NASH BARGAINING AND CO-OPERATIVES

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This paper develops the generalised Nash bargaining solution for a bargaining co-operative selling its output to a single buyer. Three assumptions for co-operative members' behaviour are examined: profit maximisation, co-operative surplus maximisation and maximising members' price. Solutions are compared and comparative statics presented for these alternative assumptions and the bargaining over price and quantity transacted. The most striking feature of the results is that pursuing the objective of maximising members' price does not necessarily lead to the highest members' price.

I. Introduction

There exists a body of literature on the neo-classical theory of supply and marketing co-operatives, see for example Helmberger and Hoos (1962), Ladd (1974) and LeVay (1983). In part, the literature focuses upon price and output solutions under varying market conditions and differing behavioural assumptions for co-operatives and their members. One circumstance which has received relatively little attention in the theoretical literature however, is the bilateral monopoly case where a co-operative bargains with a single trader over sale conditions. This paper attempts to fill this gap and seeks to provide a thorough theoretical examination of the bargaining co-operative.

In particular, we focus on bargaining co-operatives and associations which negotiate, on behalf of members, with a single buyer over the price and quantity for a good. The analysis of bilateral bargaining is motivated by proposed changes to the Australian Trade Practices Act which will make it easier for individual traders to legally form groups and collectively bargain with larger firms over sale conditions (Oczkowski, 2004). In Australia, legally authorised bargaining already occurs for sugar, milk, chicken meat, tobacco leaf and wine grapes (Oczkowski, 2004).

Co-operatives in Australian agriculture have a long history. In the early 1900s co-operatives were extensively employed for marketing and producing agricultural output. However, because of free-riding and other problems, statutory marketing authorities were established in the 1920s to effectively form 'compulsory co-operatives' (Piggott, 1990). Despite recent regulation changes dismantling various statutory marketing authorities, co-operatives of various forms still operate successfully in Australian agriculture for produce such as milk, rice, cotton and sugar (Wickremarachchi & Passey, 2003).

This paper utilises the generalised Nash bargaining solution for a bargaining co-operative selling its output to a single buyer. Unlike the neo-classical model of the firm where the profit maximisation objective dominates theoretical analysis, the neo-classical co-operative literature (Bateman, Edwards & LeVay, 1979), typically examines various solutions for differing behavioural assumptions about its members.

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In the next section we setup the theoretical framework by describing the relations between the co-operative and its members, and then outline the generalised Nash bargaining model. Section III examines the general case of price and quantity bargaining, comparing various solutions and outlining the comparative statics results. Section IV draws some conclusions.

II. Co-Operative Theoretical and Bargaining Framework

Bateman, Edwards and LeVay (1979) describe and compare the various behavioural assumptions which have been employed for developing theoretical models of co-operatives. The dominant body of literature stems from the seminal paper by Helmberger and Hoos (1962) who consider the marketing co-operative as one who processes raw farmer output and then sells the processed output to the market. In contrast, we abstract from processing co-operatives and assume that the co-operative acts only as a bargaining agent. This permits us to focus on issues relating to bargaining only and is consistent with many US and Australian agricultural bargaining co-operatives and associations (Iskow & Sexton, 1992; Oczkowski, 2004). Effectively members produce the output for which the co-operative negotiates sale conditions.

Following Helmberger and Hoos (1962) assume that the co-operative only exists for the members and hence makes no profit ($\Pi C = 0$). All of the co-operative surplus (CS) is returned to members ($CS = P_M Y$), where Y is output and P_M is the per-unit price returned to members[1]. The co-operative faces fixed bargaining costs (B) which members incur if negotiations reach agreement. Bargaining costs typically relate to the hiring of specific expertise to conduct negotiations and hence are unrelated with output. The comparative statics analysis which will be presented, investigates how changes in these costs impact on solutions.

With these assumptions define the co-operative's profit function as:

$$\Pi C = P_Y Y - B - P_M Y = 0 \tag{1}$$

where, P_Y is the market price for the output.

Define the co-operative's surplus function as:

$$CS = P_Y Y - B = P_M Y \tag{2}$$

which implies, $P_M = P_Y - (B/Y)$, that is, the members' price is the market price less the average bargaining cost.

Define the members' profit function as:

$$\Pi M = P_M Y - C(Y, W) = P_Y Y - B - C(Y, W) \tag{3}$$

where $C(Y, W)$ defines total production costs which depend on output and factor input prices W.

