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Process Innovation Activity in a Mixed Oligopsony: The Role of Marketing Cooperatives

Kyriakos Drivas And Konstantinos Giannakas*

Abstract

This paper examines the market and welfare effects of cooperative involvement in cost-reducing process innovation activity in the context of a mixed oligopsony where an open-membership marketing co-op competes with an investor-owned firm. The presence of the marketing co-op is shown to result in increased producer prices and welfare gains for all farmers, members and non-members of the co-op. The effect of the marketing co-op on process innovation activity depends on the relative quality of its final products, the degree of producer heterogeneity, and the size of innovation costs. A comparison of our findings with those of Giannakas and Fulton (2005) on the impacts of input-supplying co-ops, reveals that, regardless of whether they are a backward or a forward integration of their members, parts of an oligopolistic or an oligopsonistic market structure, the involvement of cooperatives in process innovation *can* increase the innovation activity in the market, is welfare enhancing and, thus, socially desirable.

Keywords: marketing cooperatives, process innovation, mixed oligopsony, retained earnings.

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Introduction

Cooperative organizations constitute an integral part of the increasingly industrialized agri-food system accounting for 25% to 30% of total farm supply and marketing expenditures (USDA, 2003). When compared to profit-maximizing investor-owned firms (IOFs), a distinguishing feature of cooperatives (co-ops) is that the owners are also the users of the services provided by the organization (USDA, 1995; Hansmann, 1996). With members as both owners and users of its services, a co-op is typically assumed to focus on maximizing member welfare rather than profits.

The economic ramifications of the different objective function of the cooperative organization have received considerable attention in the relevant literature with the main focus being on the effect of different types of co-ops on the equilibrium conditions of various Cournot and Bertrand mixed market settings [see Sexton and Sexton (1987), Cotterill (1987), Sexton (1990), Tennbakk (1995), Albaek and Schultz (1998), Fulton and Giannakas (2001), Karantininis and Zago (2001)]. A key result of this literature is that the presence of co-ops results in more competitive conduct and increased welfare.

Being an integral part of the industrialized agri-food system, many co-ops have responded to the pressures of the increasingly competitive market place by trying to position themselves via their R&D activities. Important examples include Limagrain, Cebeco, and Cosun in Europe, while co-ops in the U.S. such as Ocean Spray have had substantial innovation activity.

Recognizing the increased cooperative involvement in R&D, Giannakas and Fulton (2005) (G&F, hereafter) examined the market and welfare effects of the involvement of input supplying co-ops in cost-reducing, process innovation activity. G&F show that the presence of the cooperative organization in an oligopolistic agricultural input market (i) can increase total process innovation activity and (ii) enhances economic welfare by reducing the prices of agricultural inputs.

An important feature of the input-supply co-ops studied in G&F is that they constitute a backward integration of their members – i.e., they are formed by agricultural producers to produce inputs (such as seeds, chemical fertilizers, pesticides etc.) used in agricultural production. Thus, the members/owners of an input supply co-op are part of the demand side of the co-op's market as they buy the product supplied by the co-op.

Unlike supply co-ops that constitute a backward integration of their members, the other important type of cooperative organizations, the marketing co-ops, constitute a forward integration of their members. In particular, marketing co-ops are formed by producers to process and market the agricultural produce of their

members. Thus, the members/owners of a marketing co-op are part of the supply side of the co-op's market as they supply the co-op with an input in its production process.

Given the prevalence of these fundamentally different types of cooperative organizations, the question that naturally arises is "*Does the type of cooperative organization matter when considering the market and welfare effects of cooperative involvement in innovation activity?*" This paper will try to answer this question by determining the effects of the involvement of marketing co-ops in process innovation activity and comparing the results with those of G&F.

In particular, this paper examines the market and welfare effects of the involvement of marketing co-ops in cost-reducing process innovation activity in the agri-food system. The paper analyzes the consequences of cooperative involvement for the amount of process innovation, the pricing behavior of firms, and social welfare in the context of a mixed duopsony where an open-membership marketing co-op and an IOF compete in procuring an agricultural product from farmers. The agricultural product is an input in the production process of the two firms and it is combined in fixed proportions with processing services to produce the final products of the co-op and the IOF. By focusing on a mixed oligopsony, the study pays particular attention to the impact of replacing a profit maximizing IOF with a member welfare-maximizing co-op. The case of a pure oligopsony is also analyzed and is used as a benchmark for determining the consequences of cooperative involvement in cost-reducing R&D.

To analyze the effects of the involvement of marketing co-ops in process innovation activity in an oligopsonistic market structure, our study follows the approach developed by G&F when examining the effects of input-supplying co-ops in an oligopolistic market structure. In particular, the strategic interaction between the firms in the pure and the mixed duopsonies is modeled as a three-stage sequential game where: in stage 1, the firms compete in (input) prices and a new process innovation that can reduce their processing costs is announced; in stage 2, the firms determine their optimal level of investment in the new cost-reducing innovation; and in stage 3, processing costs are fixed and the firms engage in (input) price competition. In what follows, stage 1 will often be referred to as the "pre-innovation stage," stage 2 as the "innovation stage," and stage 3 as the "post-innovation stage."

To capture the geographic nature of agricultural markets (Rogers and Sexton, 1994), we assume that, even though the two firms have market power when procuring the agricultural product, they are price-takers downstream, i.e., in the markets they sell their processed products. In addition, to account for the fact that agricultural products are used as inputs in the production of multiple food products, our analysis allows for the final product prices to vary between the two firms, i.e., it allows for the two firms to supply different value (quality) markets.

To avoid Nash equilibria involving non-credible strategies, the different formulations of the game are solved using backward induction – the pricing behavior of the firms at the post-innovation stage is considered first, the optimal investment in the cost-reducing innovation is analyzed next, and the solution to the pre-innovation pricing problem determines the subgame perfect equilibrium amount of cost-reducing R&D, the pricing of the agricultural product, and producer decisions in the pre- and post-innovation stages of the game.

In addition to being intuitively appealing, this structure of the strategic interaction in the mixed oligopsony enables us to explicitly account for the different objective function of the co-op (member welfare maximization vs. profit maximization pursued by IOFs) as well as for the need of the co-op to rely on earnings raised at the pre-innovation stage to finance its subsequent investment in cost-reducing innovation. Note that the inability of open membership co-ops to restrict the allocation of benefits from an investment activity to those members that have incurred the investment costs (i.e., their inability to exclude from the benefits of an investment the members that have not contributed to the financing of this investment), creates incentives for opportunistic behavior and free riding that undermine the co-ops' ability to raise investment capital (Vitaliano, 1983; Cook, 1995). A common strategy employed by co-ops to cope with this property rights problem is the financing of their investment through retained earnings (see Knoeber and Baumer (1983). On the difficulties of open membership co-ops to raise investment capital and the role of retained earnings in addressing various property rights problems see also G&F and the references therein).

