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**Cooperative Growth and Decline: A Game Theoretic Approach to Understanding
Members' Allocation Choices**

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by

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As numbers of agricultural cooperatives and memberships decline it is natural to question whether cooperatives are as competitive as other forms of agribusiness (Kraenzle et al.). A recent survey by Keeling (2004) finds that seventy-percent of respondents believed cooperative businesses were not as well managed as other agribusiness types. A slight majority (54%) of survey respondents also felt that co-ops were generally less successful than other agribusinesses.

Observed changes in the marketplace support the implication that cooperatives are indeed struggling. Inter-cooperative coordination costs have risen as members have become increasingly heterogeneous and cooperative opportunities and threats from abroad have grown as barriers to trade have declined. Not surprisingly, the role of managers and boards of directors in developing and pursuing competitive business plans has increased in complexity.

Some researchers suggest that it is not solely changes in the competitive environment that cause cooperatives stress but rather the nature of the traditional structure of cooperatives that limits their ability to adapt and survive in a volatile global marketplace. Specifically, Cook and Iliopoulos report that vaguely defined property rights are responsible for free-rider, horizon, portfolio, control, and influence problems. Cross and Buccola find that as markets become more competitive, traditional cooperative structures encourage lower investment and higher probability of bankruptcy than does an IOF. Keeling (2005) finds that board size may affect cooperative performance and that farm supply co-ops, in particular, are prone to having detrimentally large boards.

In this chapter, a complementary explanation for the struggles and failures of traditional cooperatives is developed. In particular, I explore a situation in which a partial-buyer cooperative and a monopsonistic IOF share a commodity market. An exogenous shock occurs that increases both firms'

processing costs. Cooperative processing costs may further increase if members leave the cooperative (Sexton). The first member to leave the cooperative will be that for whom the benefits from cooperative membership are less than from available alternatives and the perceived cost of processing his raw product is the lowest relative to other cooperative members (Sexton). As members leave the co-op, the firm's economies of size advantage decreases and additional members will find it more beneficial to leave the cooperative to seek out alternative processing arrangements.

The situation described above is analogous to a bank run but can also be described as a cooperative "death spiral" in which declining membership and increasing costs ultimately force a cooperative to close. The eventual failure of the cooperative may take several periods as members of the heterogeneous group of cooperators leave at different times. Circumstances surrounding the closure of the Rice Growers Association of California (RGA) closely resemble those described above. In particular, RGA's former managers witnessed the firm's largest growers (low cost producers) leave first and the smallest growers, representing roughly 5% of the total California volume, remaining until the cooperative closed.

The present investigation into cooperative growth and decline takes place in the context of a multi-period cooperative game, a potential improvement over static cooperative models. An agent's choice is modeled to be a function of an alternative investment opportunity, choices made by other agents who are faced with an identical set of possible strategies, and exogenous shocks that affect cooperative performance. Payoffs from cooperation will be modeled as functions of the number of members in the cooperative. Once an agent has made the decision to remain at the cooperative, the agent may re-evaluate alternatives in each period. The result is a multi-period repeated game in which the growth or decline of a cooperative is determined.

The proceeding pages begin with a discussion of various conditions for club and cooperative formation/dissolution. Next, a general methodological framework in which to study cooperative decline resulting from an exogenous shock is developed. After that, the post-shock environment is described. Finally, this chapter concludes with a summary of the research findings and discussion of potential applications.

Literature Review

Studies of cooperative formation and failure can trace their roots to pioneering investigations in club theory. Justifications for club formation have been based on a number of rationales; however, Tiebout and Wiseman were the first to investigate economies of scale as the primary basis for club creation. This rationale is frequently used to justify the existence of both marketing and farm supply type cooperatives. Similar to Tiebout and Wiseman, Olsen recognized that clubs would form to take advantage of scale economies but also distinguished between inclusive and exclusive clubs. These types of clubs are similar to the open and closed cooperatives that currently characterize the agribusiness environment. Cost reductions from team production and scale economies were also investigated by McGuire.

Game theory has assisted in the advancement of club and cooperative theory by aiding in the determination of optimal numbers of clubs, membership size, and organizational stability. John von Neumann and Oskar Morgenstern developed the concept of an n -person game, with respect to game theory, a population of size n is comprised of potential members and non-members for whom there are numbers of possible club formations. Within the game-theory framework, the concept of the core was developed. The core solution implies that “no individual or set of individuals can improve upon their

situation by forming a different partition (club)” (Sandler and Tschirhart). When the entire population is in the club, the core is stable and Pareto optimal as no individual or set of members will have an incentive to leave. This characterization of the solution evokes super-additivity of the benefit function which implies that clubs will only form when benefits from membership are strictly greater than the sum of benefits that would accrue to members if they acted individually (Pauly 1967).

