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Patronage Refunds, Producer Expectations, and Optimal Pricing by Agricultural Cooperatives

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This paper presents a dynamic model of a processing cooperative in which patronage refunds are taken into consideration by producers in making marketing decisions and by the cooperative in establishing pricing strategies. An adaptive expectations framework is used to represent the formation of producer expectations of patronage refunds. The model suggests that cooperatives can successfully distribute earnings to producers as patronage refunds while using prices as instruments for achieving and maintaining optimal output levels. This result challenges conventional ideas about cooperative market behavior and implies that public support for cooperatives should be based on empirical analysis rather than theoretical arguments alone.

Introduction

Patronage refunds are a quintessential feature of agricultural cooperatives. They are the primary means by which cooperatives return earnings to member producers according to use, a concept critical to the definition of a cooperative. In addition, patronage refunds allocated to members, but retained by the organization, are the largest source of equity capital for most cooperatives. Yet, despite the fundamental importance of patronage refunds, cooperative theorists have given little attention to explaining how they are taken into consideration by producers when making marketing and purchasing decisions and by cooperatives when establishing pricing strategies. The literature suggests that the existence of patronage refunds limits the ability of cooperatives to restrict producer output to optimal levels and that, as a consequence, cooperatives are unable to pursue objectives or exercise market power in the same manner as other firms. However, the validity of these conclusions is subject to challenge because they have been drawn in the absence of any model for explaining how patronage refunds are determined and how they affect producer behavior.

This paper presents a model of a processing cooperative in which the cooperative sets the raw product price it pays producers according to an objective and in

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a manner consistent with producer expectations of patronage refunds. The supply decisions of producers are based on the raw product price and the expected value of the per-unit patronage refund, the latter of which is determined within an adaptive expectations framework. The model suggests that, contrary to conventional thinking, cooperatives can successfully distribute surplus earnings to producers as patronage refunds while using prices as instruments for achieving and maintaining optimal output levels. This result has important market policy implications that are discussed. Although this paper focuses exclusively on marketing cooperatives, similar results would apply to farm supply associations.

Previous Research

Helmberger and Hoos (1962) made no mention of patronage refunds in their classic model of a marketing cooperative. They assumed that the objective of the cooperative is to maximize the raw product price for whatever quantity producers choose to supply.[1] Short-run equilibrium for the cooperative and producers occurs where the net return per unit of raw product processed equals the supply price. At equilibrium, the cooperative breaks even because payments to producers exhaust cooperative surplus.

Royer (1982) developed a model that gives explicit recognition to patronage refunds. Each year, the cooperative sets the current raw product price and allocates patronage refunds based on the previous year's business. Producers are assumed to maximize expected profit, including the present value of the expected patronage refunds, which are a function of actual patronage refunds in past years. The model differs from the Helmberger-Hoos model in two fundamental ways. First, price is not the sole means by which the cooperative distributes surplus. Because patronage refunds can be used to distribute surplus in excess of raw product price, the cooperative can use price as an instrument. Second, the cooperative is assumed to maximize producer profits, including patronage refunds. The optimum level of output occurs where the marginal revenue product of the raw product equals its marginal cost. Raw product supply is a function of the cash price and the expected patronage refund per unit. Producer expectations of a patronage refund would shift the supply curve, decreasing the cash price the cooperative must pay to ensure the optimal level of output. The model does not specify how current patronage refunds affect future expectations. Neither does it consider the interrelationships among price, cash and noncash patronage refunds, and the financial needs of the cooperative.

Conventional cooperative theory holds that the output level associated with maximization of producer profits is unstable and that the Helmberger-Hoos breakeven solution is the only stable solution, therefore making their objective the only one consistent with long-run equilibrium.[2] The argument is that at any output less than the breakeven level, receipt of patronage refunds will provide producers an incentive to expand output until it reaches the quantity at which the net return per unit equals the supply price.

