Christoph Weiss and Dieter Pennerstorfer

On the Relative Disadvantage of Cooperatives: Vertical Product Differentiation in a Mixed Oligopoly

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Dieter Pennerstorfer[+)]

Christoph R. Weiss[++)]

Abstract:

We investigate the incentive to provide goods of high quality in a vertically related market for different types of business organizations, a farmer-owned cooperative and an investor-owned firm. Contrary to the firm, the cooperative is characterized by decentralized decision making, which gives rise to overproduction and problems coordinating the quality decisions of its members (free riding). Comparing both manufacturers acting as monopolists we show that the cooperative will never supply final goods of higher quality than the firm, and that the problem of quality coordination is mitigated if the cooperative succeeds in preventing overproduction. When a cooperative faces competition of an investor-owned firm (mixed duopoly), it will – except in one limit case – never produce final goods of a higher quality than the firm and will deliver lower quality in a number of scenarios.

Keywords: Cooperatives; Mixed Oligopolies; Agricultural Markets; Product Quality

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[+)] **Corresponding author:** Dr. Dieter Pennerstorfer, Austrian Institute of Economic Research (WIFO), A-1103 Vienna, Austria, P.O. Box 91. Email: dieter.pennerstorfer@wifo.ac.at; Tel.: +43 1 798 26 01 - 473; Fax: +43 1 798 93 86.

[++)] Prof. Dr. Christoph Weiss, Department of Economics, Vienna University of Economics and Business Administration, Augasse 2-6, A-1090 Vienna, Austria. E-mail: cweiss@wu.ac.at; Tel.: +43 1 313 36 - 4503; Fax: +43 1 313 36 - 725.

Introduction

Cooperatives and investor-owned firms are alternative forms of business organization that coexist and compete in many vertically related markets. Whereas the theoretical literature has identified a number of comparative advantages and disadvantages of cooperatives (Fulton, 1995; Albaek and Schultz, 1998; Karantininis and Zago, 2001; Bogetoft, 2005), one characteristic of traditional cooperatives is that each member (upstream supplier; farmer) individually decides what to produce and deliver to the cooperative (downstream manufacturer). As the final product is (at least partly) determined by the quantity and quality of inputs, this decentralized decision making gives rise to the problem of coordination and free-riding: Although an individual farmer realizes that an increase in production or a reduction in quality reduces the price in the final market, he does not internalize the profit loss stemming from the price decrease incurred by the other members of the cooperative. The quantity coordination problem is a classical problem of cooperatives (Phillips, 1953), but also the problem of free-riding on product quality is well-recognized in the literature on cooperatives (see, among others, Cook, 1995, and Fulton, 1995). A coordination problem of this kind is absent for investor-owned firms, as they centrally decide about what is supplied to the market.

Although competition between cooperatives and firms can be observed in many markets, theoretical findings on ownership structure and product quality are scarce. A number of authors, however, have investigated the quality choice in 'pure' duopolies with two investor-owned firms. In pure duopolies it is a well-established result that the firm producing higher quality earns higher profits, irrespective whether producing higher quality increases fixed costs (Lehmann-Grube, 1997; Motta, 1993), variable costs (Motta, 1993) or does not influence costs at all (Choi and Shin, 1992). The decision which of the two rivals produces higher quality products however is not of interest in these studies since the duopolists typically are assumed to be identical ex ante.

Albaek and Schultz (1998) investigate the consequences of the free-riding behavior in a mixed duopoly setting, where a cooperative competes with an investor owned firm (but for homogenous goods only). The authors find that due to the decentralization of output decisions, cooperatives tend to overproduce. Interestingly, this negative externality turns out to be a comparative advantage of cooperatives in Cournot competition. Overproduction in the cooperative serves as a commitment device for credibly and profitably gaining market shares: '… the results of this paper suggest that in the long run all farmers would be members of the cooperative' (Albaek and Schultz, 1998: 401).