The concept of the core as an equilibrium cooperative solution is explored in Sexton. This game theoretic investigation into cooperative formation reveals that members or potential members may have incentives to form or leave a cooperative based on assumptions about the nature of pricing schemes the cooperative employs. Members will remain in the cooperative so long as benefits from membership outweigh benefits from alternative investment opportunities. Similarly, Staatz finds that for cooperatives to attain stability and not induce member defections, the cost allocated to the cooperative group must be less than or equal to the cost that any subgroup of the cooperative can guarantee itself. This implies that a cooperative’s membership base is stable so long as each agent finds it more beneficial to be a member of the existing cooperative than to create a new cooperative out of a subgroup of members or seek alternative investment opportunities. An important finding from the above literature is that agent’s choices are interrelated, i.e. a member’s choice to leave or join a cooperative affects other agents’ choices to leave or join. It remains, however, to analyze cooperative change as a function of agent choice in a multi-period framework.

The bank run literature offers insight into the set up of a multi-period game. In particular, this literature has examined the multiple equilibria that may be attained as a result of potential and current members (investors) actions. Diamond and Dybvig demonstrate that agents playing a multi-period game may be influenced by an exogenous random variable such as stock market performance. In the case of

cooperatives, an exogenous random variable may influence firm performance leading to lower (higher) grower returns that result in membership defections (increases) and cooperative decline (growth).

Postlewaite and Vivies build on Diamond and Dybvig's model but argue that a unique equilibrium may be reached. In their model, an agent's choice to withdraw funds from a bank is based not on the need to consume, but rather on self-interest and is modeled as a Prisoner's Dilemma. Similar to other models, each agent's strategy is a best response to his conjecture about the behavior of the other agent and payoffs from each strategy are known with certainty.

The Mathematical Model

Following Sexton and Sexton, the inquiry begins in a market environment in which an incumbent monopsonist has allowed the entry of a cooperative competitor. Due to market stratification, the IOF is able to continue acting as a monopsonist after the partial-supplier cooperative has been formed. Thus the IOF will max profits according to the following equation:

$$\Pi_{IOF} = P(\eta \sum_i q_i) * Q_{IOF} - C(Q_{IOF}, \psi) \quad (1)$$

In (1) above, $P(\eta \sum_i q_i)$ is price the IOF receives for the processed product, $Q_{IOF} = \sum_i (1 - \alpha_i) q_i$ is the sum of producer deliveries the IOF, $\eta \sum_i q_i$ represents the total amount of processed product in the output market which is fully supplied by the IOF and the co-op, $C(Q_{IOF}, \psi)$ is the costs to the IOF to create the processed product, and ψ represents firm fixed costs of production. Using the above profit max equation, the IOF sets price according the following decision rule:

$$\frac{\partial P(\eta \sum_i q_i)}{\partial Q_{IOF}} - \frac{\partial C(Q_{IOF}, \psi)}{\partial Q_{IOF}} = 0 \quad (2)$$

Where, $\frac{\partial P(\eta \sum_i q_i)}{\partial Q_{IOF}}$ is equivalent to marginal revenue and $\frac{\partial C(Q_{IOF}, \psi)}{\partial Q_{IOF}}$ represents marginal cost.

Both the co-op and the IOF have market power in the processed good or output market. Any profits the co-op realizes from selling the processed good are returned to the co-op membership in the form of patronage dividends that are given in proportion to each member's use of the cooperative. The cooperative maximizes profits according to the following objective function:

$$\Pi_{coop} = P\left(\eta \sum_i q_i\right) * (\alpha_i q_i + Q_{-i}) - r * (\alpha_i q_i + Q_{-i}) - C(\alpha_i q_i + Q_{-i}, \beta) \quad (3)$$

Where $r * (\alpha_i q_i + Q_{-i})$ the cash price is paid to the cooperative's members upon delivery of their product to the cooperative, $C(\alpha_i q_i + Q_{-i}, \beta)$ is the cooperatives cost to produce the processed product, and β represents co-op fixed costs of production. The cooperative practices open membership and is unable to choose deliveries such that they equal the profit maximizing level. It is possible that by chance deliveries are expected to be optimal and this has some implications for producer_i's distribution choice.

Every cooperative member has the choice to supply the IOF or the cooperative or distribute his production between the two. Non-member producers may only supply the IOF. All producers grow a homogeneous product though producers themselves are heterogeneous and have different cost functions.

The farmer's profit max equation appears below:

$$\Pi_i = P_{IOF} * (1 - \alpha_i) q_i + r * \alpha_i q_i + f(\alpha_i, q_i, Q_{-i}) * (\Pi_{coop}) - c(q_i) \quad s.t. 0 \leq \alpha_i \leq 1 \quad (4)$$

Where $Q_{-i} = \sum_{j \neq i} \alpha_j q_j$ is farmer i's expectation on the sum of deliveries to the cooperative less farmer i's

delivery to the co-op, α_i represents the proportion of farmer i's total production that is delivered to the cooperative and $1 - \alpha_i$ is thus the proportion of farmer i's total production that is delivered to the IOF.