To analyze these arguments, we present in figure 1 a model of a cooperative that processes a single raw product for which it faces an upward-sloping supply curve. We define net revenue as total revenue in the final product market less the total cost of processing and marketing the product, exclusive of the cost of the raw product. The net average revenue product (*NARP*) is net revenue divided by the quantity of raw product processed, and net marginal revenue product (*NMRP*) is the change in net revenue due to an incremental increase in the quantity of raw product. Marginal factor cost (*MFC*) is defined as the marginal cost of the raw product to the processor given the supply curve (*S*).

A profit-maximizing processor would set the raw product price at N_{Π} in order to operate at output level R_{Π}, the quantity at which net marginal revenue product equals marginal factor cost. Consequently, the processor would earn a surplus of $A_{\Pi} - N_{\Pi}$ per unit of raw product processed.[3] A processor that seeks to maximize producer profits, including patronage refunds, would set the raw product price at $N_{\Sigma\pi}$ in order to operate at $R_{\Sigma\pi}$, the level at which net marginal revenue product equals raw product price. The processor would earn a per-unit surplus of $A_{\Sigma\pi} - N_{\Sigma\pi}$ to be refunded to producers. A processor that pursues the Helmberger-Hoos objective of maximizing raw product price would set its price at N_b in order to operate at R_b, at which net average revenue product equals the price and cooperative surplus is zero.

According to conventional theory, a cooperative processor that seeks to maximize processor or producer profits will face a difficulty not encountered by noncooperative processors. This problem results from the distribution of per-unit surplus $A_{\Pi} - N_{\Pi}$ or $A_{\Sigma\pi} - N_{\Sigma\pi}$ as a patronage refund. Once producers expect to receive a patronage refund, they will have an incentive to increase their output beyond R_{Π} or $R_{\Sigma\pi}$. This expansion will continue until output reaches R_b, at which point producers no longer have an incentive to increase output because the raw product price equals the net average revenue product and patronage refunds are zero. Thus, despite whichever objective a cooperative pursues, distribution of the cooperative's surplus to producers on a patronage basis will eventually result in output at the breakeven level R_b.[4]

Only Cotterill (1987, 190–92) has presented a model to explain the process by which a cooperative tends toward this equilibrium. In the marketing analogue of his model, which is based on a simple lagged adjustment mechanism, raw product supplied is a function of the cash price plus the expected per-unit patronage re-

