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Measuring X-Efficiency and Scale Efficiency for a Sample of Agricultural Cooperatives

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This paper examines the efficiency of a sample of Great Plains grain marketing and farm supply cooperatives during 1988 to 1992. In general, larger cooperatives were more X-efficient and scale efficient. Labor tended to be under-utilized and capital over-utilized. Petroleum product sales and fertilizer sales were negatively related to overall efficiency. Sales of goods other than grain, fertilizer, agricultural chemicals, petroleum products, and feed was positively related to overall efficiency. Overall efficiency was significantly correlated with the rate of return to assets.

Increased competition and consolidation have intensified the interest in the structure of the grain marketing and farm supply cooperative industry. Grain marketing and farm supply cooperatives have consolidated dramatically over the last decade. Farmer Cooperative Statistics (Kraenzle et al. 1999) indicate nominal net cooperative business volume increased from $72.1 billion in 1989 to $104.7 billion in 1998, but the total number of marketing and farm supply cooperatives declined from 4,353 in 1987 to 3,210 in 1998; a net decline of 26%. The long term decline in the number of cooperatives reflects, in part, the decreasing number of farmers in the U.S.

Achieving X-efficiency and scale efficiency is critical to the future of individual cooperatives. Leibenstein argues that X-inefficiency arises from the fact that "neither individuals nor firms work as hard, nor do they search for information as effectively, as they could (p. 407)." More specifically, Berger (1993) defines X-efficiency as the ratio of the minimum costs that could have been expended to produce a given output bundle to the actual costs expended. Scale efficiency measures whether a firm is operating at the optimal size.

The structure of the cooperative industry has been studied by others. Akridge and Hertel (1992) compared the efficiency of midwestern cooperative and investor-oriented grain and farm supply firms and concluded that investor-oriented firms were more efficient in their use of plant and equipment. Thraen, Hahn, and Roof (1987) examined processing costs, labor efficiency, and economies of size in fluid milk cooperatives and found that processing costs decline with increases in plant volume. Schroeder (1992) found the existence of economies of scale and product specific economies of scale among farm supply and marketing cooperatives and indicated that this may lead to fewer cooperatives in the industry. Each of the above studies used econometric methods to estimate an average rather than a frontier cost function. Furthermore, these studies did not consider X-efficiency.

The first objective of this study is to examine efficiency differences among a sample of Great Plains grain marketing and farm supply cooperatives. The second objective is to examine the relationship between efficiency indices and financial variables, managerial expertise, and other key economic variables. The future structure of the cooperative sector will ultimately depend on the relative efficiency of individual cooperatives. Providing insight into the overall efficiency of the industry and examining factors associated with superior performance can provide cooperative boards of directors and managers the necessary information to more effectively compete.

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Conceptual Framework

Based on the results of Featherstone and Rahman, the objective of the individual cooperatives was assumed to be cost minimization. Cooperatives that do not minimize costs per unit of output produced will have problems competing with noncooperative producers. X-inefficiency and scale inefficiency measures were used to compare costs among cooperatives. X-inefficiency can result from a failure to produce on the production frontier and/or failure to use the optimal mix of inputs. Scale inefficiency arises when firms are not producing at the optimal size of plant. X-efficiency and scale efficiency can be measured using a series of linear programs (Fare et al. 1985).

Before presenting the linear programs needed to measure X-efficiency and scale efficiency, it is necessary to introduce some notation. Input prices faced by cooperatives can be represented as $w = (w_1, w_2, \ldots, w_n) \in R^+$. Similarly, output prices faced by cooperatives can be represented as $p = (p_1, p_2, \ldots, p_m) \in R^+$. The transformation set formed by the $n*k$ input matrix (X) and $m*k$ output matrix (Y) can be written as follows:

(1) $S^t = [(x, y): y \leq Yz, Xz \leq x, z \in R^+]$.

Note that the transformation set corresponds to a total product curve under constant returns to scale, and it shows the minimum feasible inputs for given levels of outputs.