Define the processor's (buyer's) profit function as:

$$\Pi P = R(Y) - P_Y Y \tag{4}$$

where $R(Y)$ defines the processor's revenue function. We assume that the processor seeks to maximise profits.

[1] A list of all notation and definitions for variables appears in the appendix. All subscripts in this paper denote respective partial derivatives except for price, where the subscript distinguishes the market and member prices. The analysis assumes a passive co-operative and hence abstracts from issues relating to any possible conflicts between the co-operative and its members. Also, this paper abstracts from individual member differences and hence employs aggregate production quantities and average price returns for all members.

The alternative behavioural assumptions relate to co-operative members' behaviour. We consider three of the most common assumptions employed in the literature[2], see Bateman, Edwards and LeVay (1979) for a motivation for these assumptions: 1) maximise members' profits (ΠM); 2) maximise the co-operative surplus or members' total revenue (CS); 3) maximise the average per-unit return to members ($P_M = CS/Y$). In a broad sense, assuming the co-operative sells into a competitive market with a downward sloping demand curve, objective 3) produces the lowest output level but highest market price, objective 2) the highest output level and lowest price, while output and price fall in-between these extremes for objective 1). Effectively, maximising members' price is achieved by restricting output, while maximising co-operative surplus is a growth objective producing a larger output level and a consequent lower price.

In all subsequent models we make use of the generalised Nash bargaining model (Binmore, Rubinstein & Wolinsky, 1986). In addition to the standard axomatic foundation of the Nash (1950) program, solutions from the generalised framework are also consistent with various strategic models of bargaining with alternative offers (Rubinstein, 1982). In particular, asymmetric bargaining strengths are permitted and these can be related to players' traits such as their levels of risk aversion and impatience (Muthoo, 1999, chs 3–4).

For all bargaining models we assume the Nash disagreement point is a zero payoff for both the co-operative and processor[3]. The impasse point is the status quo, players will not trade if it makes them worse off given their objective. We assume that outside options, available during negotiations, are available but these are not attractive. That is, the outside options are worse positions than the Nash solution and hence will not constrain the Nash solution (Muthoo, 1999, ch 5). This latter recognition motivates the examination of bilateral bargaining even in the presence of other traders. In Australia, the Australian Competition and Consumer Commission (ACCC) has authorised collective bargaining on a regional or State basis for dairy and chicken meat, without any communication between bargaining groups (Oczkowski, 2004). In these circumstances bargaining can only occur between two agents and unattractive outside options have no impact on bargaining solutions.

III. Price and Quantity Bargaining

We consider the generalised Nash program for jointly determining the bargained output (Y) and price (P_Y) for the various behavioural assumptions of co-operative members. Assuming a zero

[2] Very little empirical literature exists on which optimisation objectives co-operatives actually pursue in practice. Traditionally, co-operatives were thought to maximise the co-operative surplus and this formed the basis of early theoretical models such as Helmberger and Hoos (1962). Recently, Boyle (2004) examined the behaviour of Irish dairy co-operatives and found that firms acted as if they were profit maximisers and that this statistically differed from maximising the co-operative surplus. Substantially more research into the empirical validity of the various objectives needs to be undertaken before definitive conclusions can be made about relative uptake of these objectives.

[3] This assumption implies zero costs for no trade, or no fixed costs. For the case of production costs we will employ long-run costs which assume the absence of any fixed factors. For the fixed bargaining costs, we assume that members' incur bargaining costs only if a trade is negotiated. Effectively the co-operative is not paid if it fails to reach agreement for members. An alternative is to assume a fixed bargaining cost differential of: $B = (B_1 - B_2) > 0$, with B_1 being the cost if agreement is reached and B_2 if disagreement occurs. On the other hand, if the same fixed bargaining cost is also incurred in the case of disagreement, then these costs will have no impact on bargaining outcomes. If the product to be traded is perishable then with either zero of B_2 bargaining costs in the case of disagreement, one expects the bargaining power of the co-operative to be diminished.

disagreement point and maximising members' profits (ΠM), the Nash bargaining program is to find optimal Y and P_Y for:

$$\text{Max } F = (\Pi M)^{\tau} (\Pi P)^{(1-\tau)} = \{Y(P_Y - ATC)\}^{\tau} \{Y(AR - P_Y)\}^{(1-\tau)} \tag{5}$$

where τ ($0 \leq \tau \leq 1$) measures the bargaining strength of the co-operative and $\tau = 0.5$ implies equal bargaining power. AR (= $R(Y)/Y$) is average revenue and ATC (= $\{B + C(Y, W)\}/Y$) is average total cost.