The per unit delivery price paid to the farmer by the co-op is r , while the IOF will pay P_{IOF} per each unit until farmer i delivers. The producer does not have bargaining power with the IOF and acts as a price taker. In addition, when farmer i supplies the cooperative, he will also receive a share of cooperative profits in proportion to his deliveries. Farmer i's share of co-op profits is represented by the function

$f(\alpha_i, q_i, Q_{-i}) = \frac{\alpha_i q_i}{(\alpha_i q_i + Q_{-i})}$ which is increasing in α_i and q_i and decreasing in Q_{-i} . Both the cooperative and

IOF have market power in the output market, $P\left(\eta \sum_i q_i\right)$ is the price the cooperative and IOF receive

for selling a unit of processed product in the output market and is a function of total production $\sum_i q_i$

multiplied by a transformation parameter that indicates the efficiency with which inputs are processed

into outputs, thus the output price, $P\left(\eta \sum_i q_i\right)$, is a function of input deliveries to the IOF, and to the co-

op. Once the Kuhn-Tucker constraints are added, the farmer's profit max function becomes the following constrained optimization problem:

$$L_i = P_{IOF} * (1 - \alpha_i) q_i + r * \alpha_i q_i + f(\alpha_i, q_i, Q_{-i}) (\Pi_{coop}) - c(q_i) + \lambda (1 - \alpha_i) - \delta (\alpha_i) \quad (5)$$

Due to the bounded non-negativity constraints we have cases:

Table 1: Complementary Slackness Conditions			
$\lambda=0, \delta=0$	$(1-\alpha_i)>0, \alpha_i >0$	Interior Solution, Both Co-op and IOF Deliveries	$0 < \alpha_i < 1$

$\lambda > 0, \delta = 0$	$(1 - \alpha_i) = 0, \alpha_i > 0$	Corner Solution, No IOF Deliveries	$\alpha_i = 1$
$\lambda > 0, \delta > 0$	$(1 - \alpha_i) > 0, \alpha_i = 0$	Corner Solution, No Cooperative Deliveries	$\alpha_i = 0$
$\lambda = 0, \delta > 0$	$(1 - \alpha_i) > 0, \alpha_i = 0$	Non-rational	

These complementary slackness conditions correspond to situations in which the marginal benefit from cooperating can be equated with the marginal benefit from supplying the IOF for some value of α_i , when the marginal benefit from cooperating is larger than supplying the IOF for every value of α_i less than one, and finally when the marginal benefit from cooperating is less than supplying the IOF for every value of α_i . In the proceeding sections producer_i's distribution decisions are analyzed in the context of these three cases.

The profit maximizing farmer will have two decision rules. The first decision is to choose the level of quantity produced, q_i such that profit is maximized. The producer's profit maximizing level of production is determined by setting the first derivative of the profit function with respect to q_i such that it is equal to zero. The following is the first characteristic equation.

$$\frac{\partial \Pi_i}{\partial q_i} = P_{IOF}(1 - \alpha_i) + r\alpha_i + \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial \Pi_{coop}}{\partial q_i} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial q_i} * \Pi_{coop} \right] - \frac{\partial c(q_i)}{\partial q_i} = 0 \quad (6)$$

This characteristic equation above sets the marginal cost of production equal to marginal revenue earned from supplying both the IOF and cooperative.

The farmer has an additional choice variable to determine, α_i the proportion of production farmer i will deliver to the co-op, hence there will be a second characteristic equation. The first step to determining the equation is to take the derivative of farmer i's profit function with respect to α_i . Since

the farmer is optimizing, this will set the marginal benefit from cooperation less the marginal benefit of delivering to the IOF, equal to zero, this is the second characteristic equation.

$$\frac{\partial \Pi_i}{\partial a_i} = -P_{IOF}q_i + rq_i + \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial \Pi_{coop}}{\partial a_i} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial a_i} * \Pi_{coop} \right] - \lambda - \delta = 0 \quad (7)$$