Overall efficiency (the product of X-efficiency and scale efficiency) represents the minimum cost of producing output vector y_i, given input prices and a constant returns to scale technology, and can be measured as:

(2) $$\rho_i = C_i(w, y, S_c) \,/\, w_i\, x_i$$

The denominator $w_i x_i$ is the cost the i^{th} cooperative incurred to produce the output vector y_i. The numerator is the minimum cost of producing outputs given prices and constant returns to scale technology and can be determined by the following LP:

(3) $$\begin{aligned} &C_i(w, y, S_c) = Min\ w_i\, x_i \\ &s.\ t. \\ &\sum_{k=1}^{K} x_{nk}\, z_k \leq x_{ni} \\ &\sum_{k=1}^{K} y_{mk}\, z_k - y_{mi} \geq 0 \\ &z_k \geq 0 \end{aligned}$$

where z_k is the intensity of use of the k^{th} cooperative's technology. The subscript k represents the number of cooperatives, i denotes the cooperative of interest, n is the number of inputs, and m is the number of outputs. The intensity variables (z's) construct the frontier technology set. The solution of this LP problem is divided by the cooperative's actual cost to determine overall efficiency.

X-inefficiency can be due to either technical or allocative inefficiency. Technical efficiency examines whether a firm is producing on the production frontier. Technical efficiency for each cooperative can be measured using the following linear program:

(4) $$\begin{aligned} &Min\ \lambda_i \\ &s.\ t. \\ &\sum_{k=1}^{K} x_{nk}\, z_k \leq \lambda_i x_{ni} \\ &\sum_{k=1}^{K} y_{mk}\, z_k - y_{mi} \geq 0 \\ &\sum_{k=1}^{K} z_k = 1 \\ &z_k \geq 0 \end{aligned}$$

The firm is technically efficient if $\lambda_i = 1$. If $\lambda_i < 1$, the firm is technically inefficient.

Allocative efficiency examines whether a firm is using the optimal input mix. Allocative efficiency (γ_i) can be determined by dividing the minimum cost under variable returns to scale technology by the actual cost adjusted for technical efficiency:

(5) $$\gamma_i = C_i(w, y, S_v)/w_i\, \lambda_i\, x_i$$

The minimum cost under variable returns to scale technology is solved by the following LP:

(6) $$\begin{aligned} &C_i(w, y, S_v) = Min\ w_i\, x_i \\ &s.\ t. \\ &\sum_{k=1}^{K} x_{nk}\, z_k \leq x_{ni} \\ &\sum_{k=1}^{K} y_{mk}\, z_k - y_{mi} \geq 0 \\ &\sum_{k=1}^{K} z_k = 1. \\ &z_k \geq 0 \end{aligned}$$

Allocative efficiency is determined by dividing the minimum cost from the above LP by the actual cost multiplied by technical efficiency.

Scale efficiency (θ_i) is determined by:

(7) $$\theta_i = C_i(w, y, S_c) \,/\, C_i(w, y, S_v).$$

Scale efficiency is estimated by dividing the minimum cost from model (3) by the minimum cost from model (6). To determine whether each firm is operating under constant, increasing, or decreasing returns to scale, the equal to constraint that sums the z's in equation (6), is changed to a less than or equal to constraint. The solution to this LP problem is denoted as $C_i(w, y, S^*)$. If $\theta_i \neq 1$ and $C_i(w, y, S_c) = C_i(w, y, S^*)$, the firm is operating in a region of increasing returns to scale (decreasing average cost curve). If $\theta_i \neq 1$ and $C_i(w, y, S_c) \neq C_i(w, y, S^*)$, the firm is operating in a region of decreasing returns to scale (increasing average cost curve).

Overall efficiency is the product of scale, allocative, and technical efficiencies. This relationship can be shown by using equations (4), (5), and (7),

$$(8) \quad \rho_i = C_i(w, y, S_c) \,/\, w_i x_i = \lambda_i * \gamma_i * \theta_i.$$

The measure of X-efficiency can be determined by multiplying gamma by lambda. X-efficiency measures the ratio of the minimum costs that could have been expended to produce the same output mix that the firm produced (Berger 1993). It measures the distance that the firm is off the cost curve. Meador, Ryan, and Schellhorn (1997) suggest two testable hypotheses related to X-efficiency and firm output choice. The first is a diversification hypothesis that suggests that X-efficiency increases when managers make resource-allocation decisions for a broader range of distinct, but related, inputs. The alternative is a concentration hypothesis that says X-efficiency increases when managers focus on a particular area of expertise and a small number of product lines.