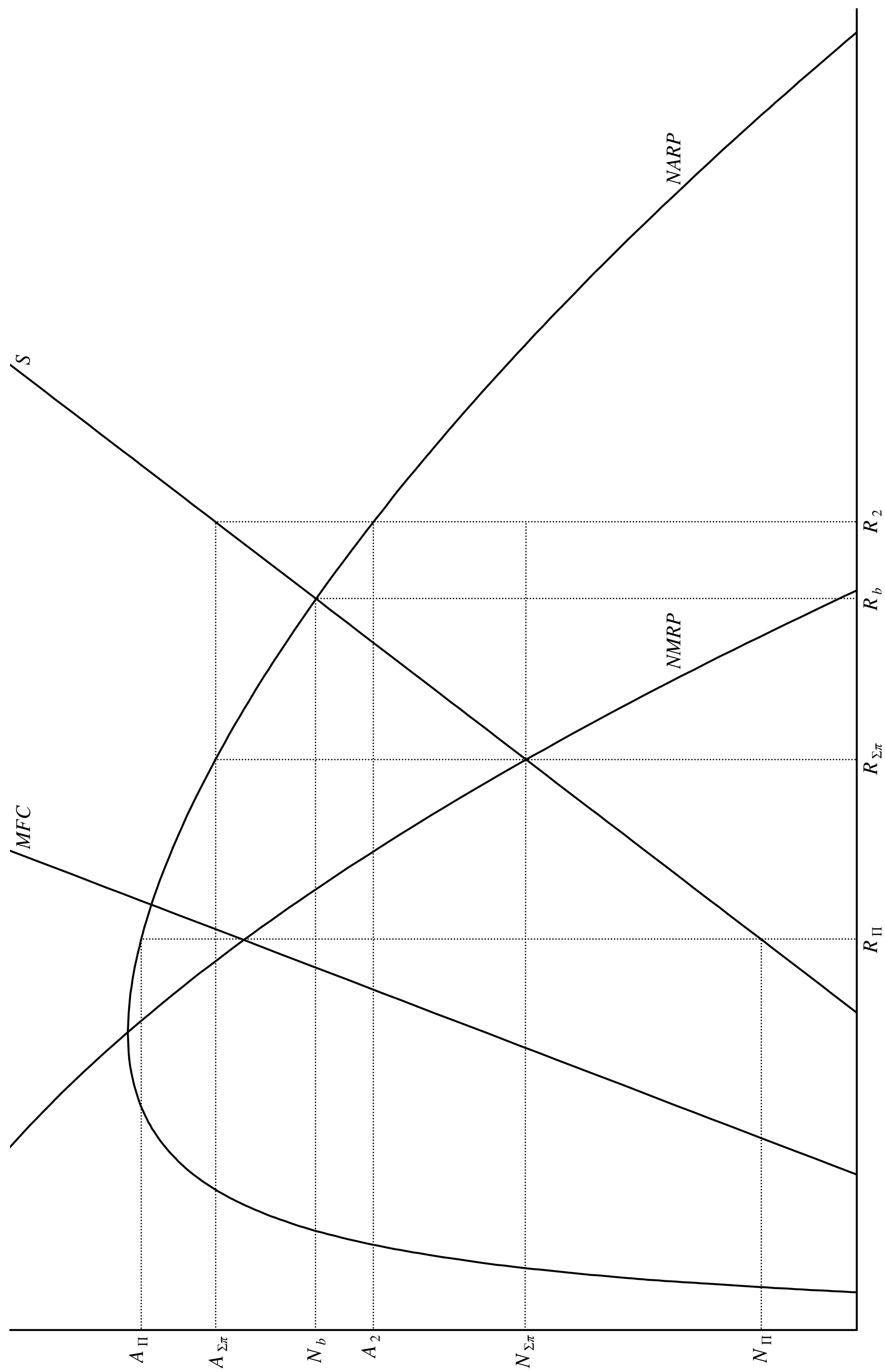

Figure 1. Price and output under alternative objectives for a processing firm

fund, which is defined as the actual refund in the preceding period. The cooperative seeks to maximize producer profits by offering the raw product price $N_{\sum\pi}$. Producers, at first not expecting a patronage refund, supply $R_{\sum\pi}$, which results in a per-unit surplus of $A_{\sum\pi} - N_{\sum\pi}$ that is distributed as a patronage refund. In the second period, the cooperative continues to offer a cash price of $N_{\sum\pi}$, but producers, now expecting a patronage refund of $A_{\sum\pi} - N_{\sum\pi}$, supply R_2 units of raw product. This oversupply reduces the per-unit surplus to $A_2 - N_{\sum\pi}$. Producers then adjust their expectation of the patronage refund and reduce supply. This adjustment process continues along a cobweb path until equilibrium is established at net price N_b and quantity R_b.

Cotterill's model is subject to the usual restriction inherent in cobweb models. Unless the net average revenue product curve has a smaller absolute slope than the supply curve, the net price and the quantity will not converge to their equilibrium values.[5] More importantly, the model depends on the unrealistic assumption that the processor maintains a constant price throughout the adjustment process.[6] We think it is more reasonable to expect the processor, when faced with oversupply relative to the quantity mandated by its objective, to lower the price it offers producers for the raw product.

Assume now that in the second period, the processor lowers the cash price to $2N_{\sum\pi} - A_{\sum\pi}$. Producers, expecting a per-unit patronage refund of $A_{\sum\pi} - N_{\sum\pi}$, will react to an expected net price of $N_{\sum\pi}$ by supplying the optimal quantity $R_{\sum\pi}$. The patronage refund for the second period will now be $2\left(A_{\sum\pi} - N_{\sum\pi}\right)$ because of the cost savings to the processor due to the lower cash price. In the next period, the cooperative must lower its price further to offset producer expectations of a larger patronage refund.

Obviously, this process cannot be continued indefinitely without achieving the counterintuitive result of producers paying the processor for accepting the raw product in order to receive an inordinate per-unit patronage refund. However, we shall demonstrate in the following section that a strategy based on this process can be used to restrict supply in a more realistic model that accounts for producer opportunity costs and the role of patronage refunds in processor financing.