The solution to (5) is:

$$P_Y = \tau AR + (1 - \tau)ATC \quad \text{and} \quad P_M = \tau (AR - AB) + (1 - \tau)AC \tag{6}$$

$$Y = (AR - ATC)/(ATC_Y - AR_Y) \quad \text{or} \quad C_Y = R_Y \tag{7}$$

where, the Y subscripts on the cost and revenue variables denote partial derivatives with respect to Y.

The bargained price falls between an upper limit determined by the processor's average revenue and a lower limit determined by the co-operative's average total cost, the latter includes both bargaining and production costs. Price depends upon the bargaining strength of players. Transacted quantity occurs at the intersection of the marginal cost and marginal revenue curves. This is the standard bilateral monopoly solution, see for example Blair, Kaserman and Romano (1989).

As previously indicated the solution encapsulates Nash's (1950) axioms of Pareto-optimality, rational and fully knowledgeable players. The measure of the co-operative's bargaining strength (τ) however, can be related to some of the co-operative's relative (to the processor) traits. These predictions are based on game theoretic strategic models of bargaining. Some theoretical findings (Muthoo, 1999) include: the more patient the co-operative the higher the price; the more risk averse the co-operative the lower the price; if the co-operative makes the first offer price is higher; and bargaining strength is unaffected by the existence of less attractive outside voluntary outside trades.

If we next assume members wish to maximise the co-operative's surplus (CS) the program is to find optimal Y and P_Y for:

$$\text{Max } F = (CS)^{\tau} (\Pi P)^{(1-\tau)} = \{Y(P_Y - AB)\}^{\tau} \{Y(AR - P_Y)\}^{(1-\tau)} \tag{8}$$

where AB (= B/Y) is average bargaining cost.

The solution to (8) is:

$$P_Y = \tau AR + (1 - \tau)AB \quad \text{and} \quad P_M = \tau (AR - AB) \tag{9}$$

$$Y = (AR - AB)/(AB_Y - AR_Y) \quad \text{or} \quad R_Y = 0 \tag{10}$$

In this case average bargaining costs determine the lower limit, production costs play no role. Here members' price is equal to the proportion of the available per unit bargaining pie ($AR - AB$) going to the co-operative. Setting marginal revenue to zero determines quantity.

Finally, if we assume members wish to maximise average returns (P_M) the program is to find optimal Y and P_Y for:

$$\text{Max } F = (P_M)^{\tau} (\Pi P)^{(1-\tau)} = \{P_Y - AB\}^{\tau} \{Y(AR - P_Y)\}^{(1-\tau)} \tag{11}$$

with a solution of:

$$P_Y = \tau AR + (1 - \tau)AB \quad \text{and} \quad P_M = \tau (AR - AB) \tag{12}$$

$$Y = (1 - \tau)(AR - AB)/(AB_Y - AR_Y) \quad \text{or} \quad R_Y = \tau(AR - AB) \tag{13}$$

In this case $P_Y = R_Y + AB$ and $P_M = R_Y$. Interestingly, for maximising members' price, both the price and quantity depend upon the bargaining strength of players (τ). If $\tau = 0$ and no co-operative bargaining strength, then $R_Y = 0$ determines Y, and if $\tau = 1$ the co-operative has complete bargaining strength then no trade occurs $Y = 0$. In the latter case no trade occurs as the processor would incur a loss if it agreed to a positive trade.

Direct comparisons between the price and quantity solutions are not possible given that a general closed form solution for quantity does not exist for (7), (10) or (13). However, we will consider a specific functional form for costs and revenues, to illustrate a closed form quantity solution and to make comments about the relative positions of price and quantity solutions for the three alternative assumptions.

Consider the following quadratic forms for production costs and revenues:

$$C = c_0 Y + c_5 Y^2 \quad R = r_1 Y + r_2 Y^2 \tag{14}$$

$$\text{where, } c_0 = c_1 + c_2 w_1 + c_3 w_2 + c_4 w_1 w_2 + c_6 w_1^2 + c_7 w_2^2$$

It is assumed that there exist two normal factor inputs (w_1 and w_2) and given the other standard properties (see the appendix) of the cost and revenue functions we have: $c_0 > 0$, $c_4 > 0$, $c_5 > 0$, $c_6 < 0$, $c_7 < 0$, $r_1 > 0$, $r_2 < 0$. These functions imply linear average and marginal revenue and cost curves.