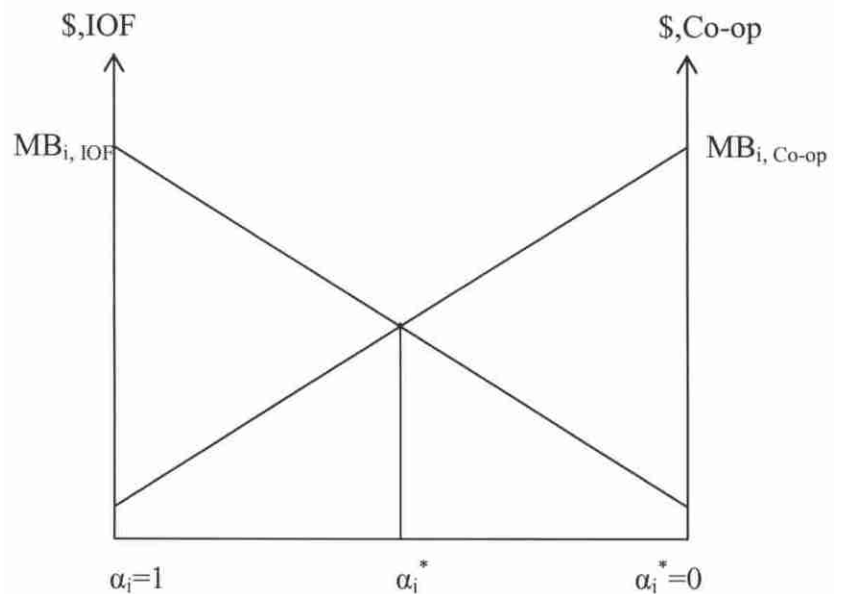
In the above equation, the IOF term is negative to indicate that there is a marginal opportunity cost associated with increasing the proportion of farmer i's deliveries to the cooperative. In the case of an interior solution, where farmer i divides his production between the IOF and cooperative, λ, δ , are equal to zero and drop out of the characteristic equation. The derivative terms can then be re-arranged as follows:

$$P_{IOF}q_i = rq_i + \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial \Pi_{coop}}{\partial a_i} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial a_i} * \Pi_{coop} \right] \quad (8)$$

$$MB_{i,IOF} = MB_{i,COOP} \quad (9)$$

The relationship where farmer i equates the marginal benefit of supplying the IOF and cooperative is represented graphically in the figure below.

Each farmer determines the optimal distribution of his production between the IOF and the cooperative by setting marginal benefit from supplying both equal to zero. Solving for α_i^* allows the producer to determine $(1 - \alpha_i^*)q_i$ and $\alpha_i^*q_i$, the optimal distribution of production



between the IOF and cooperative respectively.

In order to determine the mathematical nature of the relationship between α_i and q_i , producer_{*i*}'s endogenously determined choice variables, and Q_{-i} , the amount of production delivered to the cooperative by other producers, it is necessary to use the implicit function theorem (IFT). IFT will assist with determining the sign of $\frac{\partial \alpha_i}{\partial Q_{-i}}$, the primary comparative static of interest. This comparative statistic will help to understand how individual producer's decisions to allocate production to the cooperative are affected by the level of other producers' deliveries. After setting up the farmer's profit max equation and taking the derivative of the equation with respect to α_i and q_i , the next step in signing the comparative statistic is to take derivatives of the characteristic equations with respect to choice variables α_i and q_i .

Represented in general form below is the Jacobian matrix containing the first derivatives of the two characteristic equations. These derivatives are actually a matrix of second derivatives of producer_{*i*}'s profit equation.

Table 2: Jacobian Matrix of Two Characteristic Equations	
$\frac{\partial \Pi_i^2}{\partial q_i \partial q_i} = a_{11}$	$\frac{\partial \Pi_i^2}{\partial q_i \partial \alpha_i} = a_{21}$
$\frac{\partial \Pi_i^2}{\partial \alpha_i \partial q_i} = a_{12}$	$\frac{\partial \Pi_i^2}{\partial \alpha_i \partial \alpha_i} = a_{22}$

Element a_{11} describes the change in producer_{*i*}'s marginal revenue from cooperating less the change in marginal costs of production all with respect to a change in quantity produced. The derivative

of cooperative profit with respect to q_i and α_i , element a_{21} , describes how marginal revenue from supplying the cooperative and IOF will change with respect to a change in the proportion of production that producer_i distributes to the cooperative. The change in marginal revenue associated with the IOF is negative, indicating that this is a change in marginal opportunity cost. Applying Young's theorem to the mixed cross-partial derivatives in this problem implies that element a_{12} is equivalent to element a_{21} . This convenient result ensures that these derivatives are of the same value and sign although they are different derivatives from different functions. Element a_{22} gives an expression for the change in marginal benefit from cooperating with respect to a change in the proportion of farmer i's production that is delivered to the cooperative. Benefits from cooperating depend on cooperative profitability which in turn depends upon the level of supply delivered to the cooperative. If there is too much or too little supply, the cooperative may not be profitable and may provide fewer financial benefits to individual producers than could be accrued through delivering to the IOF. The influence of producer_i's delivery decision on the cooperative's profitability is in question and results in cases under which the signs of the above equations may vary.

