The Scale Efficiency of Local Supply and Grain Marketing Cooperatives in the Upper Midwest

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Consolidation has been a trend among local cooperatives for most of the past century. Earlier studies show that these cooperatives face size-related economies and that consolidation is to be expected as cooperatives seek to improve their efficiency and competitiveness. In this article we revisit the question using data from 377 local cooperative associations in operation during the 1990s. Methods involve using nonparametric cost frontiers that enable us to distinguish the effects of scale inefficiency from other production inefficiencies. Our results suggest that many local cooperatives are at or near an efficient scale of operation.

All business concerns must be operated efficiently to remain economically viable. However, an understanding of the efficiency of cooperatives is of particular concern. One justification for cooperatives is that they can set the pace for competition in the industries in which they operate. Nourse (1992, 105–11), an early leader in cooperative thought, championed this idea. He argued that, so long as cooperatives control modest market shares and compete effectively, their very presence disciplines the pricing decisions of non-cooperative firms. While the role of market disciplinarian may not apply to all cooperatives in agriculture, it is especially relevant for cooperatives involved in the input supply and grain marketing sectors of the economy. In these sectors, cooperatives and non-cooperative firms have been in competition throughout the past century. As farmers faced abuses, real or perceived, these cooperatives have offered an alternative outlet for farm products and an alternative source for supplies.

The search for efficiency is, indeed, one way to explain or justify consolidation among local cooperatives. If cooperatives face size-related economies then consolidation and growth are necessary to remain competitive in the markets they serve. Earlier findings suggest that such economies are present. Schroeder (1992, 93–103) estimated a multi-product cost function based on data from twenty-nine local cooperatives between 1979 and 1988. He found that these firms faced multi-product economies of scale; product-specific economies of scale in grain marketing, petroleum products, and feed; and economies of scope between many of the products they handle.[1] In another study, Akridge and Hertel (1986, 928–938) present further evidence supporting efficiency gains through

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size-related economies. Akridge and Hertel analyzed twenty-four retail fertilizer plants using data for the period 1975 through 1982. They found that these plants also faced multi-product economies of scale, along with economies of scope, between anhydrous ammonia and other fertilizer products. It is not clear whether the plants analyzed in the study were branches of a cooperative; however, the results do provide evidence that supply cooperatives handling similar product lines could lower costs through growth and/or diversification.

Between 1988, the last year reflected in Schroeder's analysis, and 1998, the number of grain marketing cooperatives in the United States has declined from 1,482 to 964, while the number of supply cooperatives has declined from 1,836 to 1,347 (USDA Rural Business-Cooperative Service 1988; Kraenzle et al. 1999). This decline in number of cooperatives reflects a trend towards fewer and larger firms rather than a diminishing role for cooperatives. In fact, cooperatives have maintained steady shares of input purchases and grain marketed by farmers. In 1988, cooperatives accounted for 25 percent of input purchases and 30 percent of grain and oilseed marketings (Kraenzle 1990, 12–13). In 1999, these numbers were 27 percent and 34 percent, respectively (Kraenzle 2001, 7–9, 31). There is little doubt that mergers and acquisitions accounted for a considerable portion of the decline in numbers. These occurrences accounted for 48 percent of all farmer cooperatives removed from U. S. Department of Agriculture (USDA) records between 1989 and 1998 (Kraenzle et al. 1999). Based on the results of the earlier studies, a trend towards fewer and larger cooperatives is expected as cooperatives seek to improve their cost position. Rapid consolidation, however, may have exhausted opportunities for size-related efficiency gains.

In this article, we revisit a main question raised in the earlier papers mentioned above; namely, to what extent can cooperatives improve their cost position by capturing scale economies. More specifically, we examine multi-product returns to scale based on nonparametric cost frontiers. In the next section, we describe this method and explain how cost frontiers can be used to obtain information about economies of scale. The third section describes our data set based on 377 cooperative firms operating during the 1990s and is followed by the empirical results. The final section of the article relates our findings back to earlier studies and outlines the limitations and managerial implications of the study.

Approach

The frontier method we use to analyze the cost structure of cooperatives involves linear programming methods. Instead of specifying a form for the cost frontier and then estimating the frontier through statistical methods, the approach uses observed levels of outputs and inputs of cooperative firms to build constraints within a programming framework that defines the production technology. The general approach, often called data envelopment analysis or DEA, is used widely, and readers interested in further details may wish to refer to Chavas and Aliber (1993, 1–16), Färe and Grosskopf (1985, 594–604), or Färe, Grosskopf, and Lovell (1994). Coelli (1995, 219–245) provides a general comparison of DEA methods with statistical frontier methods and discusses the advantages and disadvantages of the alternative approaches.