Model

The cooperative operates a fixed processing plant and faces static final product demand and raw product supply curves. The raw product supply curve is assumed to be upward sloping, reflecting increasing marginal costs at the producer level and/or some degree of spatial monopsony.[7] The processor's net average revenue product curve is assumed to be declining, either because of a downward-sloping final product demand curve or increasing processing costs (Schmiesing 1989, 162–63).[8] For convenience and without loss of generality, we assume that one unit of final product is produced from each unit of raw product. Producers maintain a constant level of equity in the cooperative through a revolving fund consisting of retained patronage refunds. These refunds are redeemed in cash on a first-in/first-out basis according to a fixed-length revolving cycle.

On a given delivery date, producers provide raw product to the processor based on the cash price set by the processor and the expected value of the per-unit patronage refund, which is based on the value of the patronage refunds paid in previous periods. Later, at the end of its business year, the processor allocates its surplus to patrons as patronage refunds and redeems those retained patronage refunds scheduled for redemption. Current patronage refunds necessary for replacing those redeemed are retained, and the balance is paid to patrons in cash. Both cash and noncash patronage refunds are allocated to individual patrons in proportion to the quantity of raw product delivered earlier.

Producer expectations of patronage refunds are assumed to conform to the adaptive expectations model frequently used in econometric analyses (Judge et al. 1985, 379–80, and Pindyck and Rubinfeld 1998, 232–34). In our application of the model, the difference between the expected value of the per-unit patronage refund in the current period (S_t^*) and the expected value in the previous period (S_{t-1}^*) is assumed to be a proportion of the difference between the actual value in the previous period (S_{t-1}) and the expected value in the previous period:

$$S_t^* - S_{t-1}^* = \theta\left(S_{t-1} - S_{t-1}^*\right) \qquad 0 < \theta \leq 1 \tag{1}$$

where θ is the coefficient of expectations. Here it will be useful to express the model as

$$S_t^* = \theta S_{t-1} + (1-\theta) S_{t-1}^*, \tag{2}$$

which states that the expected value of the patronage refund in the current period is a weighted average of the actual value in the previous period and the expected value in the previous period. From (2), it is possible to derive

$$S_t^* = \theta \sum_{s=0}^{\infty} \left(1-\theta\right)^s S_{t-s-1}, \tag{3}$$

which shows that the expected value of the per-unit patronage refund can also be expressed as an average of all actual values observed in prior periods.[9]

The actual value of the per-unit patronage refund can be expressed as

$$S_t = \left[\frac{\alpha_t}{(1+r_1)^w} + \frac{1-\alpha_t}{(1+r_2)^{w+T}} \right] \left(\frac{\sigma_t}{R_t} \right) \qquad r_1, r_2 > 0;\ 0 < w < 1 \tag{4}$$

where α_t is the proportion of patronage refunds in period *t* paid in cash. The cash portion is discounted over period *w* using a short-term discount rate r_1. Period *w* extends from delivery of the raw product to allocation of the patronage refund, when the producer receives the cash portion from the processor. The noncash portion is discounted, using a long-term discount rate r_2, over period $w+T$, where T is the length of the cooperative's revolving cycle. The ratio σ_t / R_t represents the per-unit patronage refund, which is equal to the cooperative surplus divided by the quantity of raw product processed by the cooperative. Cooperative surplus is defined here as exclusive of payments to producers:

$$\sigma_t = P_t R_t - C_t - N_t R_t \tag{5}$$

where P_t is the price received by the processor for the final product, C_t is total processing cost, and N_t is the cash price paid the producers by the processor for the raw product in period *t*. The proportion of patronage refunds paid in cash is

$$\alpha_t = 1 - \frac{E}{\sigma_t T} \tag{6}$$

where *E* represents the producers' equity in the processing plant. The raw product supply function is assumed to be of the general form

$$R_t = R_t \left(N_t + S_t^* \right) \tag{7}$$

where raw product supplied is a function of the sum of the cash price offered by the processor and the expected value of the patronage refund.