In order to determine the sign on the primary comparative statistic of interest, $\frac{\partial \alpha_i}{\partial Q_{-i}}$, it is also necessary to sign the derivative of each characteristic equation with respect to Q_{-i} , the expected amount of other producer's deliveries to the cooperative. Because cooperative profits may be affected positively or negatively by the size of Q_{-i} , the sign on these expressions will again depend upon assumptions made about the level of total deliveries made to the cooperative relative to the optimal level of input. The derivative of equation (6) with respect to Q_{-i} describes the change in marginal revenue from cooperating with respect to changes in the expected deliveries of other producers to the co-op. There is

no change in the marginal revenue derived from supplying the IOF when Q_{-i} increases or decreases.

The change in marginal benefit to producer_i from cooperating with respect to Q_{-i} is evaluated as derivative of equation (7) with respect to Q_{-i} . For both derivatives, the impact of a change in Q_{-i} on cooperative profits and the producer's share of these profits will determine the rate of change in marginal revenue and marginal benefit for the individual producer.

In order to determine how producer_i's allocation of production changes when deliveries of other cooperators changes, each element of the Jacobian in addition to two mixed-partial derivatives taken with respect to Q_{-i} are signed under a variety of circumstances. Next, to determine the sign on the comparative statistic of interest, Cramer's Rule is used to divide the determinant of the modified Jacobian, in which the negative of the mixed partial derivatives with respect to Q_{-i} are substituted into the first column of the original Jacobian, by the original as shown in equation (10).

$$\frac{\partial \alpha_i}{\partial Q_{-i}} = \frac{\begin{vmatrix} \frac{\partial \Pi_i^2}{\partial q_i \partial Q_{-i}} & \frac{\partial \Pi_i^2}{\partial q_i \partial q_i} \\ \frac{\partial \Pi_i^2}{\partial \alpha_i \partial Q_{-i}} & \frac{\partial \Pi_i^2}{\partial \alpha_i \partial q_i} \end{vmatrix}}{\begin{vmatrix} \frac{\partial \Pi_i^2}{\partial q_i \partial q_i} & \frac{\partial \Pi_i^2}{\partial q_i \partial \alpha_i} \\ \frac{\partial \Pi_i^2}{\partial \alpha_i \partial q_i} & \frac{\partial \Pi_i^2}{\partial \alpha_i \partial \alpha_i} \end{vmatrix}} < 0 \quad (10)$$

Each element of the above partial and mixed-partial derivatives is signed, however, the sign on the derivative will vary based on assumptions about cooperative deliveries relative to the profit maximizing level, the size of patronage revenue relative to the delivery price, and in particular, the relative marginal benefits from supplying the cooperative versus the IOF. In the section below, the comparative statistic of interest is analyzed under different relative marginal benefit scenarios. I will first focus on the

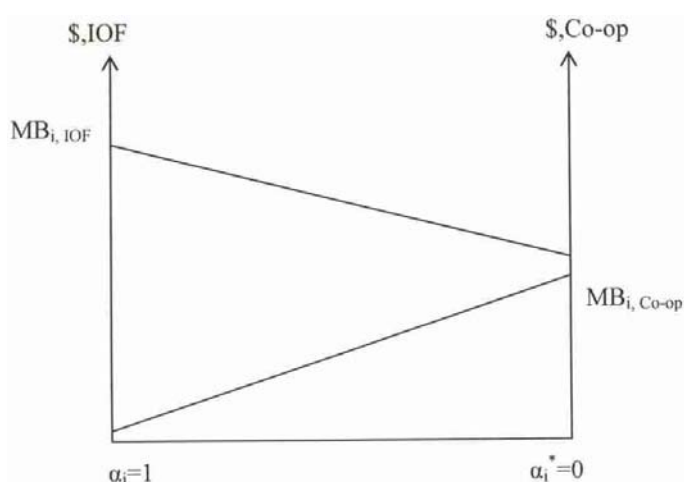
situation in which $\alpha_i = 0$, the second will look at when the producer distributes his production between the IOF and co-op and $0 < \alpha_i < 1$, and the final scenario will cover the situation when the optimal decision is to fully supply the cooperative and $\alpha_i = 1$.

Case 1: $MB_{i,IOF} > MB_{i,COOP}, \forall \alpha_i > 0, \alpha_i = 0$

In this case, the marginal benefit from supplying the IOF outweighs the benefits for supplying the cooperative at every allocation of the producer’s crop. This does not necessarily mean that cooperative profits are negative, simply that the combination of marginal benefits accruing to the producer from delivering to the cooperative plus the marginal benefits stemming from the patronage allocation are smaller than the benefits that can be derived from distributing solely to the IOF.

When cooperative profits are negative there are two circumstances in which $\alpha_i = 0$. For example, if a loss is passed onto the producer and his share of the loss is greater than the revenue earned from his initial delivery to the cooperative, revenue from supplying the cooperative will be negative. Certainly, if the cooperative is passing on losses to producers that offset the positive initial delivery payment, no producer will supply the cooperative as doing so will incur a loss.