The linear programming model used to identify the minimal or frontier production cost for each firm observation relative to a technology that satisfies constant returns to scale (CRS) is as follows.

$$C^*_{CRS} = \min \sum_{n=1}^{N} w_n^i x_n$$

subject to:

$$\sum_{j=1}^{J} z^j y_m^j \geq y_m^i \forall m = 1,...,M \tag{1}$$

$$\sum_{j=1}^{J} z^j x_n^j \leq x_n^i \forall n = 1,...,N$$

$$z^j \geq 0 \forall j$$

Where the optimal objective function value, C^*_{CRS}, is the frontier production cost, $x = (x_1, x_2,...,x_N)$ is a vector of inputs, and $y^i = (y_1^i, y_2^i,...,y_M^i)$ and $w^i = (w_1^i, w_2^i,...,w_N^i)$ are vectors of outputs and input prices that correspond to the ith firm observation. The superscripts $i, j = 1, 2,....., J$ index the firm observations. The z^j are intensity variables that enable the creations of feasible production activities (i.e., output-input combinations) through radial contractions, radial expansions, or convex combinations of those activities observed in the sample.

To illustrate the method, consider panel A of figure 1. Each point on the diagram represents an amount of two inputs, x_1 and x_2, that can produce a fixed level of output, $y = y^*$. In the actual application, these points reflect observations from a sample of firms. Keep in mind that a linear program must be solved for each firm in the sample. The intensity variables z^j in the linear program allow the frontier of the technology to be defined in a piece-wise, linear fashion. The data points for firms A, B, C, and D, and convex combinations thereof, envelope the data and define the frontier of the technology (isoquant for $y = y^*$). If one were interested in projecting an inefficient firm such as E onto the frontier of the technology, the solution to the linear program for firm E

Figure I. Illustration of Production Technology

Panel A   Panel B
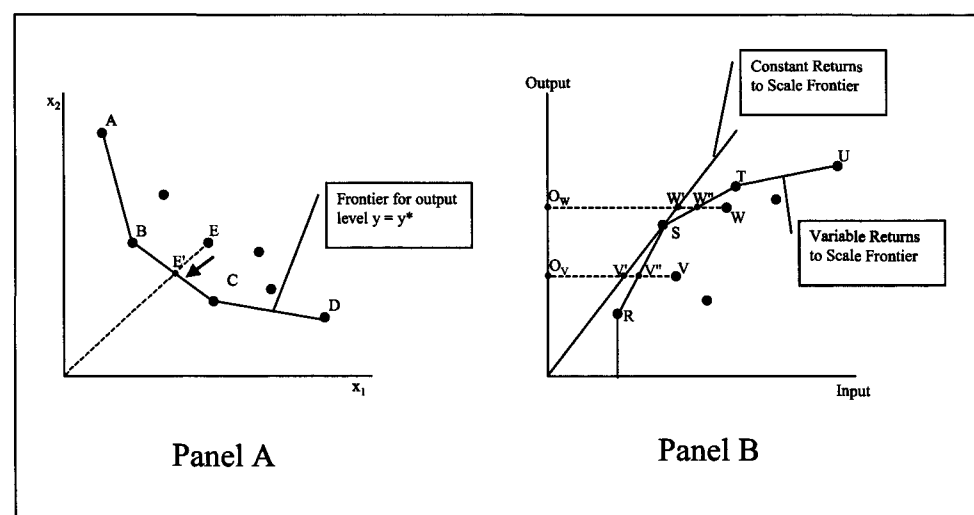
would compute the frontier level of input use as, E', a combination of points B and C. In the optimal solution to the linear program for firm E, the intensity variables z^B and z^C would be greater than zero. In the case of an efficient firm, say, point C on the diagram, the only non-zero intensity variable would be z^C.