Other than facilitating the explicit consideration of these important idiosyncrasies of cooperative organizations, this structure of strategic interactions makes our results directly comparable to those of G&F. Given that both studies consider the market and welfare effects of cooperative involvement in cost-reducing, process innovation, a comparison of our results will enable us to determine whether the type of co-op (input-supply co-op considered in G&F versus the marketing co-op considered here) and market structure (oligopoly in G&F versus oligopsony here) matter when considering the effect of cooperative involvement in process innovation activity.

The rest of this paper is organized as follows. The next section examines the producer decisions and derives the supplies faced by the duopsonists before and after the process innovation activity. The sections following derive the equilibrium conditions in the pure and mixed oligopsonies, and determine the effect of marketing co-ops on cost-reducing process innovation, the prices received by agricultural producers, and the welfare of the groups involved. The final section summarizes and concludes the paper.

Producer Decisions and Welfare

Before examining the innovation and pricing decisions in the pure and mixed oligopsonies, we need to analyze the way farmers make their selling decisions at the pre- and post-innovation stages. By doing so, we can derive the supplies faced by each firm and obtain measurements of producer (farmer) welfare before and after the cost-reducing process innovation activity.

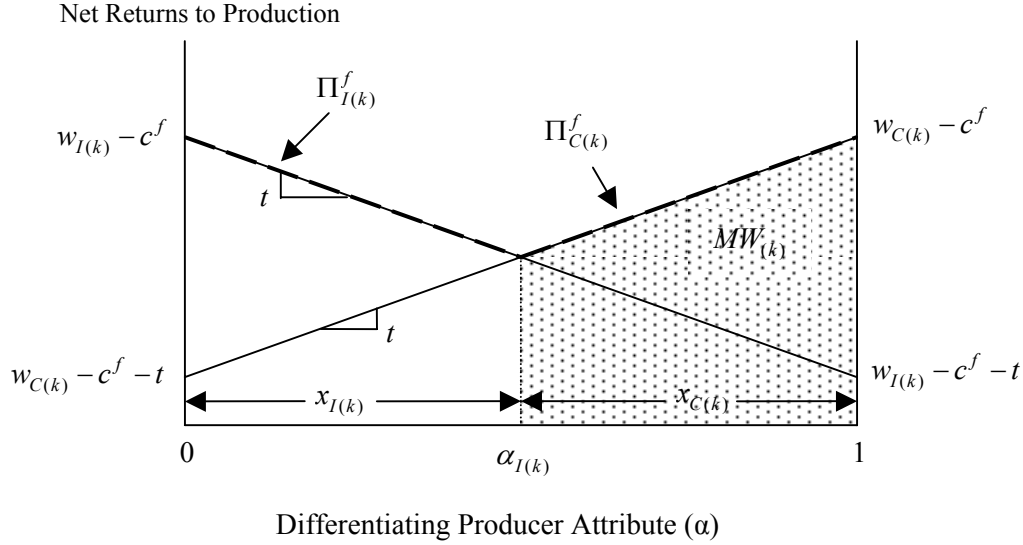
In both the pre- and post-innovation stages of the game, farmers have to decide whether to sell their product to Firm I or Firm C. Due to differences in their location, commitment to the two firms (Fulton and Giannakas, 2001), and/or the prices offered by the two firms, their net returns depend on the firm they will deliver their product to. Let $\alpha \in [0,1]$ be the attribute that differentiates agricultural producers. The farmer with attribute α has the following net returns function at the pre- and post-innovation stages of the game:

$$(1) \quad \begin{aligned} \Pi_{I(k)}^f &= w_{I(k)} - c^f - t\alpha && \text{If a unit of product is sold to Firm I} \\ \Pi_{C(k)}^f &= w_{C(k)} - c^f - t(1-\alpha) && \text{If a unit of product is sold to Firm C} \end{aligned}$$

where k denotes the stage of the game; $\Pi_{I(k)}^f$ and $\Pi_{C(k)}^f$ are the per unit net returns when the farm output is delivered to Firm I and Firm C, respectively; $w_{I(k)}$ and $w_{C(k)}$ are the per unit prices paid by Firm I and Firm C, respectively; and c^f is the farmers' cost of producing the agricultural product. The parameter t is non-negative and captures the degree of producer heterogeneity (when producers differ in their physical location, t denotes the transportation cost they face). *Ceteris paribus*, producers with large values of α prefer to sell their product to Firm C, while producers with low values of α prefer selling to Firm I. The greater is t , the greater the difference in the net returns associated with selling the farm product to the two firms.

To ensure positive market shares for the two firms, it is assumed that t exceeds the difference in the prices of the two firms (see equations (3) and (4)), while, to retain tractability, the analysis assumes that producers are uniformly distributed between the polar values of α . Each farmer produces a unit of the agricultural product and their selling decision is determined by the relationship between $\Pi_{I(k)}^f$ and $\Pi_{C(k)}^f$.

Figure 1 shows the decisions and welfare of producers. The downward sloping curve shows the net returns when the farm product is supplied to Firm I, while the upward sloping curve shows the net returns when the product is supplied to Firm C for different values of the differentiating attribute α (i.e., for different producers). The intersection of the two net returns curves determines the level of the differentiating attribute that corresponds to the indifferent producer.

Figure 1. Producer Decisions and Welfare at the Pre- and Post-Innovation Stages

The producer with differentiating characteristic $\alpha_{I(k)}$ given by:

$$(2) \quad \alpha_{I(k)} : \Pi_{I(k)}^f = \Pi_{C(k)}^f \Rightarrow w_{I(k)} - c^f - t\alpha = w_{C(k)} - c^f - t(1 - \alpha) \Rightarrow$$

$$\alpha_{I(k)} = \frac{t + w_{I(k)} - w_{C(k)}}{2t}$$

is indifferent between selling to Firm I or to Firm C as the net returns from selling to the two firms are the same. Farmers located to the left of $\alpha_{I(k)}$ (i.e., farmers with $\alpha \in [0, \alpha_{I(k)})$) sell to Firm I while farmers with $\alpha \in (\alpha_{I(k)}, 1]$ sell to Firm C. Aggregate producer welfare is given by the area underneath the effective net returns curve shown as the (bold dashed) kinked curve in Figure 1.

When farmers are uniformly distributed with respect to their differentiating attribute α , $\alpha_{I(k)}$ determines the share of producers delivering their product to Firm I. The share of producers supplying Firm C is given by $1 - \alpha_{I(k)}$. By normalizing the mass of producers at unity, these shares give the input supplies faced by Firm I, $x_{I(k)}$, and Firm C, $x_{C(k)}$, at the k th stage of the game, respectively. Formally, $x_{I(k)}$ and $x_{C(k)}$ can be written as:

$$(3) \quad x_{C(k)} = \frac{t - w_{I(k)} + w_{C(k)}}{2t}$$

$$(4) \quad x_{I(k)} = \frac{t + w_{I(k)} - w_{C(k)}}{2t}$$

After determining the supplies faced by the two firms at the pre- and post-innovation stages, we will now proceed to deriving the subgame perfect equilibria in the pure and mixed oligopsonies.

