Optimal Strategies of Marketing Cooperatives Regarding Nonmember Business

Jeffrey S. Royer and Holger Matthey
Department of Agricultural Economics
University of Nebraska-Lincoln
Lincoln, NE

1 Selected Paper, American Agricultural Economics Association Meetings, Nashville, TE, August 8 - 11, 1999.

2 Professor and Graduate Student, Department of Agricultural Economics, University of Nebraska.

Copyright 1999 by Jeffrey S. Royer and Holger Matthey. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.
Abstract

This paper analyzes the pricing and output decisions of a cooperative that purchases and processes an agricultural raw product from both member and nonmember producers. Because of the complexity of the optimality conditions, simulation analysis is used to demonstrate solutions for various scenarios under monopsony market structure.
This paper analyzes the interactions of a marketing cooperative with nonmember producers of agricultural raw products. A cooperative is a business firm owned by the users of the firm’s services (Buccola 1994, p. 431). The net revenue of the cooperative is returned to the cooperative’s members on the basis of their use. This paper focuses on marketing cooperatives that assemble, process, and sell farm products.

Figure 1 illustrates the cooperative’s optimization problem (Buccola 1994, p. 438).

![Figure 1: Alternative output levels of a cooperative](image)

A cooperative that controls members’ output reaches its optimal output at the point where the net marginal revenue (\(NMR\)) intersects the members’ supply function \(S\). The price paid to the members is \(P\). The difference between the price paid and the net average revenue (\(NAR\)) is the cooperative’s surplus. This surplus is returned to the members, raising the price received to the full price (\(FP\)). Helmberger (1969) argues that the cooperative is unable to set output at the income-maximizing level. In this model, the patronage refund raises the price received by the members from \(P\) to \(FP\), which induces members to increase their output to level \(X_1\). Through a dynamic adaptation process, members’ output converges to the equilibrium level \(X_e\), where \(NAR\) and \(S\) intersect. From the
perspective of member welfare this is the wrong signal because it results in overproduction and lower total welfare. Pareto optimality is reached at the output level $X_0$ if the cooperative is a price taker in the processed product market.

Issues of interaction of the cooperative with the market have been addressed by LeVay and, in greater detail, by Lopez and Spreen. The Lopez-Spreen model proposes a solution to the question of how much raw product the cooperative should trade with nonmembers. The main result of this model is that the members of the cooperative set their raw product quantity according to the market raw product price. If the market price equals the price defined by the intersection of the marginal net revenue curve and the supply function of the members, the cooperative has no incentive to interact with the open market. If that price is below the equilibrium price, the cooperative should buy from nonmembers. If the market price exceeds the equilibrium, the cooperative should sell part of its members’ raw product to the market. Assumptions critical to these results are that the cooperative pursues a single pricing strategy for all suppliers, the marginal surplus of the cooperative is equal from all sources, and members receive the average net revenue product as compensation for the raw product delivered.

Our model makes different assumptions about the market. We assume that the cooperative sets different prices for members and nonmembers. It may also set the processed product price. Before discussing nonmember business, it is useful to review cooperative production and pricing decisions using a simple model of a marketing cooperative. In this model, the cooperative processes and markets a single raw product purchased from members. Although we use a set of specific functions to derive numerical solutions, the derived results are generally applicable to any set of well-behaved functions.
Simple Cooperative Model

The price \( (P) \) the cooperative receives for the processed product is:

\[
P = a + bQ \quad \quad a > 0, \quad b \leq 0 \quad (1)
\]

where \( Q \) is the quantity produced. The total cost \( (C) \) of processing the raw product is:

\[
C = c + dQ \quad \quad c > 0, \quad d > 0 \quad (2)
\]

For simplicity, each unit of raw product is assumed to yield one unit of processed product. Alternative assumptions would complicate the analysis without enhancing the results.