Another situation may arise when the producer’s initial co-op delivery payment is sufficient to offset the producer’s share of cooperative losses. Even if total benefits from cooperating are positive, though likely small, the producer may still have no incentive to supply the co-op as the marginal benefit



from supplying the IOF may dominate marginal benefits from cooperating for every positive value of α_i . When cooperative profits are negative but

total benefits from cooperating are positive, the producer may have an incentive to partially supply the cooperative. This situation is similar to one observed at the Rice Grower's Association cooperative in 1985. When the cooperative issued bills to members instead of an expected progress payment, the following year many producer's reduced their deliveries to the cooperative or simply terminated their membership. Those that fully or partially supplied the co-op did so because the marginal benefits at their chosen level of patronage were equivalent to the perceived marginal benefits from supplying alternative organizations. This situation is described in more detail in the next section.

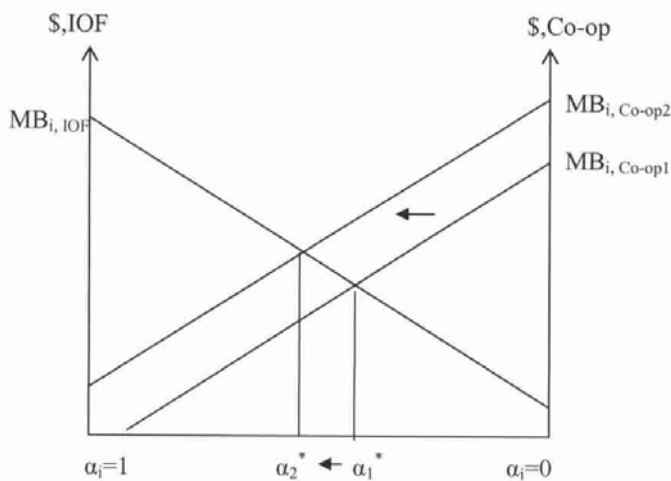
No deliveries to the co-op may be observed even when cooperative profit is positive. In this case the producer would earn positive revenues from the co-op delivery payment and from his patronage refund (share of the positive cooperative profits). However, the producer does not supply the cooperative as marginal benefits from supplying the IOF are larger for every allocation of his production. This situation is represented graphically at left.

In all three of these cases in which $\alpha_i = 0$, the effect of an increase in expected cooperative deliveries by other producers, Q_{-i} , will depend upon the value of relaxing the Kuhn-Tucker non-negativity constraint, λ . When benefits from cooperating increase with additional expected supply, an allocation of producer_i's production to the co-op may exist such that $MB_{i,IOF}$ can be equated with the $MB_{i,COOP}$. In this instance, the sign on the comparative statistic of interest will be positive, $\frac{\partial \alpha_i}{\partial Q_{-i}} > 0$. However, if the benefit of relaxing the Kuhn-Tucker constraint is zero or negative and does not increase producer_i's marginal benefit from cooperating, then there will be no change in α_i and $\frac{\partial \alpha_i}{\partial Q_{-i}} = 0$.

Case 2: $MB_{i,IOF} = MB_{i,COOP}, 0 < \alpha_i < 1$

This is perhaps the most interesting case as there are numerous situations in which the producer will choose to distribute his production between both the IOF and co-op. This case is also perhaps the most complex as there are a number of scenarios in which the producer's allocation to the cooperative could increase or decrease as a result of changes in expected deliveries to the cooperative. The producer's decision to allocate more of less of his production to the cooperative is dictated by the need to equate the marginal benefit from supplying the cooperative with the marginal benefit of supplying the cooperative. The marginal benefit accruing to the producer from delivering to the IOF is known with certainty, however, the marginal benefits from delivering to the cooperative will depend on profitability and the producer's share of profits (or losses).

The cooperative operates under the traditional principle of open membership and unlimited



member deliveries, as such the cooperative has little control over the amount of inputs it will receive and then process into products to be sold in the output market. Depending on patronage levels, the cooperative may be operating at different profitability levels. When cooperative deliveries are less than optimal, $MR_{co-op} < MC_{co-op}$, increasing Q_{-i} will boost cooperative profits (or reduce losses).

The figure above represents the case when marginal benefits from cooperating grow (or become positive) when Q_{-i} and when the marginal benefits from supplying the IOF and co-op are equitable, a positive α_i exist and $\frac{\partial \alpha_i}{\partial Q_{-i}} > 0$.