Benchmark Case: Innovation and Pricing Decisions in a Pure Oligopsony

Price Competition at the Post-Innovation Stage (3rd Stage of the Game)

In the post-innovation stage of the pure duopsony, the two IOFs seek to determine the input prices that maximize their profits holding Nash conjectures (i.e., assuming that their decisions will not affect the behavior of their rival).¹ Specifically, the problem of the two IOFs at the 3rd stage of the game can be expressed as:

$$(5) \quad \max_{w_{i(3)}} \Pi_{i(3)} = (p_i - c_i - w_{i(3)})x_{i(3)}$$

where $i \in \{C, I\}$, p_i is the price of Firm i 's final product, and c_i is the post-innovation marginal processing cost of Firm i . All other variables are as previously defined.

Solving the problem of the two IOFs gives their best response functions as:

$$w_{i(3)} = \frac{1}{2}(w_{j(3)} + p_i - t - c_i)$$

where $j \in \{C, I\}$ and $i \neq j$. Solving these best response functions simultaneously and substituting $w_{C(3)}^*$ and $w_{I(3)}^*$ into equations (3) and (4) gives the Nash equilibrium prices and quantities as:

$$(6) \quad w_{i(3)}^* = \frac{1}{3}(2p_i + p_j - 2c_i - c_j - 3t)$$

$$(7) \quad x_{i(3)}^* = \frac{3t - c_i + c_j + p_i - p_j}{6t}$$

The equilibrium profits of each IOF are then given by:

$$(8) \quad \Pi_{i(3)}^* = \frac{(3t - c_i + c_j + p_i - p_j)^2}{18t}$$

and are a function of the degree of producer heterogeneity, the prices of the products produced by the two IOFs, and their post-innovation processing costs. *Ceteris paribus*, the lower the post-innovation processing cost of a firm, the greater its profits at the 3rd stage of the game.

1 The assumption of Nash conjectures is maintained throughout the analysis.

Innovation Competition (2nd Stage of the Game)

In stage 2, the two IOFs seek to determine their optimal cost-reducing, process innovation effort. Assuming that the two firms have the same pre-innovation processing costs and effectiveness of innovation effort (i.e., the degree to which innovation effort is translated into cost reductions), the relationship between the amount of innovation, r , and the post-innovation marginal costs of processing the farm input is given by:

$$(9) \quad c_{i(3)} = c - r_i$$

where c is the (strictly positive) marginal cost of processing the farm input at the pre-innovation stage of the game, and $r_i \geq 0$. In addition to simplifying our exposition, imposing symmetry on the two firms' pre-innovation costs and effectiveness of innovation effort allows us to focus on the effect of the different objective function of the co-op in the mixed duopsony on the equilibrium innovation and pricing decisions.

While, as indicated by equation (8), innovation effort has the potential to increase the post-innovation profits of a firm, cost-reducing innovation requires resources. Without loss of generality, innovation costs are assumed to be an increasing function of the innovation effort (Shy), i.e.,

$$(10) \quad I_i = \frac{1}{2}\psi r_i^2$$

where ψ is strictly positive scalar reflecting the size of innovation costs.

Thus, at the innovation stage of the game each IOF seeks to determine the innovation effort that maximizes its post-innovation profits minus the cost of innovation effort, i.e.,

$$(11) \quad \max_{r_i} \Pi_{i(2,3)} = \Pi_{i(3)}^* - I_i = \frac{(3t + r_i - r_j + p_i - p_j)^2}{18t} - \frac{1}{2}\psi r_i^2$$

From the first order conditions for each IOF's problem we obtain their best response function as:

$$(12) \quad r_i = \frac{3t - r_j + p_i - p_j}{9t\psi - 1}$$

Solving the best response functions simultaneously, we get the Nash equilibrium levels of innovation for each firm as:

$$(13) \quad r_i^* = \frac{9t\psi - 2 + 3\psi(p_i - p_j)}{3\psi(9t\psi - 2)}$$

Substituting the equilibrium levels of innovation in the expressions for innovation costs and post-innovation profits, we get the net profits of each firm in stages 2 and 3 as:

$$(14) \quad \Pi_{i(2,3)}^* = \frac{(9t\psi - 1)[2 - 9t\psi + 3\psi(p_j - p_i)]^2}{18\psi(2 - 9t\psi)^2}$$

Price Competition at the Pre-Innovation Stage (1st Stage of the Game)

In this stage, the two firms seek to determine the input prices that maximize their profits. Since the firms' payoffs in stages 2 and 3 are not dependent on pre-innovation prices or quantities, the objective of the two IOFs in stage 1 is to maximize their pre-innovation profits only, i.e.,

$$(15) \quad \max_{w_{i(1)}} \Pi_{i(1)} = (p_i - c - w_{i(1)})x_{i(1)}$$

The Nash equilibrium prices, quantities and profits at the pre-innovation stage are then:

$$(16) \quad w_{i(1)}^* = \frac{1}{3}(2p_i + p_j) - c - t$$

$$(17) \quad x_{i(1)}^* = \frac{3t + p_i - p_j}{6t}$$

$$(18) \quad \Pi_{i(1)}^* = \frac{(3t + p_i - p_j)^2}{18t}$$

Table 1 summarizes the subgame perfect equilibrium in the pure oligopsony. It can be seen that the equilibrium is asymmetric with the differences in input prices, quantities, profits and innovation effort being determined by the relative quality of the final products produced by the two IOFs (reflected in the relative prices of these products). In particular, the firm with the higher quality product will offer a higher price to farmers, will enjoy higher market shares and profits in the 1st and 3rd stages of the game, and will exert higher innovation effort than its low quality rival.

Table 1. Subgame Perfect Equilibrium in the Pure Oligopsony

Pre-innovation Stage (1 st Stage)	$w_{i(1)}$	$\frac{1}{3}(2p_i + p_j) - c - t$
	$x_{i(1)}$	$\frac{3t + p_i - p_j}{6t}$
	$\Pi_{i(1)}$	$\frac{(3t + p_i - p_j)^2}{18t}$
Innovation Stage (2 nd Stage)	r_i	$\frac{9t\psi - 2 + 3\psi(p_i - p_j)}{3\psi(9t\psi - 2)}$
	r_T	$\frac{2}{3\psi}$
Post-innovation Stage (3 rd Stage)	$w_{i(3)}$	$\frac{3\psi[(6t\psi - 1)p_i + (3t\psi - 1)p_j] - (9t\psi - 2)(3t\psi + 3c\psi - 1)}{3\psi(9t\psi - 2)}$
	$x_{i(3)}$	$\frac{3\psi(p_i - p_j) + 9t\psi - 2}{18t\psi - 4}$
	$\Pi_{i(2,3)}$	$\frac{(9t\psi - 1)[2 - 9t\psi + 3\psi(p_j - p_i)]^2}{18\psi(2 - 9t\psi)^2}$

Innovation and Pricing Decisions in a Mixed Oligopsony

In this case, Firm C is a co-op instead of an IOF. The market structure is, thus, a mixed duopsony consisting of an IOF (Firm I) and a co-op (Firm C).

