cost	Dollars	17,074	18,323	22,483	25,367	27,223
Net returns	do.	926	1,677	3,517	4,633	4,777
Cost per dollar of gross income	do.	.9486	.9162	.8647	.8456	.8507
Farm organization:						
Cows in herd	Number	35	33	35	40	43
Hogs	Litters	0	0	0	0	0
Total land	Acres	113	142	203	234	276
Corn silage	do.	25	23	25	28	30
Corn grain	do.	17	15	16	19	20
Corn for sale	do.	25	60	116	133	13
Oats	do.	12	11	12	13	14
Alfalfa	do.	35	32	35	40	43
Soybeans	do.	0	0	0	0	156
Chopped corn stalks for bedding	do.	30	26	30	35	37
Commercial fertilizer	Cwt.	0	38	91	105	0
Silos	Number	1	1	1	1	1
Hired seasonal labor	Hours	326	323	779	1,246	1,250
Jan.-Mar.	do.	0	0	0	0	0
Apr.-May	do.	0	0	17	109	130
June-July	do.	102	94	101	118	125
Aug.	do.	52	48	51	59	63
Sept.	do.	146	135	144	165	177
Oct.-Nov. 15	do.	26	46	188	390	273
Nov. 16-Dec.	do.	0	0	0	0	0
Add to full-time labor	do.	0	0	278	405	482
Full-time hired and operator labor	do.	2,430	2,435	2,404	2,251	2,250
Management of hired labor	Hours	65	65	96	249	250
Total investment	Dollars	108,611	115,131	135,288	148,518	163,228
Land	do.	33,789	42,467	60,746	70,092	82,859
Dairy facilities	do.	26,158	25,005	26,023	27,911	28,856
Dairy herd	do.	13,116	12,111	12,971	14,967	15,965
Machinery	do.	35,548	35,548	35,548	35,548	35,548
Hog facilities	do.	0	0	0	0	0
Investment/cow in dairy facilities	do.	739	765	744	691	670

$21,500, the proportion from selling corn grain can no longer increase (above point B, figure 3). For gross income levels above $30,000, both full-time and seasonal labor are fully employed. For higher output levels, soybeans are substituted for corn grain so that total labor employed is constant.[6] Dairy, soybeans, and corn grain account for 60, 36, and 4 percent, respectively, of the $32,000 gross income.

[6] Soybeans require less labor per dollar of gross income than corn grain for sale, enabling higher gross income levels with a given labor supply. However, substituting soybeans for corn grain increases the cost per dollar of gross income.

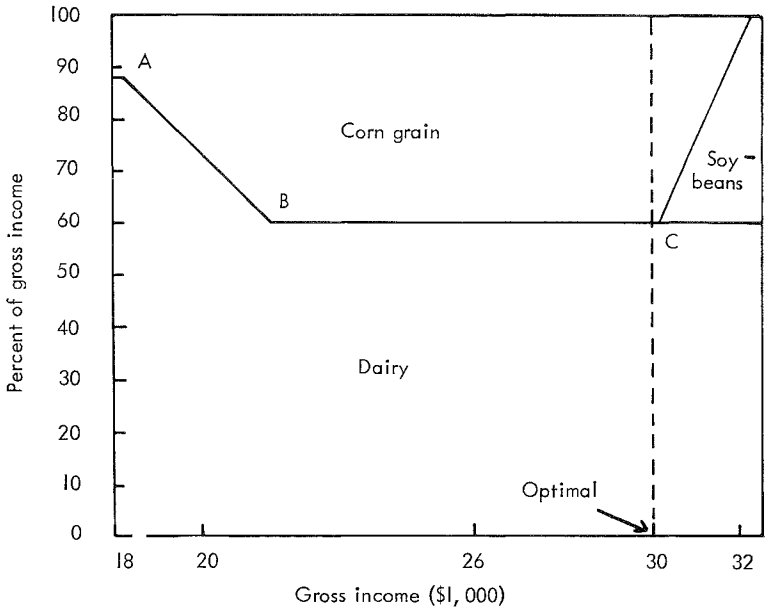

Figure 3. Sources of gross income at various gross income levels, farm situation 15121.

Total land at the least-cost $30,000 gross income level is 234 acres, of which 133 are planted to corn grain for sale and 101 acres are for feed production for the dairy herd.

Total investment in this farm situation at $30,000 gross income is $148,500. Of this total, land represents 47 percent, the dairy herd and facilities represent 29 percent, and field machinery represents 24 percent (table 4). The fixed complement of machinery is a smaller percentage of the total investment than with the stanchion barn arrangement.

Farm Situation 25123

This farm situation is a two-man farm with a loose housing loafing shed, double-4 herringbone milking parlor, and a baled hay ration. The largest complement of machinery (group III) has the lowest unit cost for the optimal two-man farm. However, unit costs and net returns for all three machinery groups are very similar for this farm situation. Machinery group III, having the lowest labor requirements, allows the given labor supply to generate higher gross income levels than either machinery group I or II.

The least-cost solutions for two gross income levels are presented in table 5. Unit cost is a minimum 80.2 cents at $60,000 gross income. The unit cost is more than 4 cents lower and the optimum gross income level is $30,000 higher on this two-man farm than on the optimal one-man farm (situation 15121). Lower unit cost and higher output volume result in over $7,000 higher net return than for situation 15121.

Table 5. Minimum unit costs, net returns, farm organization, and investments for selected gross income levels, farm situation 25123: Two-man farm, loose housing loafing barn, double-4 herringbone milking parlor, baled hay ration, machinery group III

Item	Units	Gross income	
		$54,000	$60,000
Percentage of gross income from dairy	Percent	60	60
Total cost	Dollars	43,624	48,131
Net returns	do.	10,376	11,869
Cost per dollar of gross income	do.	.8079	.8022
Farm organization:			
Cows in herd	Number	73	81
Hogs	Litters	0	0
Total land	Acres	421	467
Corn silage	do.	51	57
Corn grain	do.	34	38
Corn for sale	do.	240	267
Oats	do.	24	27
Haylage-alfalfa	do.	72	80
Soybeans	do.	0	0
Chopped corn stalks for bedding	do.	62	38
Commercial fertilizer	Cwt.	189	210
Silos	Number	2	2
Additional tractors	do.	0	0
Hired seasonal labor:	Hours	696	1,250
Jan.-Mar.	do.	0	0
Apr.-May	do.	0	0
June-July	do.	140	157
Aug.	do.	70	78
Sept.	do.	183	203
Oct.-Nov. 15	do.	230	335
Nov. 16-Dec.	do.	0	0
Add to full-time labor	do.	61	476
Full-time hired and operator	do.	4,361	4,250
Management of hired labor	do.	639	750
Total investment	Dollars	243,156	263,003
Land	do.	126,166	140,184
Dairy facilities	do.	40,214	43,050
Dairy herd	do.	26,940	29,934
Machinery	do.	49,835	49,835
Hog facilities	do.	0	0
Investment/cow in dairy facilities	do.	553	531

The relative importance of the alternative enterprises in producing gross income is similar to farm situation 15121 (figure 3). Once all full-time and seasonal labor is employed at about $60,000 gross income, soybeans are substituted for corn grain for sale as described under farm situation 15121. At the optimal gross income level, dairy and corn grain account for 60 and 40 percent of total gross income, respectively.

The full-time hired man is contributing 2,500 hours, while the owner-operator is contributing 1,750 hours to the crop and dairy enterprises. The owner-operator also contributes 750 hours of management time associated with the full-time and seasonal labor employed.

The optimal farm organization includes 81 milk cows and 467 acres of land, of which 267 acres are planted to corn grain for sale and 200 acres are used for feed production for the dairy herd.

Table 6. Minimum unit costs, net returns, farm organization, and investments for selected gross income levels, farm situation 36323: Three-man farm, loose housing loafing barn, double-8 herringbone milking parlor, baled hay ration, machinery group III

Item	Units	Gross income		
		$74,000	$78,000	$80,000
Percentage of gross income from dairy	Percent	60	60	60
Total cost	Dollars	58,299	60,929	62,244
Net return	do.	15,701	17,071	17,756
Cost per dollar of gross income	do.	.7878	.7811	.7781
Farm organization:				
Cows in herd	Number	100	105	108
Hogs	Litters	0	0	0
Total land	Acres	567	607	623
Corn silage	do.	70	74	75
Corn grain	do.	47	49	50
Corn for sale	do.	329	347	356
Oats	do.	33	35	35
Alfalfa	do.	98	104	106
Soybeans	do.	0	0	0
Chopped corn stalks for bedding	do.	85	89	92
Commercial fertilizer	Cwt.	190	273	280
Silos	Number	2	2	2
Additional tractors	do.	1	1	1
Hired seasonal labor:	Hours	493	876	1,098
Jan.-Mar.	do.	0	0	0
Apr.-May	do.	0	0	0
June-July	do.	48	51	52
Aug.	do.	97	102	104
Sept.	do.	167	176	181
Oct.-Nov. 15	do.	163	240	280
Nov. 16-Dec.	do.	0	0	0
Add to full-time labor	do.	18	329	481
Full-time hired and operator labor	do.	6,501	6,325	6,282
Management of hired labor	do.	1,099	1,175	1,218
Total investment	Dollars	304,786	317,971	324,564
Land	do.	172,894	182,239	186,013
Dairy facilities	do.	53,703	55,546	56,468
Dairy herd	do.	36,918	38,914	39,911
Machinery	do.	41,272	41,272	41,272
Hog facilities	do.	0	0	0
Investment/cow in dairy facilities	do.	539	529	524

Total investment in this farm situation when it produces the optimal $60,000 gross income is $263,003. Land represents 53 percent, dairy herd and facilities represent 28 percent, and machinery represents 19 percent of this total.

Farm Situation 36323

This farm situation is a three-man farm with loose housing loafing barn, double-8 herringbone milking parlor, and the baled hay ration. The dairy herd is divided and housed in two groups but milked in the same parlor (part B, figure A-2). The largest group of field machinery has the lowest unit cost on this size farm.

Least-cost solutions for three gross income levels are presented in table 6. Unit costs reach a minimum of $77.81 cents at about $80,000 gross income. The minimum unit cost is slightly more than 2 cents lower for this three-man farm than for the optimal two-man farm. The optimal output level is about $20,000 higher and net return ($17,756) is over $5,000 higher with farm situation 36323 than with farm situation 25123.

The relative importance of the alternative enterprises in producing gross income is also similar to farm situation 15123 (figure 3). At the optimal $80,000 gross income, dairy and corn grain for sale account for 60 and 40 percent of total gross income, respectively.

Two full-time hired men contribute 5,000 hours of labor directly to the crop and dairy enterprises. The owner-operator contributes 1,280 hours to the dairy and crop activities and 1,220 hours of management and supervisory time associated with the full-time and seasonal labor.

Total investment in this farm situation at $80,000 gross income is about $325,000. Land represents 57 percent, dairy herd and facilities represent 30 percent, and machinery represents 13 percent of this total (table 6).

Farm Situation 46323

This farm situation is the same as model 36323 except that there are four rather than three full-time men employed.

Least-cost solutions at four gross income levels are presented in table 7. Unit costs are a minimum 76.96 cents at about $105,000 gross income. The optimal farm organization includes 141 cows and 817 acres of land, of which 467 are planted to corn grain for sale. Dairy accounts for the minimum 60 percent of gross income, while corn grain accounts for the remaining 40 percent. Cost per dollar of gross income is slightly less than 2 cents lower on farm situation 46323 than on farm situation 36323. However, the higher output level results in about a $7,000 higher net return for farm situation 46323 than for farm situation 36323. Net return at the near optimal $105,000 level is $24,194. The relative importance of alternative enterprises at various gross income levels is similar to that for farm situation 15121.

Three hired men contribute 7,500 hours to crop and livestock enterprises at $105,000 gross income level. The owner-operator contributes 800 hours to crop and livestock enterprises and 1,700 hours to management and supervision of hired labor.

Land represents 59 percent of the total $416,434 investment. Dairy herd and facilities represent 29 percent and machinery represents 12 percent of the total investment.