Tobit models were used to examine the relationship between cooperative characteristics and efficiency. The inefficiency index is derived by taking one minus the observed efficiency measure for each of the measures of efficiency. The inefficiency indices were pooled over time resulting in 445 observations for a particular inefficiency measure (89 cooperatives times 5 years). Selected cooperative financial characteristics were obtained from the Cooperative Finance Association (CFA) data base. Inefficiency indices were hypothesized to be related to the Herfindahl index of the output sales mix, the current ratio, the equity to asset ratio, the average collection period, gross income to personnel expense, and total sales.

The Herfindahl index is used to examine the degree of diversification or specialization of a cooperative's output mix. The Herfindahl index is the sum of the squared values of a firm's output sales shares for a given time period. A high Herfindahl index value indicates specialization while a low index value implies diversification. A positive sign on the Herfindahl index variable would indicate that specialization increases inefficiency (improves efficiency) while a negative sign would indicate that specialization decreases inefficiency.

The current ratio measures the firm's ability to meet current liabilities and is computed by dividing current assets by current liabilities. It is a key measure of a short term financial strength and the adequacy of cash flow to meet near term obligations. A positive sign on the current ratio variable would indicate that cooperatives with a strong liquidity position are more inefficient (less efficient) while a negative sign would indicate that these cooperatives are less inefficient (more efficient).

Equity to assets is the proportion of total assets financed by members' equity and is a key measure of the cooperative's long-term financial structure. Featherstone and Al-Kheraiji found that the use of debt is associated with a short-run misallocation of resources in U.S. cooperatives which would lead to a deterioration in efficiency. Based on the Featherstone and Al-Kheraiji study, a positive relationship between equity to assets and inefficiency is expected.

Average collection period measures the number of days of total farm supply sales in accounts receivable. It is an indicator of the effectiveness of credit management policies along with other day-to-day management abilities. If effective credit policies improve efficiency, the coefficient on the average collection period variable would be positive.

Gross income to personnel expense measures how effectively personnel are used to generate gross income and serves as a proxy for labor productivity. Cooperatives with effective personnel management would generate more income per employee and would have lower per unit costs. Thus, a negative sign on the gross income to personnel expense variable is expected.

Total sales measures the size of a cooperative operation. Based on work by Schroeder, economies of size are expected to exist so a negative relationship between total sales and inefficiency is expected.

The explanatory variables in the Tobit models were tested for possible multicollinearity problems using the correlation coefficient of 0.8 (Griffiths, Hill, and Judge) as the critical value. The highest correlation coefficient, 0.46, was found between the Herfindahl index and total sales.

Other regressions were used to examine the relative importance of input costs and specific product sales in explaining efficiencies, and to establish the relationship between profitability and efficiency. The relative importance of each cost was examined by regressing logged capital costs as a percent of total costs and logged labor costs as a percent of total costs on logged efficiency indices. A significant, negative relationship between a cost item and efficiency would indicate that the input was being under-utilized while a significant, positive relationship would indicate that the input was being over-utilized. The regressions examining the relationship between the percentage of gross income derived from individual product sales and efficiency indices were used to indicate whether cooperatives with relatively more sales of a particular product have relatively higher or lower efficiency indices than other cooperatives. The regression that examines the relationship between profitability and efficiency was used to establish the link between improving efficiency and cooperative profits. The rate of return to assets was used to measure cooperative profitability. All percentage variables used in the regressions described above were expressed in decimal form.

Data

Annual time series financial records from 1988 through 1992 were obtained from the CFA, a subsidiary of Farmland Industries. The CFA data contain complete balance sheet and income statement data, taken from audited financial statements. To investigate efficiencies, input and output quantity data or indices, and firms' output and input prices or indices are required. Dollar values of the expenses and the annual sales are adjusted for inflation by converting to 1992 constant dollars. Six product sale categories were defined for the cooperatives: grain, feed, fertilizer, agricultural chemicals, petroleum products, and other goods (antifreeze, tires, batteries, automotive parts, food items, and miscellaneous). Input expenses included capital and labor. Capital expenses were defined as the sum of annual depreciation, total assets times the Bank of Cooperative interest rate, and rents and leases. Labor also included management expenses. Expense information for items other than capital and labor was not available.