Price Competition at the Post-Innovation Stage in the Mixed Oligopsony

Similar to the pure oligopsony case, at the 3rd stage the IOF seeks to determine the input price that maximizes its profits. Thus, both its objective function and its best response function are identical to those in the post-innovation stage of the pure duopsony.

Unlike Firm C in the pure oligopsony, the co-op seeks to identify the input price that maximizes the welfare of its members (i.e., farmers that patronize its activities) subject to not incurring economic losses. Member welfare is given by

the shadowed area $MW_{(k)}$ in Figure 1 where $k=3$ and the coop+erative's problem can be expressed as:

$$(19) \quad \max_{w_{C(3)}} MW_{(3)} = (w_{C(3)} - c^f) x_{C(3)} - \frac{1}{2} t x_{C(3)}^2$$

$$\text{s.t. } \Pi_{C(3)} \geq 0 \Rightarrow p_C - w_{C(3)} - c_C \geq 0$$

Solving the optimality conditions of the co-op's problem, shows that the co-op will find it optimal to not exercise its oligopsonistic power when procuring the farm product at the post-innovation stage (i.e., $w_{C(3)} = p_C - c_C$).² The Nash equilibrium prices and quantities at the post-innovation stage of the mixed oligopsony are:

$$(20) \quad w'_{I(3)} = \frac{1}{2} (p_C + p_I - c_C - c_I - t)$$

$$(21) \quad x'_{I(3)} = \frac{t - c_I + c_C - p_C + p_I}{4t}$$

$$(22) \quad w'_{C(3)} = p_C - c_C$$

$$(23) \quad x'_{C(3)} = \frac{3t - c_C + c_I + p_C - p_I}{4t}$$

The profits of the two firms and the welfare of the group that patronizes the co-op are then:

$$(24) \quad \Pi'_{I(3)} = \frac{(t - c_I + c_C - p_C + p_I)^2}{8t}$$

$$(25) \quad \Pi'_{C(3)} = 0$$

$$(26) \quad MW'_{(3)} = (p_C - c_C - c^f) x'_{C(3)} - \frac{1}{2} t x_{C(3)}'^2$$

Innovation Competition in the Mixed Oligopsony

In this stage, the two firms seek to determine their optimal innovation effort. Similar to the pure oligopsony case, the problem of the IOF is to determine the

2 It should be noted that this will be the optimal pricing strategy of the co-op at the post-innovation stage no matter if it seeks to maximize the welfare of all farmers that deliver their product to the co-op at this stage or the welfare of only a subset of its post-innovation membership. The obvious reason is that the welfare of any producer group is positively related to the farm product prices.

amount of innovation that maximizes its post-innovation profits minus its innovation costs, i.e.,

$$(27) \quad \max_{r_I} \Pi_{I(2,3)} = \Pi'_{I(3)} - I_I = \frac{(t + r_I - r_C - p_C + p_I)^2}{8t} - \frac{1}{2}\psi r_I^2$$

On the other hand, the problem of the co-op is to maximize the welfare of farmers that are members at the time the decision to invest in innovation is being made (this group will be referred to as the “pre-innovation membership”). As will be shown below (in stage 1), the pre-innovation membership is the group that, by selling to the co-op at reduced prices in the pre-innovation stage, provides the co-op with earnings that finance its subsequent cost-reducing innovation effort. Thus, even though the co-op knows that its cost-reducing process innovation activity will result in increased input pricing that can attract new farmers/members to the co-op at the post-innovation stage, when making its innovation decisions the co-op considers only the welfare of farmers that finance its innovation activity (by patronizing the co-op in stage 1).

Algebraically, the problem of the coop can be expressed as:

$$(28) \quad \max_{r_C} MW_{(2,3)} = MW'_{(3/1)} - I_C = (p_C - c + r_C - c^f)x_{C(1)} - \frac{1}{2}tx_{C(1)}^2 - \frac{1}{2}\psi r_C^2$$

where $x_{C(1)}$ is the share of the co-op in stage 1, $MW_{(2,3)}$ is the welfare of the pre-innovation membership in stages 2 and 3, and $MW'_{(3/1)}$ is the welfare of the pre-innovation membership in stage 3. Solving the problems of the co-op and IOF, we get their best response functions as:

$$(29) \quad r_C = \frac{x_{C(1)}}{\psi}$$

$$(30) \quad r_I = \frac{t - r_C + p_I - p_C}{4t\psi - 1}$$

Solving these best response functions simultaneously, we get the equilibrium levels of innovation:

$$(31) \quad r_C' = \frac{x_{C(1)}}{\psi}$$

$$(32) \quad r_I' = \frac{t\psi - x_{C(1)} + \psi(p_I - p_C)}{\psi(4t\psi - 1)}$$

The total innovation in the mixed duopsony is then:

$$(33) \quad r'_T = r'_C + r'_I = \frac{t\psi + x_{C(1)}(4t\psi - 2) + \psi(p_I - p_C)}{\psi(4t\psi - 1)}$$

Plugging r'_C and r'_I in the expressions for innovation costs, post-innovation profits, and member welfare, we get:

$$(34) \quad \Pi'_{I(2,3)} = \frac{[x_{C(1)} - t\psi + \psi(p_C - p_I)]^2}{2\psi(4t\psi - 1)}$$

$$(35) \quad MW'_{(2,3)} = \left(p_C - c + \frac{x_{C(1)}}{\psi} - c^f \right) x_{C(1)} - \frac{1}{2} t x_{C(1)}^2 - \frac{x_{C(1)}^2}{2\psi}$$

Price Competition at the Pre-Innovation Stage in the Mixed Oligopsony

Unlike the pure oligopsony case, in the mixed duopsony the outcome of price competition in the pre-innovation stage affects firms' optimal decisions and payoffs in subsequent stages (see equations (31), (32), (34) and (35)). Thus, in stage 1 the IOF seeks to determine the input price that maximizes its total profits (i.e., its profits at the pre-innovation stage plus its profits at the post-innovation stage minus its innovation costs), i.e.,

$$(36) \quad \max_{w_{I(1)}} \Pi_I^T = (p_I - c - w_{I(1)})x_{I(1)} + \frac{[x_{C(1)} - t\psi + \psi(p_C - p_I)]^2}{2\psi(4t\psi - 1)}$$