Derivation of the LRUC Curve

A SRUC curve showing the relationship between cost per dollar of gross income and amount of gross income produced was derived for each of the 60 farm situations. Six of these curves are illustrated in figure 4 (situations 18721, 15121, 25121, 25123, 36323, and 46323). A smooth

Table 7. Minimum unit costs, net returns, farm organization, and investments for selected gross income levels, farm situation 46323: Four-man farm, loose housing loafing barn, double-8 herringbone milking parlor, baled hay ration, machinery group III

Item	Units	Gross income			
		$90,000	$98,000	$105,000	$110,000
Percentage of gross income from dairy	Percent	65	60	60	60
Total cost	Dollars	70,649	75,884	80,806	85,600
Net return	do.	19,351	22,116	24,194	24,400
Cost per dollar of gross income	do.	.7850	.7743	.7696	.7782
Farm organization:					
Cows in herd	Number	132	132	141	148
Hogs	Litters	0	0	0	0
Total land	Acres	674	763	817	870
Corn silage	do.	92	92	99	104
Corn grain	do.	62	62	66	46
Corn for sale	do.	346	436	467	312
Oats	do.	43	43	46	48
Alfalfa	do.	130	130	139	146
Soybeans	do.	0	0	0	213
Chopped corn stalks for bedding	do.	113	113	120	126
Commercial fertilizer	Cwt.	254	343	368	186
Buy corn concentrate	do.	0	0	0	1,143
Silos	Number	3	3	3	3
Additional tractors	do.	0	0	0	0
Hired seasonal labor	Hours	0	304	1,002	1,250
Jan.-Mar.	do.	0	0	0	0
Apr.-May	do.	0	0	0	0
June-July	do.	0	0	0	0
Aug.	do.	0	0	0	0
Sept.	do.	0	0	0	0
Oct.-Nov. 15	do.	0	214	466	388
Nov. 16-Dec.	do.	0	0	0	0
Add to full-time labor	do.	0	90	536	862
Full-time hired and operator labor	do.	8,500	8,439	8,300	8,250
Management of hired labor	do.	1,500	1,561	1,700	1,750
Total investment	Dollars	366,757	393,428	416,434	435,728
Land	do.	202,187	228,969	245,323	261,200
Dairy facilities	do.	65,786	65,733	68,892	69,815
Dairy herd	do.	48,949	48,892	52,884	54,878
Machinery	do.	49,835	49,835	49,835	49,835
Hog facilities	do.	0	0	0	0
Investment/cow in dairy facilities	do.	499	498	487	472

envelope curve, the LRUC curve, is drawn so that these six SRUC curves, together with the SRUC curves for the other 54 farms, would touch or lie entirely above it. Five of the 60 SRUC curves (situations 18721, 15121, 25123, 36323, and 46323) are tangent to the LRUC curve as illustrated in figure 4. The remaining 55 curves, like farm situation 25121 in figure 4, lie entirely above the LRUC curve.

Cost per dollar of gross income produced was almost 5 cents lower on the minimum cost two-man farm (situation 25123) than on the mini-

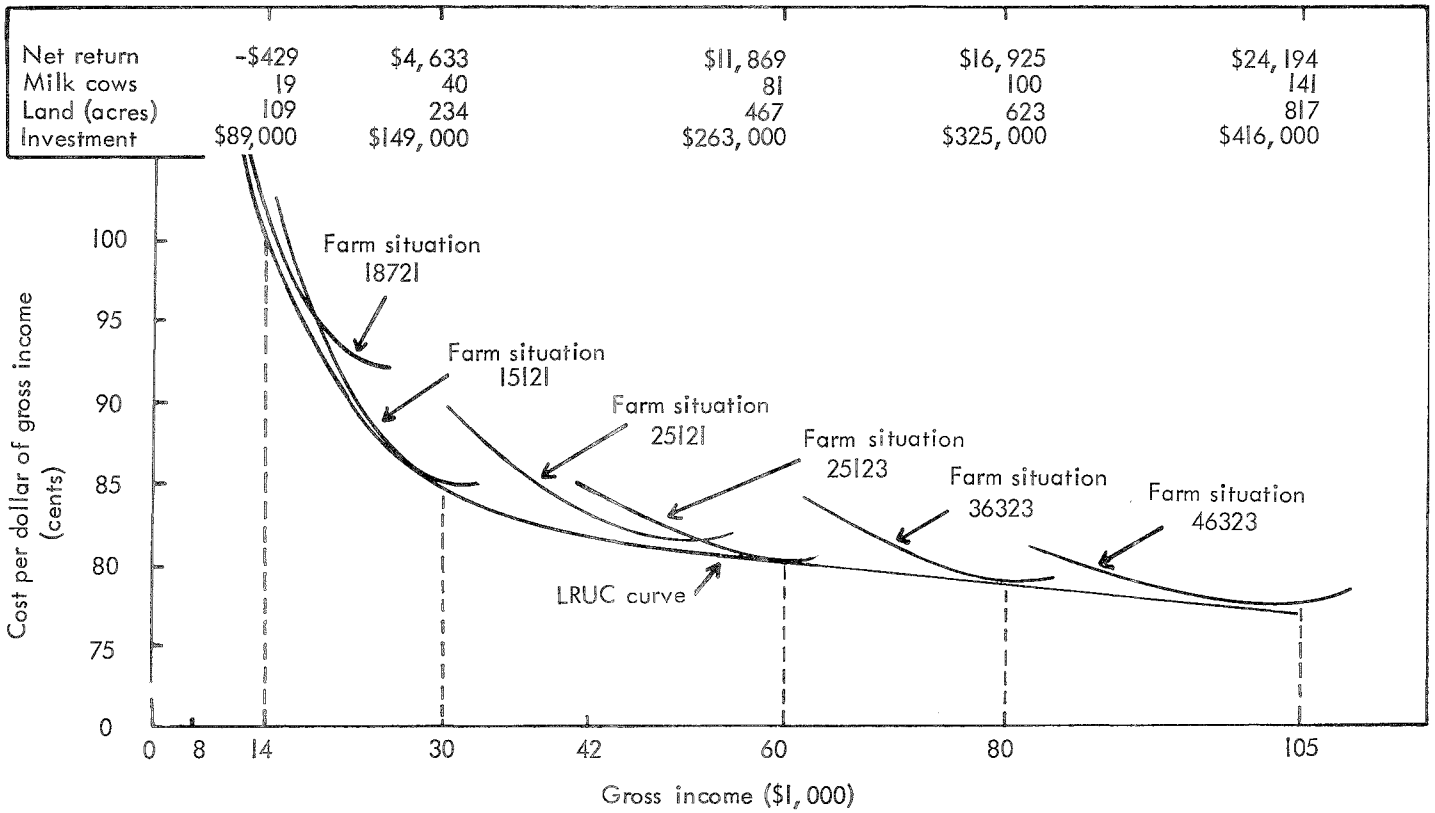

Figure 4. Derivation of the LRUC curve from five SRUC curves.

mum cost one-man farm (situation 15121). Unit cost was about 1.5 cents lower on the three-man farm than on the two-man farm and was 0.5 cent lower on the four-man than on the three-man farm. Therefore, most of the economies due to size were realized on two-man farms.

The LRUC curve indicates that per unit costs are comparatively high at the lower gross income levels. This is due to the high fixed costs associated with the large investments in field machinery, buildings, and facilities. As output is increased, these fixed costs are spread over more output units, and per unit costs decrease substantially.

At high output levels, the increased difficulty of managing the dairy operation could result in rising per unit costs. This analysis was based on the assumption of above average management ability as reflected in yields, milk production, and cost coefficients at all output levels. However, with poor management the entire cost curve would be shifted upward and probably would start to rise at higher output levels.

Net Returns

The net return to the operator's labor and management increased from the smallest up to the largest four-man farm as shown in figure 4. This figure also shows the number of milk cows, acres of land, and total investment at the gross income levels where the SRUC curves are tangent to the LRUC curve.

As long as the LRUC curve falls for higher output levels as illustrated in figure 4, net returns will rise for large farms. Hence, as long as operators attempt to maximize net return, economic pressure exists for building at least a four-man dairy operation.

Investment Per Dollar of Net Return

Total investment increases rapidly as a farm's gross income level increases. Total investments range from about $89,000 at $14,000 gross income to about $416,434 at $105,000 gross income. Over half of the total investment is in land, with the balance in field machinery, buildings, dairy facilities, and livestock.

As the gross income level increases, the investment required to generate a dollar of net return to the operator's labor and management decreases. Table 8 shows this relationship. For the optimum one-man farm, about a $32 investment is required for each dollar of net return produced. For two-, three-, and four-man farms the amounts of investment required to produce $1 of net return are $22.16, $19.17, and $17.21, respectively. This decrease in investment requirement is due largely to better utilization of fixed investments such as field machinery and the milking parlor. Investment per dollar of annual gross income also declines as farm size increases (table 8). Both gross income and net returns are sensitive to fluctuations in prices and yields and therefore will vary from year to year.

The net returns and investment per dollar of net return are based on the relatively low milk price of $3.20. Much higher net returns and lower investment per dollar of net return are possible with higher milk prices.

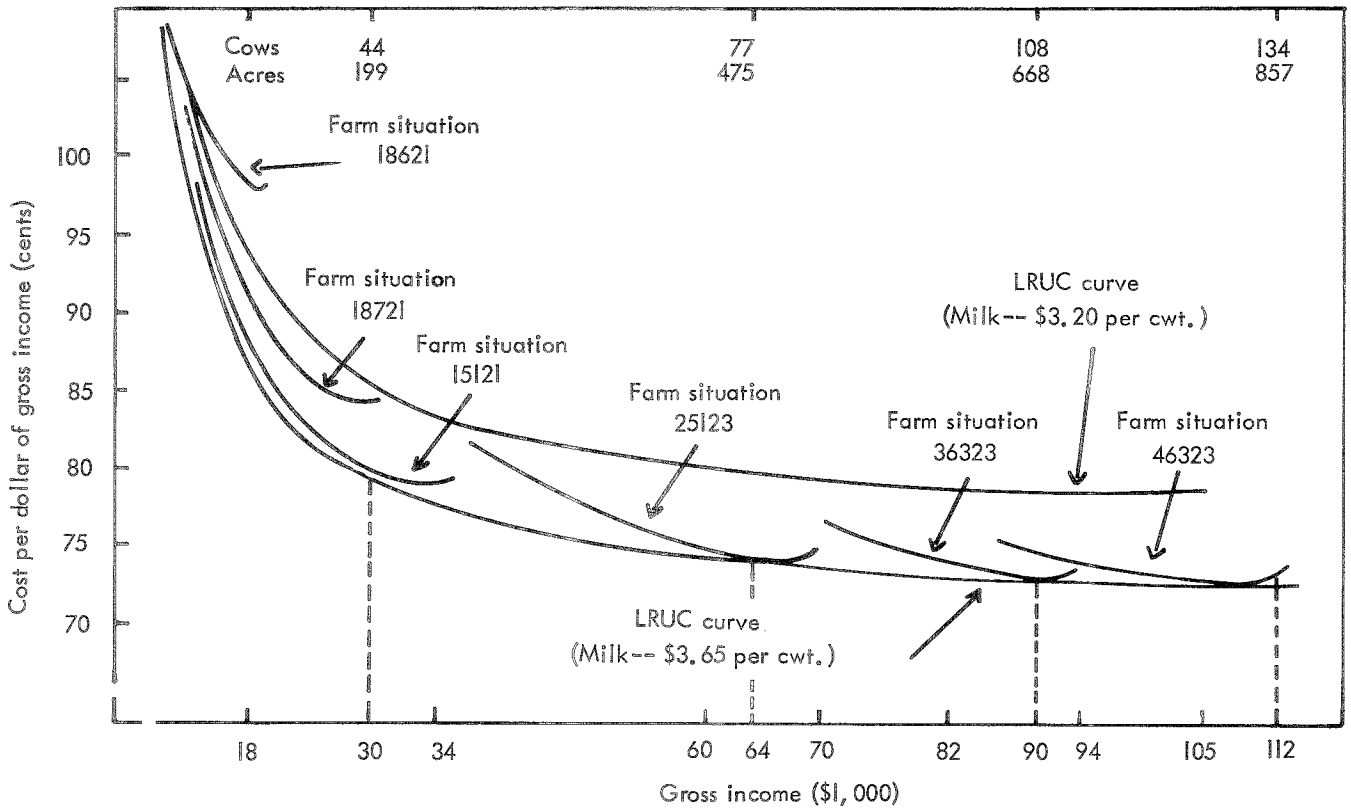

Figure 5. Shift in the LRUC curve due to milk price increase from $3.20 to $3.65 per cwt.

Table 8. Total investment per dollar of gross income and net return to operator's labor and management produced annually for four sizes of dairy farms

	Farm situation number			
	15121 (one-man)	25123 (two-man)	36323 (three-man)	46323 (four-man)
Total investment	$148,500	$263,000	$324,500	$416,434
Total investment per dollar of net return ...	$32.05	$22.16	$19.17	$17.21
Total investment per dollar of gross income	$ 4.95	$ 4.38	$ 4.06	$ 3.97

Factors Affecting the LRUC Curve

In the preceding section, minimum cost points and, therefore, the LRUC curve, were estimated assuming (1) given milk, hog, and crop prices, (2) limited rotation restrictions on crop activities, and (3) a $3,500 annual salary for full-time labor. The following section concerns how changes in these three assumptions influence the SRUC curves of the more efficient farm situations and, thereby, affect the LRUC curve.