Because only financial records were available, transformations of several data series were necessary to obtain input and output levels. Producer price indices (U.S. Department of Agriculture) and implicit price deflators (U.S. Department of Labor) were used to transform revenues and costs to outputs and inputs. Output levels were obtained by dividing sales by producer price indices. The shares of soybean, corn, sorghum, winter wheat, and spring wheat production for the state in which the cooperative was located was used to construct the producer price index for grain. The capital input was obtained by dividing capital expense by the producer price index for machinery and equipment. State average hourly earnings of production workers on manufacturing payrolls were used to create a series of labor input prices. The labor input was obtained by dividing labor expense by labor price. For more detail pertaining to the transformation of the data see Ariyaratne (1997).

Of the 89 cooperatives which had data for each year, 47 were not involved in grain marketing during at least some of the study period. Seventeen of the cooperatives did not sell fertilizer at least one year during the study period. Twenty-five, 12, 23, and 6 of the cooperatives did not sell agricultural chemicals, petroleum products, feeds, and other merchandise respectively, during at least part of the study period.

Summary statistics for the cooperatives are presented in table 1. The mean dollar value of the capital expenses in 1992 was \$3.27 million with a range from \$0.08 to \$12.92 million. The mean dollar value of labor expenses in 1992 was \$0.56 million. The mean dollar value of the grain sales in 1992 was \$1.45 million with a standard deviation of \$2.92 million. The means of fertilizer sales, agricultural chemical sales, petroleum product sales, feed sales and other merchandise sales were \$1.12, \$0.72, \$1.63, \$0.67, and \$0.73 million in 1992 dollars, respectively.

Results

Summary statistics of efficiencies for the individual years, 1988 through 1992, are presented in table 2. Average overall efficiency for the five year period ranged from 0.62 in 1991 to 0.73 in 1992. An average overall efficiency rating of 0.73 implies that cooperatives could achieve the same level of output with 27% less cost on average, if they produced on the minimum cost frontier at the point of constant returns to scale. On average, 34 cooperatives had an overall efficiency index below 0.60 and 11 cooperatives had an efficiency index of 1.00.

Average technical efficiency for the five year period ranged from 0.90 in 1992 to 0.76 in 1991 (table 2). The average technical efficiency measure of 0.90 implies that inputs could be decreased by 10% if all cooperatives produced on the frontier production function. On average, 11 cooperatives had a technical efficiency index below 0.60 and 33 cooperatives had an efficiency index of 1.00.

Allocative efficiency evaluates the optimal lev-

Table 1. Summary Statistics of Cooperatives' Real Values of Inputs & Outputs, 1988–92

	Capital Expenses ($ million)	Labor Expenses ($ million)	Grain Sales ($ million)	Fertilizer Sales ($ million)	Chemical Sales ($ million)	Petroleum Product Sales ($ million)	Feed Sales ($ million)	Other Sales ($ million)
1988 Mean	4.85	0.41	1.73	0.96	0.55	1.60	0.51	0.61
Std. Deviation	4.28	0.32	3.71	0.98	0.70	1.96	0.67	0.66
Minimum	0.19	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	24.02	1.46	22.99	4.00	3.32	12.51	3.30	2.85
1989 Mean	5.40	0.50	1.54	1.05	0.59	1.55	0.50	0.69
Std. Deviation	4.65	0.40	3.18	1.10	0.80	1.78	0.67	0.84
Minimum	0.21	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	23.34	1.83	14.49	5.01	4.14	10.80	3.33	4.02
1990 Mean	5.08	0.52	1.49	1.07	0.62	1.52	0.57	0.71
Std. Deviation	4.46	0.43	2.99	1.14	0.79	1.56	0.72	0.87
Minimum	0.19	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	23.34	1.96	13.89	5.33	4.03	7.39	3.37	4.07
1991 Mean	4.25	0.54	1.45	1.08	0.69	1.72	0.65	0.73
Std. Deviation	3.70	0.45	2.92	1.13	0.85	2.08	0.91	0.84
Minimum	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	16.74	2.20	15.95	5.54	4.52	15.06	5.24	4.21
1992 Mean	3.27	0.56	1.45	1.12	0.72	1.63	0.67	0.73
Std. Deviation	3.08	0.47	2.92	1.21	0.87	1.57	0.97	0.80
Minimum	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	12.92	2.31	14.72	5.78	4.42	7.53	5.84	3.62

els of the capital and labor inputs in the production of grain, fertilizer, agricultural chemicals, petroleum products, feed, and other outputs. Average allocative efficiency for the five year period ranged from 0.93 in 1988 to 0.89 in 1989 (table 2). The average allocative efficiency measure of 0.93 indicates that costs could be reduced 7% by modifying the input bundles. No more than 3 cooperatives had an allocative efficiency index below 0.60 and on average 25 cooperatives had an efficiency index of 1.00.