The best response function of the IOF is given by:

$$w_{I(1)} = \frac{2ct\psi + 4t\psi^2 + 8ct^2\psi^2 - t - 2ct\psi p_C + 8t^2\psi^2 p_I + (8t^2\psi^2 - 2t\psi - 1)w_{C(1)}}{16t^2\psi^2 - 4t\psi - 1}$$

Regarding the co-op, its problem at this stage is to determine the price that maximizes the welfare of its pre-innovation membership in both the pre- and post-innovation stages of the game, subject to raising earnings that can be retained to finance its cost-reducing innovation in stage 2. The capital required for the subsequent investment in innovation is $I_C = \frac{1}{2}\psi t_C^2 = \frac{x_{C(1)}^2}{2\psi}$ and the problem of the

co-op at the pre-innovation stage can be expressed as:

$$(37) \quad \max_{w_{C(1)}} MW^T = MW_{(1)} + MW'_{(3/1)} = (w_{C(1)} - c^f)x_{C(1)} - \frac{1}{2} t x_{C(1)}^2 + (p_C - c + \frac{x_{C(1)}}{\psi} - c^f)x_{C(1)} - \frac{1}{2} t x_{C(1)}^2$$

$$\text{s.t. } \Pi_{C(1)} - I_C \geq 0 \Rightarrow (p_C - w_{C(1)} - c)x_{C(1)} - \frac{x_{C(1)}^2}{2\psi} \geq 0$$

where $MW_{(1)}$ is the welfare of the pre-innovation membership in stage 1. The

optimality conditions for the co-op's optimization problem suggest that the co-op will find it optimal to choose its price such that the investment constraint binds, i.e., the co-op will price its input so that it raises exactly the amount of capital needed for its innovation activity in stage 2. The best response function of the co-op is then:

$$w_{C(1)} = \frac{4t\psi p_C + w_{I(1)} - t(4c\psi + 1)}{4t\psi + 1}$$

The Nash equilibrium prices and quantities at the pre-innovation stage of the mixed oligopsony are given by:

$$(38) \quad w'_{I(1)} = \frac{t - 4t^2\psi + (4t\psi - 3)p_C + 4t\psi p_I}{8t\psi - 3} - c$$

$$(39) \quad x'_{I(1)} = \frac{8t^2\psi^2 + 4t\psi - 3 + 8t\psi^2(p_I - p_C)}{(4t\psi + 1)(8t\psi - 3)}$$

$$(40) \quad w'_{C(1)} = \frac{4t - 12t^2\psi + (32t^2\psi^2 - 8t\psi - 3)p_C + 4t\psi p_I}{(4t\psi + 1)(8t\psi - 3)} - c$$

$$(41) \quad x'_{C(1)} = \frac{8t\psi[3t\psi - 1 + \psi(p_C - p_I)]}{(4t\psi + 1)(8t\psi - 3)}$$

Substituting the equilibrium pre-innovation membership of the co-op (equation (41)) in equations (31)-(33) gives the subgame perfect equilibrium innovation levels in the mixed duopsony. Substituting the new expressions of r_I and r_C into equations (20)-(26) gives the subgame perfect equilibrium conditions in the post-innovation stage of the game.

Table 2 summarizes the subgame perfect equilibrium in the mixed oligopsony. It can be seen that, similar to the pure oligopsony case, the equilibrium is asymmetric with the differences in equilibrium conditions being determined by the relative quality of the firms' final products, the degree of producer heterogeneity, and the size of innovation costs. When the co-op is the high quality firm (i.e., when $p_C > p_I$), it will offer higher prices to the farmers, will enjoy higher market shares in the pre- and post-innovation stages, and will undertake higher innovation effort than the low quality IOF.

Interestingly, because of its objective to maximize member welfare, even when the co-op is the low quality firm (i.e., when $p_C < p_I$) it can still price the farm product above the high quality IOF, enjoy higher market shares, and innovate more than its rival. For the high quality IOF to offer higher prices to producers and innovate more than the low quality co-op, it should enjoy a significant quality advantage relative to the co-op.

Table 2. Subgame Perfect Equilibrium in the Mixed Oligopsony

Pre-innovation Stage (Stage 1)	$w_{C(1)}$	$\frac{4t - 12t^2\psi + (32t^2\psi^2 - 8t\psi - 3)p_C + 4t\psi p_I}{(4t\psi + 1)(8t\psi - 3)} - c$
	$w_{I(1)}$	$\frac{t - 4t^2\psi + (4t\psi - 3)p_C + 4t\psi p_I}{8t\psi - 3} - c$
	$x_{C(1)}$	$\frac{8t\psi [3t\psi - 1 + \psi(p_C - p_I)]}{(4t\psi + 1)(8t\psi - 3)}$
	$x_{I(1)}$	$\frac{8t^2\psi^2 + 4t\psi - 3 + 8t\psi^2(p_I - p_C)}{(4t\psi + 1)(8t\psi - 3)}$
Innovation Stage (Stage 2)	r_C	$\frac{8t [3t\psi - 1 + \psi(p_C - p_I)]}{(4t\psi + 1)(8t\psi - 3)}$
	r_I	$\frac{t(8t\psi - 5) + [(8t\psi + 3)(p_I - p_C)]}{(4t\psi + 1)(8t\psi - 3)}$
	r_T	$\frac{t(32t\psi - 13) + 3(p_I - p_C)}{(4t\psi + 1)(8t\psi - 3)}$
Post-innovation Stage (Stage 3)	$w_{C(3)}$	$p_C - c + \frac{8t [3t\psi - 1 + \psi(p_C - p_I)]}{(4t\psi + 1)(8t\psi - 3)}$
	$w_{I(3)}$	$\frac{-5t + 18t^2\psi - 16t^3\psi^3 + (16t^2\psi^2 - 2t\psi - 3)p_C + 2t\psi(8t\psi - 1)p_I}{(4t\psi + 1)(8t\psi - 3)} - c$
	$x_{C(3)}$	$\frac{(8t\psi + 3)[3t\psi - 1 + \psi(p_C - p_I)]}{(4t\psi + 1)(8t\psi - 3)}$
	$x_{I(3)}$	$\frac{\psi [t(8t\psi - 5) + (8t\psi + 3)(p_I - p_C)]}{(4t\psi + 1)(8t\psi - 3)}$

When the difference in the prices of the products produced by the two firms is $p_I - p_C \geq \frac{3t\psi - 1}{\psi}$, the low quality co-op is driven out of the market and the high quality IOF becomes a monopsonist at the post-innovation stage of the game (i.e., $x_{C(3)} = 0$ and $x_{I(3)} = 1$). Since the co-op exits the market in stage 3, it will not invest in cost-reducing innovation in stage 2 and will seek to maximize the welfare of its pre-innovation membership in stage 1. Table 3 presents the subgame

perfect equilibrium for the case where the market structure is altered at the post-innovation stage due to the exit of the low quality marketing co-op.