This section is divided into three parts. Each part concerns the implications of changing an initial assumption. These assumptions include the influence of:

(1) Increasing milk price from $3.20 to $3.65 per cwt.

(2) Imposing rotation restrictions on cropping activities.

(3) Increasing the annual salary for full-time hired labor from $3,500 to $5,900.

Increasing Milk Price

Because gross income was used as a measure of output, a change in product price will shift the unit cost curve. A higher milk price will shift the unit cost curve down, since a given gross income level can be generated with fewer resources.

Figure 5 illustrates the shift in the LRUC curve resulting from an increase in milk price from $3.20 to $3.65 per cwt. The curve labeled "Milk $3.20 per cwt." is the same LRUC curve shown in figure 4. On the two-man farm unit, cost was about 5.5 cents lower and net return to the operator's labor and management was about $3,500 higher with the $3.65 milk price than with the $3.20 price.[7] Net returns increased more than $3,500 on three- and four-man farms and less than $3,500 on the one-man farm. With higher milk prices, the same labor supply on the four-man farm could be utilized to increase the maximum gross income level from about $103,000 to $112,000.

[7] Net returns increased from $11,869 at $60,000 gross income with the $3.20 milk price to $16,482 at $64,000 gross income with the $3.65 milk price. This is a $4,613 difference due to lower unit costs and a higher gross income level with the higher price.

The minimum cost organization at $112,000 gross income (farm situation 46323) includes 134 milk cows and 857 acres of land. The number of milk cows and acres of land where the four SRUC curves touch the LRUC curve are presented in figure 5. At each of these points, dairy and corn grain account for 60 and 40 percent of total gross income, respectively.

A higher milk price relative to hog and crop prices clearly makes a dairy enterprise more competitive with other enterprises for farm resources. This fact can be seen by comparing the results of one farm situation (15121) at both the $3.20 and $3.65 milk prices (holding other prices constant). The relative importance of crop and livestock enterprises for both the $3.20 and $3.65 milk prices is illustrated in figure 6. With the higher milk price, seasonal labor is hired to keep the dairy enterprise accounting for 88 percent of the gross income up to a level of $26,000 gross income (point A, figure 6). With the low milk price, the dairy enterprise drops down to 60 percent of the gross income at the $18,000 gross income level (point B, figure 6). However, at the optimal gross income levels for both milk prices ($33,000 for $3.65 and $30,000 for $3.20 milk), the dairy enterprise accounts for the minimum 60 percent of total gross income required of all farm situations.

Imposing Rotation Restrictions[8]

Not all land in southeastern Minnesota is suitable for raising corn without rotation restrictions. Along the Wisconsin border the land is quite hilly and subject to erosion. Cropping patterns in these areas sometimes are restricted to a corn, corn, oats, hay, hay rotation with no soybean alternative. These rotational constraints were imposed on the linear programming model to determine their effect on unit cost and net returns. The farm was allowed to sell alfalfa hay, since the rotation restrictions require that a larger proportion of total land be planted to alfalfa than without rotation restrictions.

Results for a two-man farm (situation 25121) are shown in figure 7. Cost per dollar of gross income is substantially higher at all gross income levels with crop rotation restrictions than without. The unit cost for farm situation 25121 with rotation restrictions imposed (situation 25121-B) is minimum at about $46,000 gross income where unit cost is about 78.31 cents and net return is almost $10,000 (see table 9 for summary). Cost per dollar of gross income for the same model without rotation restrictions (situation 25121-A) is minimum at about $56,000 gross income where unit cost is about 75.36 cents and net returns are almost $14,000 (see table 10 for summary). The lower unit costs and higher gross income level attainable without rotation restrictions result in about $4,000 higher net return than when rotation restrictions are imposed.

Restrictions on cropping practices and elimination of soybeans as a crop alternative greatly influence the farm organization and gross income

[8] All results discussed in this section assume a $3.65 per cwt. price for milk.

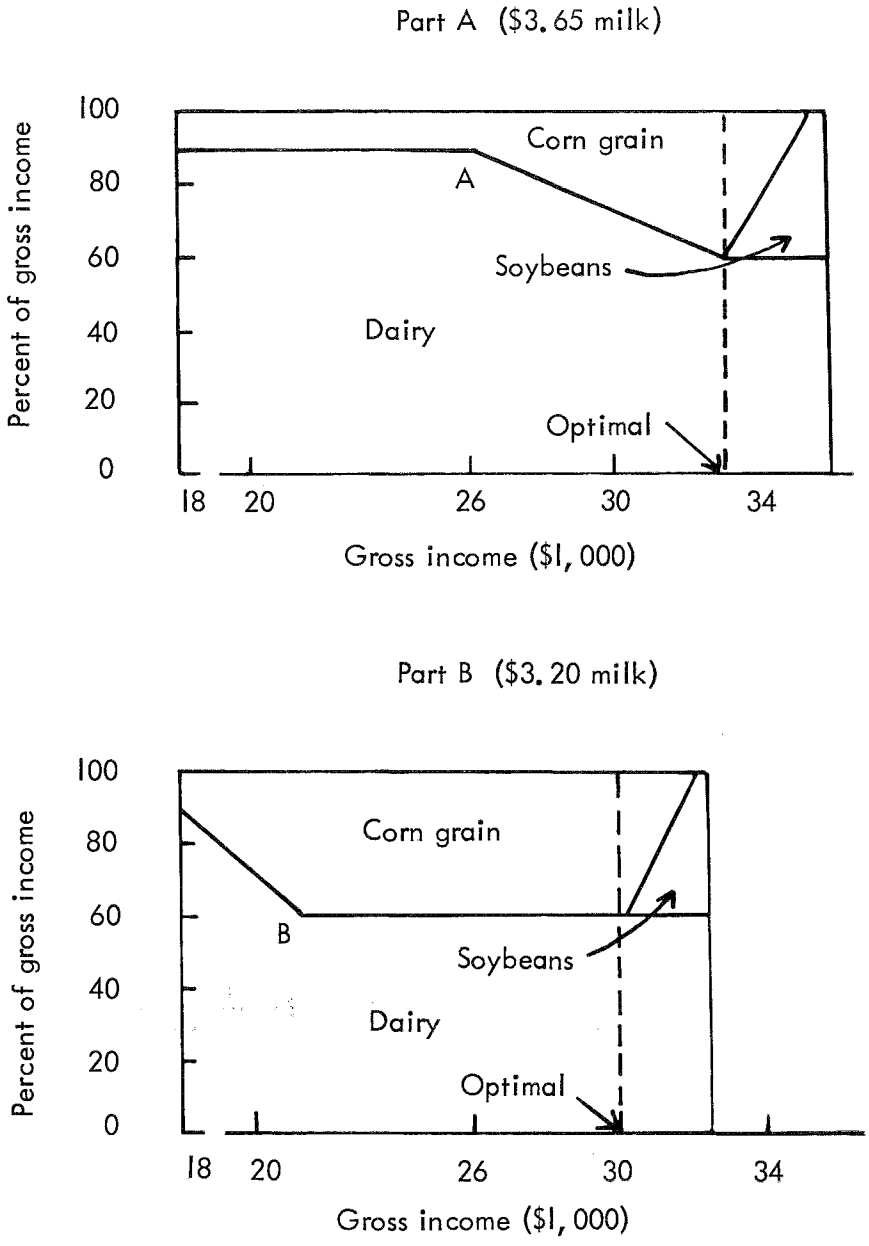

Figure 6. Relative importance of crop and livestock enterprises in the production of gross income with $3.20 and $3.65 milk prices, farm situation 15121.

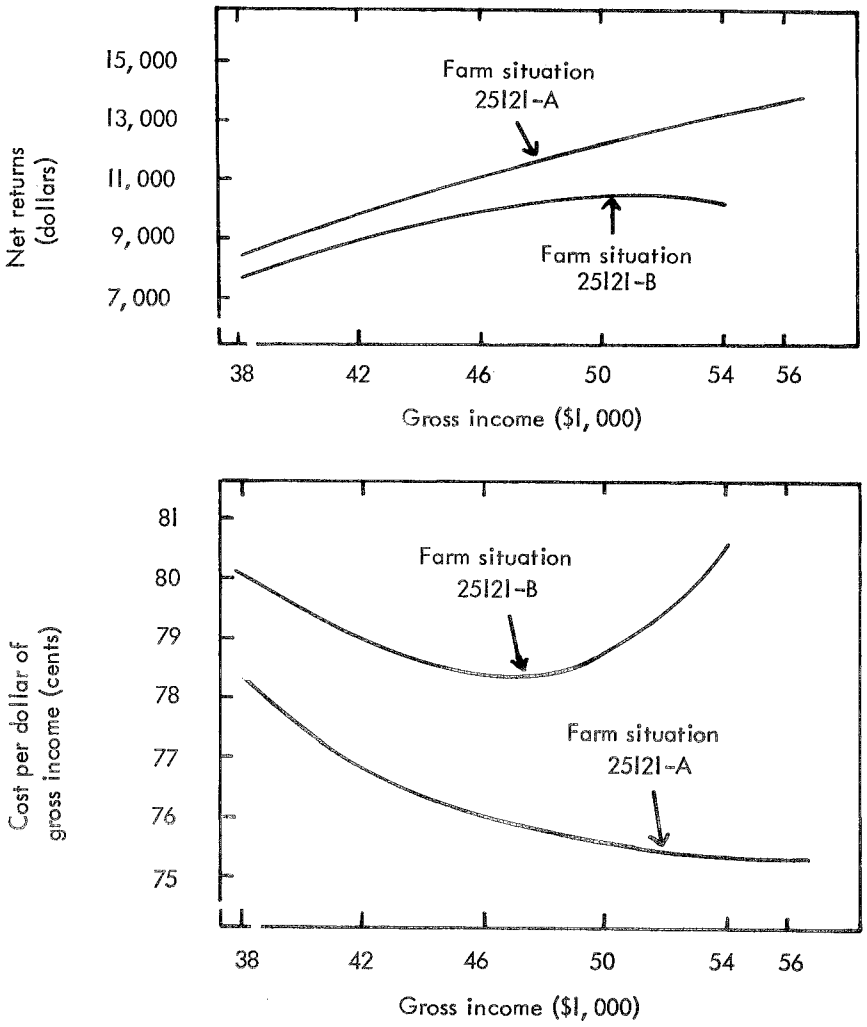

Figure 7. SRUC curves and net returns for farm situation 25121 with crop rotation restrictions (farm situation 25121-B) and without crop rotation restrictions (farm situation 25121-A).

sources. At every level of gross income, fewer acres of corn are raised and more labor is employed with rotation restrictions than without.