We assume the cooperative sets the price it offers producers for the raw product in order to optimize a particular objective function. Because the following results are not limited to a particular objective, the objective function does not need to be specified at this point. It can be maximization of processor or producer profits, or any other objective that requires restriction of output to some optimal level less than the breakeven quantity. If we let *k* represent the net price for which producers supply the optimal quantity R_o, the cooperative will set the cash price at

$$N_t = k - S_t^*. \tag{8}$$

We will demonstrate that if the cooperative follows the pricing strategy represented by equation (8), equilibrium values for the raw product price and the per-unit patronage refund exist and the time paths for these variables converge toward those equilibrium values. We begin by advancing equation (2) one period:

$$S_{t+1}^{*} = \theta S_t + (1-\theta) S_t^{*}. \tag{9}$$

By substituting the relationships in equations (4), (5), (6), and (8) into equation (9) and replacing P_t and R_t with P_o and R_o, their values at the optimum, we can state (9) as a first-order difference equation of the form

$$S_{t+1}^{*} + aS_t^{*} = c \tag{10}$$

where a and c are constants.[10]

Solving (10) (Chiang and Wainwright 2005, 548–50), we derive the particular integral, which represents the intertemporal equilibrium for the variable S_t^{*}:

$$\overline{S} = \frac{1}{1-(1+r_1)^{w}} \left\{ k - P_o + \frac{1}{R_o} \left[C_o \left(1 - \frac{(1+r_1)^{w}}{(1+r_2)^{w+T}} \right) \frac{E}{T} \right] \right\}. \tag{11}$$

From equation (9), it is apparent that the variable S_t must also equal $\overline{S}$ at equilibrium for ΔS_{t+1}^{*} to equal zero. The characteristic root of equation (10) is

$$b = 1 - \left(1 - \frac{1}{(1+r_1)^{w}} \right) \theta. \tag{12}$$

The root will always be between zero and one given the restrictions on r_1, w, and θ. Thus S_t^{*} and S_t must converge toward the equilibrium value expressed by (11) in a nonoscillating manner (Chiang and Wainwright 2005, 551–54). Moreover, for reasonable values of r_1, the root will be close to one. Thus we would normally expect convergence toward equilibrium to occur relatively slowly. The time path of S_t^{*} is

$$S_t^{*} = \left(S_0^{*} - \overline{S} \right) b^{t} + \overline{S} \tag{13}$$

where $\overline{S}$ and b are determined by equations (11) and (12). By using equation (13) for S_t^{*} and making the appropriate substitutions, the time paths of N_t, S_t, and α_t, as well as other variables, can also be determined.

Hypothetical Illustration

To provide a numerical illustration of the model, we make the following assumptions. The processor faces a downward-sloping final product demand curve of the form

$$P_t = a_0 + a_1 R_t \qquad a_0 > 0;\ a_1 < 0. \tag{14}$$

Total processing costs take the linear form

$$C_t = c_0 + c_1 R_t \qquad c_0, c_1 > 0, \tag{15}$$

which implies constant marginal costs. In order to derive a linear supply function, we assume that total on-farm production costs take the quadratic form

$$F_t = \int_0^{R_t} \left(\frac{1}{f} R_t - \frac{e}{f} \right) dR_t = \frac{1}{2f} R_t^2 - \frac{e}{f} R_t + g \qquad e \le 0;\ f, g > 0 \tag{16}$$

where e and f are parameters and the constant of integration g represents fixed costs.

Producers maximize profits by setting the marginal cost of production equal to the cash price offered by the processor plus the expected per-unit patronage refund:

$$\frac{1}{f} R_t - \frac{e}{f} = N_t + S_t^*. \tag{17}$$

Solving (17) for R_t, the supply function facing the processor is

$$R_t = e + f\left(N_t + S_t^*\right). \tag{18}$$

Solutions of this problem for cooperatives maximizing processor profit, producer profits, and raw product price are presented in table 1 for the parameters listed at the foot of the table. As expected, the Helmberger-Hoos objective of maximizing raw product price results in the greatest output and the lowest final product price. Maximization of processor profit yields the lowest output and greatest final product price. Under the Helmberger-Hoos objective, there is no cooperative surplus for distribution to producers, and the solution is stable. In the other two cases, cooperative surplus exists, and the cooperatives must employ a pricing strategy in coordination with the distribution of surplus to maintain producer output at optimal levels.