Our paper is most closely related to the analysis of Hoffmann (2005), who is to our knowledge the first who investigates firms' price and quality choices in mixed duopoly settings in a vertically related market with vertically differentiated products. Hoffmann endogenously derives the exact quality level, but decides exogenously, which organization produces higher quality. He shows that investor owned firms produce higher quality goods than cooperatives if producing high quality raises fixed costs, whereas the result is reversed in markets where producing high quality increases variable costs of production.[1]

The present paper investigates this free-riding problem in determining quantity and quality within a marketing cooperative in a vertically related market. Upstream firms (farmers) deliver inputs to the downstream market, where a cooperative and / or an investor-owned firm use the components delivered to produce a composite good which is then sold to consumers. We compare a cooperative acting as a monopolist to an investor-owned firm as the only manufacturer and, in a second step, analyze a mixed duopoly market. In contrast to previous studies on quality competition in an oligopolistic market (Lehmann-Grube, 1997;

[1] For a more comprehensive review on existing literature see e.g. Pennerstorfer and Weiss (2011).

Choi and Shin, 1992; Hoffmann, 2005) the decisions which manufacturer actually delivers the high quality product is endogenous here. In a monopolist setting we find that (i) even if the cooperative can control the quantity problem, the cooperative will never supply a final good of a higher quality than the firm. We further find that the quantity and the quality coordination problem are closely related and that (ii) if the cooperative faces a free-rider problem with respect to quantity, the quality coordination problem aggravates and the cooperative will certainly deliver products of lower quality than the firm in a number of scenarios. When a cooperative and an investor-owned firm compete in the downstream market (mixed duopoly setting), we find that (iii) in general the quality of the composite good of the firm will be at least as high as the product of the cooperative (and certainly of a higher quality in some scenarios) except (iv) if the quality of the final good is determined by the minimum quality of its components, where no clear results can be derived.

In the next section we set up the model. The third section compares the quality decision of a firm and a cooperative acting as a monopolist, whereas section four considers a mixed duopoly setting. The last section concludes.

The model

To investigate the relationship between ownership structure and product quality, we follow Albaek and Schultz (1998) as well as Karantininis and Zago (2001) and consider a situation where there are two manufacturers and n farmers who sell through one or the other manufacturer. We call one manufacturer the cooperative (C) and the other the investor-owned firm, for short the firm (F). From the n farmers, n_C deliver to the cooperative and n_F to the firm ($n = n_F + n_C$). If a farmer delivers to the cooperative, she has to decide whether to produce high or low quality and what quantity (q) to produce and to deliver. On the other hand, the decision-making process of the firm is centralized: the firm decides which quantity and which quality each farmer has to deliver to the firm.

The manufacturers use the components delivered from the farmers and produce a composite good which is then sold to consumers. The quantity (Q) and the quality (s) of the final product are solely determined by the quantity and the quality of the inputs. Each farmer's product is associated with a number $s_i^g > 0$, $g \in \{H, L\}$ which represents its quality level.[2] To simplify notation, we normalize $s_i^L = 1$, $s_i^H = 1 + s_i$ with $s_i > 0$ exogenously given.

Consumers' preferences are formalized in the spirit of Gabszewicz and Thisse (1979) and Tirole (1988). There is a continuum of consumers distributed uniformly over the interval $[\theta - 1, \theta]$ with unit density, where $\theta > 1$. Each consumer either buys high quality, low quality or does not buy at all.[3] The consumer indexed by the parameter $\tilde{\theta} \in [\theta - 1, \theta]$ maximizes the following utility function:

$$u_{\tilde{\theta}} = \begin{cases} \tilde{\theta}(1+s) - p^H & \text{if he buys a product of high quality} \\ \tilde{\theta} - p^L & \text{if he buys a product of low quality} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

All consumers prefer higher quality at a given price, but a consumer with higher $\tilde{\theta}$ is willing to pay a higher mark-up for higher quality. The inverse demand functions for high and low quality are

$$p^H = \theta - Q^H - Q^L + (\theta - Q^H)s$$

$$\text{and} \quad (2)$$

$$p^L = \theta - Q^H - Q^L,$$

[2] We use subscripts to denote organizational forms (C and F) and superscripts to identify the level of product quality (H and L). A subscript M in addition to the organizational form indicates that we analyze a manufacturer acting as a monopolist.

[3] The assumption that each consumer buys one unit of a good at most is unrealistic, especially in the context of food products. Most of the contributions on vertical differentiation use this restriction (see, e.g. Choi and Shin, 1992; Lehman-Grube, 1997), even if they explicitly deal with the food industry as Hoffmann (2005). We recognize that this is a rather simplifying approach but maintain this assumption for the tractability of the model and for consistency with the literature on vertical product differentiation.

where Q^H and Q^L is the aggregate quantity of the high and low quality products respectively (see appendix A for a detailed derivation of the inverse demand functions).