A dairy enterprise is a relatively more important source of gross income with crop rotation restrictions than without (figure 8). As long as full-time or seasonal labor is available, a dairy enterprise accounts for about 98 percent of total gross income, while the sale of excess alfalfa hay accounts for the remaining 2 percent. All labor, full-time and seasonal, is employed at about $44,000 gross income. For higher output levels, corn is raised for sale and each acre planted requires an additional acre

Table 9. Minimum unit costs, net returns, farm organization, and investments for selected gross income levels, farm situation 25121-B, with rotation restrictions

Item	Units	Gross income $38,000	$42,000	$46,000	$50,000	$54,000
Percentage of gross income from dairy	Percent	98	98	85	65	60
Total cost	Dollars	30,396	33,150	36,021	39,319	43,591
Net returns	do.	7,604	8,850	9,979	10,682	10,409
Cost per dollar of gross income	do.	.7999	.7892	.7831	.7864	.8072
Farm organization:						
Cows in herd	Number	75	82	78	66	65
Hogs	Litters	0	0	0	0	14
Total land	Acres	203	224	295	397	331
Corn silage	do.	52	58	55	46	45
Corn grain	do.	29	32	23	8	0
Corn for sale	do.	0	0	40	102	87
Oats	do.	41	45	59	79	66
Alfalfa	do.	81	90	118	159	133
Soybeans	do.	0	0	0	0	0
Sell hay	Tons	27	29	150	345	253
Chopped corn stalks for bedding	Acres	54	60	46	20	31
Commercial fertilizer	Cwt.	0	0	0	0	0
Buy corn concentrate	do.	0	0	0	0	2,261
Buy soybean oil meal	do.	0	0	0	0	0
Silos	Number	2	2	2	1	1
Additional tractors	do.	0	0	0	1	0
Hired seasonal labor	Hours	482	1,034	1,250	1,250	1,250
Jan.-Mar.	do.	0	0	0	0	0
Apr.-May	do.	0	0	0	11	6
June-July	do.	159	176	232	312	260
Aug.	do.	80	88	115	156	133
Sept.	do.	205	227	215	181	176
Oct.-Nov. 15	do.	0	0	0	0	68
Nov. 16-Dec.	do.	0	0	0	0	0
Add to full-time labor	do.	38	543	687	590	607
Full-time hired and operator labor	do.	4,404	4,293	4,250	4,250	4,250
Management of hired labor	do.	596	707	750	750	750
Total investment	Dollars	164,937	177,009	196,178	223,376	207,186
Land	do.	60,757	67,153	88,362	119,126	99,438
Dairy facilities	do.	40,922	43,682	43,280	39,873	37,921
Dairy herd	do.	47,710	30,626	28,989	24,413	23,996
Machinery	do.	35,548	35,548	35,548	39,965	35,548
Hog facilities	do.	0	0	0	0	10,284
Investment/cow in dairy facilities	do.	547	528	553	605	586

of alfalfa hay to meet the rotation restriction. The alfalfa hay not used for the dairy herd is sold along with the corn grain sold. From $44,000 to $51,000 the proportion of total gross income from selling corn grain and alfalfa hay increases, while the proportion from dairy decreases. Above $51,000, where the dairy enterprise accounts for the minimum 60 percent of gross income, hogs enter the farm organization and produce

Table 10. Minimum unit costs, net returns, farm organization, and investments for selected gross income levels, farm situation 25121-A, without rotation restrictions

Item	Units	Gross income				
		$38,000	$42,000	$46,000	$54,000	$56,500
Percentage of gross income from dairy	Percent	89	89	89	66	60
Total cost	Dollars	29,739	32,264	34,957	40,942	42,579
Net returns	do.	8,261	9,736	11,043	13,058	13,921
Cost per dollar of gross income	do.	.7826	.7682	.7599	.7582	.7536
Farm organization:						
Cows in herd	Number	67	75	82	71	68
Hogs	Litters	0	0	0	0	0
Total land	Acres	215	237	260	381	422
Corn silage	do.	47	52	57	50	47
Corn grain	do.	32	35	38	33	31
Corn for sale	do.	47	52	57	205	240
Oats	do.	22	25	27	23	22
Alfalfa	do.	67	74	81	70	67
Soybeans	do.	0	0	0	0	13
Chopped corn stalks for bedding	Acres	58	70	70	61	58
Commercial fertilizer	Cwt.	0	0	0	155	193
Buy concentrate	do.	0	0	0	0	0
Silos	Number	1	2	2	2	1
Additional tractors	do.	0	0	0	1	1
Hired seasonal labor	Hours	3,821	671	1,187	1,239	1,250
Jan.-Mar.	do.	0	0	0	0	0
Apr.-May	do.	0	0	0	0	15
June-July	do.	131	145	158	138	131
Aug.	do.	65	72	79	69	65
Sept.	do.	185	205	224	195	186
Oct.-Nov. 15	do.	0	0	124	322	416
Nov. 16-Dec.	do.	0	0	0	0	0
Add to full-time labor	do.	0	249	600	525	437
Full-time hired and operator	do.	4,461	4,366	4,262	4,250	4,250
Management of hired labor	Hours	539	634	738	750	750
Total investment	Dollars	162,375	175,242	187,146	220,365	229,095
Land	do.	64,408	71,187	77,968	114,425	126,506
Dairy facilities	do.	37,417	40,873	43,364	39,641	37,606
Dairy herd	do.	25,002	27,634	30,266	26,334	25,107
Machinery	do.	35,548	35,548	35,548	39,965	39,965
Hog facilities	do.	0	0	0	0	0
Investment/cow in dairy facilities	do.	558	545	529	558	553

an increasing proportion, while both corn grain and alfalfa account for a decreasing proportion of gross income. The total labor supply (6,250 hours) is used for all gross income levels above $44,000, and higher output levels are attained by reorganizing the farm enterprises as described above. Each reorganization required to obtain a higher gross income level with the same labor supply involves including an enterprise in the farm organization that requires relatively less labor but higher cost per dollar of gross income.

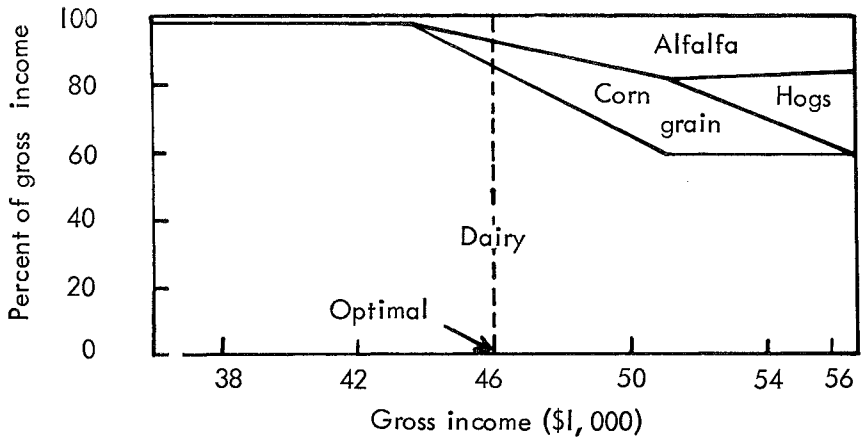

Figure 8. Relative importance of crop and livestock enterprises in the production of gross income with crop rotation restrictions, farm situation 25121.

Increasing Full-time Hired Labor Salary[9]

As discussed earlier, salaries for full-time hired labor are treated as fixed costs and do not influence the least-cost farm organization at each output level. The $5,900 annual salary, like the $3,500 annual salary, is subtracted at each gross income level.

Figure 9 illustrates the shift in the LRUC curve resulting from the higher salary paid to full-time hired labor. There is no change in resource combination on farm organization on one-man farms, since salaries for full-time help are fixed and subtracted out of gross returns after the optimal farm organization has been determined. Unit costs are about 5 cents higher on the two-man farms, while unit costs at the optimal output level on three- and four-man farms are 6 and 7 cents higher, respectively.

The LRUC curve at first declines for higher gross income levels, then rises as the gross income level increases on two-, three-, and four-man farms. On the large farms, a greater proportion of gross income is produced with hired labor and the higher annual salary results in higher unit cost. If a return to the owner-operator's labor and management is included in the total cost (rather than being treated as a residual), the LRUC curve would decline for all higher gross income levels.

Even though the LRUC curve increases on two-, three-, and four-man farms, net returns to the operator's labor and management are higher on successively larger farms. Net returns at the optimal gross income levels for the one-, two-, three-, and four-man farms are $7,278; $14,082; $19,382; and $23,094; respectively.

[9] $5,900 per year is considered a competitive wage for production workers in manufacturing industries. Results are used to determine the effect of unit cost on income of dairy farmers paying a competitive wage.

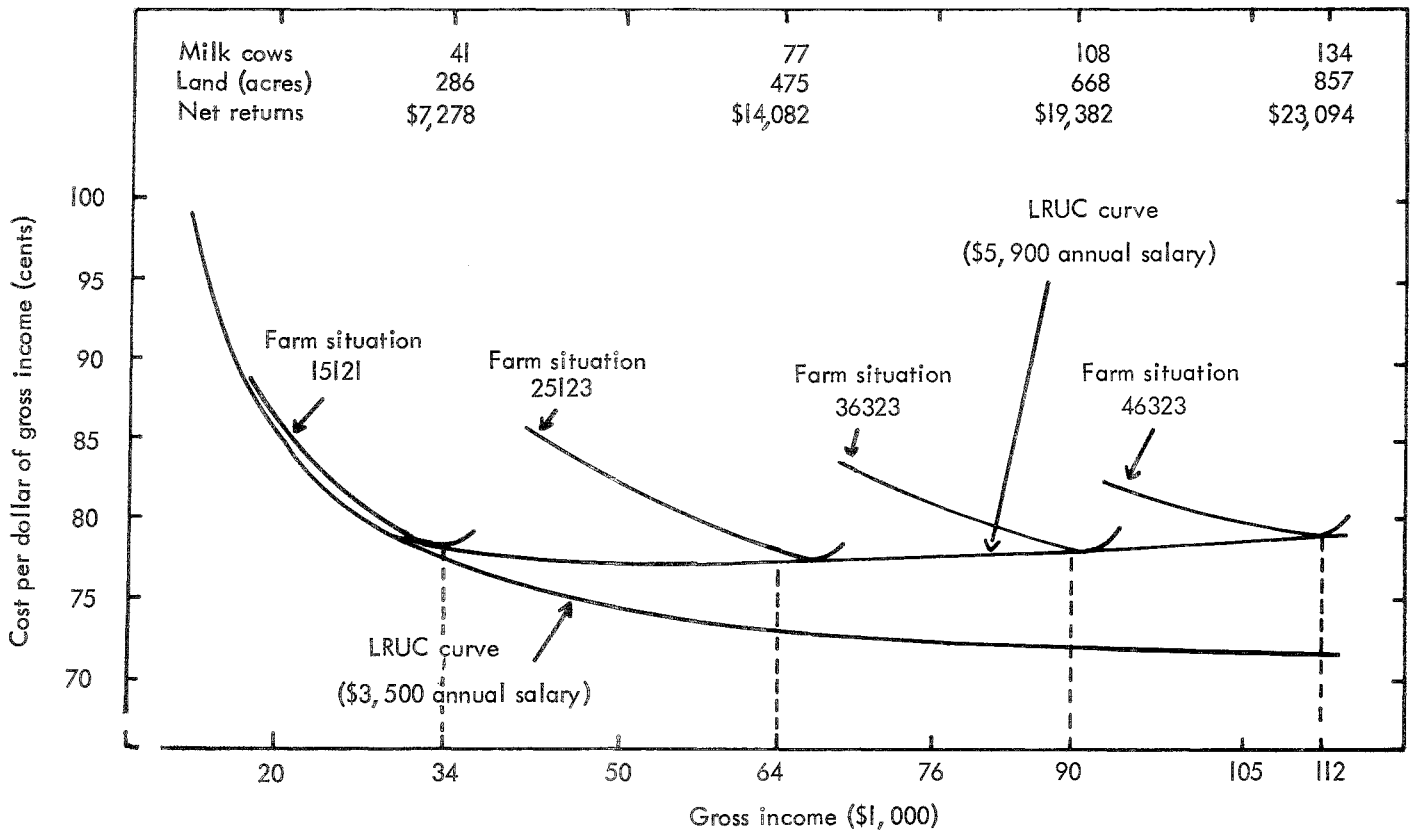

Figure 9. Shift in the LRUC curve due to increasing the annual wage for full-time help from $3,500 to $5,900.

Appendix A

Dairy Farm Situations

Dairy farm situations were identified by a situation number whose digits indicate in order (1) the amount of full-time labor available to the farm, (2) the type of housing for dairy cows, (3) the size and type of milking parlor, (4) the feeding program, and (5) the size of field machinery. Size of dairy housing facilities, acres of land, and money-capital used were varied with the output level for each farm. In total, 60 synthetic dairy farm situations were constructed and are summarized in table A-1.

Table A-1. Summary of labor, housing, milking, feeding, and machinery situations, 60 synthetic dairy farm situations

	Codes for synthetic farm situations*			
One-man farms	18621	15411	11411	13111
	18721	15421	11421	13411
	15111	11111	17111	
	15121	11121	17411	15123
Two-man farms	25211	25511	21111	27511
	25221	25521	21121	23111
	25311	21211	21511	23211
	25321	21221	21521	23311
	25111	21311	27111	23511
	25121	21321	27311	25122
				25123
Three-man farms	36311	36211	32311	32211
	36321	36221	32321	32221
	37211	37311	34311	34211
				36323
Four-man farms	46311	42311	47311	
	46321	42321	44311	46323

* Codes for synthetic farm situations refer to the following labor supplies, housing, milking and feeding technologies, and field machinery complement.