The closed form quantity solutions for equations (7), (10) and (13) respectively are: $Y(\Pi M) = (r_1 - c_0)/2(c_5 - r_2)$; $Y(CS) = -r_1/2r_2$ and $Y(P_M) = -(1 - \tau)r_1/2r_2$. Simple comparisons confirm that, $Y(CS) > Y(\Pi M)$ and $Y(CS) \geq Y(P_M)$, but the relation between $Y(\Pi M)$ and $Y(P_M)$ depends upon bargaining strength. At the extremes $\tau = 0 \Rightarrow Y(\Pi M) < Y(P_M)$ and $\tau = 1 \Rightarrow Y(\Pi M) > Y(P_M)$. Thus output is highest with maximising co-operative surplus, but is not necessarily lowest for maximising members' price, for very weak co-operative bargaining strength ($\tau \rightarrow 0$) output is lowest for profit maximisation.

For market prices and a given τ, $P_Y(CS) < P_Y(\Pi M)$ and $P_Y(CS) \leq P_Y(P_M)$, but again the relation between $P_Y(\Pi M)$ and $P_Y(P_M)$ depends upon bargaining strength. At the extremes $\tau = 0 \Rightarrow P_Y(\Pi M) > P_Y(P_M)$ and $\tau = 1 \Rightarrow P_Y(\Pi M) < P_Y(P_M)$. Thus market price is lowest with maximising co-operative surplus, but is not necessarily highest for maximising members' price, for very weak co-operative bargaining strength ($\tau \rightarrow 0$) market price is highest for profit maxi-misation. The relations between members' prices for the three solutions are the same as for market prices, that is, P_M is lowest for the maximising CS objective and the highest price depends upon bargaining strength, with high τ implying $P_M(P_M) > P_M(\Pi M)$ and low τ $P_M(P_M) < P_M(\Pi M)$.

For illustrative purposes we present the solutions graphically. Figure 1 depicts the output solutions and limits (P_U upper limit and P_L lower limit) for market price bargaining. The output solutions are consistent with $MC = MR$ for $Y(\Pi M)$ and $MR = 0$ for $Y(CS)$. The depicted circumstance assumes that τ is suitably low so that $Y(\Pi M) < Y(P_M)$. The upper and lower bargaining limits reflect: $P_Y(\Pi M) > P_Y(P_M) > P_Y(CS)$.

Figure 2 presents a comparison of market and members' prices for the three solutions for a given τ. The F functions are employed to depict the various price solutions: $F_1 = F_4 + AB + (1 - \tau)AC$, $F_2 = F_4 + AB$, $F_3 = F_4 + (1 - \tau)AC$ and $F_4 = \tau(AR - AB)$. F_1 determines $P_Y(\Pi M)$, F_2 determines $P_Y(CS)$ and $P_Y(P_M)$, F_3 determines $P_M(\Pi M)$, and F_4 determines $P_M(CS)$ and $P_M(P_M)$. Since $(1 - \tau)AC > 0$ and $AB > 0$, then F_1 is the highest curve, F_4 is the lowest curve and F_2 can be above or below F_3. Again the depicted circumstance assumes that τ is suitably low so that $Y(\Pi M) < Y(P_M)$ but here using equation (13), $Y(P_M)$ is determined by the intersection between MR and F_4.

In summary, for maximising members' profits, Y is determined by $MC = MR$ and F_1 and F_3, determine market and members' price respectively. For the co-operative surplus maximising