The average measure of X-efficiency which is the product of allocative and pure technical efficiency ranged from 0.70 in 1991 to 0.82 in 1992. Average X-efficiency was 0.76 for the five year period. Total costs could have been reduced by an average of 24% for this set of cooperatives while maintaining the same level of output.

The scale efficiency measure compares the optimally sized operation to all others. The optimally sized, or scale efficient firm operates at the minimum point on the aggregate average cost curve. Average scale efficiency for the five year period ranged from 0.91 in 1988 to 0.87 in 1990 (table 2). On average, three cooperatives had an scale efficiency index below 0.60 and 11 cooperatives had an efficiency index of 1.00. Individual cooperative analysis indicated that on average, 49 cooperatives operated in the region of increasing returns to scale, 11 cooperatives operated at constant returns to scale, and 29 cooperatives operated under decreasing returns to scale. Although the annual cost curves indicate that a substantial number of cooperatives could be more efficient by adjusting their size, cost curves were relatively flat as indicated by the high levels of scale efficiency.

Table 3 presents Tobit regression results. Total sales were negatively related to technical inefficiency and statistically significant at the 1% levels. Those cooperatives that had more sales were more technically efficient. Average collection period was positively related to technical inefficiency and statistically significant at the 5% level indicating that effective credit management policies led to firms that were more technically efficient. The average collection period may be a proxy for other day to day management issues.

Allocative inefficiency was negatively related to the Herfindahl index and total sales while positively related to average collection period and gross income to personnel expense ratio (table 3). This indicates that large and more specialized cooperatives are more allocatively efficient. Larger cooperatives with a specialized product line and strong credit management may have an ability to negotiate and take advantage of favorable terms of trade, such as cash discounts on purchases, allowing them to be more allocatively efficient. The positive sign on the gross income to personnel expense ratio variable suggests that labor productivity does not lead to improvements in efficiency.

Scale inefficiency was negatively related to total

Table 2. Summary Statistics for Individual Efficiency Models

Summary Statistics		Technical Efficiency	Allocative Efficiency	Scale Efficiency	X-Efficiency	Overall Efficiency
1988	Mean	0.83	0.93	0.91	0.77	0.71
	Std. Deviation	0.18	0.10	0.12	0.19	0.20
	Minimum	0.12	0.58	0.26	0.12	0.03
	Maximum	1.00	1.00	1.00	1.00	1.00
	Less than 0.6	11	1	2	17	25
	0.6 to 1	48	64	75	48	52
	1	30	24	12	24	12
	Returns to Scale: Increasing = 51, Decreasing = 26, and Constant = 12					
1989	Mean	0.83	0.89	0.89	0.75	0.67
	Std. Deviation	0.16	0.14	0.11	0.20	0.19
	Minimum	0.41	0.19	0.50	0.19	0.15
	Maximum	1.00	1.00	1.00	1.00	1.00
	Less than 0.6	9	3	1	21	33
	0.6 to 1	52	63	78	45	46
	1	28	23	10	23	10
	Returns to Scale: Increasing = 50, Decreasing = 29, and Constant = 10					
1990	Mean	0.84	0.91	0.87	0.76	0.66
	Std. Deviation	0.18	0.12	0.14	0.21	0.19
	Minimum	0.14	0.49	0.14	0.11	0.02
	Maximum	1.00	1.00	1.00	1.00	1.00
	Less than 0.6	9	2	3	18	37
	0.6 to 1	46	60	78	44	44
	1	34	27	8	27	8
	Returns to Scale: Increasing = 45, Decreasing = 36, and Constant = 8					
1991	Mean	0.76	0.92	0.89	0.70	0.62
	Std. Deviation	0.22	0.11	0.15	0.23	0.22
	Minimum	0.12	0.53	0.13	0.12	0.02
	Maximum	1.00	1.00	1.00	1.00	1.00
	Less than 0.6	23	2	6	34	46
	0.6 to 1	41	67	73	35	33
	1	25	20	10	20	10
	Returns to Scale: Increasing = 64, Decreasing = 15, and Constant = 10					
1992	Mean	0.90	0.92	0.89	0.82	0.73
	Std. Deviation	0.15	0.12	0.12	0.18	0.19
	Minimum	0.39	0.57	0.53	0.36	0.32
	Maximum	1.00	1.00	1.00	1.00	1.00
	Less than 0.6	3	1	3	11	26
	0.6 to 1	39	56	72	46	49
	1	47	32	14	32	14
	Returns to Scale: Increasing = 35, Decreasing = 40, and Constant = 14					