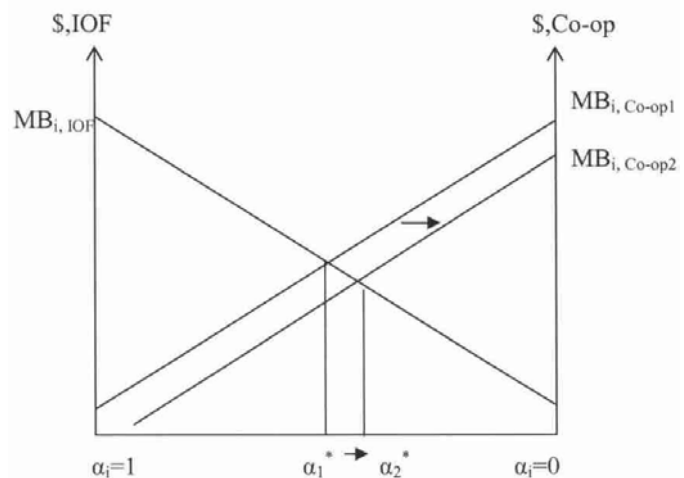
Due to the concavity of the cooperative profit function, increases in Q_{-i} that result in input supply that is above optimal will lead to decreases in co-operative profits. If the co-op was very close to having an optimal level of inputs and only a small increase in supply results from a change in Q_{-i} then the effect on profitability may be quite small and serve only to slightly reduce producer_i's marginal benefits and hence allocation of production to the co-op, $\frac{\partial \alpha_i}{\partial Q_{-i}} < 0$.

Because the cooperative profit function is concave in total deliveries, it is known that additional deliveries beyond the optimal level will decrease profits at an increasing rate. As such, if an increase in Q_{-i} occurs when deliveries were already projected to be significantly above optimal, expected profits will decrease by more than when delivery levels are close to the profit maximizing level. Furthermore, producer_i's relative share of profits will

decrease, assuming profits are positive this further reduces benefits from cooperating and decreases the individual producer's profit maximizing allocation of production,

$\frac{\partial \alpha_i}{\partial Q_{-i}} < 0$. Both situations in which

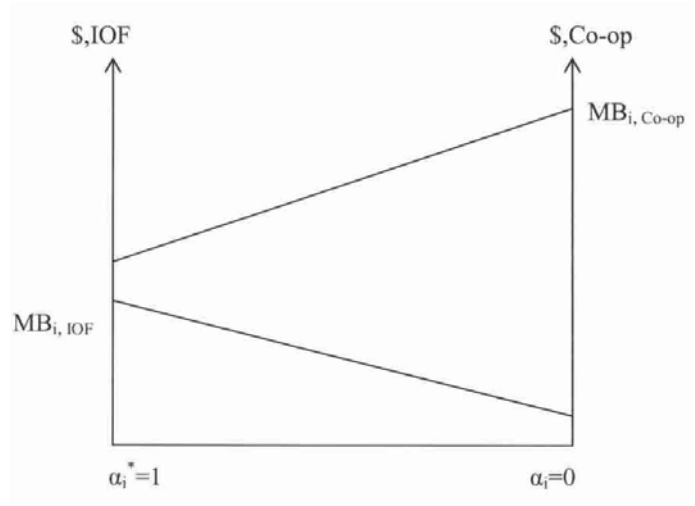
producer_i's allocation of production decreases



with increased supply to the co-op are represented in the figure at right.

Case 3: $MB_{i,IOF} < MB_{i,COOP}, \forall \alpha_i < 1 \alpha_i = 1$

In this case, the marginal benefit from supplying the co-op outweighs benefits from supplying the IOF at every allocation of the producer's crop (see figure at right). This does not necessarily mean that cooperative profits are positive, simply that the combination of marginal benefits accruing to the producer from delivering to the cooperative plus the marginal benefits stemming from the patronage allocation are greater than the benefits that can be derived from distributing through the IOF.



The corner solution when $\alpha_i = 1$ may be

maintained when Q_{-i} rises under a variety of circumstances. In particular, if the cooperative is operating where $MR_{co-op} < MC_{co-op}$, increasing Q_{-i} will boost cooperative profits. Even when the producer's share of profits is relatively smaller than before, benefits from cooperating are likely to increase. Since revenue generated from supplying the IOF is not affected by Q_{-i} . The relative marginal benefit from supply the IOF will decrease and the cooperator will have no incentive to alter his

allocation of production and $\frac{\partial \alpha_i}{\partial Q_{-i}} = 0$.

If the cooperative was initially maximizing total profits and then Q_{-i} increased, cooperative profits will decline slightly. However, even if the producer's marginal benefit from cooperative also

decline, so long as it is greater than the marginal benefit from supplying the IOF, no redistribution of production will be observed and $\frac{\partial \alpha_i}{\partial Q_i} = 0$. On the other hand, if the increase in Q_i alters co-op profits to such a degree that the marginal benefit's from co-op'ing are reduced and can be equated with the marginal benefit of supplying the IOF for some allocation of $\alpha_i < 1$, then $\frac{\partial \alpha_i}{\partial Q_i} < 0$. Investigating the complementary slackness conditions will assist with determining the benefit to the cooperator of decreasing α_i . When $\alpha_i = 1$, $\delta = 0$, if the benefit of relaxing this constraint is large, then for increases in Q_i , it is more likely that the producer will reduce his allocation to the cooperative. However, if the benefit of relaxing the constraint is zero or negative, no change in allocation will occur and the producer will continue to deliver all of his production to the cooperative.