Table 3. Subgame Perfect Equilibrium in the Mixed Oligopsony when the IOF is a Monopsonist in Stage 3

Pre-innovation Stage (Stage 1)	$w_{C(1)}$	$p_C - c$
	$w_{I(1)}$	$\frac{1}{2}(p_C + p_I - 2c - t)$
	$x_{C(1)}$	$\frac{3t + p_C - p_I}{4t}$
	$x_{I(1)}$	$\frac{t + p_I - p_C}{4t}$
Innovation Stage (Stage 2)	r_C	0
	r_I	$\frac{1}{\psi}$
	r_T	$\frac{\psi}{\psi}$
		ψ
Post-innovation Stage (Stage 3)	$w_{C(3)}$	—
	$w_{I(3)}$	$p_C + t - c$
	$x_{C(3)}$	0
	$x_{I(3)}$	1

Finally, when $p_C - p_I \geq \frac{t(8t\psi - 5)}{8t\psi + 3}$ it is the co-op that becomes the sole buyer

of the farm product at the post-innovation stage of the game. Since the IOF exits the market in stage 3, it will not invest in cost-reducing innovation in stage 2, and will seek to maximize its pre-innovation profits in stage 1. Table 4 presents the subgame perfect equilibrium for the case where the market structure is altered at the post-innovation stage due to the exit of the IOF.

It is interesting to note that it is not necessary for the co-op to produce the higher quality product for it to end up being a monopsonist at the post-innovation stage. Indeed, the relationship $p_C - p_I \geq \frac{t(8t\psi - 5)}{8t\psi + 3}$ indicates that, for certain

(low) values of the degree of producer heterogeneity and the size of innovation costs, the presence of the marketing co-op can induce exit of the IOF at the post-innovation stage even when the co-op produces the lower quality product, i.e., when $p_C < p_I$.

Table 4. Subgame Perfect Equilibrium in the Mixed Oligopsony when the Co-op is a Monopsonist in Stage 3

Pre-innovation Stage (Stage 1)	$w_{C(1)}$	$\frac{8t\psi p_C + p_I - 3t}{8t\psi + 1} - c$
	$w_{I(1)}$	$\frac{4t\psi p_C + (4t\psi + 1)p_I - 2t(2t\psi + 1)}{8t\psi + 1} - c$
	$x_{C(1)}$	$\frac{2\psi(3t + p_C - p_I)}{8t\psi + 1}$
	$x_{I(1)}$	$\frac{2t\psi + 1 + 2\psi(p_I - p_C)}{8t\psi + 1}$
Innovation Stage (Stage 2)	r_C	$\frac{2(3t + p_C - p_I)}{8t\psi + 1}$
	r_I	0
	r_T	$\frac{2(3t + p_C - p_I)}{8t\psi + 1}$
Post-innovation Stage (Stage 3)	$w_{C(3)}$	$\frac{6t + (8t\psi + 3)p_C - 2p_I}{8t\psi + 1} - c$
	$w_{I(3)}$	—
	$x_{C(3)}$	1
	$x_{I(3)}$	0

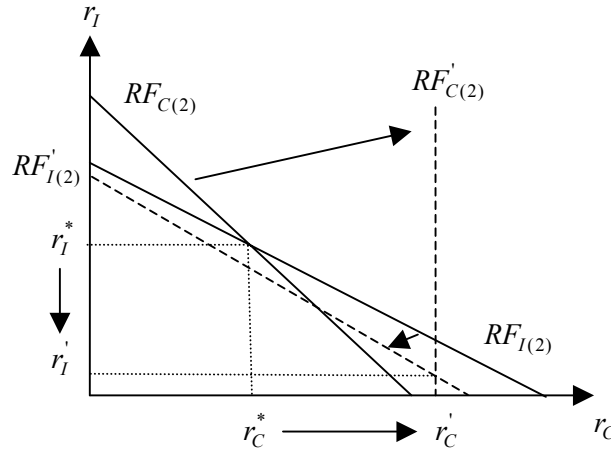
The Market and Welfare Effects of Cooperative Involvement in Process Innovation

Having determined the subgame perfect equilibrium conditions for the pure and mixed oligopsonies, we can now examine the ramifications of cooperative

involvement for cost-reducing process innovation activity, pre- and post-innovation agricultural producer prices, and the welfare of the groups involved. We begin by considering the general case of the mixed duopsony at the post-innovation stage of the game.

Figure 2 graphs the innovation reaction functions of the firms in the pure and mixed oligopsonies. When compared to the reaction function of Firm C in the pure oligopsony ($RF_{C(2)}$), the reaction function of the co-op ($RF'_{C(2)}$) is shifted outwards and rotated rightwards. The co-op has increased incentives to innovate because, by seeking to maximize the welfare of its members, it is better able to internalize the cost and benefits associated with its process innovation activity.

Figure 2. Effect of Cooperative Involvement on Innovation Activity



At the same time, the cooperative involvement reduces the marginal profitability of the IOF's investment in innovation by increasing the equilibrium agricultural product prices. Graphically, the involvement of the co-op results in the reaction function of Firm I (the IOF in both the mixed and pure oligopsonies) shifting inwards in rightward rotation. These changes in the reaction functions result in increased innovation by the co-op relative to Firm C in the pure duopsony and reduced innovation by Firm I in the mixed duopsony case, i.e.,

$$(42) \quad r'_C > r_C^* \text{ and } r'_I < r_I^*$$

Regarding the total cost-reducing process innovation activity, the effect of cooperative involvement depends on the relative quality of the products produced by the marketing co-op and the IOF, the size of innovation costs, and the degree of

farmer heterogeneity. In particular, the difference between the total innovation activity in the mixed and pure duopsonies is given by:

$$(43) \quad r_T' - r_T^* = \frac{32t^2\psi^2 - 31t\psi + 6 + 9\psi(p_I - p_C)}{3\psi(4t\psi + 1)(8t\psi - 3)}$$

It is important to note that the difference $r_T' - r_T^*$ is negatively related to p_C indicating that the lower is the quality of the marketing co-op's product, the more likely it is that cooperative involvement will result in increased total process innovation in this market. When the relative quality of the co-op's product is the lowest (i.e., when $p_I - p_C$ approaches its maximum value of $\frac{3t\psi - 1}{\psi}$ under the co-existence of the two firms in stage 3), $r_T' > r_T^* \forall t\psi$. When $p_I = p_C$, $r_T' > r_T^*$ if $t\psi > 0.701444$, while, when the relative quality of the co-op's final product is the highest (i.e., when $p_C - p_I$ approaches $\frac{t(8t\psi - 5)}{8t\psi + 3}$), then $r_T' > r_T^*$ if $t\psi > 0.914764$.