The raw product \( (R) \) supplied by members is a function of the price \( (N) \) offered by the cooperative:

\[
R = e + fN \quad \quad e < 0, \quad f < 0 \quad (3)
\]

Thus the supply function for the raw product can be written:

\[
N = \frac{1}{f} \left[ R - \frac{e}{f} \right] \quad (4)
\]

Members are assumed to supply raw product at the level at which the price they receive equals the marginal cost of production. Thus equation \( (4) \) represents the marginal cost function. The total cost of production \( (F) \) can be expressed:

\[
F = \int_{0}^{R} \left[ \frac{1}{f} \left( R - \frac{e}{f} \right) \right] dR = \frac{1}{2f} R^2 - \frac{e}{f} R + g \quad (5)
\]
where the constant of integration \( g \) is fixed cost, which is an arbitrary value.

We identify three different objectives a cooperative can pursue. To illustrate these outcomes, we calculate a numerical example. The parameters used in the analysis are shown in Table 1.

1a. Cooperative Maximizes Profits

In the first case, the cooperative behaves like a profit-maximizing firm. It takes only the cooperative surplus into account. The objective function of the cooperative is:

\[
\pi = PQ - C - NR
\]  

This function is maximized with respect to the raw product price. The decision criterion to determine the price paid to members is:

\[
MNR = MIC
\]  

where \( MIC \) is the marginal input cost. This cost is the sum of the marginal processing cost and the marginal cost of purchasing the input from the members. The numerical results are shown in Table 2. The cooperative maximizes its profits, which are redistributed to the membership. Members receive a patronage refund of 4.85 in addition to the price of the raw product.

1b. Cooperative Maximizes Joint Welfare

Enke introduced a consumer cooperative objective function, which was applied to marketing cooperatives by Royer (1978, 1982) and argued by Ladd. This objective function aggregates the profits of the cooperative and its members into a joint objective function:
\[ L = PQ - C - F \]  \hspace{1cm} (8)

The cooperative is assumed to have direct control over the raw product quantity members produce. Therefore, we differentiate equation (8) with respect to the quantity of processed product, which yields the following first-order condition:

\[ NMR = N \]  \hspace{1cm} (9)

or net marginal revenue equals raw product price. In this case the cooperative acts like a fully integrated firm. The on-farm cost of the members are internalized. Members receive 2.07 in patronage refunds, raising the total price received by members to 13.07. The cooperative has to restrict members’ output to the optimal level, by disassociating the raw product price from the patronage refunds. Table 2 shows the optimal solution in the welfare maximizing case.

1c. Cooperative Maximizes Price Paid Members

Helmberger and Hoos, in their classic article, argued that a cooperative does not have direct control over members’ output quantity. Such a cooperative finds its equilibrium quantity where the member supply function intersects the NAR function of the cooperative. This type of cooperative does not have a distinct objective function. Instead it processes whatever quantities of the raw product members choose to deliver. The price of the raw product is derived from the behavioral condition, that members react to the sum of raw product price and patronage refund. Thus the price paid to members is:
Equation (10) can alternatively be expressed as:

\[ N = NAR \]  \hspace{1cm} (11)

This behavioral condition drives cooperative profit to zero. No patronage refund is paid. Members overproduce, compared to the previous case. To illustrate this solution, we calculated a numerical example given the parameter values presented in Table 1. Table 2 shows these results.

**Models of Cooperative with Nonmember Business**

If the cooperative is assumed to purchase raw product from both members and nonmembers, the raw product supply function represented by equation (3) is replaced by two equations:

\[ R_1 = e + fN_1 \hspace{1cm} e < 0, f > 0 \]  \hspace{1cm} (12)

and

\[ R_2 = h + lN_2 \hspace{1cm} h < 0, l > 0 \]  \hspace{1cm} (13)

where \( R_1 \) and \( R_2 \) respectively represent the quantity of raw product supplied by members and nonmembers, and \( N_1 \) and \( N_2 \) are the prices offered members and nonmembers by the cooperative.
2a. *Cooperative Maximizes Profits*

In this case, the cooperative treats members and nonmembers alike. The objective function of the cooperative reflects this:

\[ \pi = PQ - C - N_1R_1 - N_2R_2 \]  \hspace{1cm} (14)

The cooperative maximizes its profits with respect to the two raw product prices. It exercises its monopsony power in the member and nonmember market. The decision criteria to determine the prices paid to the suppliers of the raw product are:

\[ NMR = MFC_1 \]  \hspace{1cm} (15)

and

\[ NMR = MFC_2 \]  \hspace{1cm} (16)

Nonmembers receive only the raw product price. Members receive the rents that the cooperative earn as patronage refund. They get an additional 11.14 in patronage refunds. Table 2 shows the numerical solution in this case.