The cooperatives can maintain output at optimal levels by adopting the decision rule in equation (8), i.e., setting the raw product price equal to the difference between the price in table 1 and the expected value of the per-unit patronage

Table 1. Solutions of hypothetical problem for three objectives

Maximand	Raw product processed	Final product price	Average net revenue product	Raw product price	Surplus per unit
	Units	($)			
Processor profit	466.67	17.67	11.43	8.67	2.77
Producer profits	700.00	16.50	11.68	11.00	0.68
Raw product	760.11	16.20	11.60	11.60	0.00

Parameters: $a_0 = 20$, $a_1 = -0.005$, $c_0 = 1{,}975$, $c_1 = 2$, $e = -400$, $f = 100$.

refund. We will demonstrate this strategy for the case of the cooperative that maximizes producer profits. Note, however, that this strategy is equally applicable to maintaining the level of output required for maximizing processor profit or any other desired level of output. Table 2 shows the results of this strategy for three scenarios over a five-year period given the parameters listed. The equilibrium values for N_t, S_t, S_t^*, and α_t are the same for all three scenarios, as are the equilibrium levels of cash and noncash patronage refunds (CPR_t and $NCPR_t$). Indeed, $NCPR_t$ is constant over time because of the constant stock of equity and the fixed revolving period.

In the first scenario, we assume that the initial expected value of the per-unit patronage refund is zero and that the coefficient of expectations is one, as in the Cotterill lagged adjustment model. In the second and third scenarios, we assume that some adjustment has already occurred and that the period begins with producers expecting patronage refunds. Specifically, we assume that the initial expected value of the patronage refund is three-fourths the equilibrium value. In the second scenario, we assume the coefficient of expectations is also one, but we set it at .5 in the third scenario, which implies that 97 percent of the information used in determining the expectation is contained within the previous five years.

In all three scenarios, the cooperative must lower the raw product price each year to maintain the optimal level of output. However, substantive changes in the variables are necessary only in the first scenario, which is based on extreme values for the initial expected value of the patronage refund and the coefficient of expectations.[11] In the second and third scenarios, the required adjustments in price and other variables are relatively small. Comparison of the last two scenarios demonstrates that a lower coefficient of expectations requires less adjustment in the raw product price but that this effect is relatively minor when a substantial amount of adjustment has already occurred.

Table 2. Equilibrium values and time paths for selected initial values and coefficients of adjustment

t	N_t	S_t	S_t^*	α_t	CPR_t	$NCPR_t$
			Equilibrium values			
	9.45	1.55	1.55	.71	1.59	0.64
			$S_0^* = 0, \theta = 1$			
0	11.00	0.07	0.00	.05	0.04	0.64
1	10.93	0.14	0.07	.14	0.11	0.64
2	10.86	0.21	0.14	.22	0.18	0.64
3	10.79	0.27	0.21	.27	0.24	0.64
4	10.73	0.33	0.27	.32	0.30	0.64
5	10.67	0.39	0.33	.36	0.36	0.64
			$S_0^* = .75\overline{S}, \theta = 1$			
0	9.84	1.18	1.16	.65	1.20	0.64
1	9.82	1.20	1.18	.65	1.22	0.64
2	9.80	1.21	1.20	.66	1.23	0.64
3	9.79	1.23	1.21	.66	1.25	0.64
4	9.77	1.24	1.23	.66	1.27	0.64
5	9.76	1.26	1.26	.67	1.28	0.64
			$S_0^* = .75\overline{S}, \theta = .5$			
0	9.84	1.18	1.16	.65	1.20	0.64
1	9.83	1.19	1.17	.65	1.21	0.64
2	9.82	1.20	1.18	.65	1.22	0.64
3	9.81	1.21	1.19	.66	1.22	0.64
4	9.80	1.21	1.20	.66	1.23	0.64
5	9.79	1.22	1.21	.66	1.24	0.64

Parameters: $E = 6,750$, $r_1 = 0.10$, $r_2 = 0.20$, $T = 15$, $w = 0.5$.