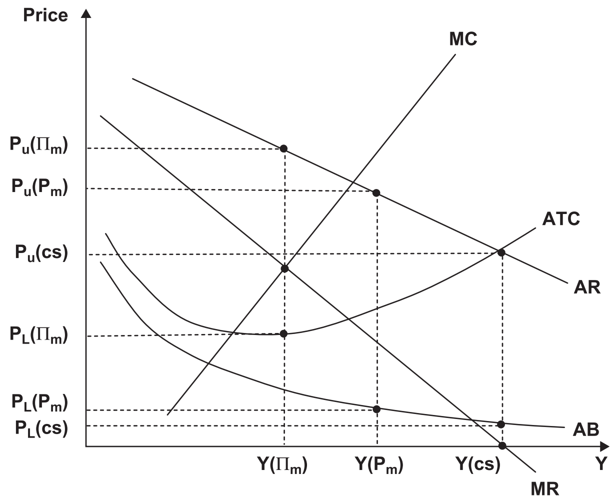

Figure 1. Price bargaining limits

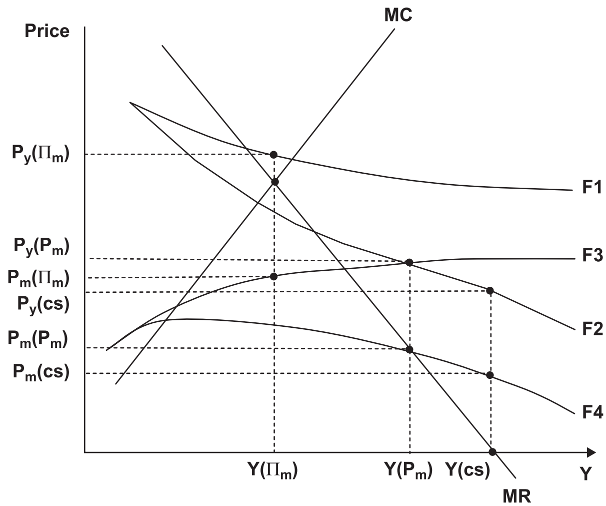

Figure 2. Bargaining market and member prices

objective, Y is determined by $MR = 0$ and F_2 and F_4, determine market and members' price respectively. For the members' price maximising objective, Y is determined by the intersection of MR and F_4, and F_2 and F_4, determine market and members' price respectively.[4]

[4] Figure 2 and the F functions can also be used to establish some of the relations between the solutions. Comparing the profit and surplus maximising objectives: since MR is downward sloping and MC is positive then $Y(\Pi M) < Y(CS)$, since F_3 lies above F_4 then $P_M(\Pi M) > P_M(CS)$ and since F_1 lies above F_2 then $P_Y(\Pi M) > P_Y(CS)$. Comparing the members' price and surplus maximising objectives: since MR is downward sloping and F_4 is positive then $Y(P_M) < Y(CS)$, since both F_2 and F_4 are downward sloping (from the first order conditions) then $P_M(P_M) > P_M(CS)$ and $P_Y(P_M) > P_Y(CS)$. Finally, for varying values of τ all the F functions shift (upwards for increasing τ) while MR and MC remain unchanged, this implies that the relations between output and prices for the profit and members' price maximising objectives depends upon bargaining strength.

We present in Table I the comparative statics for the key endogenous variables, ΠM, CS, Y, P_Y and P_M given changes in the exogenous variables, τ, B and W. Where possible, the signs for the partial derivatives have been provided. Increasing the bargaining strength of the co-operative, increases objective values and prices for all maximising objectives. For the maximising P_M objective, a higher τ reduces output. Interestingly, higher bargaining costs, decrease objective values and members' prices, but increase market prices for the ΠM and CS objectives. Effectively, the burden of higher bargaining costs is shared by co-operative members and the processor. However, for the P_M objective the impact of higher bargaining costs on market prices depends upon the level of bargaining costs with low costs ($B < (Y^2/\tau)R_{YY}(\tau - 1)$) leading to higher market prices. Conversely, for a high level of bargaining costs, increasing bargaining costs further reduces market prices. Higher bargaining costs increase output levels for the P_M objective only.

Changes in factor input prices only affect the profit maximising objective. Higher factor prices reduce members' profits and increase prices if bargaining strength is relatively high. Increasing W, leads to higher market prices if τ is such that $P_Y > C_Y$ and to higher members' prices if $P_Y > (C_Y + AB)$.

IV. Conclusion

This paper has analysed bargaining co-operatives' price and quantity solutions under alternative behavioural assumptions employing the generalised Nash bargaining solution. The most striking feature of the results relate to the objective of maximising members' average returns P_M. The bargaining strength of the co-operative impacts upon both output and prices for this objective. For this objective, higher bargaining strength reduces output, while higher bargaining costs increases output. Perversely, maximising members' prices does not necessarily lead to the highest average return to members. Only for high co-operative bargaining strength will pursing the maximising P_M objective lead to an average return to members higher than that produced by pursuing profit maximisation. These findings question the relevance of seeking to optimise members' prices as an objective for members facing a bilateral bargaining structure.

