22186

1992

Cooperative Incentives for Vertical Integration: The Bilateral Monopoly Case

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Integration

AAEA 1992

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Abstract

A model for evaluating farmer cooperative incentives for integrating forward into processing activities is presented for the bilateral monopoly market structure. Analysis suggests that cooperatives lack an incentive to integrate unless they are successful in restricting producer output to optimal levels. This result provides an additional explanation for empirical observations.

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Farmer cooperatives are typically involved in first-stage marketing and food processing activities as a result of their role as vertical extensions of the farming operations of their members. As a result, the marketing and processing activities in which cooperatives participate are generally characterized by low margins and little market power. For most commodities, the amount of processing, value added, and product differentiation is greater in later stages. Considerable discussion has focused on explaining why cooperatives have not integrated forward into these stages to a greater extent (Caves and Petersen; Rogers and Marion). Explanations include the argument that cooperatives are not sufficiently capitalized to make the substantial investments in research and development and advertising necessary to be successful in processed markets.

Unfortunately, there is a lack of theoretical analysis of the incentives cooperatives may have for integrating forward into later processing stages despite its importance to cooperatives and their members. In this paper, we take a first step toward analyzing the problem by developing a model for evaluating the incentives cooperatives have for integrating forward from marketing to processing activities within the framework of a bilateral monopoly. Although we choose this structure because it is the simplest with which to begin, it has considerable appeal due its prevalence in some cooperative markets, particularly some dealing in perishable commodities such as milk, fruits, and vegetables. We analyze vertical integration by cooperatives under two sets of behavioral assumptions. In addition, we analyze integration by an investor-owned firm (IOF) as a benchmark for comparisons. Our results provide an additional explanation, based on market power, for the relatively low degree of integration by cooperatives.

Previous Research

Despite the attention given to bilateral monopoly in industrial organization literature, little analysis has focused on bilateral monopoly in the context of vertical integration decisions. The analysis that exists (e.g., Nicholls; Machlup and Taber; Wu; Warren-Boulton) is primarily descriptive. Many of the quantitative vertical integration models are based on the concept of successive monopoly (Sheldon, p. 8). These models assume "arm's length" pricing by the upstream monopoly, i.e., the downstream monopoly (or monopolies) accepts the price as parametric and exercises no monopsony power. Thus models based on this assumption ignore the possibility of dominance by the downstream monopoly-monopsony in the bilateral case. In our model, we consider dominance by both the monopolist and the monopsonist.

Model

We consider a bilateral monopoly consisting of an assembler and a processor. Producers (A) sell a single raw product to the assembler (B), which markets the product to the processor (C). The processor manufactures a finished product it sells to consumers. We assume that the assembler faces an upward-sloping raw product supply curve and the processor faces a downward-sloping final product demand curve. Both the assembler's cost of handling the raw product and the processor's cost of finishing it are constant. For ease of presentation, we assume that the processor produces one unit of final product from each unit of raw product. Although there is debate about the appropriateness of assuming fixed-proportions production technology (Sheldon, pp. 11-12), we do not consider the fixed-proportions assumption to be especially unrealistic in the context of agricultural commodities. In any case, the conclusions presented in this paper are qualitatively equivalent to those we have derived from a variable-proportions model based on a Cobb-Douglas production function.

The assembler is alternately assumed to be an IOF and a cooperative. The IOF assembler is used as a basis for comparing the incentives cooperatives have to integrate forward by acquiring the processor and the price and quantity effects that would result. The IOF and cooperative analyses are conducted for both the case of assembler dominance and the case of processor dominance. Although the price paid the assembler by the processor will depend on the relative bargaining power of the two parties, these solutions are useful in identifying the bounds for the price and quantity outcomes.

The cooperative analyses are conducted under two alternate behavioral assumptions. Under the first, the cooperative maximizes the joint profits of producers and the assembler by successfully satisfying the appropriate first-order condition. Under the second, the cooperative is passive in that it does not or cannot set the quantity of raw product it handles in order to maximize joint profits. Instead it accepts whatever quantity of output producers choose to market. The receipt of patronage refunds provides producers an incentive to expand output until it reaches the quantity at which the average net return equals the supply price (Cotterill, pp. 190-92; Schmiesing, pp. 159-62; or Staatz, pp. 4-5).