After finding the solution to equation 1 for each firm, a measure of overall cost efficiency is obtained as the ratio of the firm's frontier cost to its observed cost, $C_{obs.}$.

$$Overall\ Efficiency = \frac{C^*_{CRS}}{C_{obs.}} \tag{2}$$

This measure is bounded between zero and one with a value of one indicating efficient production. For firms with overall efficiency measures less than one, the observed inefficiency may be due to technical inefficiency, allocative inefficiency, and/or scale inefficiency. Technical inefficiency refers to waste in the production process, in this case failing to produce a given level of output with the smallest level of inputs. Allocative inefficiency, sometimes called price inefficiency, refers to a failure to employ cost-minimizing combinations of inputs given the prevailing input prices.

Of course, an analysis of scale efficiency requires that the production technology be modeled with returns to scale assumptions that are less restrictive than CRS. Furthermore, it is necessary to obtain a measure of scale efficiency that does not include technical and or allocative inefficiencies. This can be done by placing an additional constraint on the intensity variables and thereby altering the way in which the frontier envelopes the data. To model a technology that satisfies variable returns to scale (VRS), the intensity variables are constrained so that $\sum_{j=1}^{J} z^j = 1$.

To illustrate, consider panel B of figure 1. For simplicity, the points on the diagram reflect a production technology with one input and one output. As before, in practice such points are observed from a sample of firms. Under CRS, the only restriction on the intensity variables is that they are greater than or equal to zero. This allows the frontier of the technology to be defined as a ray from the origin through an efficient point such as S. In the solution to the linear programs for inefficient points like firms V or W, the projection to the CRS frontier is at V' or W', both of which are either a radial contraction or a radial expansion of point S. In the linear programs for V or W, the intensity variable, z^S, enters the optimal solution as a positive number. With the VRS restriction requiring the z^j sum to one, the projection of V to the VRS frontier is given by V'' and would involve a combination of points R and S. The additional restriction on the intensity variables places limits on a radial contraction and prevents an unbounded radial expansion of any given data point (Färe, Grosskopf, and Lovell 1994, 50). Points V and W on the diagram can also be used to illustrate the computation of scale efficiency. Scale efficiency measures for these two points are computed as the ratios OV'/OV'' and OW'/OW'', respectively.

To measure scale efficiency we solve equation 1 a second time for each observation after adding the additional VRS constraint, $\sum_{j=1}^{J} z^j = 1$. The optimal objective function values, C^*_{VRS}, are the frontier costs under a VRS technology and include any costs that are due to an inefficient scale. A measure of scale efficiency for the ith firm is computed in terms of its frontier costs under the VRS and CRS assumptions as:

$$Scale\ Efficiency = \frac{C^*_{CRS}}{C^*_{VRS}} \tag{3}$$

This measure is also bounded between zero and one. A measure that is equal to one implies that the firm is scale efficient, while a measure less than one implies production at an inefficient scale. For multi-product technologies, a scale efficiency measure that is equal to one corresponds to production at the smallest ray average cost (Chavas and Aliber 1993, 1–16).[2]

The final step is to determine whether observed scale inefficiency is due to production in a region of increasing returns to scale or decreasing returns to scale. To do this we replace the VRS restriction in the linear program with a restriction requiring that $\sum_{j=1}^{J} z^j \leq 1$ and solve the linear program a third time for each observation in the sample. With this restriction in place, the technology satisfies non-increasing returns to scale (NIRS). Note that, like the CRS case, this restriction does allow a contraction of any data point along a ray to the origin. Unlike the CRS case, the restriction places limits on the expansion of any data point. Referring a final time to panel B of figure 1, the NIRS frontier is identical to the CRS frontier from the origin to point S. At point S and beyond, the technology exhibits decreasing returns to scale, and the NIRS frontier follows the VRS frontier. If one were to draw a horizontal line through point S, data points located south of this line, such as firm V, are operating in a region of increasing returns to scale. Points to the north of the line, such as W, are in a region of decreasing returns to scale. With knowledge of frontier costs under the NIRS technology, one can determine the source of observed scale inefficiency. If the scale efficiency measure is less than one and $C^*_{CRS} = C^*_{NIRS}$, the observed scale inefficiency is due to production at a region where the technology exhibits increasing returns to scale. Alternatively, if the scale efficiency measure is less than one and $C^*_{CRS} < C^*_{NIRS}$, then the source of the scale inefficiency is due to production in a region of decreasing returns to scale.

