FARM SIZE ECONOMIES IN NORTHWEST CENTRAL NORTH DAKOTA

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A reduction in farm numbers and an accompanying increase in average farm size have been occurring since the 1930's. These changes have occurred largely because farm mechanization has increased the size of farm which is most efficient to operate. The relationship between farm size and production costs for a small grain producing area in North Dakota is examined in this study.

Data and Procedures

Cost and return data were obtained for 81 cash grain farms for 1978 and 1979 in a 13-county area in northwest central North Dakota (Figure 1). The data were taken from the farm records of the Minot Production Credit Association members who used the Agrifax record keeping system. Farms producing similar products in a limited geographic area were selected to minimize variability. To be classified as cash grain farms, 65 percent of gross income must have come from crop sales and crop inventory changes. In addition, the following maximums were set on gross income permitted from noncrop sources: livestock — 25 percent, custom work — 15 percent, and other sources — 25 percent. Average costs and returns from two years, 1978 and 1979, were used to reduce variability attributed to factors unique to one year.

The Agrifax farm records provided income, expenses, inventories, and depreciation schedules for the farms. Landlords' income and expenses had to be estimated based on the rental agreement.

The Agrifax records were adjusted to make the information more comparable among farms. Machinery values were updated to account for inflation since date of purchase. Inventory and depreciation were placed in dollars of 1978-79 purchasing power. Depreciation was made uniform using the straight line method, including an estimated salvage value (ASAE, 1978). Years of use were those specified on the depreciation schedules.

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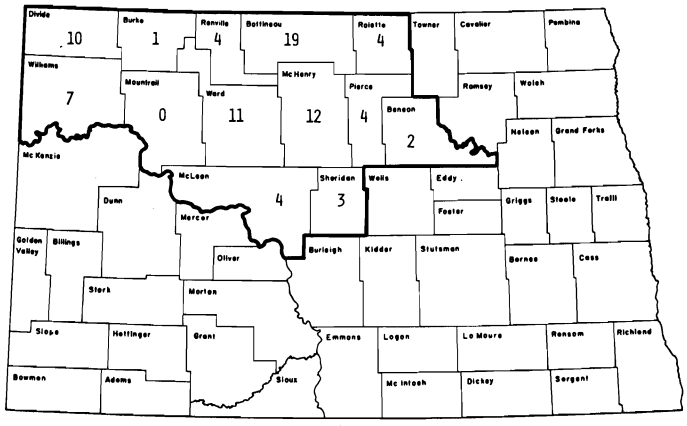

Figure 1. Study Area With Number of Farm Records Reported for Each County

Capital invested in nonreal estate assets were charged a uniform interest cost whether owned or financed. This procedure put all sizes of farms on the same basis regardless of debt situation. Since asset value increases due to inflation were not included in income, a noninflation real interest rate of 4 percent was charged against asset values rather than a nominal interest rate.

Land was either owned, rented for cash, or rented for a share of the crop. A cost was imputed for owned land to place all farms on the same basis. The county average cash rent paid in 1978-79 was charged for owned land. A cash rent equivalent was calculated for share rented land based on the rental agreement.

Unpaid family labor was valued at $709 per month — the average hired farm labor wage in 1978-79 (USDA).

Unless the operator had an off-farm job, it was assumed the farmer would spend 12 months of labor and management on the farm. A previous study indicated that as farm size increases, more time is spent on management activities and less time is spent driving tractors and on other physical work (Johnson and Hvinden). The results of the prior study were used to estimate the hours of labor contributed by the farm operator. Labor time was charged at hired farm labor rates. The management charge, based on common management fees of professional farm managers, was set at 7 percent of gross income (Batte).

Land and Labor and Use by Farm Size

The farms ranged in size from 600 to 6,000 tillable acres. Farms were divided into four size groups based on tillable acres. The total owned, rented, tillable, and summer fallowed acres operated per farm by farm size groups are shown in Table 1. The average number of workers including the operator is also shown in Table 1.