As the decision process is centralized for the firm, there is no doubt in assessing the product quality of the firm: All farmers supplying the firm either produce high or low quality. The quality of the final product of the cooperative is determined as the (weighted) average of the quality of inputs delivered by farmers. This assumption can be represented by a linear aggregation function for product quality:[4] $\sum_{i=1}^{n_C} \omega_i s_i^g$, where ω_i represents the weight attached to the quality of farmer *i*'s product delivered, with $\sum_{i=1}^{n_C} \omega_i = 1$ and $\omega_i = \frac{1}{n_C}$.[5] As the members of the cooperative can choose different quality levels, the cooperative might end up producing a final good of 'mixed quality'. Consumers perceive this mixed quality as high quality (and are therefore willing to pay p^H) only if (i) the mixed quality maintains a certain 'threshold quality' s^T (therefore $\sum_{i=1}^{n_C} \omega_i s_i^g \geq s^T$, with $s^L < s^T \leq s^H$) and if (ii) there is no product of higher quality in the market.[6]

This specification includes as a limit case that the quality of the manufacturers' composite good is determined by the minimum of the quality levels of its components, $s = \min(s_i)$, as

[4] The linear aggregation function might be plausible in the case of wine production for example, where the quality of the wine depends on the quality of all grapes delivered.

[5] The assumption that the weights are $\frac{1}{n_C}$ for each member simplifies the analysis, as an individual farmer can affect aggregate quality only by changing her quality level and not by changing her output. With this assumption in place all farmers produce the same quantity, irrespective of their individual quality level (as quality affects only fixed, but not variable costs; see below), which serves as an ex-post justification for this assumption. However, without assuming equal weights each member can change aggregate quality by changing its output and firms might end up 'trapped' in an unfavourable situation where they do not produce the profit maximizing output for a given quality, but cannot adjust output as this would altering the aggregate quality which reduces profits even more strongly.

[6] These assumptions can be justified as most food products are experience goods, like – for example – wine: First, wine can be sold as 'quality wine' instead of 'table wine' if it exceeds a threshold quality level. Second, consumers often rely on wine guides assessing the quality of wine. As the rating (number of stars or points) is difficult to interpret, the ranking of products might be more important than the actual grade a wine receives.

proposed by Economides (1999).[7] In this case the threshold quality is given by $s^T = s^H$. The consequences of the limit case will be briefly discussed after analyzing the general form of linear aggregation.[8]

We assume that manufacturers have constant marginal costs which are normalized to zero. Farmers, on the other hand, have positive production costs. Producing high quality inputs is assumed more costly then producing low quality inputs: $c(q) = \frac{1}{2}cq^2 + f^g$ with $f^H > f^L$. To simplify notation, we normalize $f^L = 0$ and $f^H = f \geq 0$. The higher fixed costs for producing higher quality can be viewed as investment in new equipment or in professional training for the farmer, which is independent of the quantity produced. For a given product quality, all farmers have the same production technology.[9]

Due to the 'individualistic' decision-making process of the cooperative, where each member decides how much and which quality to deliver, the cooperative has no control over what is actually supplied to the market. The extent to which the individual members of the cooperative coordinate their output decisions will be represented by a parameter $\lambda \equiv \frac{\partial q_j}{\partial q_i}$ for $i \neq j$. We view λ as the outcome of some unknown game, $\lambda = 1$ would imply perfect coordination, $\lambda = 0$ corresponds to Cournot behavior within the cooperative. The

[7] Economides (1999: 903) motivates this assumption with the following example: ‚a long distance call requires the use of long distance lines as well as local lines at the two terminating points. The fidelity of sound in such a phone call is the minimum of the qualities of the three services used'. The probability of success of a complex process is given by the joint probability of success of all its parts.

[8] As a second limit case, the quality of the final product is determined by the highest quality of the inputs delivered, $s = \max(s_i)$. In this case the threshold quality can be characterized as $s^L < s^T \leq \sum_{j \neq i} \omega_j s_j^L + \omega_i s_i^H$. We will not discuss this special case any further, as it seems to be a quite unrealistic assumption when analyzing food production.