Data and Procedures

Data were obtained from the St. Paul Bank for Cooperatives and reflect firms located in a five-state region consisting of Michigan, Minnesota, North and South Dakota, and Wisconsin. The data reflect annual observations over an eight-year period of 1989 through 1996. In total, we use 2,531 observations from 377 local supply or grain marketing cooperatives. Data required for the solution of the linear programming models described in the previous section include measures of outputs, inputs, and input prices. We consider a production technology with six outputs and three inputs. The outputs are (1) grain marketed, (2) feed, (3) fertilizers and chemicals, (4) petroleum products, (5) services, and (6) general merchandise. The inputs are (1) labor, (2) general operating expenses, and (3) capital. As described in the previous section, three linear programming models are solved for each observation, one under each of the CRS, VRS, and NIRS assumptions. Each of the 7,593 linear programming models was solved using the GAMS (General Algebraic Modeling System) version 2.25 software.

The grain output was measured as an approximated, hundred-weight (cwt.) volume of grain handled over a one-year period. The raw dataset provided sales figures by crop. Prices and marketing percentages that reported by the USDA National Agricultural Statistics Service (USDA-NASS) were used to construct an average-per-cwt. price for each grain or oilseed crop corresponding to a cooperative's fiscal year. These prices were then used to convert sales figures for each crop into an approximated cwt. value. We then summed over crops to obtain a cwt. measure of grain handled by the cooperative over the year.

All remaining output values were measured on an annual basis in dollar values by adjusting itemized sales figures by corresponding price indexes for the cooperative's fiscal year (see Table 1). These price indices, reported monthly or quarterly, were aggregated to obtain an index number corresponding to the cooperative's fiscal year. The services output includes revenues from activities such as grain storage, drying, application of fertilizers or chemicals, and mixing. As shown in Table 1, the general merchandise output includes sales from items such as seed, hardware, parts, tires, or grocery sales through a convenience store.

The input prices were obtained from secondary data sources and were averaged over the cooperative's fiscal year. The price of labor was measured as a labor price index based on the state-level manufacturing wage reported monthly by the U. S. Department of Labor. The producer price index for machinery and equipment was used to measure the price of capital. Finally, the implicit GNP price deflator was used as the price of general operating expenses.

The labor input is measured as the firm's annual expenditure on salaries and benefits divided by a corresponding labor price index. The capital input is calculated as the sum of the firm's depreciation and lease expense deflated by the producer price index for machinery and equipment. The general operating expense input category is measured as general operating expenses divided by the GNP price deflator.

One data problem arises from the way the service output is measured. The type of services that a cooperative provides depends heavily on its primary line of business. For example, storage and handling revenues are a major component of service revenues for the typical grain marketing cooperative. However, these revenues are small or non-existent for supply cooperatives, which derive the largest share of service revenues from the application of fertilizers and chemicals. Similar differences emerge in the types of sales that comprise the general merchandise output among cooperatives with different primary business lines. If all firms were pooled, there would be substantial output aggregation bias that results from the way the general merchandise and service outputs are measured. In the context of DEA efficiency analysis, this problem is important as the linear programming models rely on data from the entire sample to assess the frontier costs of any given firm observation.

To account for this problem, firms in the data set were categorized into four mutually exclusive groups, and scale efficiency was measured for each observation relative to observations from firms in a similar group. The groups are as follows:

Table 1. Price Indexes Used for Those Outputs Measured in Dollar Values

Output	Price Index
Feed	Feed (USDA-NASS)
Fertilizers & Chemicals	Agricultural Chemicals (PPI commodity code 065)
Petroleum	Petroleum Products (USDA-NASS)
Services	Farm Services (USDA-NASS)
General Merchandise	
Seed	Seed (USDA-NASS)
Lumber	Lumber and Bldg. Supplies (USDA-NASS)
Equipment Machinery & Parts	Farm Machinery (USDA-NASS)
Twine and Hardware	General Farm Supplies (USDA-NASS)
Tires & Automotive	Tires, Tubes and Tread Material (PPI commodity code 0712)
Groceries	Food and Beverage (CPI)

- *Grain Cooperatives.* The first group contains 470 observations on 68 cooperatives that are involved primarily in grain marketing. Many of these cooperatives do provide inputs to their members but these inputs generally comprise a small portion of the business. On average, grain marketing accounts for 90 percent of total sales by these cooperatives.
- *Grain/Supply Cooperatives.* The second group contains 784 observations on 120 diversified cooperatives that are involved heavily in both grain marketing and in the provision of farm supplies. On average, roughly half of all sales are derived from farm inputs.
- *Supply Cooperatives.* The third group contains 744 observations on 108 general farm supply cooperatives. The largest part of sales for these cooperatives is derived from the sale of fertilizers and chemicals. However, petroleum sales are also an important revenue source. None of these cooperatives are involved in grain marketing.
- *Petroleum Cooperatives.* Finally, the fourth group contains 533 observations on 81 specialized petroleum cooperatives. On average 75 percent of the sales of these firms are derived from petroleum products.

