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What Do We Know About the Economic Efficiency of Cooperatives: An Evaluative Survey

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A debate has arisen concerning the economic efficiency of cooperatives relative to other organizational forms. This paper discusses the efficiency concepts and economic theory relevant to the debate and then proceeds to study the empirical evidence. No credible evidence exists to support the proposition that cooperatives are inefficient relative to investor-owned businesses.

Public policy toward agricultural cooperatives in market-oriented economies such as the United States and Western Europe is often favorable. In the United States public support for cooperatives is considered to include beneficial tax treatment, access to favorable credit terms, limited immunity from antitrust laws, and free technical assistance. Such policies have, however, been called into question. An important line of criticism is that cooperatives operate less efficiently than comparable for-profit firms. This view is widely held by both farmers and cooperative "experts" as surveys by Schrader et al. and Cain, Toensmeyer, and Ramsey document. Thus, it is possible that government support of cooperatives fosters an inefficient organization form. For example, Porter and Scully opine as follows: "[P]ublic resources provided to cooperatives foster and promote an inefficient form of organizing production." And Ferrier and Porter conclude that "agricultural cooperatives have survived in the U.S., nurtured by government support."

This paper analyzes the cooperative efficiency issue and evaluates the conflicting claims that have emerged in this arena. We begin by defining the economic efficiency concepts that are relevant to the discussion and then relate these concepts to cooperative theory to derive alternative hypotheses regarding the efficiency of cooperatives. Given this conceptual basis, studies of cooperative efficiency are reviewed, compared, and critiqued. The discussion is limited to agricultural marketing and supply cooperatives in market-oriented economies.[1] Our primary conclusion is

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that, despite a number of recent studies addressing cooperative efficiency, evidence on the economic efficiency of cooperatives is limited and does not support the popular perception that cooperatives are less efficient than comparable investor-owned firms.

Economic Efficiency: Concepts and Empirical Methodology

One problem in comparing and evaluating studies of cooperatives' efficiency is that many studies do not use formal concepts of economic efficiency derived from theory. Three distinct efficiency concepts, each relevant to cooperatives, can be derived. *Technical efficiency* refers to a firm's ability to generate the maximum output from a given set of inputs. *Allocative efficiency* refers to a firm's ability to choose the cost minimizing method of producing a given output. Finally, *scale* or *price efficiency* describes a firm's ability to choose the "correct" level of output.

To focus the ensuing discussion, it is useful to provide formal definitions of each concept. Let Q denote output, $\mathbf{X} = \{X_1, \ldots, X_n\}$ a vector of inputs, $\mathbf{W} = \{W_1, \ldots, W_n\}$ the corresponding vector of parametric input prices, and P the parametric output price. In referring to cooperatives, it will be useful to decompose $\mathbf{X}$ as follows: $\mathbf{X} = \{X_1, \mathbf{X}_{\sim 1}\}$, where X_1 denotes the raw product input supplied by members and $\mathbf{X}_{\sim 1} = \{X_2, \ldots, X_n\}$ denotes other inputs. Efficient transformation of inputs to outputs is characterized by the production function $Q = f(\mathbf{X})$, which shows the maximum output attainable for different combinations of inputs. $f(\mathbf{X})$ is referred to as the *production frontier*. Consider a firm that employs the input vector $\mathbf{X}_o$ and produces output level Q_o. The firm is technically efficient if:

$$Q_o = f(\mathbf{X}_o), \tag{1}$$

and exhibits technical inefficiency otherwise (i.e., $Q_o < f(\mathbf{X}_o)$).

Allocative efficiency mandates that a given output level, Q_o, be produced at the minimum cost possible. Technical efficiency is necessary but not sufficient to achieving allocative efficiency. In addition inputs must be employed so that their ratios of marginal products to input prices are equated:

$$(\partial f(\mathbf{X})/\partial X_1)/W_1 = (\partial f(\mathbf{X})/\partial X_2)/W_2 = \ldots = (\partial f(\mathbf{X})/\partial X_n)/W_n \tag{2}$$

Deviations from equation (2) represent allocative inefficiency. In the case of a marketing cooperative, equation (2) would be evaluated for all variable inputs *excluding* X_1.