First digit: Labor supply committed to the farm
- 1—Owner operator
- 2—Owner operator plus one full-time hired man
- 3—Owner operator plus two full-time hired men
- 4—Owner operator plus three full-time hired men

Second digit: Type of housing facilities
- 1—Cold pole frame barn with free stalls
- 2—Cold pole frame barn with free stalls (herd divided)
- 3—Warm confinement barn with free stalls, slatted floors, and liquid manure
- 4—Warm confinement barn with free stalls, slatted floors, and liquid manure (herd divided)
- 5—Loose housing barn with bedded loafing area
- 6—Loose housing barn with bedded loafing area (herd divided)
- 7—Warm confinement barn with free stalls and liquid manure
- 8—Two story stanchion barn

Third digit: Type of milking facilities
- 1—Double-4 herringbone parlor
- 2—Double-6 herringbone parlor
- 3—Double-8 herringbone parlor
- 4—Single-3 in line side opening parlor
- 5—Double-3 side opening parlor
- 6—Two-unit carry for stanchion barn
- 7—Three-unit pipeline for stanchion barn

Fourth digit: Type of feeding
- 1—Corn silage with summer haylage ration (inside feeding facilities)
- 2—Corn silage with baled alfalfa hay ration (outside feeding facilities)

Fifth digit: Field machinery group
- 1—Group I
- 2—Group II
- 3—Group III

Description of Enterprise Technologies

Dairy facilities were selected from among technologies currently available to dairy farmers.[10] Primarily because of their labor efficiency, certain equipment items such as gutter cleaners, silo unloaders, and mechanical feeders were assumed for farm situations.

The component parts of the dairy facilities were divided into housing, milking, and feeding facilities. For example, housing facilities for the stanchion barn included the main barn, a barn cleaner, stalls, pens, calf stalls, well, and waterers; milking facilities included the milkhouse, bulk tank, and a three-unit pipeline milker; and feeding facilities included the silo (with unloader), mechanical bunks, and storage for ear corn and alfalfa hay.

Total investment was broken down into "fixed" and "additional investment per cow" to better estimate the cost advantage of larger dairy farms. The fixed investment is that part of the total investment that is required regardless of herd size. For example, the fixed investment in a loafing barn is the investment in the two ends, which are required regardless of shed length or cow numbers. The additional investment per cow is the increase in total investment required initially to build a longer barn to handle one additional cow and her replacements.

The sum of the investments for component parts of the dairy operation provided an estimate of total investment for housing, milking, and feeding facilities. Total annual cost including depreciation, interest, taxes, repairs, maintenance, and insurance was estimated as a percentage of original investment (table C-1).

Housing Facilities

The two types of housing facilities discussed in this bulletin are stanchion barn and loose housing loafing barn. Adequate space was provided for adult cows and all replacements in both types of housing. One maternity pen was provided for every 20 adult cows. Individual calf stalls were provided until calves were 2 months old, when they were placed in group pens holding about 10 calves. Heifers 12-18 months of age (through freshening) were housed with the dry cows.

Stanchion barn. The stanchion barn was assumed to be similar to the conventional stanchion barns on many Minnesota dairy farms (figure A-1). Table A-2 shows the estimated investment and annual cost for each component of the stanchion barn.

Estimated total investment for a given herd size was computed by multiplying the number of milk cows by the total "additional per milk cow" and adding the total fixed investment. The same procedure was used to determine total annual cost. For example, estimated total investments in stanchion barn housing for herds of 19 and 31 milk cows were

[10] Initial investment for each component was estimated from information obtained from building and equipment dealers. Annual costs were computed as a percentage of initial investment.

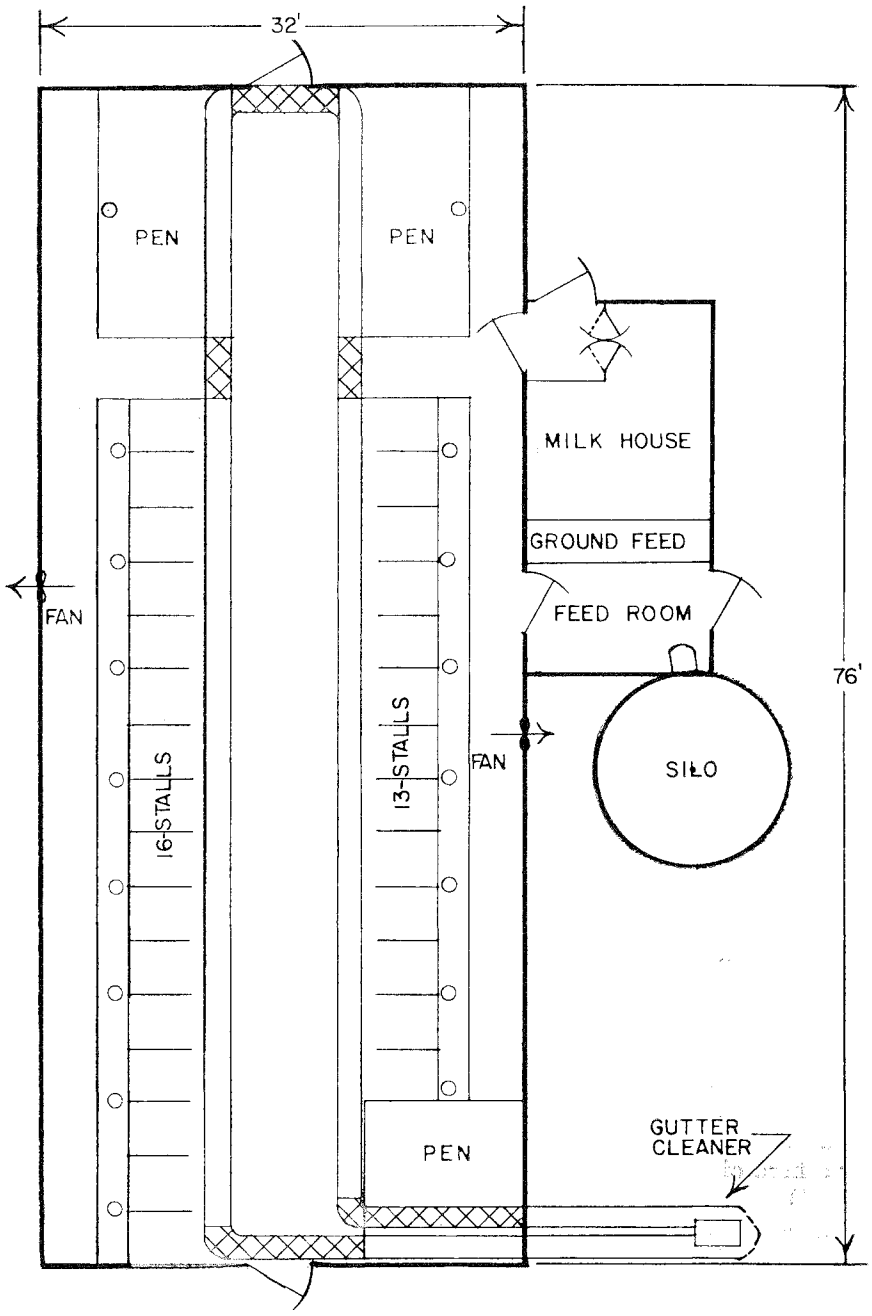

Figure A-1. Illustration of a stanchion barn housing technology.

Table A-2. Investment and annual cost per adult cow for component parts of stanchion barn housing*

	Investment		Annual cost	
	Fixed	Additional per milk cow	Fixed	Additional per milk cow
Buildings				
Main barn	$1,439	$214.00	$263.34	$38.58
Milk house	1,071	0	195.99	0
Loose housing for heifers	0	14.85	0	2.67
Equipment				
Stalls	0	30.00	0	4.21
Water bowls	0	5.88	0	.82
Barn cleaner	1,174	8.14	164.71	1.14
Bulk tank cooler	1,843	30.35	260.11	3.74
Well	850	0	107.95	0
Total	$6,377	$303.22	$992.10	$51.16

* See table C-1 for breakdown of percentage of initial investment used to determine annual cost.

$12,140 ($303.30 times 19 cows plus $6,377) and $15,780 ($303.30 times 31 cows plus $6,377), respectively. Similarly, total annual cost in stanchion barn housing for 19 cows and 31 cows was $1,964 ($51.16 times 19 cows plus $992.10); for 31 cows it was $2,578 ($51.16 times 31 cows plus $992.10). Therefore, investment per cow and annual cost per cow are both lower when the stanchion barn is constructed for large than for small herds. Total investment per cow was estimated at $630 when built for 19 cows and $510 when built for 31 cows. Total annual costs per cow were $103 and $83 for 19 and 31 cow herds, respectively.

Loose housing barn with bedded loafing area. Parts A and B of figure A-2 illustrate the plans from which investment, annual cost, and labor requirements were estimated for the loose housing with bedded loafing area.[11]

Table A-3 shows the estimated investment and annual cost for each component part of the loose housing barn with bedded loafing area.

Estimated total investment for a given herd size was computed in the same manner as for the stanchion barn. The number of milk cows multiplied by the total "additional per milk cow" was added to the total fixed investment. Total annual cost was determined using the same procedure. For example, total investment in the loose housing facility for a herd of 40 cows was $12,945 ($194.96 times 40 milk cows plus $5,147); for a herd of 132 cows it was $30,882 ($194.96 times 132 milk cows plus $5,147).

Like the stanchion barn housing, both average investment and average annual cost were lower when loose housing facilities were con-

[11] The authors thank Arnold Flikke and Donald Bates, Department of Agricultural Engineering, University of Minnesota, and Russell Larson, Agricultural Engineer, ARS, USDA, for helpful suggestions and consultation. However, the authors take full responsibility for the plans.

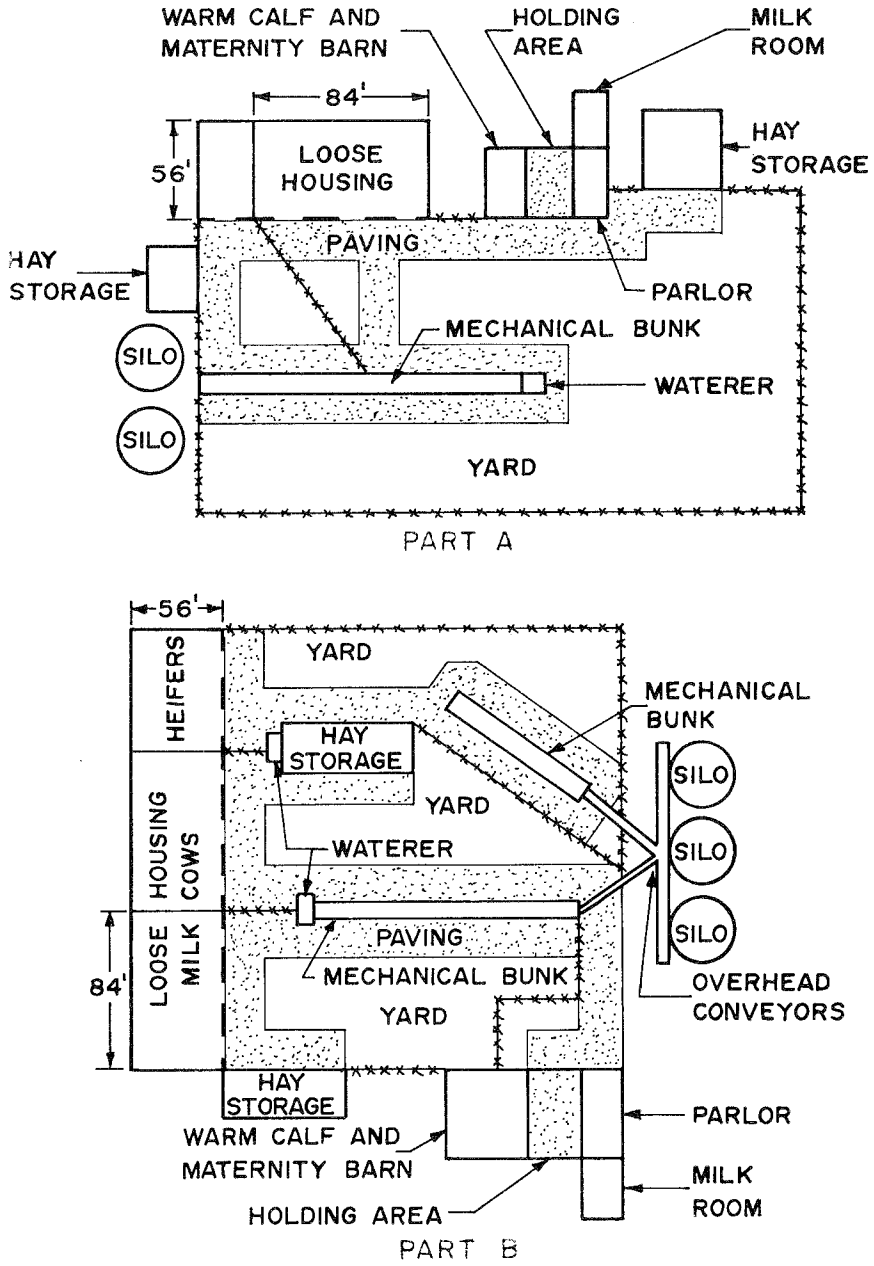

Figure A-2. Illustration of a loose housing loafing barn technology (part A, less than 75 cows; part B, 75 or more cows).