[9] Note that different assumptions concerning the cost of quality have been made in the literature so far. Here, we do not consider the cost of quality as a variable cost component which considerably simplifies the analysis. Assuming a change in product quality to influence variable costs introduces an additional interdependence between quantity and quality decisions of manufacturers. A detailed discussion of this issue is available in Hoffmann (2005). An interesting extension would also be to consider heterogeneous farmers and investigate, which type of farmer delivers to the cooperative and the firm respectively. Karantininis and Zago (2001) investigate this issue in more detail.

cooperative also retains no profit. Without free-riding on quality (which will be analyzed below), an individual members' profit depends on the prices received (p^H or p^L), and is

$$\pi_C^g = p^g q_C - \frac{1}{2} c q_C^2 - f^g . \qquad (3)$$

The firm on the other hand is characterized by 'centralized' decision making. Following Albaek and Schultz (1998), we assume that the firm has a (perfect) contract with farmers specifying the quantity as well as the quality of their inputs. As the distribution of profits between farmers and the firm is not essential here, the firm's behavior can be described as if it maximizes the vertically integrated profit of itself and its suppliers. In order to facilitate comparison with the behavior of the cooperative, we follow Albaek and Schultz (1998) in assuming that the vertically integrated profit is distributed among all farmers delivering to the firm.[10] By assumption, there is thus no difference between the firm and the cooperative in our model with respect to the degree of vertical integration: the cooperative is vertically integrated and the firm acts as if it is vertically integrated. This allows us to focus on the implications of coordination in decision making for the provision of product quality.

Depending on whether the firm supplies high or low quality, its problem is to maximize

$$\Pi_F^g = p^g Q_F - n_F \frac{1}{2} c \left(\frac{Q_F}{n_F} \right)^2 - n_F f^g \qquad (4)$$

with $Q_F = n_F q_F$. Each individual farmer receives $\pi_F^g = \frac{\Pi_F^g}{n_F}$.

It seems a very strong assumption that the firm can monitor the quality of its suppliers perfectly, whereas the cooperative cannot even offer incentives to encourage its members to produce high quality inputs and has therefore no control over the quality delivered by its upstream suppliers. We basically assume that the firm can control and enforce the quality of

[10] An alternative would be to view the firm as acting in a Cournot duopsony. As long as farmers patronizing the firm are price takers, the firm will pay according to the farmers' supply function (i.e. aggregate marginal costs). A detailed discussion of the effects of buyer market power of downstream manufacturers towards upstream firms (farmers) in a mixed duopoly is available in Tennbakk (1995).

its supplies better than the cooperative. Assume that the cooperative can control and enforce a certain quality level (and call this quality level s^L), whereas the firm can monitor the quality supplied up to a higher quality level (s^H). Both manufacturers can control quality levels below s^L, and both cannot enforce qualities above s^H. We simply focus on the quality levels between s^L and s^H, where the abilities of the firm and the cooperative with respect to monitoring and enforcing quality levels differ, and a mixed duopoly is therefore most interesting to analyze.

The cooperative and the firm as monopolists

In this section we analyze the behavior of the firm and the cooperative acting as monopolists, considering the situation of a profit maximizing firm first. Maximizing profits in (4) with respect to Q_F one can derive equilibrium profit levels for each farmer delivering to the firm when the firm produces high quality ($\pi^H_{F,M}$) or low quality ($\pi^L_{F,M}$) (see appendix B for output and profit equations). The firm decides to produce high quality if it is more profitable to do so, therefore if $\pi^H_{F,M} > \pi^L_{F,M}$. Quality choices can be illustrated by means of an 'isoprofit' contour ($IP_{F,M}$ in Figure 1), which represents all combinations of f and s for which $\pi^H_{F,M} = \pi^L_{F,M}$.

< Figure 1 around here >

If f = 0 and s = 0, there are no quality differences (neither in production costs nor in the consumers' willingness to pay for quality), and so the isoprofit curve $IP_{F,M}$ originates in this point. As the costs of producing a high quality product relative to a low quality product (f) increase, the consumers' willingness to pay for higher quality (s) also has to increase in order to guarantee each farmer the same level of profits (the isoprofit curves slope upwards, see proposition 1 in appendix C). If, for a given $s = s_1$, the additional costs for producing high quality (f) are large ($f > f_1$), the firm will choose to supply low quality. Area A in Figure 1 represents all combinations of f and s where the firm (as a monopolist) delivers low quality. The firm delivers high quality in areas B and C.