Table 1. Average Number of Acres Operated and Percentages Owned, Tillable, Tillable Land Summer-Fallowed and Number of Workers by Four Farm Size Groups, Northwest Central North Dakota, 1978-79

	Farm Size Groups in Tillable Acres			
Item	600-1,050	1,051-1,500	1,501-1,965	1,966-6,000
Number of Farms	16	26	21	18
Acres Operated	1,047	1,448	2,026	3,269
Percent Owned	52	42	45	34
Acres Tillable	851	1,245	1,717	2,981
Percent Tillable	81	83	85	91
Summer Fallow (%)	18	23	20	20
Labor — # of Workers	1.2	1.4	1.5	2.3

Larger farm operators tended to own less of their land, and a greater share of the land was tillable than for the smaller farm operators. No relationship to farm size was noted in the portion of tillable land summer fallowed. Except for the largest size group, nearly all labor is provided by the operator and his family.

Average size farm with sales of $2,500 or more in the 13-county area in 1978 was 1,047 acres of which 790 was cropland (U.S. Department of Commerce). The smallest size group in the study is almost identical in size to the census average in the area.

Operator's Returns

A summary of income, expenses, and farm operator's returns by farm size group is shown in Table 2. The data are for the farm operator only and do not include the landlord's income or expenses.

Table 2. Average Operator's Income, Expenses, and Returns by Farm Size Group, Northwest Central North Dakota, 1978-79

	Farm Size Groups in Tillable Acres			
Item	600-1,050	1,051-1,500	1,501-1,965	1,966-6,000
Gross Income	$48,192	$74,284	$128,123	$210,030
Expenses	40,253	61,916	99,971	179,997
Net Income	$ 7,939	$12,368	$ 28,152	$ 30,033
Labor and Management Earnings or (Losses)	($ 50)	$ 2,488	$ 16,698	$ 16,645
Rate of Return to Capital	.34%	1.61%	4.18%	3.51%

Net income represents what the farm operator earned on his equity in land and other assets, his management, plus his labor and that of unpaid family members. It does not include appreciation in land and other asset values. Labor and management earnings are the residual after deducting unpaid family labor and a charge for the use of owned land and other equity capital. Labor and management earnings increased from a small negative amount for the smallest farms to over $16,000 for the two largest size groups. Rate of return to capital was calculated by subtracting a charge for all unpaid labor and management from net income, adding interest paid, and dividing the result by the average capital invested. The average rate of return was very low for the smallest farms but increased to 4.18 percent for the next to largest size group. This was the earned rate of return, because appreciation in land and machinery values was excluded. The average rate of return for all groups was 3 percent, which compares to the earned rate of 4.4 percent reported for all farms in the United States for 1978 and 1979 (Melichar and Balides).

Whether operator's labor and management earnings or rate of return to capital are used as the criteria, the results suggest that operators of smaller farms on average were not earning as high a return as the operators of larger farms. In addition, the data indicated that the largest farms did not earn any better returns than the 1,501-1,965 acre size group.

Costs and Returns Per Tillable Acre

Sources of farm size economies can be identified by examining differences in costs and returns per tillable acre among farm size groups. For this purpose, costs have been categorized into eight groups. Gross income and cost per tillable acre for each cost category for the four farm size groups are presented in Table 3. All figures are for the whole farm including the landlord's share of income and expenses.

Table 3. Average Gross Income, Component Costs, and Profit or Loss Per Tillable Acre by Farm Size Groups, Northwest Central North Dakota, 1978-79