An interesting implication of these results is that the effect of marketing co-ops on innovation activity is more likely to be negative when the co-op is the high quality firm. The reasoning is as follows. When the co-op is the high quality firm, it receives a high price for its product and is able to raise more capital for innovation activity in stage 1. Increased process innovation by the high quality co-op leads to reduced costs and increased farm prices at the post-innovation stage of the game. Since innovation efforts are strategic substitutes and the prices offered to farmers are strategic complements, the increased innovation effort and prices of the co-op reduce the IOF's incentive to innovate. The greater the relative quality of the co-op's product, the more likely it is that the increase in co-op's innovation will be outweighed by the reduction in IOF's innovation and the total innovation activity will be reduced.

Regarding the effects of the degree of producer heterogeneity, t , and the size of innovation costs, ψ , on total innovation activity, the analysis shows that the greater is $t\psi$, the more likely it is that the mixed oligopsony will result in higher total innovation than the pure oligopsony. The increased likelihood that total innovation is greater in the mixed oligopsony under higher innovation costs is the direct outcome of the co-op internalizing the effects of its innovation activity to (at least some) farmers.

In terms of the effect of the degree of farmer heterogeneity on the total innovation undertaken under the pure and mixed oligopsonies, the argument is slightly different. To begin, note that while t does not affect the amount of total

innovation in the pure oligopsony, it affects the innovation effort of both the co-op and the IOF in the mixed oligopsony case. In particular, a high value of t allows the co-op to increase its earnings in stage 1 (used to finance its innovation activity in stage 2) without drastically reducing the size of its pre-innovation membership. At the same time, a high value of t provides the IOF with incentives to increase its innovation effort since, under increased farmer heterogeneity, this firm can reduce its price (and increase its profits) at the post-innovation stage of the game. Thus, as farmer heterogeneity increases, so does total innovation in the mixed oligopsony.

Consider next the effect of cooperative involvement on farm product prices. Figure 3 graphs the price reaction functions in the pure and mixed oligopsonies and illustrates the changes in equilibrium prices caused by the presence of the member welfare maximizing co-op at the pre-innovation stage of the game. When compared to Firm C in the pure oligopsony, the co-op's reaction function ($RF'_{C(1)}$) is shifted outwards in leftward rotation. At the same price, the presence of the co-op causes the reaction function of Firm I (IOF in both the pure and mixed oligopsonies) to shift upwards in rightward rotation. The result is that both firms in the mixed duopsony pay higher prices to farmers than the IOFs in the pure duopsony. Since both prices are increased in the mixed oligopsony, all farmers, members and non-members of the co-op, benefit from the presence of the co-op in the pre-innovation stage of the game.

Figure 3. Effect of Cooperative Involvement on Pre-Innovation Prices

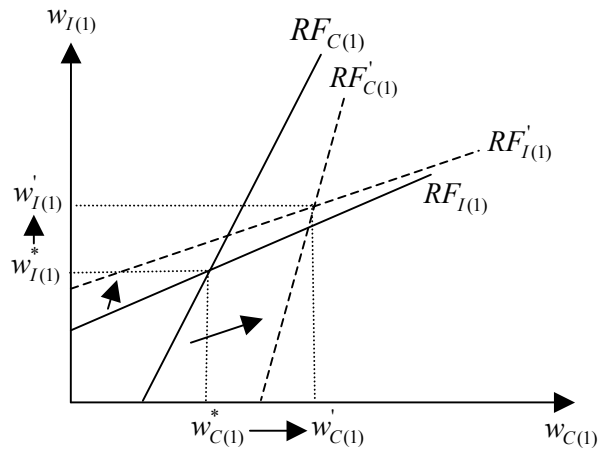
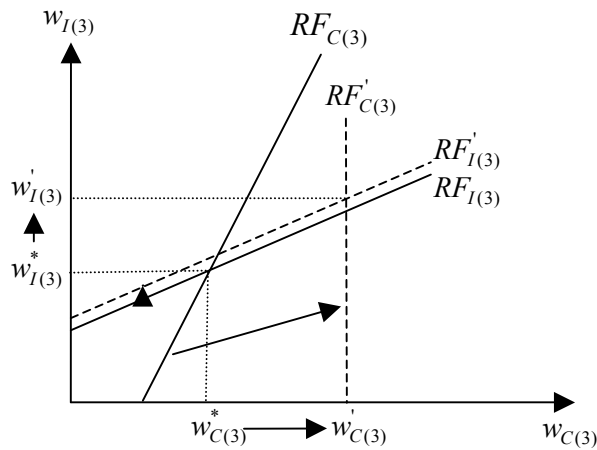


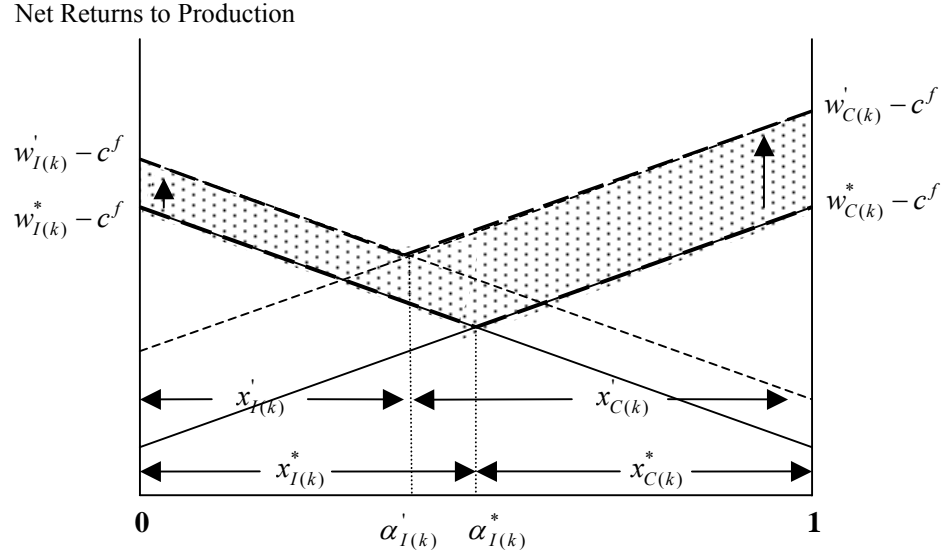
Figure 4 graphs the post-innovation price reaction functions in the pure and mixed oligopsonies and illustrates the changes in equilibrium prices caused by the presence of the member welfare maximizing marketing co-op. When compared to Firm C in the pure oligopsony, the co-op's reaction function ($RF'_{C(1)}$) is shifted outwards and becomes vertical at $p_C - c_C$ (recall that the optimal post-innovation strategy of the co-op does not depend on the pricing of its rival IOF). At the same time, the presence of the co-op causes the reaction function of Firm I to shift outwards in a parallel mode. The result is that both firms in the mixed duopsony pay higher prices than the IOFs in the pure duopsony. Since both prices are increased in the mixed oligopsony, all farmers, members and non-members of the co-op, benefit from the presence of the co-op in the post-innovation stage of the game.