IOF Assembler: Assembler Dominance

The processor's profit function is

(1) $$\pi_C = p_C q - p_B q - kq$$

where p_i (i=A, B, or C) represents the price received by the producers, assembler, or processor and k is the per-unit processing cost. The processor exercises monopoly power in the final product market. However, because the assembler is dominant, the processor takes the price the assembler sets for the assembled raw product. Thus the processor's first-order condition for profit maximization is

(2) $$\frac{d\pi_C}{dq} = \left(p_C + q\frac{dp_C}{dq}\right) - p_B - k = 0.$$

Rearranging, we derive the processor's inverse factor demand function for the assembled raw product:

(3) $$p_B = MR_C - k.$$

The assembler is a monopsonist in the raw product market and a monopolist in the assembled product market. Its profit function is

(4) $$\pi_B = p_B q - p_A q - hq$$

where h is the per-unit handling cost. Because the assembler is dominant, it sets the price for the assembled product in order to maximize profit given the processor's demand function. Substituting the processor's inverse demand function (3) into (4), the assembler's profit function is rewritten

(5) $$\pi_B = MR_C q - p_A q - (h+k)q.$$

Thus the assembler's first-order condition for profit maximization is

(6) $$\frac{d\pi_B}{dq}=\frac{d(MR_Cq)}{dq}-\left(p_A+q\frac{dp_A}{dq}\right)-h-k=0.$$

This condition can be rewritten

(7) $$MFC_A+h=\frac{d(MR_Cq)}{dq}-k.$$

The dominant assembler maximizes profit when its marginal factor cost plus the per-unit handling cost equals the value marginal to the processor's marginal revenue function less the per-unit processing cost.

IOF Assembler: Processor Dominance

The assembler's profit function is (4). Because the processor is dominant, the assembler takes the price it receives for the assembled product as given while exercising monopsony power in the raw product market. Its first-order condition is

(8) $$\frac{d\pi_B}{dq}=p_B-\left(p_A+q\frac{dp_A}{dq}\right)-h=0.$$

From this, we derive the assembler's inverse factor supply function:

(9) $$p_B=MFC_A+h.$$

Substituting (9) into (1), the processor's profit function is

(10) $$\pi_C=p_Cq-MFC_Aq-(h+k)q.$$

The corresponding first-order condition is

(11) $$\frac{d\pi_C}{dq}=\left(p_C+q\frac{dp_C}{dq}\right)-\frac{d(MFC_Aq)}{dq}-h-k=0$$

and can be rewritten

(12) $$\frac{d(MFC_A q)}{dq}+h=MR_C-k.$$

The dominant processor maximizes profit when the value marginal to the assembler's marginal factor cost function plus the per-unit handling cost equals the processor's marginal revenue less the per-unit processing cost.

IOF Assembler: Post-Integration

If the assembler integrates forward by acquiring the processor, it will maximize the joint profits from assembling and processing the raw product:

(13) $$\pi_{BC}=p_C q-p_A q-(h+k)q.$$

The new firm is a monopsonist in the raw product market and a monopolist in the final product market. Thus its first-order condition for profit maximization is

(14) $$\frac{d\pi_{BC}}{dq}=\left(p_C+q\frac{dp_C}{dq}\right)-\left(p_A+q\frac{dq_A}{dq}\right)-h-k=0,$$

which can be rewritten

(15) $$MFC_A+h+k=MR_C.$$

The integrated firm maximizes profit when the sum of its marginal factor cost, the per-unit handling cost, and the per-unit processing cost equals its marginal revenue from the final product.

Active Cooperative Assembler: Assembler Dominance

Here we assume that the cooperative maximizes the joint profits of producers and the assembler:

(16) $$\pi_{AB}=p_B q-F-hq$$

where F is total on-farm production costs. Substituting the processor's inverse factor demand function (3) into (16), the cooperative assembler's objective function is rewritten

(17) $$\pi_{AB}=MR_C q-F-(h+k)q.$$

The corresponding first-order condition is

(18) $$\frac{d\pi_{AB}}{dq}=\frac{d(MR_C q)}{dq}-\frac{dF}{dq}-h-k=0$$

and can be rewritten

(19) $$MC_A+h=\frac{d(MR_C q)}{dq}-k.$$

The cooperative assembler maximizes the joint profits of producers and the assembler when the producers' marginal cost plus the per-unit handling cost equals the value marginal to the processor's marginal revenue function less the per-unit processing cost.