	Farm Size Groups in Tillable Acres			
Item	600-1,050	1,051-1,500	1,501-1,965	1,966-6,000
Income/Tillable Acre				
Crops	$56.94	$63.50	$71.93	$77.52
Livestock	5.85	3.04	7.79	0.46
Other[a]	1.24	2.30	2.55	4.53
Total Income	$63.77	$68.84	$82.27	$82.51
Costs/Tillable Acre				
Land	$24.53	$22.97	$25.30	$29.22
Labor	12.65	9.81	7.08	6.15
Management	4.52	4.89	5.83	5.84
Capital	4.16	4.33	5.38	4.81
Machinery[b]	16.83	17.97	17.11	15.26
Seed, Fertilizer, & Spray	8.07	9.72	8.45	12.99
Livestock	0.66	0.35	1.21	0.14
Other[c]	9.41	8.94	12.08	10.10
Total Costs	$80.83	$78.98	$82.44	$84.51
Profit or (Loss)	($17.06)	($10.14)	($ 0.17)	($ 2.00)

[a]Includes grain storage payments, patronage dividends, machinery sold, and miscellaneous items.
[b]Depreciation, repairs, fuel and oil, plus net custom hire.
[c]Includes insurance, utilities, supplies, building depreciation, and miscellaneous expenses.

Gross income per tillable acre increased with size of farm but was nearly the same for the two largest farm size groups. Crop income did not include the value of feed produced and fed to livestock, so part of the livestock income represented the value of crop production marketed through livestock. Differences in the value of crop production were not due to intensity of land use since the percentage of land in summer fallow was

similar among farm size groups. The higher crop value produced by the larger farms was due to a combination of higher yields, higher valued crops produced, and better prices received. Information was not available to determine the relative importance of each factor. The higher gross income per tillable acre tends to indicate superior management on the larger farms.

Land costs were similar among the three smallest size groups. The higher land cost for the largest size group may indicate better quality land but also could be a reflection that the largest farm operators tend to be the most competitive in the land rental market.

The major cost advantage of larger farms was in labor costs. Labor costs include hired, operator, and family labor. There are two reasons for the lower labor costs on larger farms. First, the larger farms are using machinery and equipment with greater capacity, so less labor per acre was used. Second, nearly all operators spent 12 months on the farm. Especially on smaller farms, the operator is somewhat underemployed during the winter months. The amount of off-season operator labor tended to be nearly constant among size groups, so off-season labor was much less per acre for the larger farms.

Management costs were based on gross income and, therefore, varied directly with gross income per acre.

Capital costs were only slightly higher for the two largest size categories. The greater investment in livestock for the 1,501-1,965 acre group and more crops in storage for the largest size group accounted for the higher per acre capital cost for the two largest size groups.

Machinery costs included depreciation, repair, fuel, and net custom hire. Although per acre depreciation tended to decline slightly with farm size, other components of machinery costs showed no relationship to size of farm.

Seed, fertilizer, and spray costs included any of these costs paid by the landlord. The higher crop costs for the largest farms were due to greater expenditure for all three crop input items. The higher crop expenditure by the larger farms was expected since crop income per acre also was higher for these farms.

Livestock and other costs per acre were not strongly related to farm size. Other costs were composed of supplies, insurance, utilities, and building depreciation.

Since both paid and imputed costs have been included, the bottom line loss represents the amount by which contributed resources of land, labor, management, and capital did not earn their assumed values. This loss does not represent an actual cash reversal nor necessarily a reduction in net worth.

Cost-Size Relationships

The relationship between total cost per tillable acre and farm size is shown graphically in Figure 2. Regression analysis was used to develop the farm size-average cost relationship presented.[1] Per acre costs were influenced by both the number of tillable acres as well as the gross income per tillable acre. Multiple regression analysis was used to isolate the effects of tillable acres on per acre costs. Gross income per tillable acre was held constant at its mean of $78.25.

Figure 2. Relationship of Total Cost Per Acre to Tillable Acres Farmed, Northwest Central North Dakota, 1978-79

Total cost per tillable acre for each of the 81 farms studied was adjusted for gross income per acre based on the results of the multiple regression analysis.[2] The adjusted total cost per tillable acre for each farm has been plotted on Figure 2.

Three conclusions emerge from the information shown. First, total cost per acre tended to decline with size of farm, but the decline was at a decreasing rate and appeared to be insignificant beyond approximately 2,400 tillable acres. Second, there was a great deal of divergence around the average relationship indicating that many moderate size farms have average costs as low or lower than many larger farms. Third, the number of very large farms studied was too few to be able to make conclusions concerning economies or diseconomies of size beyond approximately 3,300 acres.