2b. *Cooperative Maximizes Joint Welfare*

The objective function of the cooperative is:

\[ L = PQ - C - N_2R_2 - F \]  \hspace{1cm} (17)
The cooperative has two control variables, \( N_1 \) and \( N_2 \). The decision criteria are derived by differentiating the objective function with respect to the two raw product prices that are offered to members and nonmembers. This differentiation produces two first-order conditions. From the conditions placed on equations (12) and (13) we see that neither \( \frac{\partial R_1}{\partial N_1} \) nor \( \frac{\partial R_2}{\partial N_2} \) is assumed to be zero. Thus the first-order conditions can be written:

\[
NMR = N_1 \quad (18)
\]

and

\[
NMR = MFC_2 \quad (19)
\]

\( MFC_2 \) represents the marginal factor cost of the raw product supplied by the nonmembers. This is equivalent to stating that for a maximum value of the objective function, the cooperative will produce the quantity of the processed product at which the marginal net revenue equals the price that it offers members for the raw product and the marginal factor cost of the raw product supplied by nonmembers.

Equations (18) and (19) can be solved for the optimal values of the prices offered members and nonmembers given the relationships presented by equations (1), (2), (12), and (13) and the values of the parameters. The optimal solutions for the prices offered members and nonmembers for the raw product are shown in Table 2. Again, nonmembers receive only the raw product price, while cooperative members get 5.91 per unit of raw product in addition to their price. The internalization of the on-farm cost of the members allows the cooperative to act like a partially
integrated firm. Only nonmember output is restricted to the monopsony level, while members produce at the competitive level.

2c. Cooperative Maximizes Price Paid to Members

The cooperative cannot maximize members welfare directly, because it does not control members raw product output. The nonmember business is used as an instrument to improve members welfare. The objective function cannot be maximized with respect to the member price. The first-order condition represented by equation (15) is replaced by the behavioral constraint:

$$N_1 = \frac{PQ - C - R_2N_2}{R_1}$$  \hspace{1cm} (20)

The member price $N_1$ is no longer a decision variable as it can be defined as a function of the parameters and $N_2$. The only control variable in this model is the nonmember price $N_2$. Differentiating the objective function with respect to the nonmember price gives the following first-order condition.

$$NMR = MFC_2$$  \hspace{1cm} (21)

Equation (21) states that the cooperative will set the nonmember price such that the net marginal revenue from the total processed product equals the marginal factor cost of the nonmember raw product. The behavioral constraint and the first-order condition define the optimal behavior of a cooperative that is unable to control members’ raw product quantity directly. The solutions of our
Comparison of Solutions

In the simple cooperative model, members receive the highest per-unit payments for their raw product if the cooperative maximizes only its profits. Members receive 13.52 per-unit. The cooperative behaves like a monopsonist and restricts output to 467 units. Even though per-unit payments are high, total payments to members are the lowest, the cooperative only purchases the monopsony quantity. If the cooperative maximizes the joint welfare of the cooperative and its members, total payments are maximized. In this case, payments to members are 13.07 per unit of the raw product. Members deliver 700 units of the raw product.

Cotterill and others have pointed out that this solution is unstable. If members expect to receive a patronage refund, they will increase output according to the supply function until the raw product price is equal to average net revenue and the patronage refund is zero. In this case, where the cooperative does not exercise any control over the quantity delivered by members, the per-unit payments are the lowest and production volume is at its maximum. The value of the cooperative objective function is less because members overproduce, increasing on-farm production costs beyond the incremental increase in net revenue.