For each of the three scenarios, comparison of the final raw product price with the initial and equilibrium values shows that only a fraction of the adjustment toward equilibrium occurs by the end of the five-year period.[12] This result implies that the adjustment process cannot be completed within the short run. Changes in the structural parameters of the model would be expected to affect the prices paid by the cooperative before equilibrium is attained.

Implications

Public support for cooperatives is based largely on their perceived market behavior and the salutary effect they are expected to have on rival firms in concentrated markets. According to conventional thinking, cooperatives are unable to exercise market power because of the incentive patronage refunds provide producers to expand output beyond optimal levels and the inability of cooperatives to restrict it.[13] Consequently, cooperative processors operating in monopsonistic markets are generally expected to benefit both producers and consumers. Monopsony earnings of the cooperative flow to member producers, who respond by expanding output beyond what they would supply a profit-maximizing firm. Consumers benefit from greater quantities of final product at lower prices (Rhodes 1983, 1091–92). Expanded output by cooperatives is also expected to exert a procompetitive effect in oligopsonistic markets.[14]

The suggestion that cooperatives can use pricing strategies to pursue objectives and exercise market power in the same manner as other firms challenges the certainty of these conclusions. Maximization of processor or producer profits would decrease output and increase the final product price. In addition, the procompetitive effect on rival firms in an oligopsonistic market would be less (Sexton 1990, 717).

There is some justification for expecting cooperative behavior to be similar to that of other firms. Enke (1945) offered several reasons why cooperatives might choose to maximize processor profit. He argued that by maximizing its profits, a cooperative would increase funds available for patronage refunds or internal financing and would avoid hostility and retaliatory pricing by rival firms (149–50). Profit maximization could also become part of a cooperative's corporate culture through hiring managers from noncooperative firms or because it is the objective cooperative directors pursue in their individual farming operations. Conceptually, a profit-maximizing cooperative operating in a monopsonistic or oligopsonistic market would behave no differently than other firms under the same conditions.

The ability of cooperatives to pursue various objectives, including profit maximization, also implies that judgments about cooperative performance should not be made on the basis of theoretical arguments alone. If we allow for the possibility that a cooperative, in pursuit of some objective, might restrict output to a level below the breakeven quantity, we cannot conclude *a priori* that cooperatives will necessarily have a positive effect on markets. As a result, evaluation of cooperative performance and consequent decisions regarding public support for cooperatives should be based on empirical analyses that examine their actual behavior. The few empirical studies of cooperative behavior that have been conducted provide conflicting results with respect to the objectives cooperatives pursue.[15] However, there is evidence that some cooperatives have been successful in restricting output to levels necessary for pursuing objectives such as the maximization of processor or producer profits.

Notes

1. In a subsequent model, Helmberger (1964) assumed that the cooperative's objective is to maximize the per-unit net return to members and that the price members receive consists of a provisional (or market) price plus a per-unit patronage refund.

2. This notion is pervasive throughout the literature on cooperative theory. For explicit articulations, see Cotterill (1987, 190–92), Schmiesing (1989, 159–62), Staatz (1989, 4–5), and Buccola (1994, 437–38).

3. Here, and throughout the rest of this paper, surplus is defined as earnings at the processor level exclusive of payments to producers for the raw product based on the raw product cash price. This definition differs from that used by Helmberger and Hoos (1962). In their model, cooperative surplus is defined as payments to producers for the raw product. Consequently, surplus as defined here would be zero.

4. Other objectives, including maximization of producer returns per unit of raw product marketed and maximization of the per-unit patronage refund, are possible within this context. The conclusions presented in this paper relevant to maximizing processor and producer profits apply to these objectives as well. See Bateman, Edwards, and LeVay (1979) for a comparison of various objectives.

5. We note that this condition is violated in many of the diagrams used in the literature to argue that the breakeven solution is uniquely stable.

6. In addition, an attempt to construct a simple mathematical model of this process produces an insolvable nonlinear difference equation if there are fixed processing costs.