Active Cooperative Assembler: Processor Dominance

If the processor is dominant, the cooperative assembler takes the price set by the processor for the assembled product. Thus the first-order condition for maximization of the cooperative's objective function (16) is

(20) $$\frac{d\pi_{AB}}{dq}=p_B-\frac{dF}{dq}-h=0.$$

Rearranging, we derive the cooperative's inverse factor supply function:

(21) $$p_B=MC_A+h.$$

Substituting this into the processor's profit function (1), the latter is rewritten

(22) $$\pi_C=p_C q-MC_A q-(h+k)q.$$

The first-order condition for profit maximization is

(23) $$\frac{d\pi_C}{dq}=\left(p_C+q\frac{dp_C}{dq}\right)-\frac{d(MC_A q)}{dq}-h-k=0,$$

which can be rewritten

(24) $$MFC_A+h=MR_C-k.$$

The processor maximizes profit when the assembler's marginal factor cost plus the per-unit handling cost equals the processor's marginal revenue less the per-unit processing cost.

Active Cooperative Assembler: Post-Integration

If the cooperative assembler integrates forward by acquiring the processor, it will maximize the joint profits from producing, assembling, and processing the raw product:

(25) $$\pi_{ABC}=p_C q-F-(h+k)q.$$

The first-order condition for this objective is

(26) $$\frac{d\pi_{ABC}}{dq}=\left(p_C+q\frac{dp_C}{dq}\right)-\frac{dF}{dq}-h-k=0,$$

which can be rewritten

(27) $$MC_A+h+k=MR_C.$$

The cooperative maximizes the joint profits from producing, assembling, and processing the raw product when the sum of the producers' marginal cost, the per-unit handling cost, and the per-unit processing cost equals the marginal revenue from the final product.

Passive Cooperative Assembler: Assembler Dominance

Here we assume that the cooperative is passive in terms of accepting whatever quantity of output producers choose to market. Producers recognize the existence of patronage refunds and produce the quantity for which marginal cost equals the sum of the price and the per-unit patronage refund:

(28) $$MC_A=p_A+r.$$

The per-unit patronage refund equals the profit of the cooperative assembler divided by the quantity of raw product assembled:

(29)
$$r=\frac{p_B q-p_A q-hq}{q}$$
$$=p_B-p_A-h.$$

Substituting (29) into (28), we derive the cooperative's inverse factor supply function, which is identical to (21) for the active cooperative assembler under processor dominance. Setting (21) equal to the processor's inverse factor demand function (3), we derive the equilibrium solution:

(30)
$$MC_A+h=MR_C-k.$$

Equilibrium occurs at the quantity for which the marginal cost of producing and assembling the raw product equals the marginal revenue from the final product less the per-unit processing cost.

Passive Cooperative Assembler: Processor Dominance

Solution of the model is identical for a dominant processor regardless of whether it purchases the assembled product from a cooperative actively pursuing the joint profit function (16) or one that passively accepts whatever quantity of output producers choose to market. After substituting the cooperative's inverse factor supply function (21) into the processor's profit function (1), the latter is equivalent to (22), the profit function of a dominant processor that purchases from an active cooperative. The first-order condition is equivalent to (23), or alternatively (24).

Passive Cooperative Assembler: Post-Integration

If the passive cooperative assembler integrates forward by acquiring the processor, it will still accept whatever quantity of raw product producers choose to market. Producers again determine the quantity of raw product according to (28). However, the per-unit patronage refund is now

(31)
$$r=\frac{p_C q-p_A q-(h+k)q}{q}$$
$$=p_C-p_A-h-k.$$

Substituting (31) into (28) and rearranging, we derive the equilibrium solution:

(32) $$MC_A+h+k=p_C.$$

Equilibrium occurs at the quantity for which the marginal cost of producing, assembling, and processing the raw product equals the final product price. Because producers act according to the patronage refund and the cooperative passively accepts whatever quantity producers choose to market, the cooperative is unable to exercise market power in the final product market by acting as a monopolist.

Quantitative Solutions

To determine quantity, price, and profit solutions for each of preceding situations, we make the following additional assumptions. The processor faces a final product demand curve of the form

(33) $$p_C=a+bq \qquad a>0;\ b<0.$$

In order to derive a linear raw product supply curve, we assume total on-farm production costs take this form:

(34) $$F=\int_0^q\left(\frac{1}{f}q-\frac{e}{f}\right)dq=\frac{1}{2f}q^2-\frac{e}{f}q+g \qquad e\leq 0;\ f,\ g>0$$

where the constant of integration g represents fixed costs. The producer maximizes profit by setting the marginal cost of production equal to the price offered by the assembler:

(35) $$MC_A=\frac{dF}{dq}=\frac{1}{f}q-\frac{e}{f}=p_A.$$

For convenience, in the case of a passive cooperative, we set the price p_A such that the per-unit patronage refund r is zero. Solving (35) for q, the supply function facing the assembler is

(36) $$q=e+fp_A.$$

Solutions are presented in table 1 for the parameters listed. Although the parameters were chosen for illustrative purposes, our experience indicates that the qualitative conclusions based on the table are valid over a broad range of values.