Table A-3. Investment and annual cost per adult cow for component parts of loose housing loafing barn

	Investment		Annual cost	
	Fixed	Additional per milk cow	Fixed	Additional per milk cow
Buildings				
Cold barn (loafing shed)	$ 508	$ 98.77	$ 71.42	$13.39
Warm calf and maternity barn	846	15.10	119.02	2.12
Equipment				
Paving and curbing (inside and out)	0	35.12	0	4.95
Maternity pens	0	2.28	0	.32
Individual calf stalls	0	.95	0	.13
Group pens	0	1.59	0	.22
Fences and gates	655	4.22	90.78	.64
Waterer	0	4.34	0	.68
Well	850	0	107.95	0
Pipeline and trenches	445	2.14	49.80	.24
Bulk tank cooler	1,843	30.35	260.11	3.74
Total	$5,147	$194.86	$699.08	$26.43

structed for large than for small herds. Investments per cow were estimated at $324 when housing facilities were built for 40 cows and $234 when housing facilities were built for 132 cows. Total annual costs per cow were $43.90 and $31.73 for 40 and 132 cow herds, respectively.

Milking Facilities

The three milking arrangements discussed are the three-unit pipeline milker for stanchion barns and the double-4 and double-8 herringbone milking parlors used with loose housing loafing barns.

Three-unit pipeline milker. The three-unit pipeline system for the stanchion barn was equipped with a vacuum line and a glass pipeline that carries milk directly from the milking stalls to the bulk tank cooler. Investments and annual costs are listed in table A-4. Total investment and annual cost for milking facilities were determined by the same procedure as that used for loose housing facilities.

Herringbone milking parlor.[12] Figure A-3 illustrates a double-4 herringbone milking parlor. Its main feature is the angle placement of cows. Batches of four cows are arranged in a relatively short linear space (reducing the operator's travel time during milking) by angling cows about 30 degrees. Cows are brought into the parlor in batches of four and a

[12] See Morris M. Lindsey, *The Herringbone Milking System,* Prod. Res. Rept. 45, ARS, USDA, Sept. 1960.

Table A-4. Investment and annual cost for three-unit pipeline milking system for stanchion barn housing *

Item	Fixed	Additional per milk cow
Receiving vessel panel assembly	$ 700	0
Vacuum pump	219	0
Three milking units (for pipeline)	248	0
Vacuum line	25	$ 7.59
Milk pipeline (glass)	207	12.36
Hot water heater	126	0
Space heater	250	0
Cleaning kit and wash vat	100	0
Total	$1,875	$19.95
Annual cost	$ 320.64	$ 3.41

* Cost data obtained from equipment dealers.

milking unit is placed on each cow. While the first batch of cows is being milked, a second batch is brought into the opposite side of the parlor and prepared for milking. When the first batch is finished the milking units are shifted across the operator's area and placed on the second batch of cows. The first group is then released and a new group brought in and prepared for milking. This procedure is repeated until the entire herd has been milked. A milkroom for the bulk tank and milking equipment is adjacent to the parlor.

Milk is transferred from the cow to the bulk tank by a glass pipeline. The entire milking system is cleaned in place automatically, leaving the operator free to do other chores in the immediate vicinity.

The double-8 herringbone is similar to the double-4, except the farmer handles cows in batches of eight. Total investments and annual

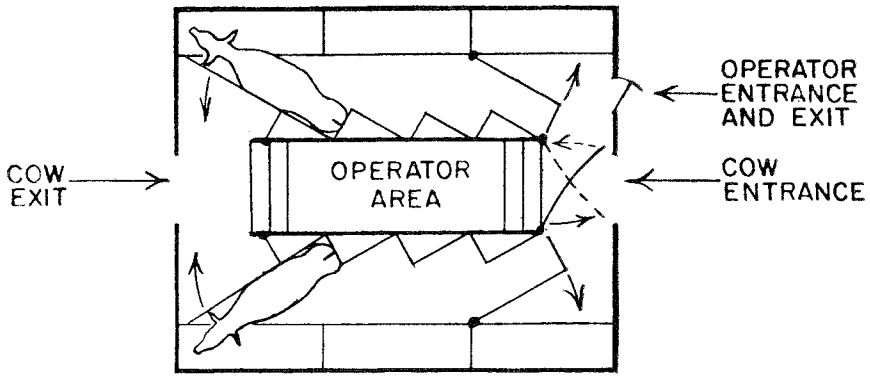

Figure A-3. Illustration of the double-4 herringbone milking parlor.

Table A-5. Investment and annual cost for double-4 and double-8 herringbone milking parlors

	Double-4	Double-8
Building*	$3,294	$ 4,696
Milking stalls†	1,157	2,224
Milking equipment†		
Receiving vessel panel assembly	700	700
Vacuum pump	325	672
Milk pipeline (glass)	186	300
Vacuum pipeline	48	95
Milking units‡	330	660
Hot water heater	127	127
Space heater	250	300
Cleaning kit	10	10
Concentrate feeding system†	737	849
Total investment	$7,164	$10,633
Annual costs§		
Building	577	823
Milking stalls	157	301
Milking equipment	338	490
Miscellaneous	120	142
Concentrate feeding system	100	115
Total annual cost	$1,292	$1,871

* Ray Hoglund, J. S. Boyd, and W. W. Snyder, "Herringbone and Other Milking Systems—Operations and Investment," Quarter Bull., Mich. Agr. Exp. Sta., Vol. 41, No. 3, Feb. 1959. Cost based on 777 and 1,105 square feet at $4.75 per square foot for the double-4 herringbone and double-8 herringbone parlors, respectively. Cost includes the milkroom but not the bulk tank.

† Cost data obtained from dealers.

‡ Based on four and eight milking units for the double-4 herringbone and double-8 herringbone, respectively.

§ See table C-1 for annual cost expressed as a percentage of initial cost.

costs of the building, stalls, and milking equipment for both sizes of herringbone systems are summarized in table A-5.

Feeding Technology

The dairy herd was fed in drylot the year round. In the dairy ration, corn silage and alfalfa hay each made up 50 percent of the roughage requirement.[13] The dairy ration is outlined in detail in appendix B.

Storage was provided for a year's corn silage requirement, and hay storage was provided for the hay requirement from the last cutting in August until the first cutting the following June. Table A-6 lists the estimated investment and annual costs of facilities required for the corn silage-baled hay ration.

[13] Thanks are due to John Donker, Department of Animal Science, University of Minnesota, who reviewed the dairy rations and offered helpful suggestions. The authors, however, accept full responsibility for the rations.

Table A-6. Investment and annual cost of facilities for the baled hay feeding ration

Facilities and equipment for silage-baled hay feeding ration	Investment		Annual cost	
	Fixed	Additional per milk cow	Fixed	Additional per milk cow
Silo	$ 964	$ 71.23	$124.87	$19.23
Silo unloader	1,557	.....	324.29	.....
Mechanical bunks	336	17.45	60.85	3.16
Baled hay storage	0	44.07	0	6.38
Corn crib for ear corn	126	33.78	17.74	4.75
Total	$2,983	$166.53	$527.75	$33.52

Labor Requirements

Total labor requirements for handling dairy cows were divided into the following chores:

1. Baled hay feeding: two feedings per day.
2. Silage feeding: with mechanical bunk feeders and silo unloaders in loose housing; with silage carts and silo unloaders in the stanchion barn.
3. Care and feeding of calves: in individual stalls and calf pens.
4. General cleaning: scraping and cleaning the paved yard and the holding area in loose housing and milking parlor setup.
5. Bedding the herd.
6. Care of fresh cows and new calves and general health of the entire herd.
7. Grain grinding.
8. Removing the manure: each spring in a loose housing loafing barn; each day in a stanchion barn.
9. Artificial breeding.
10. Cleaning bulk tank: every other day on one- and two-man farms; each day on three- and four-man farms.
11. Minor repairs, including labor for repairing fences and for other miscellaneous work.

Like investment, labor for each chore was broken down into "fixed" and "additional per milk cow" components. To compute total labor for a particular herd size the additional hours per cow multiplied by the number of milk cows in the herd were added to the fixed labor. Table A-7 lists the total fixed hours and additional hours per week per cow for chore labor (excluding milking) in the alternative housing systems.

Milking labor, summarized in table A-8, assumes that one man is milking in the double-4 and two men are milking in the double-8 system.

Table A-7. Weekly labor requirements per adult cow and replacements for chore activities (excluding milking) for two housing systems, winter and summer*

Chore	Stanchion barn				Loose housing (loafing area)			
	Winter		Summer		Winter		Summer	
	Fixed	Additional per cow	Fixed	Additional per cow	Fixed	Additional per cow	Fixed	Additional per cow
	hours				hours			
1. Baled hay feeding	1.4700	.0499	1.4700	.4978	0.8500	.0365	1.0300	.038
2. Silage feeding†	0.9237	.0852	0.9237	.0852	0.0308	.0399	0.0308	.0399
3. Calf care and feeding	0.0	.2872	0.0	.2584	1.8400	.0216	−0.96	.0645
4. General cleaning	0.0	.00	0.0	.00	0.3900	.0690	0.92	.021
5. Bedding the herd	1.0800	.0422	−0.19	.0085	2.0590	.0501	0.1481	.0027
6. Care of fresh cows and new calves (general health)	0.2600	.0105	0.2600	.0105	0.2600	.0105	0.2100	.0083
7. Grain grinding	0.0	.0414	0.0	.0414	1.1800	.0090	0.1600	.0230
8. Manure handling‡	2.2600	.0674	2.2600	.0674	0.0	.00**	0.0	.00**
9. Artificial breeding	0.0	.0114	−0.0900	.0084	0.0	.0114	−0.09	.0084
10. Cleaning bulk tank§	1.8100	.0000	1.8100	.0000	0.875	.0000	0.8750	.00
11. Minor repairs including fences and other miscellaneous work	2.6900	.0610	3.5000	.0130	1.8300	.00	1.5	.00
12. Grain feeding	0.9900	.0498	0.9900	.0498	.....	....	.....	....
Total baled hay ration	10.5600	.6207	10.0100	.5072	9.3148	.2480	3.8239	.2058
Total haylage ration#	.....	....	.....	....	7.2848	.2025	2.7939	.1678
Herd divided‡‡								
Total baled hay ration	.....	....	.....	....	10.2205	.2531	4.7296	.2109
Total haylage ration	.....	....	.....	....	8.1905	.2076	3.6996	.1729

* Unless specifically footnoted, labor requirements were obtained from the following source: Earl I. Fuller and Harald R. Jensen, "Alternative Dairy Chore Systems in Loose Housing," Univ. of Minn. Agr. Exp. Sta. Bull. 457, Feb. 1962, pp. 34-40.

† Ralph G. Kline and William F. Hall, "An Economic Analysis of Silage Storing and Feeding." Va. Agr. Exp. Sta. Bull. 511, Mar. 1960, p. 37.

‡ See Gunnor oygard. "A Review of Recent Studies of Liquid Manure Handling and the Use of Slatted Floors," "Dairy Systems in Northwestern Europe," 1960-1965, pp. 3-4, and "Farm Journals Ltd.." Autumn 1965, The National Trade Press Ltd., Fleet St.. London, pp. 27-28.

§ C. F. Bortfeld, P. L. Kelly, and V. E. Davis, Jr., "Cost of Operating Bulk Milk Tanks," Kans. State Coll. Agr. Exp. Sta. Bull. 383, Nov. 1956, p. 9.

** Add 2.31 hours per cow in labor period 2.

For systems considered with both baled hay and haylage ration the following changes in labor requirements are made:
(1) Zero fixed and variable labor for "feeding baled hay" chore using haylage ration.
(2) Zero fixed and variable labor for "grain grinding" chore for winter season using haylage ration.
All other chore labor requirements are the same for both baled hay and haylage rations.

‡‡ Changes in the labor requirement for divided herd compared to single herd are:
(1) Add 0.0308 hour per week to fixed labor and 0.0051 hour per week to variable labor for "silage feeding."
(2) Add 0.875 hour per week to fixed labor for "cleaning the bulk tank."