7. We make no distinction between open and restricted membership policies but conceive the supply curve to be simply a relationship between the raw product price and the quantity supplied the cooperative, regardless of whether it comes from current or new members. For discussion of the relationship between the slope of the net average revenue product curve and optimal membership policies, see Helmberger and Hoos (1962) or Cotterill (1997).

8. If the net average revenue product curve is relatively flat over the relevant range, the difference in output between maximization of producer profits and maximization of the raw product price may be minor. However, so long as the raw product supply curve is upward sloping, maximization of processor profit will result in a lower level of output.

9. The authors acknowledge various shortcomings of the adaptive expectations model. These include the existence of systematic forecasting errors, the fixity of the coefficient of expectations, and the exclusion of other variables in determining the forecast (Takayama 1993, 364). An alternative is to assume rational expectations on the part of the economic agents, an approach frequently taken in macroeconomic analyses (Scarth 1996). However, in the absence of stochastic error, the assumption of rational expectations implies perfect foresight by producers in this model, something we consider untenable and contrary to the assumptions generally made in the literature.

10. The constants a and c are respectively

$$a = \left(1 - \frac{1}{(1+r_1)^w}\right)\theta - 1$$

and

$$c = \left\{ \frac{1}{(1+r_1)^w} \left[\frac{1}{R_o}\left(\alpha - \frac{E}{T}\right) - k \right] + \frac{1}{(1+r_2)^{w+T}} \left[\frac{1}{R_o}\left(\frac{E}{T}\right)\right]\right\}\theta.$$

11. Note that under the first scenario, the proportion of patronage refunds paid in cash during each of the first two years is less than the 20 percent required by Subchapter T (sections 1381–88) of the Internal Revenue Code, which specifies the income tax treatment of cooperatives. Experiments with an alternative nonlinear programming formulation of the problem that takes this constraint into consideration indicated that only minor deviations from the optimum were necessary to satisfy the constraint and that the cooperative followed a similar time path toward equilibrium once the constraint became nonbinding.

12. The fraction of adjustment is 21 percent for both of the first two scenarios ($\theta = 1$) and 13 percent for the third ($\theta = .5$).

13. Several nonprice instruments for restricting output are potentially available. Lopez and Spreen (1985, 389) mention delivery quotas, processing rights, and penalty schemes in addition to allocating cooperative surplus to producers according to a criterion unrelated to patronage. Rhodes (1983, 1092) suggests that, contrary to the assumption of Helmberger and Hoos (1962), not all processors have an obligation to accept all the raw product producers choose to deliver.

14. As LeVay (1983) has observed, when the cooperative is a price taker in the final product market, the socially optimal level of output corresponds to maximization of producer profits. Output in the Helmberger-Hoos breakeven solution exceeds the socially optimal level because the value of the raw product input is greater than its derived demand. Nonetheless, presence of the cooperative in an oligopsonistic market could be expected to provide a net benefit to society because its conduct would induce rivals to increase their output to a level closer to that at which net marginal revenue product equals the raw product supply price (107–9). Sexton (1990) also has argued that cooperatives may have a procompetitive effect in oligopsonistic markets.

15. In an analysis of California cotton ginning cooperatives, Sexton, Wilson, and Wann (1989) concluded that their data suggested that the cooperatives operated near the maximum of the NARP curve, a result consistent with the objective of maximizing producer returns per unit of raw product marketed. That conclusion was challenged by Caputo and Lynch (1993), who applied different econometric procedures to the same data and found that the cooperatives were characterized by

technical inefficiency rather than allocative inefficiency, upon which Sexton, Wilson, and Wann had based their results. Featherstone and Rahman (1996) conducted an analysis of Midwestern farm supply and marketing cooperatives in which they concluded that there was strong support for the minimization of average cost and little support for profit maximization as the objective of the cooperatives. More recently, Boyle (2004), in a study of Irish dairy processing cooperatives, concluded that the rule those cooperatives used to price milk was based on the NMRP curve instead of the NARP curve, a finding consistent with an objective of maximizing either processor or producer profits.

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