Quantity, price, and profit levels differ according to the degree of market power exercised by the assembler and processor. In general, the cooperative assemblers produce more competitive results than the IOF. The cooperatives result in greater quantities of raw product marketed, higher prices for producers, and lower prices for the assembler and processor compared with the IOF.

Similarly, the results under processor dominance are generally more competitive than those under assembler dominance. However, the passive cooperative provides an exception to this conclusion. Because of the expansion of output by producers due to patronage refunds, assembler dominance by a passive cooperative results in greater output, higher producer prices, and lower consumer prices than processor dominance. Processor dominance of the passive cooperative assembler offsets the expansion of output due to patronage refunds, resulting in the same output and price levels as under processor dominance of the active cooperative assembler. Both of these solutions are identical to that of the IOF after integration.

In all cases, the quantity marketed is greater and the price paid by consumers is less after integration. Thus consumers are always better off as the result of integration. The price received by producers (both cash and net) is always greater as well. Thus it might appear that producers are always better off. Certainly, this is true in the IOF case. As a result of the IOF assembler's acquisition of the processor, producers produce more, they receive a higher price, and π_A increases. The joint profit π_{BC} of the integrated assembler-processor is greater than the combined profits of the assembler and processor prior to integration. Thus the IOF assembler has an incentive to integrate.

Assessing the benefits of integration is more complex when the assembler is a cooperative. In these cases, π_A increases, but the joint profit π_{BC} of the integrated assembler-processor is less than the combined profits of the assembler and the processor prior to integration. In the case of the active cooperative, the joint profit π_{ABC} of the producers and the assembler-processor is greater than the combined profits of the producers, assembler, and processor prior to integration. Thus the cooperative assembler would be able to pay the owners of the processing firm its capitalized value without making producers worse off than before.

However, in the case of the passive cooperative, the joint profit π_{ABC} after integration is less than the combined profits of the producers, assembler, and processor prior to integration. The cooperative assembler would not be able to pay the owners of the processing firm its capitalized value without making producers worse off. Thus, unless the cooperative can restrict the quantity of raw product it handles using some sort of delivery quota, processing right, or penalty scheme (Lopez and Spreen, p. 389), it has no incentive to integrate forward into processing.

Conclusions

We have examined the incentives for cooperatives to integrate forward into processing activities under both assembler-dominant and processor-dominant bilateral monopoly structures. The critical determinant of the incentive for cooperatives to integrate forward is whether they are successful in restricting producer output to optimal levels. If they are, integrating forward into the consumer market allows them to capture monopoly profits by setting the marginal cost of producing, assembling, and processing the commodity equal to marginal revenue in the final product market. If they are not successful in restricting producer output, they will behave like a competitive firm, operating where marginal cost equals final product price. Following the classic Helmberger and Hoos model of a marketing cooperative, cooperative theorists have argued that the receipt of patronage refunds provides producers an incentive to expand output. Under these circumstances, unless the cooperative can restrict the quantity of raw product it handles using a nonprice mechanism, it will have no incentive to integrate forward into processed markets. This result provides an additional explanation, based on market power, for the relatively low degree of cooperative forward integration.

Table 1. Quantity, Price, and Profit Solutions

	Investor-Owned Firm			Active Cooperative			Passive Cooperative		
	Assembler Dominance	Processor Dominance	Post-Integration	Assembler Dominance	Processor Dominance	Post-Integration	Assembler Dominance	Processor Dominance	Post-Integration
					Million				
q	10.36	11.15	16.11	12.08	16.11	20.71	20.71	16.11	32.22
					Dollars				
p_A	40.41	40.45	40.64	40.48	40.64	40.83	40.83	40.64	41.29
r				1.21	0.00	1.04	0.00	0.00	0.00
p_A+r				41.69	40.64	41.86	40.83	40.64	41.29
p_B	41.96	40.99		41.79	40.74		40.93	40.74	
p_C	44.48	44.44	44.19	44.40	44.19	43.96	43.96	44.19	43.39
					Million Dollars				
π_A	0.15	0.49	3.19	0.92	3.19	6.58	6.58	3.19	18.77
π_B	15.02	4.98		14.60	0.00		0.00	0.00	
π_C	5.36	16.17		7.30	23.36		21.45	23.36	
π_{AB}				15.52	3.19		6.58	3.19	
π_{BC}			23.36			21.45			0.00
π_{ABC}						28.04			18.77

Parameters: $a=45$, $b=-0.05$, $e=-1{,}000$, $f=25$, $g=2$, $h=0.1$, $k=2$.

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