Conclusions

Both the analysis of net returns to farm resources and costs and returns per tillable acre lead to the conclusion that there are size economies for small grain operations in the study area. The cost advantages are greatest when moving from one farm size level to another within the smaller size range. However, size economies continue considerably beyond the average size farm in the study area.

Greater economic efficiency associated with larger farms occurs primarily from better utilization of the labor of the farm operator and higher crop income per acre. The large differences in costs and returns not accounted for by size of farm indicate considerable effi-

[1]The regression equation is:
$TC/TA = 10.36 + 11{,}897.7(1/TA) + .8338(GI/TA)$
where TC = total cost, TA = tillable acres, and GI = gross income. $R^2 = .6564$. Regression coefficients differ significantly from zero at the .05 probability level.

[2]Adjusted cost/acre = actual cost/acre + .8338 (gross income — $78.25).

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These values are minimums. In many instances, it will be prudent to multiply these minimum values by 1.20 or add .05 percent available phosphorus, whichever is greater. Used constructively, these calculated available phosphorus "requirements" may be combined with the available phosphorus informtaion for individual feedstuffs to save dollars for North Dakota swine producers. The constructive combination of this information will aid in the economical producion of animals having desirable rates and efficiencies of gain as well as strong bones.

Using These Values in Turkey Rations

Turkey producers frequently operate on a margin of a few cents per bird, so an optimum combination of minimum cost and bird performance must be achieved. Turkey producers are correctly hesitant to feed suboptimum levels of phosphorus because they are aware that a lame bird will be reluctant to move to the feeder and therefore will gain weight more slowly and less efficiently than a structurally sound bird. (A lame bird is also more susceptible to cannibalism.)

The following calculated values for estimated available phosphorus requirements of turkeys must be recognized as estimates. Turkey rations are frequently based upon a more complex misture of ingredients than will be found in many swine rations. Therefore, a modest margin of safety has been incorporated into the following estimates.

Age of Bird	Estimated Available Phosphorus Requirement %
0-4 weeks	.40
4-8	.37
8-12	.34
12-16	.32
16-20	.30
20 +	.28

The value of these estimates to turkey producers will be influenced by the ingredients that they may utilize. Large amounts of wheat screenings are commonly used in turkey rations. It could well be that the information concerning phosphorus availability from screenings will be the single item of greatest value to turkey producers.

SUMMARY

The results of a series of experiments concerned with the available phosphorus content of a variety of feedstuffs have been centered upon their use in swine and turkey rations. (The availability of plant phosphorus to ruminants cannot be estimated from the data presente din this report.) These values may be of considerable value to North Dakota swine and poultry producers evne at low rates of implementation.

Feedstuff	Percent Phosphorus	Availability	Percent Available Phosphorus
Barley			
Sample 1	.29	.43	.12
Sample 2 (ground)	.38	.28	.11
(pelleted)	.38	.25	.10
Oats (ground)	.31	.47	.15
(pelleted)	.31	.23	.07
Corn (ground)	.30	.22	.07
(pelleted)	.30	.04	.01
Soybean meal	.63	.11	.07
(pelleted)	.63	.10	.06
Wheat, HRSW	.43	.06	.03
Field-sprouted HRSW	.41	.16	.07
HRSW screenings	.37	.19	.07
Dicalcium phosphate	18.99	.57	10.82
Meat and bone meal	11.06	.69	7.63
Sunflower meal (42% CP)	.96	.22	.21
(28% CP)	.89	.23	.21

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ciencies possible through better management on farms of all sizes.

The upward pressure on farm size is likely to continue as the better managers seek to improve their income positions through lower unit costs and larger gross incomes associated with increasing size. The greatest improvement in farm income, as well as in overall production efficiency, would occur from public policies designed to help smaller size farms enlarge rather than from further growth of large farms.

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