Although disagreements have arisen as to the appropriate objective function for a cooperative organization,[2] it is important to stress that achieving technical and allocative efficiency is necessary for attaining any reasonable cooperative objective. A similar conclusion does not hold, however, for the concept of scale or price efficiency, which refers to the firm's specific choice of output level. Two different concepts of the "correct" output level have been proposed. Most authors (e.g., Atkinson and Halvorsen and Kumbhakar, Biswas, and Bailey) have equated scale efficiency with the choice of the profit maximizing output for a competitive firm. Denoting $C(\mathbf{W}, Q)$ as the dual cost function derived by minimizing $W_1X_1 + \ldots + W_nX_n$ subject to $f(\mathbf{X})$, this concept is manifest in the form of the familiar equating of price and marginal cost:

$$P = \partial C(\cdot)/\partial Q \tag{3}$$

Departures from equation (3) represent price or scale inefficiency.[3]

To apply this concept to a marketing cooperative, we must assumc initially that the processed product is produced in fixed proportion to the amount of raw product input, X_1. The production function $Q = \min\{\lambda X_1, h(\mathbf{X}_{\sim 1})\}$ embodies this property. Raw product costs are separable from other processing costs in the dual cost function associated with this production function:

$$C(\mathbf{W}, Q) = W_1Q/\lambda + c(W_2, \ldots, W_n, Q),$$

where $c(\cdot)$ denotes the "processing" cost function. $P - \partial c(\cdot)/\partial Q$ then represents the net marginal revenue product (*NMRP*) of X_1. Equating *NMRP* with the members' aggregate marginal cost (*MC*) function for producing X_1, yields a cooperative analogue to the price efficiency condition:

$$NMRP = \Sigma_k MC_k(X_{1k}), \tag{3'}$$

where $k = 1, \ldots, m$ indexes members.[4] Satisfaction of equation (3′) is equivalent to a cooperative attaining the value-maximizing solution first proposed for a consumer or farm supply coop by Enke and for a marketing coop by Ohm.

Porter and Scully and Ferrier and Porter employ a different concept of scale efficiency. A firm is scale efficient in their framework if and only if it produces a level of output that corresponds with the minimum value of the average cost function. Let AC^* denote the minimum value of average cost defined as:

$$AC^* = \min\{Q\}\; C(\mathbf{W}, Q)/Q.$$

Scale inefficiency for an output level Q_o is measured as the deviation of the average cost $AC(Q_o)$ of producing Q_o using best-practice production methods from AC^*.[5]

Both programming and econometric approaches have been developed to measure efficiency based on equations (1)–(3) or (3′). We provide only a brief summary of the approaches, referring interested readers to the original references for more details. Programming approaches are based on work by Farrell. Technical efficiency is computed for each observation by first normalizing each firm's input and output quantities by its level of output and then, using linear programming (LP), finding the maximum output producible for each normalized input vector. Firms are judged technically inefficient if the maximum output associated with their normalized input vector exceeds 1.0. Allocative efficiency is found similarly by using LP to find the cost minimizing input vector $\mathbf{X}^*$ for each firm's observed output level and then computing the ratio $\mathbf{W}'\mathbf{X}^*/\mathbf{W}'\mathbf{X}_o \leq 1.0$, where $\mathbf{X}_o$ for each observation is the observed input vector. Given knowledge of technical efficiency from the preceding step, deviations in this ratio from its maximum value can be decomposed into technical and allocative inefficiency components. This approach is incapable of measuring scale efficiency as defined in equations (3) or (3′), but Ferrier and Porter show how it may be used to measure their concept of scale efficiency.