Table A-8. Milking labor for alternative milking systems

Milking system	Men milking	Hours per week	
		Fixed	Variable per cow
Stanchion*			
3-unit pipeline	1	11.7	.44
Herringbone†			
Double-4	1	6.43	.4512
Double-8	2	9.896	.4165

* Includes time to (1) prepare to milk, (2) milk, (3) cleanup, and (4) feed grain. Source: E. I. Fuller and L. D. Rhoades, "Management Memos—Dairy Series," Vol. I, No. IA, Dept. of Agr. Econ., Univ. of Mass., Amherst, Mass.

† M. M. Lindsey, "The Herringbone System," Prod. Res. Rpt. 45, ARS, USDA, Sept. 1960.

Labor and Management Availability

Full-time labor was available only in man-year equivalents and was fixed in amount for each synthetic farm situation. One full-time man was assumed to be the owner-operator of the farm and two-, three-, and four-man farms were assumed to have one, two, and three full-time hired men, respectively. Table A-9 summarizes the total hours of labor available on one-, two-, three-, and four-man farms.

Each hour worked by hired help reduces the operator's labor by 0.2 hour and reflects the added time requirements for supervision and management by the operator. Total cost for full-time hired labor at two salary levels also is listed in table A-9. This cost does not depend on the quantity of gross income produced but is fixed for each of the synthetic farm situations.

Initial adjustments were made in the operator's time for machinery maintenance, buying and selling, and management time required to operate the farm, excluding the management of hired labor.[14] The owner-operator can contribute a net of 2,500 hours per year for crop and livestock activities and management of hired labor.

A hired man can add 2,500 hours to the labor supply, but this requires 500 hours of additional management and supervisory time by the operator (0.2 times 2,500 = 500). Therefore, the net addition of one full-time hired man is 2,000 hours. A second full-time man would likewise add only 2,000 hours to the total labor supply, since an additional 500 hours of management and supervisory time are required by the owner-operator.

Primarily because of crop enterprises, the labor requirements were not uniform throughout the year.[15] Planting, caring for, and harvesting crops are seasonal tasks, causing increased labor requirements during the crop season. Seven labor periods were selected on the basis of major crop operations. In each period, a maximum of 300 hours per month per

[14] No unpaid family labor is assumed in the synthetic farm situations.

[15] Labor for a dairy enterprise varies slightly from winter to summer but is quite uniform throughout the year.

Table A-9. Hours of labor available and annual wages on one-, two-, three-, and four-man farm situations

	Management of full-time and seasonal hired labor	Hours available for crop and livestock activities	$3,500 annual salary	$5,900 annual salary
	hours		dollars	
One-man farm				
Operator	250	2,250	0	0
Seasonal	0	1,250	1,562.50	1,562.50
Total	250	3,500	1,562.50	1,562.50
Two-man farm				
Operator	750	1,750	0	0
1st hired man	0	2,500	3,500.00	5,900.00
Seasonal	0	1,250	1,562.50	1,562.50
Total	750	5,500	5,062.50	7,462.50
Three-man farm				
Operator	1,250	1,250	0	0
1st hired man	0	2,500	3,500.00	5,900.00
2nd hired man	0	2,500	3,500.00	5,900.00
Seasonal	0	1,250	1,562.50	1,562.50
Total	1,250	7,500	8,562.50	13,362.50
Four-man farm				
Operator	1,750	750	0	0
1st hired man	0	2,500	3,500.00	5,900.00
2nd hired man	0	2,500	3,500.00	5,900.00
3rd hired man	0	2,500	3,500.00	5,900.00
Seasonal	0	1,250	1,562.50	1,562.50
Total	1,750	9,500	12,062.50	19,262.50

full-time man was available for all activities. This allowed the 2,500 hours to be used at a faster rate during the heavy labor seasons but still restricted the labor for the entire year.

Seasonal labor. Seasonal labor could be hired during any of seven periods. Supervision and management requirements for seasonal labor were assumed to be the same as for full-time hired help, that is, 0.2 hour of the operator's time was required for each hour of seasonal labor hired.

Total seasonal and harvest labor could not exceed 1,250 hours in any year. The net addition to total labor available from employing 1,250 hours of seasonal labor was 1,000 hours, since 250 additional hours for supervision and management were required by the owner-operator.

Hired harvest labor. On most farms, some harvest operations require more than one man. In harvesting corn silage, for example, one man runs the forage harvester and two men run wagons and load the silo. In this situation the farm operator must hire labor regardless of whether or not his own labor is being fully utilized. The amount of hired harvest labor is less on two-man farms, since the second man would be available

for harvest activities. Harvest labor was considered as part of the 1,250 hours of seasonal labor and could be purchased at $1.25 per hour.

Machinery Requirements

Except for a grain combine, each farm operator owned a full complement of field machinery. Custom harvesting of oats and soybeans was assumed because acreages of these crops were relatively small. One of three different machinery group sizes could be used on a given farm. Each machinery group represented a given tractor size with corresponding sized equipment. Table A-10 lists the tractors and equipment size for each machine group. The larger sized machine groups required higher investment expenditures but had lower labor requirements.

Variable equipment costs including fuel, oil, filters, repairs, maintenance, and lubrication were charged directly to the farm enterprise for which the equipment was used.

Table A-10. Field machinery complements for dairy farms, machinery groups I, II, and III

	Machinery group		
	I	II	III
Tractors	.....	.....	5-b (new)
	.....	4-b (new)	4-b (new)
	3-b (new)	3-b (new)	3-b (new)
	2-b (new)	2-b (new)	2-b (new)
	2-b (used)*	2-b (used)*	2-b (new)
Equipment			
Plow	3-14″ bottoms	4-14″ bottoms	5-14″ bottoms
Disk	9′ 10″	12′ 2″	14′ 6″
Harrow	18′	24′	30′
Corn planter	2-row	2-row	4-row
Cultivator	2-row	2-row	4-row
Spray attachment for corn planter	2-row	2-row	4-row
Grain drill	10′	12′	14′
Mower	7′	7′	7′
Rake	7′	7′	7′
Conditioner	7′	7′	7′
Baler	PTO	PTO	PTO
Elevator	32′	44′	52′
Forage harvester	1-row	2-row	2-row
Forage blower	50′	50′	50′
Sprayer	16′	24′	32′
Wagons (two)	140 bu. cap.	(3) 140 bu.	(3) 140 bu.
Wagon boxes (with hoist)	(two)	(3)	(3)
Fertilizer distributor	8′	10′	12′
Cornpicker	2-row	mounted 2-row	mounted 2-row
Scraper blade	6′	6′	6′
Manure loader	42″ bucket	42″ bucket	42″ bucket
Manure spreader	140 bu.	140 bu.	140 bu.
Feed grinder and mixer	PTO	PTO	PTO
Pickup truck	½ T	½ T	½ T
Truck and stock rack	1½ T	1½ T	1½ T

* Cost is figured on basis of purchase price of used tractor.

Total investment and annual cost for the three equipment groups were:

	Machinery group		
	I	II	III
Investment	$35,550	$43,400	$51,900
Annual cost*	$ 4,220	$ 5,030	$ 5,961

* Annual cost includes straight line depreciation, interest on the average machine value, taxes calculated on the average machine value, insurance, and housing.

Budgets for Crop Enterprises

Cropping alternatives for the synthetic farm situations included corn silage, corn grain, oats, alfalfa, and soybeans.[16] Field operations for crop alternatives are listed in table A-11.

Table A-12 contains crop budgets for alternative crop enterprises and labor requirements for the three machinery groups. Gross income was calculated only for crops that could be sold from the farm, but yields are listed for all crops. Seeding, fertilizer, and chemical rates are recommended rates for southeastern Minnesota.[17]

Table A-11. Field operations for production of specified crops, by labor period

	Labor period				
	Apr.-May	June-July	Aug.	Sept.	Oct.-Nov. 15
Corn silage	Disk, harrow, plant	Two cultivations	.....	Harvest	Disk, plow
Corn for grain	Disk, harrow, plant	Two cultivations	.....	.....	Harvest, disk, plow
Alfalfa	Fertilize, spray	First and second cuttings, bale	Third cutting, bale	.....	.....
Oats	Disk. harrow, plant, fertilize	Swath, combine, haul, store	Bale straw	.....	Disk, plow
Soybeans	Disk, two-thirds plant	One-third plant, rotary hoe	.....	.....	Combine
Haylage	Fertilize, spray	First and second cuttings, haul, store in silo	Third cutting, haul, store in silo	.....	.....

[16] All land on synthetic farms could be used for any of the crop alternatives with limited rotation restrictions. However, on the more hilly land in the counties adjacent to Wisconsin in southeastern Minnesota, erosion is a problem and crop rotations are required. Rotation restrictions for this type of land were considered in this study. Also, few soybeans are raised in this area. See P. R. McMiller, *Soils of Minnesota*, Univ. of Minn. Agr. Ext. Bull. 278, Dec. 1954.

[17] Curtis J. Overdahl, Harley J. Otto, Merle Halverson, and Lowell D. Hanson, *Crop Production Guide for Minnesota*, Univ. of Minn. Agr. Ext. Pamp. 194, Jan. 1963.

Table A-12. Estimated gross income, yield, variable costs, and labor requirements per acre for cropping alternatives in dairy farm situations

	Units	Corn for silage			Corn for grain		
		Amount	Price	Value	Amount	Price	Value
1. Gross income							
Yield	Bu.	....	....	....	90	1.01	90.90
	Tons	16	....	....	....	....	....
2. Variable costs							
Working capital							
Seed	Lb.	12	0.23	2.77	12	0.23	2.77
Fertilizer	Tons	0.1[a]	74.50	7.45	0.1[a]	74.50	7.45
Chemicals	Lb.	1[b]	2.58	2.58	1[b]	2.58	2.58
Lime	Tons	....	....	....	....	....	....
Insurance[c]	Acres	....	....	2.20	....	....	2.20
Fuel, oil, lubricants, and repairs[d]	do.	....	....	6.99	....	....	5.02
Custom harvest	do.	....	....	....	....	....	....
Working capital charge[e]	Dollars	....	....	0.62	....	....	0.56
Total variable cost per acre	do.			$22.61			$20.58
		Machinery group			Machinery group		
		I	II	III	I	II	III
3. Labor and tractor requirements							
Total labor	Hours	9.306	7.384	6.548	4.302	3.636	2.700
Apr.-May	do.	1.088	0.931	0.645	1.088	0.931	0.645
June-July	do.	0.828	0.828	0.416	0.828	0.828	0.416
Aug.	do.	....	....	....	....	....	....
Sept.	do.	6.359	4.848	4.848	....	....	....
Oct.-Nov. 15	do.	1.031	0.777	0.639	2.386	1.877	1.739
Tractor hours	do.	6.203	5.202	4.405	4.152	3.586	2.293

Footnotes to table appear on page 48.

Table A-12 (continued). Estimated gross income, yield, variable costs, and labor requirements per acre for cropping alternatives in dairy farm situations

	Units	Haylage			Alfalfa		
		Amount	Price	Value	Amount	Price	Value
1. Gross income							
Yield	Tons	7.65	....	....	3.65	....	....
2. Variable costs							
Working capital							
Seed	Lb.	(10)1/3	0.63	2.10	(10)1/3	0.63	2.10
Fertilizer	Tons	0.15[f]	61.50	9.23	0.15[f]	61.50	9.23
Chemicals	Lb.	0.75[g]	0.38	0.29	0.75[g]	0.38	0.29
Lime	Tons	0.9[i]	1.70	1.53	0.9	1.70	1.53
Insurance[c]	Acres	....	....	....	....	....	....
Fuel, oil, lubricants, and repairs[d]	do.	....	....	6.55	....	....	5.31
Custom harvest	do.	....	....	....	....	....	....
Working capital charge[e]	Dollars	....	....	0.66	....	....	0.66
Total variable cost per acre	do.			$20.36			$19.12
		Machinery group			Machinery group		
		I	II	III	I	II	III
3. Labor and tractor requirements							
Total labor	Hours	5.791	5.661	5.602	7.249	7.119	7.060
Apr.-May	do.	0.480	0.350	0.291	0.480	0.350	0.291
June-July	do.	3.540	3.540	3.540	4.512	4.512	4.512
Aug.	do.	1.771	1.771	1.771	2.257	2.257	2.257
Sept.	do.	....	....	....	....	....	....
Oct.-Nov. 15	do.	....	....	....	....	....	....
Tractor hours	do.	5.270	5.095	5.042	3.960	3.454	3.454

Footnotes to table appear on page 48.