When we compare this situation to a market in which a cooperative is the only manufacturer, we find two main results:

Proposition (i): Even if the cooperative can control its quantity problem, the cooperative will never produce a composite good of higher quality than the firm. In situations where the firm produces low quality, the cooperative will also produce low quality, but when the firm opts for producing high quality products, the cooperative will deliver either high or low quality (we find two Nash equilibria).

Proposition (ii): If the cooperative cannot control the quantity problem (perfectly), the quality coordination problem aggravates: The cooperative will never produce higher quality products than the firm and will certainly deliver products of lower quality in a number of scenarios.

Decentralized decision making within the cooperative implies that each member (farmer) decides how much and which quality to deliver. The cooperative thus faces two (interrelated) coordination problems: a quantity and a quality control problem. The following payoff matrix (Table 1) illustrates the decision making process according to the quality of a member of the cooperative. The left column of the matrix describes the quality decision of the other members of the cooperative in contrast to the threshold quality.

< Table 1 around here >

Note that consumers have a dichotomous perception of product quality: Without competition they perceive the product to be of high quality as long as it is good enough to pass a certain threshold quality level. In the first row of the payoff matrix the final product is perceived as a high quality product, even if member *i* produces low quality. In the third row the composite good is of low quality, even if member *i* delivers a high quality input. In both situations member *i* cannot alter the quality perceived by consumers and will produce low quality, which reduces production costs without altering the market price ($\pi^{L}_{C,M} > \pi^{L-}_{C,M}$ and $\pi^{H+}_{C,M} > \pi^{H}_{C,M}$). In these situations it is always more profitable for a single member to produce and deliver low quality inputs, as indicated by the arrows in Table 1. We therefore suggests the possibility of two Nash equilibria in the decision making within the cooperative: It is <u>always</u> an equilibrium that all members produce low quality. As long as $\pi^{L}_{C,M} > \pi^{H}_{C,M}$ this is the only equilibrium and producing low quality is the dominant strategy. It <u>might</u> be an equilibrium that the cooperative produces a quality level just good enough to be perceived as a high quality product. This is the case if $\pi^{H}_{C,M} \geq \pi^{L}_{C,M}$. The indeterminacy of the equilibrium in the quality decisions within the cooperative however implies that the cooperative <u>could</u> also end up producing the low quality product even if producing high quality would generate higher profits for all members.

We observe both a free-riding and a coordination problems: First, one member can produce low quality and still receive the market price for high quality products (free-riding problem). Second, in case when producing high quality products is more profitable for all members, the cooperative cannot ensure that the cooperative ends up producing high quality products (coordination problem).

If the quality of the final product of the cooperative is determined by the lowest quality of inputs, the composite good will be of high quality only if <u>all</u> members decide to deliver high quality. In this case $s^T = s^H = \sum_{j \neq i} \omega_j s_j^H + \omega_i s_i^H$. Again all members producing low quality is always an equilibrium. If $\pi_{C,M}^H \geq \pi_{C,M}^L$ there exists a second equilibrium with all members producing high quality inputs. We again observe a coordination problem, as the cooperative cannot ensure producing high quality products, even if it is more profitable. However, free-riding is absent in this limit case, as it is not possible for any member to produce low quality inputs and still receive the market price for high quality products.

To investigate the factors influencing the profit of the cooperative when producing high or low quality ($\pi_{C,M}^H$ and $\pi_{C,M}^L$), we maximizes profits in equation (3) with respect to q_C^g (see again appendix B for equilibrium quantities and profits). Note that if quantity decisions are perfectly coordinated ($\lambda = 1$), output levels and profits for members of the cooperative and farmers delivering to the firm are identical ($q_{C,M}^g = q_{F,M}^g$ and $\pi_{C,M}^g = \pi_{F,M}^g$). Controlling the quantity coordination problem implies that the isoprofit curve for the cooperative is identical to the isoprofit curve for the firm in Figure 1: $IP_{F,M} = IP_{C,M}^{\lambda=1}$. In area *A* the cooperative acts as the firm and delivers low quality, whereas we find two Nash equilibria in areas *B* and *C*: either all members produce low quality or the cooperative produces a mixed quality, just passing the threshold quality s^T (see proposition (i)).