A popular statistical approach to measuring technical efficiency is the stochastic production frontier method suggested by Aigner, Lovell, and Schmidt. Here the production model is specified as $Q = f(\mathbf{X})e^{(\epsilon - \mu)}$, where $f(\mathbf{X})e^{\epsilon}$ represents a *stochastic production frontier*, and e^{μ}, $\mu \geq 0$, measures technical efficiency relative to the stochastic frontier for each observation. Kumbhakar, Biswas, and Bailey generalize this approach to also measure allocative and scale efficiency essentially by making equations (2) and (3) stochastic behavioral equations through the introduction of random error terms. The realized value of these error terms for each observation measures departures from allocative and scale efficiency. An alternative statistical approach developed by Atkinson and Halvorsen replaces $\mathbf{W}$ in equations (2) and (3) with $\mathbf{kW}$, where the $\mathbf{k}$ are parameters to be estimated. The $\mathbf{kW}$ represent *shadow prices* that reflect actual firm decision making. Deviations of the k_j from 1.0 measure scale inefficiency (i.e., failure to equate an input's price with its value of marginal product), and, similarly, inequalities among the k_j imply violation of equation (2) and, hence, measure allocative inefficiency.

The programming approaches and the Kumbhakar et al. approach yield efficiency estimates for each observation, whereas the Atkinson and Halvorsen approach yields an average estimate of efficiency across the sample. However, classical hypothesis tests can be performed upon the k_j that are not possible for the other approaches.[6] A further limitation of the programming and Kumbhakar et al. approaches is that input prices are assumed to be constant across observations. The Atkinson and Halvorsen approach is limited as well in that technical efficiency is a maintained hypothesis.

Economic Efficiency and Cooperatives

A cornerstone of neoclassical microeconomic theory is that market pressures discipline competitive firms to behave efficiently. When markets depart fundamentally from the axioms of competition, inefficiencies may emerge. Firms with market power may exhibit both price and technical inefficiency. Price inefficiency occurs because price exceeds marginal cost, but technical inefficiency results from excessive costs due to a firm's efforts to maintain or strengthen its monopoly power (Spence) or due to the absence of competitive pressures in the market (Leibenstein). Technical inefficiency may also exist because of the *agency costs* associated with the separation of ownership and control, as discussed by Jensen and Meckling and Fama and Jensen. Because decision makers are often not the residual claimants in the modern firm, transactions costs associated with monitoring managerial performance may be incurred. Government regulation can also distort firms' incentives, so as to induce violations of equations (1)–(3).[7]

The cooperative form of organization has been hypothesized to be inefficient relative to ordinary for-profit businesses for a number of reasons.

Porter and Scully and Ferrier and Porter argue that cooperatives will be technically inefficient because principal-agent problems are particularly acute in cooperatives. Because cooperative stock is nontransferable, no convenient performance barometer, such as a stock value, exists for cooperatives, and because ownership is usually diffused among many members, individual members have limited incentive to monitor performance. Staatz (1984) and Caves and Peterson have raised similar concerns.

Porter and Scully and Ferrier and Porter further argue that cooperatives will exhibit allocative inefficiency because of the so-called "*horizon problem*." Because members benefit from cooperative investments only over their horizon as patrons, it is hypothesized that cooperatives will underinvest in long-lived assets such as capital and pursue instead opportunities designed to generate short-run payoffs.[8] The horizon problem ordinarily does not arise in a for-profit corporation because the firm's stock value reflects the market's expectation of the firm's discounted future earnings stream. Thus owners have correct incentives to balance current profits with future profit opportunities. Other arguments alleging propensity of cooperatives to underutilize capital focus on the lack of incentive in cooperatives to contribute to the base of equity capital that, in turn, may be used to finance capital input purchases.[9]

Finally, Porter and Scully and Ferrier and Porter argue that cooperatives will often lack sufficient patronage to achieve the cost minimizing scale of operation and, thus, will exhibit scale inefficiency according to their definition. The suggested reasons are increasing costs of control as the number of principals (patrons) increases and legal restrictions on the volume of nonmember business conducted.[10]

Arguments, however, can also be raised to suggest that cooperatives will perform *more* efficiently than for-profit counterparts. One set of arguments derives from possible cost savings due to internalizing transactions through vertical integration. For example, arm's length contracting through the market may be expensive when one party to the transaction has assets specific to the transaction (i.e., assets that are sunk). As Klein, Crawford, and Alchain have noted, this situation creates incentives for trading partners of the firm with sunk assets to behave opportunistically. The potential for opportunistic behavior, in turn, raises costs of transacting due to contract writing costs, litigation expenses, and so forth.