Results

Averages for the overall cost efficiency and scale efficiency measures are reported in Table 2. The overall cost efficiency measures range from an average of 0.674 for the grain cooperatives to 0.719 for the diversified grain/supply cooperatives. The scale efficiency measures range from 0.883 for the grain cooperatives to 0.942 for the supply cooperatives. Recall that for both the scale and overall cost efficiency measures, a measure of 1 implies efficient production, while a measure less than 1 implies inefficiency. To facilitate interpretation of these numbers, suppose that a cooperative is found to have an overall cost efficiency measure of 0.7 and a scale efficiency measure of 0.9. This means that the cooperative is 70 percent efficient in terms of their costs and 90 percent efficient in terms of their scale of operations. Conversely, overall inefficiency (technical, allocative, or scale inefficiency combined) accounts for 30 percent of the observed costs. Scale inefficiency alone accounts for 10 percent of the observed costs.

In terms of cost savings, these results suggest that scale inefficiency is less important than inefficiency that arises from other sources, namely, technical and allocative inefficiency. Figure 2 shows a decomposition of total observed costs into components consisting of (1) those that would result under efficient production, (2) those that are due to scale inefficiency, and (3) those that are due to other production inefficiencies. Only in the case of grain cooperatives did costs due to scale inefficiency exceed one third of total costs attributed to inefficient production. For farm supply cooperatives, scale inefficiency accounts for only one fifth of all costs due to inefficiency.

Table 3 reports the percent of observations within each group that fall within different ranges of the scale efficiency measures. In all four groups, well over half of the observations in each group have scale efficiency measure of 0.9 or greater. Among supply cooperatives, 86 percent had scale efficiency measures of 0.9 or larger. In sum, the results provide evidence that many cooperatives were operating close to an efficient level of output during the study period.

It is also interesting to examine scale inefficiency that results from producing in a region where the technology exhibits increasing returns to scale (sub-optimal scale) or

Table 2. Overall Efficiency and Scale Efficiency by Co-op Type

| | | Overall Efficiency | All Observations | Scale Efficiency | | |
				Increasing Returns (sub-optimal)	Constant Returns (optimal)	Decreasing Returns (supra-optimal)
Grain Co-ops.	N. Obs.	470	470	261	20	189
	Mean	0.674	0.883	0.864	1.000	0.896
	Std. Dev.	0.173	0.124	0.128	—	0.116
Grain/Supply Co-ops.	N. Obs.	784	784	211	28	545
	Mean	0.719	0.905	0.932	1.000	0.890
	Std. Dev.	0.131	0.097	0.082	—	0.100
Supply Co-ops.	N. Obs.	744	744	318	20	406
	Mean	0.698	0.942	0.949	1.000	0.933
	Std. Dev.	0.143	0.105	0.119	—	0.093
Petroleum Co-ops.	N. Obs.	533	533	284	21	228
	Mean	0.667	0.894	0.912	1.000	0.861
	Std. Dev.	0.158	0.114	0.100	—	0.124

Figure 2. Decomposition of Observed Costs by Co-op Type

Grain Cooperatives
Scale inefficiency 12%
Other inefficiency 21%
Efficiency 67%

Grain/Supply Cooperatives
Scale inefficiency 9%
Other inefficiency 19%
Efficiency 72%

Supply Cooperatives
Scale inefficiency 6%
Other inefficiency 24%
Efficiency 70%

Petroleum Cooperatives
Scale inefficiency 11%
Other inefficiency 23%
Efficiency 66%

from producing in a region where the technology exhibits decreasing returns to scale (supra-optimal scale). A simple t test based on the numbers in table 2 shows scale efficiency measures are significantly lower, on average, for observations reflecting production at a supra-optimal scale than for those reflecting production at a sub-optimal scale. Observations on cooperatives in the grain group are an exception to this.[3]

Table 3 provides more details and shows that roughly half of the observations on grain cooperatives that reflect production at a sub-optimal scale had efficiency measures less than 0.9 (29 percent out of a total of 56 percent). In the cases of the supply and grain/supply cooperatives, respectively, only 5 percent and 7 percent of the observations at a sub-optimal scale have scale efficiency measures less than 0.9. Table 3 shows that, for the grain/supply and petroleum cooperatives, output levels at a supra-optimal scale have been more problematic over the study period. Among these cooperatives, close to half of the observations at a supra-optimal scale had scale efficiency measures less than 0.9.