4.4 Conclusions

Evidence from recent cooperative failures suggests that members' base delivery decisions, in part, upon their expectation of deliveries that will be made by fellow cooperative members. The exercise above is intended to demonstrate, that this determination is complex and dependent upon a variety of factors, but most importantly, it is dependent upon the individual producer's expectation of cooperative profit and the relative marginal benefits from supplying the cooperative versus an IOF. Under different circumstances, increased deliveries to the cooperative will result in decreased (increased) patronage or no change at all.

Cooperatives depend upon the notion of economies of scale to reduce processing costs and increase benefits to members. However, as shown in the above examples, cooperatives may

illicit “too much of a good thing”. As supply increases beyond the profit-maximizing optimal level, benefits from cooperative membership decline and producers will shift increasing amounts of production towards supplying competitors. If supply is expected to increase significantly above the optimal level, such that the marginal benefit from cooperating is small relative to marginal benefits from supplying the IOF, or possibly even negative, it may become irrational for producers to supply the cooperative at all.

The opposite extreme exists where initial cooperative supply is below optimal levels. Even when profits increase (or losses decrease) with the addition of more supply, marginal benefits may not increase enough that producer’s are enticed to supply the cooperative. If producer believe that others will chose to allocate production in a similar manner, overall supply to the cooperative may decline in the next period and diseconomies of scale may eventually force the cooperative to close.

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Appendix

The equations below correspond to elements in the Jacobian matrix detailed in the mathematical model. Signs of the derivatives will depend upon cooperative profitability, changes in share of cooperative profits, relative size of benefits fro supplying the cooperative relative to the IOF, and size of cooperative profits(or losses) relative to revenue from the delivery price.

$$a_{11} = \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial^2 \Pi_{coop}}{\partial q_i \partial q_i} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial q_i} * \frac{\partial \Pi_{coop}}{\partial q_i} \right] + \left[\frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial q_i} * \frac{\partial \Pi_{coop}}{\partial q_i} + \frac{\partial^2 f(\alpha_i, q_i, Q_{-i})}{\partial q_i \partial q_i} * \Pi_{coop} \right] - \frac{\partial^2 c(q_i)}{\partial q_i \partial q_i}$$

$$a_{21} = -P_{IOF} + r + \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial^2 \Pi_{coop}}{\partial q_i \partial \alpha_i} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i} * \frac{\partial \Pi_{coop}}{\partial q_i} \right] + \left[\frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial q_i} * \frac{\partial \Pi_{coop}}{\partial \alpha_i} + \frac{\partial^2 f(\alpha_i, q_i, Q_{-i})}{\partial q_i \partial \alpha_i} * \Pi_{coop} \right]$$

$$a_{12} = -P_{IOF} + r + \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial^2 \Pi_{coop}}{\partial \alpha_i \partial q_i} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial q_i} * \frac{\partial \Pi_{coop}}{\partial \alpha_i} \right] + \left[\frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i} * \frac{\partial \Pi_{coop}}{\partial q_i} + \frac{\partial^2 f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i \partial q_i} * \Pi_{coop} \right]$$

$$a_{22} = \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial^2 \Pi_{coop}}{\partial \alpha_i \partial \alpha_i} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i} * \frac{\partial \Pi_{coop}}{\partial \alpha_i} \right] + \left[\frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i} * \frac{\partial \Pi_{coop}}{\partial \alpha_i} + \frac{\partial^2 f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i \partial \alpha_i} * \Pi_{coop} \right]$$

$$\frac{\partial^2 \Pi_i}{\partial q_i \partial Q_{-i}} = \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial^2 \Pi_{coop}}{\partial q_i \partial Q_{-i}} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial Q_{-i}} * \frac{\partial \Pi_{coop}}{\partial q_i} \right] + \left[\frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial q_i} * \frac{\partial \Pi_{coop}}{\partial Q_{-i}} + \frac{\partial^2 f(\alpha_i, q_i, Q_{-i})}{\partial q_i \partial Q_{-i}} * \Pi_{coop} \right]$$

$$\frac{\partial^2 \Pi_i}{\partial \alpha_i \partial Q_{-i}} = \left[f(\alpha_i, q_i, Q_{-i}) * \frac{\partial^2 \Pi_{coop}}{\partial \alpha_i \partial Q_{-i}} + \frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial Q_{-i}} * \frac{\partial \Pi_{coop}}{\partial \alpha_i} \right] + \left[\frac{\partial f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i} * \frac{\partial \Pi_{coop}}{\partial Q_{-i}} + \frac{\partial^2 f(\alpha_i, q_i, Q_{-i})}{\partial \alpha_i \partial Q_{-i}} * \Pi_{coop} \right]$$