sales, and positively related to the Herfindahl index, equity to assets ratio, and the average collection period (table 3). Larger cooperatives were more scale efficient than smaller cooperatives. Unlike the result for allocative efficiency, diversified cooperatives were more scale efficient than specialized cooperatives. Cooperatives with better credit management policies and with a lower equity to assets ratio (higher debt to asset ratio) were also more scale efficient. Cooperatives that effectively managed accounts receivable and debt may have been able to expand their business over the study period to reach a more optimal size.

X-inefficiency was negatively related to size and positively related to average collection period (table 3). The larger the cooperative in terms of sales, the more efficient that cooperative is. Interestingly, X-inefficiency was not statistically related to output product mix, indicating that neither the diversification or the concentration hypothesis holds for cooperatives.

Overall inefficiency was positively related to the equity to assets ratio and average collection period and negatively related to total sales (table 3). Overall efficient firms were larger using sales as a measure of size. Cooperatives carrying lower levels of accounts receivable and that had less equity financing were relatively more efficient. The results with respect to equity financing are consistent with results reported by Featherstone and Al-Kheraiji. Debt tends to result in a misallocation of inputs or inefficiency.

Table 3. Relationship Between Inefficiency Indices and Financial Variables

	INT	HFDI	CR	EA	ACP	GIPE	SLS
Technical Inefficiency							
Estimate	0.191**	−0.023	−0.0005	0.089	0.001**	−0.034	−0.015***
	(0.084)	(0.063)	(0.0005)	(0.077)	(0.0006)	(0.024)	(0.003)
Allocative Inefficiency							
Estimate	−0.069	−0.099***	−0.0004	0.0002	0.0006**	0.093***	−0.011***
	(0.046)	(0.035)	(0.0002)	(0.042)	(0.0003)	(0.013)	(0.002)
Scale Inefficiency							
Estimate	−0.130***	0.224***	−0.0005	0.082**	0.0014***	−0.019	−0.012***
	(0.039)	(0.030)	(0.0006)	(0.037)	(0.0003)	(0.011)	(0.0012)
X-Inefficiency							
Estimate	0.170**	−0.060	−0.0006	0.070	0.0018***	0.029	−0.016***
	(0.080)	(0.062)	(0.0005)	(0.073)	(0.0005)	(0.023)	(0.0028)
Overall Inefficiency							
Estimate	0.062	0.095	−0.0008	0.164**	0.0017***	0.025	−0.014***
	(0.076)	(0.09)	(0.0004)	(0.069)	(0.0005)	(0.022)	(0.002)

Notes: *** = Significant at 1% and ** = Significant at 5%.
Standard errors are in parentheses.
INT = Intercept, HFDI = Herfindahl Index, CR = Current Ratio, EA = Equity of Assets, ACP = Average Collection Period, GIPE = Gross Income to Personnel Expense, and SLS = Total Sales.

In general, larger cooperatives and cooperatives with better accounts receivable policies were more efficient than smaller cooperatives and cooperatives with accounts receivable problems. Cooperatives with more diversified output mixes were more scale efficient, but less allocatively efficient. Cooperatives with less equity financing were more scale and overall efficient compared to those with high equity financing. The current ratio was not statistically associated with any of the efficiency measures.