A cooperative that purchases raw product from members and nonmembers and treats both suppliers alike, is paying identical prices to both parties. Such a cooperative employs the same amount of raw product as a simple cooperative that is maximizing joint welfare, but at a higher cost. Members produce only half of the total input and receive total per-unit payments of 18.64. The
monopsony rent that is extracted from the nonmembers is redistributed to members.

If the cooperative sets member and nonmember prices to maximize joint profits of the cooperative and its members, the members receive 15.51 per-unit of raw product. The cooperative sets the prices such that the member price $N_1$, the marginal factor cost for nonmembers raw product $MFC_2$, and the net marginal revenue $NMR_c$ all equal 9.60. According to the nonmember supply function $S_2$, marginal factor cost equals 9.60 at price $N_2$ of 6.80. The quantity produced by members $R_1$ is 560 units the nonmember quantity $R_2$ is 280 units. As the member welfare-maximizing cooperative purchases raw product from nonmembers, it reduces the member output by 140 units, compared to the simple cooperative model. At the level of 560 units member output, the marginal factor cost of the nonmember production is equal to the member price. It is efficient to replace member raw product by purchased product and extract monopsony profits. Compared to the simple model, the cooperative also increases the total output by 140 units, which decreases the final product price.

If the cooperative cannot control the production of its members, they use the extra payments from the nonmember business to increase their output further beyond the optimal level. Most of the extra profit from the nonmember business is eroded by inefficient additional member production. When the cooperative purchases raw product from members and nonmembers, members produce an additional 35 units and the cooperative purchases 169 units. Members’ per-unit profit increases only 0.18, compared to 3.14 in the member welfare maximizing case.
Table 1: Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept of demand function for processed product</td>
<td>a</td>
<td>20</td>
</tr>
<tr>
<td>Slope of demand function for processed product</td>
<td>b</td>
<td>-0.005</td>
</tr>
<tr>
<td>Fixed processing cost</td>
<td>c</td>
<td>1000</td>
</tr>
<tr>
<td>Marginal processing cost</td>
<td>d</td>
<td>2</td>
</tr>
<tr>
<td>Intercept of reciprocal of member product supply function</td>
<td>e</td>
<td>-400</td>
</tr>
<tr>
<td>Slope of reciprocal of member raw product supply function</td>
<td>f</td>
<td>100</td>
</tr>
<tr>
<td>Member fixed on-farm cost</td>
<td>g</td>
<td>0</td>
</tr>
<tr>
<td>Intercept of reciprocal of nonmember raw product supply function</td>
<td>h</td>
<td>-400</td>
</tr>
<tr>
<td>Slope of reciprocal of nonmember raw product supply function</td>
<td>l</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2: Summary of optimal Solutions

<table>
<thead>
<tr>
<th>Cases</th>
<th>Cooperative purchases only from members</th>
<th>Cooperative purchases from members and nonmembers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1a</td>
<td>1b</td>
</tr>
<tr>
<td>Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price processed product</td>
<td>17.67</td>
<td>16.50</td>
</tr>
<tr>
<td>Price member raw product</td>
<td>8.67</td>
<td>11.00</td>
</tr>
<tr>
<td>Price nonmember raw product</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Member quantity</td>
<td>466.67</td>
<td>700</td>
</tr>
<tr>
<td>Nonmember quantity</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Member welfare(^1)</td>
<td>3,355.56</td>
<td>3,900.00</td>
</tr>
<tr>
<td>Cooperative profit(^2)</td>
<td>2,267.67</td>
<td>1,450.00</td>
</tr>
<tr>
<td>Total member payments(^3)</td>
<td>6,311.11</td>
<td>9,150.00</td>
</tr>
<tr>
<td>Average net revenue</td>
<td>13.52</td>
<td>13.07</td>
</tr>
<tr>
<td>Marginal net revenue</td>
<td>13.33</td>
<td>11.00</td>
</tr>
</tbody>
</table>

\(^1\) \(L = PQ - C - N_2R_1 - F\)

\(^2\) \(\pi = PQ - C - N_1R_1 - N_2R_2\)

\(^3\) \(TMP = PQ - C - N_3R_2\)
References