To the extent these costs are incurred, they represent departures from technical efficiency. Given the input bundle employed, more output could be achieved if resources devoted to mitigating opportunism were redirected to other uses. Internalizing transactions through vertical integration creates common incentives at the stage of transfer and eliminates the problem. Cooperatives provide mutual vertical integration for their members, and, whereas cooperatives do not internalize transactions as such, they do *harmonize* interests between the transacting parties and, thereby, may diminish transactions costs of opportunism relative to what is achievable by a for-profit counterpart.

Another possible gain in technical efficiency relates to improved information flows in cooperatives. Staatz (1984) argues that, because cooperatives have an identifiable base of member-customers and because these customers are more likely to truthfully reveal information to their cooperative than to an investor-owned firm (IOF), cooperatives' cost of attaining information may be less than for a comparable IOF. For example, members may provide information on the types of products and services needed.

An Analysis and Critique of the Empirical Evidence

Testing the economic efficiency of cooperatives, especially relative to the performance of comparable for-profit firms, is difficult. The major problem in conducting tests based upon equations (1), (2), and (3) or (3′) is availability of data. Data on input quantities and costs and on output(s) are required for several cooperatives and, if they are to be studied also, investor-owned firms. Such data are generally confidential, and, moreover, most industries lack a sufficient universe of comparable cooperatives and for-profit firms to assemble a data set.

In the United States, the industry offering the greatest potential for analysis based on data availability has been dairy, and it has been the subject of most of the empirical efficiency studies conducted to date. These include Babb and Boynton; Porter and Scully; Parliament, Lerman, and Fulton; and Ferrier and Porter. Studies of agricultural cooperatives' efficiency outside of dairy include Hollas and Stansell on electrical utilities; Sexton, Wilson, and Wann and Caputo and Lynch on cotton ginning; Lerman and Parliament on fruit and vegetable processing; and Schrader et al. and Akridge and Hertel on grain marketing and farm supply procurement.[11]

In the dairy industry studies both Porter and Scully, using a statistical frontier production function approach, and Ferrier and Porter, analyzing the same data with a programming approach, concluded that cooperatives are comparatively less efficient than for-profit processors. They inferred that the cooperatives survive only through government subsidy. Babb and Boynton and Parliament, Lerman, and Fulton employed different analytical methods and reached opposite conclusions.

What sense can be made of these polar opinions? The Porter and Scully and Ferrier and Porter studies are based on a 1972 cross section of eighty-four dairy cooperatives and eighty-four randomly selected for-profit dairy processors aggregated by groups of three into twenty-eight composite observations for each organizational form. Criticisms of these studies begin with the data. Labor input was measured as production worker plant hours, but no plant-level wage data were available, so a national average wage rate was used. Manufacturing wages, however, differ considerably across states. Average weekly manufacturing wages in the United States for 1972 ranged from $112 in North Carolina and Arkansas to $211 in Michigan. Thus, unless the sample cooperative and noncooperative plants were distributed uniformly across high- and low-wage states, use of this average wage proxy introduces a bias into the relative efficiency calculations.

From Porter and Scully tables 1 and 2, the average labor-capital (L/K) ratio was higher for the sample cooperative plants than for the noncooperative plants. Stafford and Roof (table 4) report cooperatives' share of milk marketed in nine U.S. regions for 1973. Correlating these shares with the average 1972 manufacturing wage in each region yields a correlation coefficient of $r = -0.20$. In other words, cooperatives' market share was relatively greater in low-wage states in 1972–73. Therefore, cooperatives' relatively higher L/K ratios in these studies are consistent with cost minimizing behavior, given their higher incidence of operation in low-wage states, and do not support the authors' conclusion of allocative inefficiency.

Total assets was used as a proxy for capital input in both studies. Capital assets are valued at historical cost on financial statements, a number that normally bears little relation to actual capital input due to the effects of inflation, depreciation, and technical change. Moreover, total assets include accounts such as cash, inventories, accounts receivable, and land that bear no relation to investment of physical capital. To the extent that cooperatives for whatever reason have a higher proportion of these types of assets than noncooperatives, cooperatives' "capital input" as measured by Porter and Scully and Ferrier and Porter will be biased upward, creating an illusion of both technical and allocative inefficiency. Indeed, Parliament, Lerman, and Fulton present evidence suggesting this very circumstance. Cooperatives in their study maintained a consistently higher liquidity than comparable noncooperatives.