Table 4 summarizes scale efficiency measures averaged by firm over the entire study period. Although the results presented in Table 2 and Figure 2 suggest that scale inefficiency is less important that other forms of production efficiency, it is noteworthy that 28 out of the 68 grain cooperatives had scale efficiency measures less than 0.9. Diversified grain/supply firms and petroleum firms with scale efficiency measures less than 0.9 numbered 45 out of 120 and 32 out of 81, respectively. This suggests that scale efficiency continued to be a problem for cooperatives during the 1990s.

A closer examination of Table 4 shows that a number of grain cooperatives in the sample could improve their cost position by capturing scale economies. Among the grain cooperatives at a sub-optimal scale (operating under increasing returns), 13 had average scale efficiency measures of less than 0.85 and 14 had average scale efficiency measures less than 0.9. These firms account for roughly 19 and 21 percent of all firms in the sample of grain cooperatives. Among petroleum cooperatives consistently at a sub-optimal scale, 13 firms, or 16 percent of the firms in the petroleum sample, had average

Table 3. Distribution of Scale Efficiency (SE) Measures by Co-op Type (Percent of Observations)*

		SE<0.6	0.6≤SE<0.7	0.7≤SE<0.8	0.8≤SE<0.9	0.9≤SE<1.0	SE=1	Total
Grain Co-ops	Increasing Returns	3	4	7	15	27	—	56
	Constant Returns	—	—	—	—	—	4	4
	Decreasing Returns	1	2	4	7	26	—	40
	Total	4	6	11	21	53	4	100
Grain/Supply Co-ops	Increasing Returns	0	0	2	5	20	—	27
	Constant Returns	—	—	—	—	—	4	4
	Decreasing Returns	1	3	7	21	38	—	70
	Total	1	3	9	26	57	4	100
Supply Co-ops	Increasing Returns	1	0	1	2	38	—	43
	Constant Returns	—	—	—	—	—	3	3
	Decreasing Returns	1	2	4	4	44	—	55
	Total	2	2	5	6	83	3	100
Petroleum Co-ops	Increasing Returns	1	0	3	12	37	—	53
	Constant Returns	—	—	—	—	—	4	4
	Decreasing Returns	1	5	8	8	21	—	43
	Total	2	6	11	20	58	4	100

*Some percentages reported in the table do not sum to 100 because of rounding

Table 4. Scale Efficiency (SE) Averaged by Firm Over the Entire Study Period

| | Avg. Scale Efficiency | Standard Deviation | Number of Cooperatives | | | Total |
			SE≤0.85	SE≤0.9	SE≤0.95	
Firms at increasing returns to scale over the entire study period						
Grain Co-ops	0.822	0.115	13	14	19	21
Grain/Supply Co-ops	0.899	0.082	6	8	13	19
Supply Co-ops	0.935	0.133	3	4	6	29
Petroleum Co-ops	0.890	0.107	6	13	21	28
Firms that varied between increasing constant and decreasing returns to scale						
Grain Co-ops	0.945	0.044	2	5	15	32
Grain/Supply Co-ops	0.975	0.018	0	0	4	40
Supply Co-ops	0.979	0.034	1	2	4	44
Petroleum Co-ops	0.952	0.049	1	3	10	31
Firms at decreasing returns to scale over the entire study period						
Grain Co-ops	0.836	0.115	7	9	13	15
Grain/Supply Co-ops	0.866	0.094	21	37	50	61
Supply Co-ops	0.909	0.090	6	10	20	35
Petroleum Co-ops	0.811	0.115	15	16	19	22

efficiency measures less than 0.9. Firms that varied between producing at a sub-optimal and supra-optimal scale over the study period were, for the most part, very close to achieving scale efficient production; that is, they had scale efficiency measures close to 1. The only exception was a few of the grain cooperatives. Finally, the results reflecting cooperatives that operated at a supra-optimal scale (operating at decreasing returns) over the entire study period show that some of the petroleum and diversified grain/supply firms were operating at some distance from an efficient scale of production. The average scale efficiency measures for 15 of these petroleum firms (19 percent of the total sample) and 21 of these grain/supply firms (18 percent of the total sample) were below 0.85. Furthermore, 37 (31 percent) of the grain/supply firms were consistently at a supra-optimal scale and had average scale efficiency measures less than 0.90.