Table A-12 (continued). Estimated gross income, yield, variable costs, and labor requirements per acre for cropping alternatives in dairy farm situations

	Units	Soybeans			Oats		
		Amount	Price	Value	Amount	Price	Value
1. Gross income							
Yield	Bu.	34	2.19	74.46	69.1	....	....
2. Variable costs							
Working capital							
Seed	Lb.	95	.056	5.32	72	.04	2.88
Fertilizer	Ton	0.05[a]	74.50	3.73	1.25[h]	72.00	9.00
Chemicals	Lb.	3[i]	....	5.00	0.5[j]	0.30	0.15
Lime	Ton	....	....	....	....	....	....
Insurance[c]	Acre	....	....	1.43	....	....	0.80
Fuel, oil, lubricants, and repairs[d]	do.	....	....	2.37	....	....	3.70[k]
Custom harvest	do.	....	....	5.00	....	....	6.50
Working capital charge[e]	Dollars	....	....	0.64	....	....	0.65
Total variable cost per acre	do.			$23.49			$23.68

		Machinery group			Machinery group		
		I	II	III	I	II	III
3. Labor and tractor requirements							
Total labor	Hours	2.374	2.020	1.676	3.044	2.735	2.531
Apr.-May	do.	0.770	0.726	0.516	0.837	0.682	0.578
June-July	do.	0.582	0.520	0.509	0.192	0.192	0.192
Aug.	do.	....	....	....	0.984	0.984	0.984
Sept.	do.	....	....	....	....	....	....
Oct.-Nov. 15	do.	1.022	.774	0.651	1.031	0.877	0.777
Tractor hours	do.	2.321	1.896	1.438	3.033	2.567	2.427

Footnotes to table appear on page 48.

Footnotes to Table A-12

[a] Fertilizer analysis is 5-20-20 applied at planting. This fertilizer requirement assumes that corn follows alfalfa or that 9.3 tons of manure are applied per acre on cornland. When corn is neither planted on alfalfa land nor manured, an additional 70 pounds of available nitrogen are added at a cost of $8.80 per acre (a working capital charge is included).

[b] Chemical is atrazine for weed control applied at planting.

[c] Insurance is included in variable cost for crops insurable by the Federal Crop Insurance Corporation.

[d] Fuel, oil, lubrication, and repairs for machinery vary between machine groups. The cost for machinery group I is listed in the budget. Costs for machinery groups II and III are:

	Machinery group II	Machinery group III
Corn silage	$6.33	$6.15
Corn grain	4.74	4.08
Oats	3.55	3.55
Alfalfa	5.08	5.08
Soybeans	2.34	2.32

[e] A 6-percent charge is made for out-of-pocket costs tied up for more than 1 month. The formula is:

$W = 0.06\ tu$

Where: W = working capital charge
t = percent of year capital tied up
u = amount of out-of-pocket cost

[f] Fertilizer analysis is 0-12-36.

[g] In addition to 35.5 bushels of oats, 0.625 ton of straw is obtained per acre of oats.

[h] Fertilizer analysis is 4-12-36.

[i] Chemical is amiben for weed control applied at planting.

[j] Chemical is 2,4-D amine for weed control applied with a sprayer.

[k] Includes machine cost for preparing, baling, and handling straw.

[l] Three tons of lime are applied the fall before alfalfa is planted.

Budgets for Livestock Enterprises

Dairy and hogs were included as alternative livestock enterprises for the synthetic farm situations. The alternatives of purchasing rather than raising corn grain and bedding were available for both livestock enterprises. When the bedding requirement exceeded the quantity of oat straw available, corn stalks could be chopped or straw bedding could be purchased off the farm.

Table A-13. Estimated gross income and production requirements per adult cow for dairy enterprise[a]

Item	Fixed	Amount	Price	Additional per cow and replacements
1. Gross income				
Milk receipts (cwt.)	....	120	$3.20	$384.00
Sale of calves[b]	....	...	....	22.88
Sale of cull cows[c]	....	...	....	39.48
Total	....	...	....	$446.36
2. Variable costs				
Breeding fees[d]	0	...	....	5.00
Veterinary and medicine[e]	0	...	....	10.71
Dairy Herd Improvement Association[f]	38.76	...	....	2.64
Interest on cattle[g]	0	...	....	18.53
Taxes on cattle[g]	0	...	....	5.06
Hauling and marketing[h]	0	...	....	19.14
Minerals and salt[i]	0	...	....	2.72
Subtotal	38.76			$ 63.80
3. Housing facilities[j]	——			——
4. Milking facilities[j]	——			——
5. Feeding facilities[j]	——			——
6. Machine group[k]	——			——
Total	——			——

[a] Budget only includes items that are the same for all synthetic farms. Annual cost per cow for housing, milking and feeding facilities, and labor requirements depends on the type of synthetic farm situation.

[b] Assumes 0.45 2-week old bull calf at $17.50; 0.12 heifer 1 month old at $35.00; and 0.02 heifer 12 months old at $135 are sold for each adult cow in the herd.

[c] Assumes a 5-percent death loss for calves and a 25-percent replacement rate for adult cows. Each cull cow was valued at $168.

[d] Basic rate for southeastern Minnesota. Source: Edmund Graham, Dept. of Animal Science, Univ. of Minn.

[e] Source: C. D. Kearl, "Farm Cost Accounts," A. E. Res. 100, Cornell Univ., N.Y., Nov. 1962, page 10.

[f] Assumes 5 percent interest on value of one adult cow and her replacements ($370.50).

[g] Assumes a 2.45 mill rate on assessed value where true and full value equals 30 percent of market value and assessed value equals 20 percent of true and full value. Source: Edmond W. Gahr, Minn. Dept. of Taxation, St. Paul, Minn.

[h] Estimates from information obtained from Twin City Milk Producers Association, St. Paul, Minn.

[i] Assumes 34 pounds of trace mineralized salt at $0.05 for each adult cow in the herd. Source: John Donker, Dept. of Animal Science, Univ. of Minn.

[j] Cost is not the same for all synthetic farms since costs of housing, milking, and feeding facilities vary on hypothetical farms. This cost is added in the budget when considering a specific farm situation.

[k] Machinery complement is fixed on each dairy farm and, therefore, all annual cost is fixed and does not vary with the number of cows on the farm.

Table A-14. Estimated gross income and production requirements for the hog enterprise (farrowing two litters and feeding out to market weight)

	Unit	Amount	Price	Value
1. Gross income				
Pork produced*	cwt.	38.26	$15.10	$577.72
2. Variable costs				
Power, equipment	....	....	....	24.00
Annual building cost	....	....	....	24.20
Interest on building and breeding	dollars	605	.05	30.25
Interest on two sows ($120.80 per sow)	dollars	241.60	.05	6.04
Depreciation	....	....	....	40.33
Miscellaneous	....	....	....	18.00
3. Feed requirements				
Protein supplement	cwt.	23.78	4.50	107.00
Corn grain equivalent	cwt.	116	....	.....
Total	....	....	....	$249.82
4. Total animal labor requirements by labor periods				
Jan.-Mar.	hours	7.48		
Apr.-May	hours	4.03		
June-July	hours	3.99		
Aug.	hours	3.56		
Sept.	hours	1.90		
Oct.-Nov. 15	hours	2.85		
Nov. 16-Dec.	hours	2.85		
Total	....	26.66		

* Including sale of cull sows and adjusted for seasonal price variations from the annual averages of this specific two litter marketing.

Dairy

Dairy budgets varied among different farm situations according to differences in (1) the annual costs of housing facilities, feeding facilities, milking facilities, and crop machinery and (2) the labor requirements. Items in the budget that were common to all synthetic farm situations are items 1 and 2 in table A-13. Total cost per cow for a particular synthetic farm equals the sum of the costs of the housing facilities, milking facilities, feeding facilities, and crop machinery (items 3, 4, 5, and 6 in table A-13) and items 1 and 2 in table A-13. Costs for given dairy technologies are obtained from tables A-2 to A-6.

Hogs

The budget for hogs was based on a central farrowing, confinement finishing system.[18] Two litters were farrowed per year, one each during

[18] See Don C. Taylor, *Income Improving Adjustments and Normative Supply Responses for Hogs and Beef in Southwestern Minnesota*, Unpub. Ph.D. thesis, Dept. of Agr. Econ., Univ. of Minn., Aug. 1965, p. 24.

the first and third quarters. Hog activity involved two complete production cycles, including feeding the litter to market weight, disposing of the cull sow, and caring for the replacement gilt. Out of an eight-pig litter, one was retained for replacement and seven marketed at 6 months or 225 pounds. Three months after farrowing the 400-pound sow was sold. Table A-14 shows the budget for the hog activity.

Appendix B—The Dairy Ration

This ration meets the minimum nutrient standards for a 1,200-pound milk cow producing 12,000 pounds of milk annually and for the replacement stock.[19]

The feed requirement for the entire herd is produced on the farm with the alternative of purchasing part of the concentrate in the ration. Milk replacer and calf concentrate for young stock are purchased. Minerals and salt are provided in the diet by adding dicalcium phosphate and trace mineralized salt to the ration. Both are added to the ration in the amount equal to 1 percent of the total concentrate. Annual cost for minerals and salts for an adult cow and replacement is $2.72, assuming the prices of trace mineralized salt and dicalcium phosphate at $0.03 and $0.05 per pound, respectively. No provision is made for vitamin A. In some years, vitamin A may be required.

Total cost of feed inputs is reflected through the costs of producing feedstuffs on the farm plus the direct cost for milk replacer, calf concentrates, salt, and minerals. Feed production is drawn from the resources available on the farm.

Preliminary budgeting was used to determine the minimum cost combinations of feeds to use in meeting the digestible protein and total digestible nutrient requirements.

The feeding program includes baled hay fed outside in bunks adjacent to the hay storage area or from the hay mow in the case of stanchion barn housing. Corn silage is fed from an upright silo by a mechanical bunk and silo unloader.

The ration for older animals is based on corn silage and alfalfa hay, each contributing 50 percent of the total dry matter from roughage. Kinds and amounts of feed that meet the minimum nutrient requirements for each age animal are listed in table B-1. This ration is fed the entire year. The total annual feed requirement for an adult cow and her replacement is listed in table B-2.

[19] Minimum nutrient requirements for adult cows and replacements are taken from Frank B. Morrison, *Feeds and Feeding*, 22 ed., The Morrison Publishing Co., Ithaca, N.Y., 1957.

Table B-1. Average pounds of feed per day for animals of various ages

Age group	Milk replacer	Calf starter	Concentrate	Hay	Silage
Adult cow*	...	...	7	15	45
Adult cow†	...	...	3	13	39
Calf 0-2 months	2.49	1.4	...	1.9	..
Heifer 2-6 months	...	3.27	...	5	..
Heifer 6-12 months	...	...	2.3	5.78	15
Heifer 12-24 months	...	...	4	7	21
Heifer 24-28 months	...	...	4	8	24

* Producing 12,000 pounds of milk.
† Dry cow with allowance for pregnancy.

Table B-2. Total annual feed requirement per adult cow in herd in pounds

	Cow and replacement	Loss and waste*	Total*
Milk replacer	72	....	72
Calf starter	172	....	172
Concentrate (corn grain)	2,989	....	2,989
Hay (alfalfa)	6,851	411	7,262
Silage (corn)	19,644	2,750	22,394

* Add 14 percent to silage total and 6 percent to hay total for loss and waste.

Appendix C—Annual Cost as Percentage of Initial Investment

Table C-1. Annual cost as percentage of initial investment for selected dairy facilities

	Repairs and maintenance	Interest*	Depreciation†	Taxes‡	Insurance§	Total
Fencing and gates	2.50	2.50	6.67	2.00	1.36	15.03
Building	1.50	2.50	6.67	2.00	1.36	14.03
Mechanical bunks	3.00	2.75	9.00	2.00	1.36	18.11
Milking equipment	5.00	2.75	6.00	2.00	1.36	17.11
Pipe stalls	0.50	2.50	6.67	2.00	1.36	13.03
Stalls and equipment	1.00	2.50	6.67	2.00	1.36	13.53
Silos	1.20	2.50	6.67	1.82	0.74	12.93
Silo unloaders	5.00	2.50	9.00	2.00	1.36	19.86
Building (milking parlor)	5.00	2.50	6.67	2.00	1.36	17.53
Waterers	3.00	2.50	6.67	2.00	1.36	15.53
Well	1.50	2.50	6.67	2.00	...	12.67

* Calculated on average value of assets.
† 6.67 assumes 15-year depreciation with no salvage value.
6.00 assumes 15-year depreciation with 10 percent salvage value.
9.00 assumes 10-year depreciation with no salvage value.
‡ Estimated from information from the Minn. Dept. of Taxation.
§ Rate based on information from Fire Underwriters, St. Paul, Minn.

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