Only under the profit maximising objective do factor prices have any impact on prices and output levels. For all three objectives, higher bargaining costs reduce the value of each objective. In essence, the burden of both higher factor and bargaining costs are shared by co-operative members through lower returns and by the processor through higher market prices.

The level of prices for all objectives and quantity in the P_M maximising model, depend upon the co-operative's relative bargaining strength. Inferring from the results of strategic bargaining models, one probably expects this strength to be relatively low. Given the typical financial, physical and human resources of investor-owned firms such as large food processors and the relatively small resources of bargaining co-operatives, it is expected that members would be more impatient (less able to hold-out) in negotiations. Further there is a general expectation that individual sellers exhibit a relatively greater degree of risk aversion compared to the entrepreneurial focused investor-owned corporate processor. The consequences of a low τ are relatively low levels for co-operative objective values, and market and member prices.

In conclusion, it would be useful to pass comment on estimated values of bargaining strength for various markets. Unfortunately very few estimates of bargaining strength exist, the estimation of τ is particularly complex and hindered by data accessibility issues, see Griffith (2000) and Oczkowski (2004). The case of Australian milk farm-gate price deregulation illustrates

Table I Comparative statics for price and quantity bargaining models

Objective	τ	B	W
Max ΠM			
ΠM	$Y(AR - ATC) > 0$	$-\tau < 0$	$-\tau C_W < 0$
P_Y	$(AR - ATC) > 0$	$(1 - \tau)/Y > 0$	$\{(1 - \tau)C_W/Y\} + \{C_{YW}(P_Y - C_Y)/Y(C_{YY} - R_{YY})\}$
P_M	$(AR - ATC) > 0$	$-\tau/Y < 0$	$\{(1 - \tau)C_W/Y\} + \{C_{YW}(P_Y - C_Y - AB)/Y(C_{YY} - R_{YY})\}$
Y	0	0	$-C_{YW}/(C_{YY} - R_{YY}) < 0$
Max CS			
CS	$Y(AR - AB) > 0$	$-\tau < 0$	0
P_Y	$(AR - AB) > 0$	$(1 - \tau)/Y > 0$	0
P_M	$(AR - AB) > 0$	$-\tau/Y < 0$	0
Y	0	0	0
Max P_M			
P_M	$(AR - AB) + \{\tau(AR - AB)/J\} > 0$	$-(\tau/Y) - (\tau^2/YJ) < 0$	0
P_Y	$[(AR - AB)(-R_{YY} - AB_Y)]/[-R_{YY} - \tau(AB_Y - AR_Y)] > 0$	$[-R_{YY}(1 - \tau) + \tau AB_Y]/[J(1 - \tau)(AR - AB)]$	0
Y	$(AB - AR)/[-R_{YY} - \tau(AB_Y - AR_Y)] < 0$	$\tau/[J(1 - \tau)(AR - AB)] > 0$	0

where $J = \{-R_{YY} - \tau(AB_Y - AR_Y)\}/(AB_Y - AR_Y)$

some of the complexities. Since deregulation in July 2000, farm-gate milk prices have fallen significantly while retail prices have risen (Spencer, 2004). *Prima facie* this may provide evidence of a clear shift in bargaining strength away from farmers to processors. However, as argued by Spencer (2004) a whole series of factors, including processing and marketing costs, international prices, technological advances, may impact on changes in farm-gate retail price spreads. In the case of milk, the dynamic between retailers and processors further complicates matters. Spencer (2004) concludes that milk processors are not making super-normal profits and as such do not possess excessive market power over dairy farmers. This argument however, is presented within the environment where dairy farmers are forming groups to collectively negotiate with processors over prices (Oczkowski, 2004).

Appendix: model notation

Y:	total output of all members
P_Y:	unit price of output in the market
P_M:	unit price returned to members
ΠC:	co-operative profits
CS:	co-operative surplus
ΠM:	members' profits
B:	co-operative fixed bargaining costs
AB:	average bargaining costs: $AB = B/Y$
$C(Y, W)$:	members' production cost function, with input prices W
properties:	$MC = C_Y > 0$, $C_{YY} > 0$, $C_{YW} > 0$, $C_W > 0$, $C_{WW} > 0$, $C_{WY} > 0$.
AC:	average production costs: $AC = C/Y$
$TC(Y, W)$:	total cost: $TC = B + C$
ATC:	average total costs: $ATC = TC/Y$
$R(Y)$:	processor's revenue function, with $MR = R_Y > 0$, $R_{YY} < 0$.
ΠP:	processor's profit function

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