The Porter and Scully and Ferrier and Porter data are from firms in SIC 2026, a category that includes bulk fluid milk and cream, packaged fluid milk, cottage cheese, flavored milks such as chocolate milk and buttermilk, and other related products. However, physical outputs are not observed. Rather, value added is used as a proxy for output and, as such, encompasses an array of different products ranging from fluid milk to cottage cheese. A significant portion of the costs of producing and selling value-added products is for marketing and promotion. However, these costs are not measured by either study. As Parliament, Lerman, and Fulton and Stafford and Roof have noted, cooperatives operate most extensively in the low value-added, fluid milk segment of the industry. This fact alone will make the cooperatives appear to generate less "output" per unit of input (as inputs are measured in these studies) and thereby incorrectly be judged technically inefficient.[12]

A further criticism is the Porter and Scully and Ferrier and Porter studies' use of the scale efficiency concept. Scale inefficiencies are claimed to be the largest component of cooperatives' inefficiency, caused by the fact that cooperative plants in their sample were typically smaller than the for-profit plants.

Dairy markets are spatial markets, as these authors acknowledge. The spatial dimension is caused by geographically scattered production and relatively costly transportation. Optimal plant location in spatial industries involves balancing fewer plants and greater economies of size versus more plants and lower transportation costs. The more geographically scattered and less concentrated production is, the greater the number of relatively small plants that will be optimal.[13] These small plants will indeed have higher per-unit *processing* costs than larger plants, but they may minimize the *total* per-unit cost of handling the raw product, which includes both processing and transportation costs. Hauling costs, however, are not considered by Porter and Scully and Ferrier and Porter, and it is, therefore, incorrect to conclude that the smaller plants are scale inefficient.

A final criticism of these studies is their failure to consider explicitly that cooperatives often provide more ancillary services to their members such as field services, market information, insurance programs, and lobbying than do comparable noncooperatives (Babb and Boynton). These services do not contribute directly to value added but may be valued by members and may contribute to the production costs measured by Porter and Scully and Ferrier and Porter. To the extent this happens, it will contribute to an incorrect inference of cooperative inefficiency.

A reasonable conclusion is that the array of deficiencies in the Porter and Scully and Ferrier and Porter studies make them unreliable as a basis for formulating policy toward cooperatives. The Babb and Boynton and Parliament, Lerman, and Fulton studies both rely on simpler, nonparametric methods to compare cooperative and for-profit dairy processors' performance. Both studies were careful to avoid the geographic and product mix heterogeneity that hamstrung the Porter and Scully and Ferrier and Porter studies. Babb and Boynton focused exclusively on Wisconsin cheese plants,[14] and Parliament, Lerman, and Fulton compared regional dairy coops and noncoops of comparable size and product mix.

Babb and Boynton found no statistical difference in the price paid for milk between the two organization types. However, cooperatives were judged more efficient because they had a greater percentage of plant capacity utilization and exhibited lower labor and total cost per unit of product produced. However, even cooperatives' critics agree that *ex post* cooperatives may attain a comparable performance to noncooperatives. Arguably, this performance may be due to government support provided to the cooperatives. In turn, this criticism suggests the importance of analyzing efficiency in terms of the formal concepts defined above and a formal statistical or programming model.

The Parliament, Lerman, and Fulton study relies on the analysis of financial ratios and the comparison of these ratios between cooperative and for-profit firms. The study found that cooperative dairy processors achieved a comparable return on equity, had a generally lower debt-to-equity ratio, were more liquid, and achieved a higher sales-to-total-asset ratio relative to a peer group of for-profit processors.

These results are also subject to limitations. Although ratio analysis is a common tool in finance, the ratios usually lack a solid foundation in economic theory. Unlike the formal tests of efficiency conducted by Porter and Scully and Ferrier and Porter, it is difficult to lend a precise interpretation to the various ratios. Second, the ratios may be influenced to an unknown extent by public support for cooperatives, making the cooperatives' ratios more favorable than they would be in the absence of such support. Third, cooperatives and their members represent a joint, vertically integrated entity. Evaluating performance of the joint entity by examining data for only a portion of the entity (i.e., the cooperative subsidiary) will often be misleading. This criticism applies particularly to attempts to measure "profitability" and return on assets in the cooperative facility. Different outcomes can be attained here by merely shifting income, through choice of price charged to or paid to members, between stages of the vertically integrated entity.[15] This criticism does not apply to formal tests of efficiency of the cooperative plant based on equations (1), (2), and (3').