The importance of cost factors in explaining efficiency is reported in table 4. Logged capital costs as a percent of total costs and logged labor costs as a percent of total costs were regressed on logged efficiency indices. All of the regressions were significant at the 1% level of significance. Capital costs as a percent of total costs was significant and positively related to scale efficiency, and significant and negatively related to allocative efficiency, X-efficiency, and overall efficiency. Labor costs as a percent of total costs was significant and positively related to allocative efficiency, X-efficiency, and overall efficiency, and significant and negatively related to technical and scale efficiency. The results for X-efficiency and overall efficiency suggest, in general, that labor tended to be underutilized while capital was over-utilized. However, the scale efficiency results suggest that to achieve the optimal size firms need to spend relatively more on capital and relatively less on labor. The results with respect to X-efficiency and overall efficiency are consistent with the results reported by Featherstone and Al-Kheraiji who found cooperatives to be overinvested in capacity.

Regressions examining the relationship between the percentage of gross income derived from spe-

Table 4. Relationship Among Efficiency Indices and Cost Factors

Logged Independent Variables	Logged TE	Logged AE	Logged SE	Logged XE	Logged OE
Intercept	0.3775	−1.8149***	−0.6925***	−1.4375***	−2.1290***
	(0.4208)	(0.1756)	(0.1876)	(0.4832)	(0.5556)
Capital Cost/Total Cost	0.0831	−0.3942***	0.1506***	−0.3112***	−0.4615***
	(0.0916)	(0.0382)	(0.0408)	(0.1052)	(0.1209)
Labor Cost/Total Cost	−0.0027**	0.0103***	−0.0016***	0.0076***	0.0092***
	(0.0013)	(0.0005)	(0.0006)	(0.0015)	(0.0017)
R^2	0.033	0.681	0.039	0.121	0.094

Notes: *** = Significant at 1%, ** = Significant at 5%, and * = Significant at 10%.
Standard errors are in parentheses.
TE = Technical Efficiency, AE = Allocative Efficiency, SE = Scale Efficiency, XE = X-efficiency, and OE = Overall Efficiency.

Table 5. Relationship Among Efficiency Indices and Individual Product Sales

Logged Independent Variables	Logged TE	Logged AE	Logged SE	Logged XE	Logged OE
Intercept	−0.5794***	−0.2870***	−0.1087***	−0.8664***	−0.9751***
	(0.0411)	(0.0310)	(0.0194)	(0.0504)	(0.0572)
Grain/Total Sales	0.0321**	−0.0054	0.0033	0.0267	0.0300
	(0.0152)	(0.0115)	(0.0072)	(0.0187)	(0.0212)
Fertilizer/Total Sales	−0.0394**	−0.0464***	−0.0173*	−0.0858***	−0.1031***
	(0.0199)	(0.0150)	(0.0094)	(0.0244)	(0.0277)
Chemicals/Total Sales	0.0061	−0.0106	−0.0008	−0.0045	−0.0053
	(0.0127)	(0.0096)	(0.0060)	(0.0156)	(0.0176)
Petroleum Products/Total Sales	−0.1402***	0.0470***	−0.0036	−0.0932***	−0.0967***
	(0.0228)	(0.0172)	(0.0108)	(0.0281)	(0.0318)
Feed/Total Sales	−0.0091	−0.0087	0.0009	−0.0178	−0.0169
	(0.0117)	(0.0089)	(0.0056)	(0.0144)	(0.0164)
Other/Total Sales	0.0155	0.0267**	0.0018	0.0422**	0.0440**
	(0.0158)	(0.0119)	(0.0075)	(0.0194)	(0.0219)
R^2	0.117	0.047	0.011	0.083	0.080

Notes: *** = Significant at 1%, ** = Significant at 5%, and * = Significant at 10%.
Standard errors are in parentheses.
TE = Technical Efficiency, AE = Allocative Efficiency, SE = Scale Efficiency, XE = X-efficiency, and OE = Overall Efficiency

cific product sales and efficiency indices are reported in table 5. All of the regressions were significant at the 1% level of significance. Overall efficiency results suggest that cooperatives with a relatively higher level of sales of goods other than grain, fertilizer, agricultural chemicals, petroleum products, and feed were more efficient. Conversely, cooperatives with a higher level of fertilizer or petroleum product sales were less efficient. Sales of other goods were significant and positively related to X-efficiency, but were not significantly related to scale efficiency. Fertilizer sales were significant and negatively related to scale efficiency and X-efficiency. Petroleum product sales were negatively related to X-efficiency, but were not significantly related to scale efficiency.