Figure 4. Effect of Cooperative Involvement on Post-Innovation Prices



The effect of cooperative involvement on the welfare of producers in the pre- and post-innovation stages of the game is shown in Figure 5. The greater the relative quality of the co-op's product (i.e., $p_C - p_I$), the greater the producer welfare gains from the presence of the marketing co-op. Intriguingly, even though total innovation falls with an increase in the relative quality of the marketing co-op, its pricing strategy results in agricultural producers benefiting the most when the marketing co-op is a high quality firm. Finally, it should be noted that the pricing strategy of the co-op and the reduced price-cost margins under a mixed duopsony indicate that the involvement of the marketing co-op in process innovation activity enhances competition and, thus, it enhances total economic welfare in this market.

Figure 5. Market and Welfare Effects of Cooperative Involvement in Innovation at the Pre- and Post-Innovation Stages

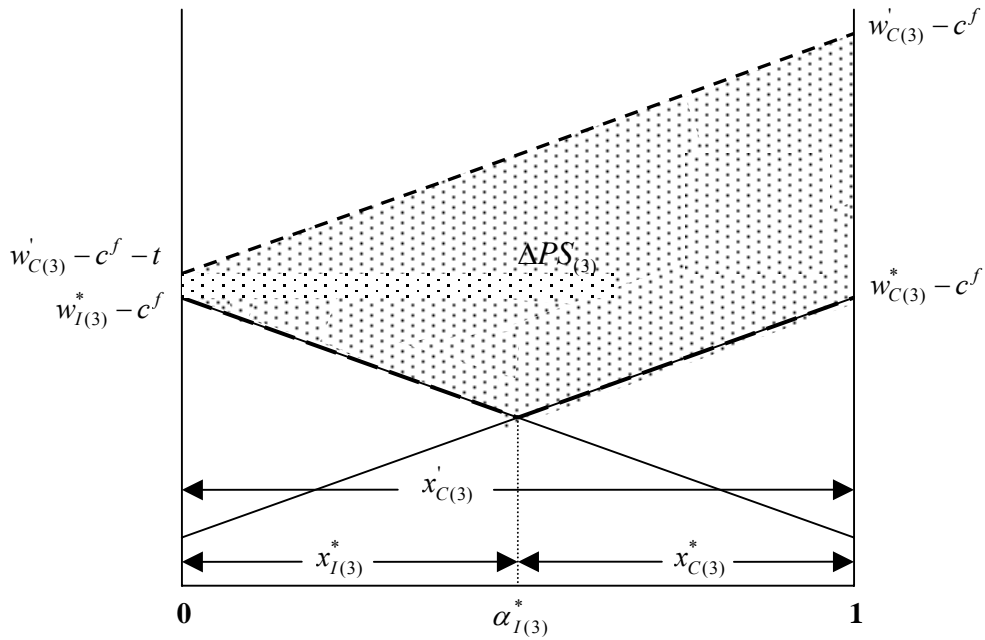


After analyzing the case where both the co-op and the IOF are in the market in stage 3, consider now the case where $p_I - p_C \geq \frac{5t\psi - 1}{3t\psi - 1}$ and the low quality marketing co-op exits the market at the post-innovation stage of the game (i.e., $x_{C(3)} = 0$ and $x_{I(3)} = 1$; see Table 3). In terms of innovation effort, not only does the high quality IOF that ends up being a monopsonist in the 3rd stage of the game innovate more than each individual IOF in the pure duopsony, it undertakes more than the total innovation in the pure duopsony. In terms of farm prices, similar to the case when both firms are in the market at the post-innovation stage of the mixed oligopsony, pre- and post-innovation prices increase in the mixed market indicating that the presence of the co-op benefits all producers, members and non-members of the co-op.

Consider finally the effects of cooperative involvement when $p_C - p_I \geq \frac{t(8t\psi - 5)}{8t\psi + 3}$ and the co-op becomes a monopsonist at the post-innovation stage of the game (Table 4). Even though the effect of cooperative involvement on total process innovation activity turns out to be, once again, ambiguous [$r'_T \geq (<) r^*_T$ when $p_C - p_I \geq (<) \frac{1 - t\psi}{3\psi}$], both firms pay higher prices in the mixed oligopsony than their counterparts in the pure oligopsony

indicating that the presence of the co-op benefits all farmers at the pre-innovation stage of the game. This is also true for the post-innovation stage since $w'_{C(3)} > w^*_{C(3)}$ and $w'_{C(3)} > w^*_{I(3)} + t$. Thus, even though the presence of the co-op does not always result in increased innovation, the price effect is such that the net returns associated with selling the product to the co-op is greater than the net returns associated with selling the product to the two IOFs in the pure oligopsony. Figure 6 depicts both the dominance of the co-op in the post-innovation stage and the farmer benefits from its presence.

Figure 6. Market and Welfare Effects of Cooperative Involvement when the Marketing Co-op ends up being a Monopsonist at the Post-Innovation Stage



Conclusions

This paper analyzed the market and welfare effects of cooperative involvement in cost-reducing, process innovation activity. The open-membership marketing co-op considered in the analysis seeks to maximize member welfare and addresses its property rights problems by financing its investment activity through retained earnings.

Analytical results show that the involvement of the marketing co-op in cost-reducing process innovation is welfare enhancing – the presence of the member welfare maximizing co-op is shown to result in increased producer prices and welfare gains for all farmers, members and non-members of the co-op. In terms of innovation activity, the effect of the marketing co-op on process innovation was shown to depend on the relative quality of the products supplied by the co-op and the IOF, the degree of producer heterogeneity, and the size of the innovation costs. Intriguingly, even though total innovation activity can fall with an increase in the relative quality of the marketing co-op, the pricing strategy of the member welfare maximizing co-op results in agricultural producers benefiting the most when the co-op is a high quality firm.

Before concluding this paper it is important to note that our key findings on the effects of the involvement of marketing co-ops in process innovation activity are consistent with the results of G&F on the effects of input-supplying co-ops. While the nature of innovation activity considered in our study is the same as the innovation activity in G&F (both studies focus on process innovation activity), the types of cooperative organizations and market structures considered in the two studies are different in that the marketing co-ops considered here constitute a forward integration of their members and are part of a mixed oligopsony, while the input-supplying co-ops considered in G&F constitute a backward integration of their members and are part of a mixed oligopoly. An important implication of this is that, when considering the effect of cooperative involvement in process innovation activity, the type of the co-op and structure of the market do not seem to matter. Regardless of whether they are a backward or a forward integration of their members, parts of an oligopolistic or an oligopsonistic market structure, the involvement of cooperatives in cost-reducing innovation activity *can* increase the innovation activity in the market, is welfare enhancing and, thus, socially desirable.

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