Despite these limitations, some of the Parliament, Lerman, and Fulton results do present credible evidence to counter the Porter and Scully and Ferrier and Porter results. The result that cooperatives achieved a higher sales-to-assets ratio on average is particularly important in this regard.

Among the nondairy applications, both Sexton, Wilson, and Wann and Hollas and Stansell applied Atkinson and Halvorsen's statistical model and both found some departures from efficiency for the cooperatives in their samples. Sexton, Wilson, and Wann rejected a test of price efficiency based upon equation (3′) but were unable to reject allocative efficiency based upon equation (2) for their sample of cooperative cotton gins in California. They also found no evidence to support a hypothesis that cooperatives underutilized capital inputs.[16] A limitation of this study was that no data on for-profit gins were generated to enable relative efficiency to be tested.

Hollas and Stansell's application to electrical utilities involved comparing for-profit and municipal utilities with cooperative utilities. The authors concluded that all three organizational forms failed tests for allocative and price efficiency, although for-profit utilities were relatively more efficient than cooperative or municipal utilities. Hollas and Stansell treated capital as a fixed input and, hence, were unable to test hypotheses concerning over- or underutilization of capital by cooperatives.

Neither Sexton, Wilson, and Wann nor Hollas and Stansell conducted formal tests for technical efficiency. Subsequent work by Caputo and Lynch using Farrell's programming methodology on the Sexton, Wilson, and Wann data pinpoints technical inefficiency as a major source of inefficiency for the ginning cooperatives. Again, no comparisons with for-profit gins were possible with this data set.

Akridge and Hertel employed a generalized translog multiproduct cost function to test for cost differences between cooperative and investor-owned farm supply firms. Formal tests based on equations (1)–(3′) were not conducted. Rather, a $\{0,1\}$ dummy variable was used to distinguish coop from noncoop observations in the cost and input share equations. Estimation results showed a small, statistically insignificant efficiency *advantage* to the cooperative firms. These results tended to affirm conclusions reached from previous analysis of the same data by Schrader et al.

Lerman and Parliament used financial ratio analysis to compare the performance of U.S. cooperative and investor-owned fruit and vegetable processors for 1976–87. The two organizational forms were found to perform similarly in the areas of return on equity and debt relative to equity, but the cooperatives exhibited lower sales to fixed assets and inventory turnover ratios. The cooperatives were also relatively less liquid. This study employed the same methodology and, hence, shares the same strengths and weaknesses of the Parliament, Lerman, and Fulton study.

Conclusions

Voluntarily organized cooperatives have played an important role in agriculture in the United States and other market-oriented economies. As more countries now move to align their economies in tune with market forces, the global role of this type of cooperative organization may expand. Therefore, research that evaluates the comparative strengths and weaknesses of the cooperative form of organization is important. This paper has surveyed and critiqued the research on one key facet of this evaluation: the relative economic efficiency of cooperative organizations. Based on the efficiency studies conducted to date, we conclude that there is little credible evidence to support the common perception of farmers and cooperative experts (Schrader et al. and Cain, Toensmeyer, and Ramsey) that investor-owned firms are more efficient than comparable cooperatives. Evidence to support a contrary perception is, however, also limited.

More research in this area is clearly needed. The ideal study should combine the careful sample selection procedures of Schrader et al.; Babb and Boynton; and Parliament, Lerman, and Fulton with the rigorous efficiency measures used by Porter and Scully and Ferrier and Porter. Implementing this type of study may require accessing data that are confidential or working with undesirable proxy variables. Because of these difficulties we are not sanguine that there will soon be definitive results on the important issue of relative cooperative efficiency. In the interim, however, it is important to recognize the limitations of the work done to date.