Ordinary least square results examining the relationship between profitability (rate of return on assets) and efficiency are presented in table 6. Of the five models estimated, three were statistically significant at the 5% level of significance. The models regressing allocative and scale efficiency on return on assets were not statistically significant. Technical efficiency was statistically correlated with the rate of return to assets (ROA) with a correlation coefficient of 0.20. X-efficiency and overall efficiency were also statistically significant with correlation coefficients of 0.16 and 0.14. Using the regression coefficients in table 6, an increase in X-efficiency and overall efficiency of 10% increased ROA by 5.2% and 4.3%, respectively.

Summary and Implications

This study estimated X-efficiency and scale efficiency for a set of Great Plains cooperatives. Technical, allocative, scale, and overall efficiencies along with X-efficiency were estimated for each of the 89 cooperatives for the 1988 to 1992 period. On average, the cooperatives were 76% X-efficient and 89% scale efficient. Although a substantial number of cooperatives could become more effi-

Table 6. Relationship Between Efficiency and Profits

Return on Assets	Intercept	Estimate	Correlation Coefficient
Technical Efficiency	.006 (.015)	.074*** (.017)	.20
Allocative Efficiency	.098*** (.025)	−.034 (.027)	−.06
Scale Efficiency	.069*** (.022)	−.003 (.025)	−.01
X-Efficiency	.028** (.012)	.052*** (.015)	.16
Overall Efficiency	.038*** (.011)	.043*** (.015)	.14

Notes: *** = Significant at 1%, ** = Significant at 5%.
Standard errors are in parentheses.

cient by adjusting their size, the cost curve is relatively flat as indicated by the high level of scale efficiency. Cooperatives are more likely to reduce costs by focusing on X-efficiency rather than adjusting the scale of operation.

To identify the sources of inefficiencies, Tobit regressions were used to examine the relationship between inefficiency and a cooperative's Herfindahl Index, current ratio, equity to assets ratio, average collection period, gross income to personnel expense, and total sales. In general, larger cooperatives were more efficient than smaller cooperatives. This result supports research by Schroeder. Cooperatives with better accounts receivable policies were more efficient than those with less effective policies. Cooperatives with more diversified output mixes were more scale efficient compared to specialized cooperatives, but cooperatives with more specialized product lines were more allocatively efficient compared to diversified cooperatives. Cooperatives with less equity financing were more scale and overall efficient compared to those with high equity financing. The results with respect to equity financing were consistent with results reported by Featherstone and Al-Kheraiji. Debt tends to result in a misallocation of inputs which lowers efficiency.

Input cost regression results suggested that labor was under-utilized and capital was over-utilized. This result supports previous research by Featherstone and Al-Kheraiji that provided evidence of an overinvestment in capacity. If a cooperative is overinvested in capacity, capital costs would appear relatively high and more output could be produced by adding labor.

Overall efficiency was significant and negatively related to fertilizer and petroleum product sales and significant and positively related to sales of merchandise other than grain, fertilizer, chemicals, petroleum products, and feed. Overall efficiency was significantly correlated with the rate of return to assets suggesting a link between improvements in efficiency and cooperative profitability.

Findings of this study reflect the ongoing changes and the future direction of the agricultural cooperative industry. The current trend in the industry, which is getting larger by diversifying or specializing cooperative operations, will likely continue. This study found that the majority of the cooperatives operated in the region of increasing returns to scale or on the decreasing region of their average cost curves. However, larger is not always better. Many cooperatives could reduce cost substantially without getting larger. This study found that an average cooperative could reduce cost more by improving X-efficiency than by increasing its size. This outcome encourages smaller cooperatives to become more efficient before they increase their size.

The following recommendations are drawn from this study.

1. Cooperatives should focus on efficient use of technology.
2. Cooperatives with high levels of X-efficiency should consider expanding their operations.
3. Cooperatives with better or effective credit management policies are more efficient; therefore, improving credit management may reduce overall costs.

Since this study did not use any random sampling procedure, generalization of the results is limited. Cooperatives in the study may possess some special characteristics which nonparticipating cooperatives do not possess. Participating cooperatives may be financially well managed, technologically progressive, or the opposite. Also, the cooperatives used in this study were farmer-owned. Examining the relative efficiency of farmer-owned and privately owned firms would be a fruitful avenue for future research.

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