To summarize, the results suggest that scale efficiency has been a problem for cooperatives during the 1990s. However, scale inefficiency has been less problematic than other forms of production inefficiency. Many of the cooperatives that operated at an inefficient scale were larger than optimal. This is particularly true for the diversified grain/supply cooperatives. The results suggest that there are opportunities only for a modest number of grain cooperatives and for an even more modest number of petroleum cooperatives to lower costs by capturing economies of scale.

Discussion

Unlike earlier studies examining the performance of cooperatives or farm supply firms in the 1980s, we find little evidence that cooperatives in the 1990s faced multi-product economies of scale. Local farm supply and grain marketing cooperatives operate in markets that are mature and have remained fairly stable since the late 1970s (Coffey 1993, 1132–1136). For many cooperatives that we found to be scale inefficient, the more common problem is being larger than an efficient scale, rather than being smaller.

Although our results with respect to multi-product scale economies differ from earlier findings, there are some ways in which our results are similar to those found in Schroeder's earlier study. First, Schroeder did not find evidence of significant product-specific economies of scale for fertilizers and chemicals. Although we did not specifically examine product-specific economies of scale, we also find little evidence of large economies or diseconomies of scale for farm supply cooperatives. On average, these cooperatives derive the largest portion of their sales from fertilizer and chemical products. Second, Schroeder found product-specific economies of scale to be large in grain marketing and petroleum products. The cooperatives in the grain category derive 90 percent of sales from grain marketing activities, and cooperatives in the petroleum category derive over 75 percent of sales from petroleum products. These categories were the only ones where the majority of scale-inefficient cooperatives were at a sub-optimal level of production. Furthermore, these are the only categories where a modest number of cooperatives could gain substantial improvements in efficiency by capturing economies of scale.

On average, our results suggest that inefficiency in some form accounts for as much as 33 percent of the observed costs. Figures such as this should be viewed with a degree of caution. The programming models used here provide an efficiency score relative to a small set of "best practice" firms in the sample. As a result, the efficiency scores may fail to take into account differences in the business environment facing cooperatives in different locales and/or the time needed to adjust to structural changes in crop and livestock production. A second caution relates to changes in technology and the sunk-cost effect, a phenomenon whereby some firms will be less likely to adopt the latest

technology having irreversibly sunk resources into a substitute technology of earlier vintage (Besanko, Dranove, and Shanley 2000). Failure to adopt the best available technology would be measured as inefficiency in a study such as ours, but may reflect rational behavior on the part of the firms in our sample.

Nevertheless, the results presented here raise a caution flag for local cooperative leaders enthusiastic about capturing efficiency gains through growth or consolidation. We find little evidence that major improvements in cost position can be expected from such activities. Local managers and board members are advised to give more attention to alternative avenues of streamlining operations such as joint ventures and strategic alliances. A recent study by Fulton, Popp, and Gray (1996, 1–15) provides some evidence of the success of these alternatives. The results presented here suggest that more research is needed on the performance impacts of these alternatives.

Notes

1. Multi-product economies of scale are said to exist when ray average costs decline as all of a firm's outputs are expanded proportionately (see note 2). Product-specific economies of scale measure the cost impacts of expanding one product line, keeping all other product lines at constant levels. Finally, economies of scope refers to a situation where the cost of producing two or more outputs under a joint production arrangement is less than the combined costs of producing the same products under specialized production arrangements.
2. Ray average cost is the multi-product analog of the more traditional average cost concept for a single-product firm. In short, ray average costs explore the behavior of the cost function as all products are increased or decreased proportionately.
3. Student's t values for the hypothesis that average scale efficiency under increasing returns is equal to average scale efficiency under decreasing returns ($H_0: \overline{SE}_{IRS} - \overline{SE}_{DRS} = 0$) are as follows: -2.722 (d.f. = 448) for the grain cooperatives, 5.434 (d.f. = 754) for the grain/supply cooperatives, 2.031(d.f. = 722) for the supply cooperatives, and 5.152 (d.f. = 510) for the petroleum cooperatives.

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