Notes

1. Efficiency issues are also a concern in worker or production cooperatives (also often called labor-managed firms). In many respects, however, these organizations present unique issues that do not facilitate a parallel treatment with agricultural marketing and supply cooperatives.

2. Surveys of cooperative theory by Sexton and also Staatz (1987) discuss this issue.

3. An issue arises as to whether marginal cost in equation (3) should be defined as a firm's actual marginal cost, in which case it may embody allocative inefficiency, or whether *MC* should be defined as efficient marginal cost based on equation (2). See Kumbhakar, Biswas, and Bailey for a further discussion on this point.

4. Horizontal summation of individual members' marginal cost curves is the correct way to derive the aggregate marginal cost of raw product to the cooperative for the plausible case when prices for inputs in the production of X_1 are exogenous to the members both as individuals and as a group.

5. These two concepts of scale efficiency can be reconciled through the notions of private versus social optimality. When a competitive firm satisfies the scale efficiency condition in equation (3), it is choosing the privately optimal level of output. When it chooses a level of output consistent with achieving unit cost AC^*, it is choosing a socially optimal output level in the sense of minimizing the resource cost associated with producing Q.

6. Ferrier and Porter and Caputo and Lynch suggest nonparametric tests of the efficiency estimates derived from the programming approach.

7. For example, Atkinson and Halvorsen show that regulated electrical utilities are biased toward overuse of capital due to Averch-Johnson effects.

8. Several methods can be employed to somewhat mitigate the horizon problem in cooperatives. Revolving fund plans with a short revolvement cycle or base capital plans with a short base period help to align ownership with benefits. Similarly, any mechanism that facilitates transfer of membership rights (for example, to heirs or buyers of the farm enterprise) may help members to capture the future income-earning potential of their investments in the cooperative. In practice, however, revolvement periods are often ten or more years and membership-transfer rights are

severely restricted, making the horizon problem a major issue for most agricultural cooperatives.

9. See Murray and also Staatz (1984). Because equity capital is not the residual claimant in a cooperative, usually receives little or no dividend, and is highly illiquid, members may be unwilling to supply equity capital to the cooperative, preferring instead to free ride on others' contributions.

10. For example, eligibility for protection under the Capper-Volstead Act and for certain income tax deductions requires U.S. cooperatives to limit nonmember business to no more than 50 percent of total business.

11. The ten studies cited in this paragraph illustrate the data availability problem in that they are based on only five independent data sets. Babb and Boynton, Schrader et al., and Akridge and Hertel all use data from a comprehensive study initiated in 1979. Parliament, Lerman, and Fulton and Lerman and Parliament are based on financial statement data generated from a survey of leading U.S. cooperatives. Porter and Scully and Ferrier and Porter rely on the same data set as do Sexton, Wilson, and Wann and Caputo and Lynch.

12. It is commonly agreed that the value-added segments of the dairy industry are its less competitive segments. Therefore, a portion of the "value added" in these segments may represent monopoly overcharges. Evidence on this point for cottage cheese is available from Haller. The average price for all brands of cottage cheese (coop and noncoop) in 1988 was $1.15 per pound. The average price for coop brands was $1.03 per pound. Several factors including monopoly power could contribute to explaining this price difference (the sample, however, was chosen to hold quality roughly constant). The key point for our purposes is that the lower coop prices contribute erroneously to their measured technical inefficiency under Porter and Scully's and Ferrier and Porter's value-added measure of output.

13. These isolated plants are more likely to be operated as cooperatives, *ceteris paribus*, because monopsony problems from patronizing a for-profit plant would be extreme in these settings.

14. The Babb and Boynton study is a component of the comprehensive analysis of comparative cooperative efficiency in several industries including dairy, grain and soybeans, fruit and vegetable processing, farm supply sales, and farm credit. The complete study is reported in Schrader et al.

15. This criticism is less important in industries where competitive pressures (for example, from creditors) cause cooperatives to behave similarly to their investor-owned competitors.

16. Rather, the evidence suggested absolute overutilization of capital, a result consistent with a hypothesis posed by Caves and Peterson. Akridge and Hertel's analysis of farm supply firms also revealed some evidence of overutilization of capital by cooperatives relative to investor-owned counterparts.

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