If, however, quantity decisions within the cooperative are not perfectly coordinated ($\lambda < 1$), we find that the incentive to supply high quality for the cooperative is smaller, ceteris paribus. With imperfect quantity coordination, cooperative members tend to overproduce ($\frac{\partial q_C^g}{\partial \lambda} < 0$). As the aggregate quantity supplied to the market increases, the consumers willingness to pay for higher quality decreases,[11] which reduces $\pi_{C,M}^H$ relative to $\pi_{C,M}^L$. We

[11] Note from equation (2) that $p^H - p^L = \left(\theta - Q^H\right)s$ is a decreasing function of Q^H.

thus find that $IP_{F,M} > IP^{\lambda<1}_{C,M}$ (see proposition 2 in appendix C). Area *B* in Figure 1 represents all combinations of *f* and *s*, where the firm (as a monopolist) delivers high quality, whereas the product of the cooperative (as a monopolist) is of low quality. In area *C* we again have two Nash equilibria for decision making within the cooperative: 'pure' low quality or a mixed quality high enough to pass s^T (see proposition (ii)).

The results derived so far illustrate the quality coordination problem within the cooperative. Although the quality of products delivered by a cooperative can be the same as those produced by a profit maximizing firm, a cooperative will deliver lower quality in a number of scenarios. In contrast, there is no combination of parameters in this model where the cooperative would deliver higher quality than the firm. For the cooperative acting as a monopolist we observe a coordination problem, because even if $\pi^H_{C,M} > \pi^L_{C,M}$ we find two Nash-equilibria: The cooperative cannot ensure, that the quality of the final product will be high enough, although it is more profitable. Additionally, we observe a free-rider problem: Some farmers produce high quality to preserve the threshold requirement (to receive p^H), while others free-ride, produce low quality and receive higher profits (as $\pi^{H+}_{C,M} > \pi^H_{C,M}$). The results further suggest that the coordination problems with respect to quality and quantity within the cooperative are closely related. Improving the coordination problem with respect to quantity also helps to reduce the quality coordination problem.

The results are similar if the quality of the final product is assumed to be determined by the minimum quality of the inputs. As the profit levels for a member of the cooperative ($\pi^H_{C,M}$ and $\pi^L_{C,M}$) are independent of the two different aggregation functions discussed, the isoprofit curves in Figure 1 do not change. The only difference is that the cooperative will produce 'pure' high quality instead of mixed quality in the general case. Again we observe a coordination problem, because even if $\pi^H_{C,M} > \pi^L_{C,M}$ the cooperative cannot ensure that the composite product will be of high quality. But we do not observe a free-rider problem in the classical sense: One member cannot benefit from the decision of the other members to produce high quality inputs (via a higher market price), without delivering high quality herself.

The specific form in which the quality of inputs is aggregated is even more important in situations where the cooperative and the firm compete in the downstream market (mixed duopoly).

The cooperative and the firm in a mixed duopoly

Assume that the firm and the members of the cooperative play a two-stage game and decide on investment in quality in the first, and about quantities in the second stage of the game. Within each stage the firm and the members of the cooperatives have to decide simultaneously about quality and output levels. The optimal output decisions for the cooperative and the firm will depend on their own as well as their rival's decision about product quality. Assuming Cournot behavior between the cooperative and the firm ($\frac{\partial Q_F}{\partial q_C} = \frac{\partial q_C}{\partial Q_F} = 0$) we solve the second stage of the game first. The optimal quantities (for given qualities) can be found by computing $\frac{\partial \pi_C^g}{\partial q_C} = 0$ from (1) and $\frac{\partial \Pi_F^g}{\partial Q_F} = 0$ from (2) and solving for q_C^g and q_F^g. The corresponding levels of profits for the individual members of the cooperative as well as for the farmers supplying the firm for all combinations of quality levels are again summarized in appendix B. Table 2 illustrates the profits for the quality levels of the firm and the cooperative:[12]

[12] In the following we denote the farmers' profits with π^{LL} and π^{HH} when both manufacturers deliver low quality (superscript *LL*) or high quality (superscript *HH*). Farmers' profits are π^{L} (π^{H}) when they supply to a manufacturer whose product is of low (high) quality whereas the quality of the rival's product is of high (low) quality. Note that *HH* is only possible if all members of the cooperative produce high quality and that if *C=H* and *F=L* the profits of those members of the cooperative, who free-ride and produce low quality increases by *f*.

< Table 2 around here >

The choice of quality levels and the corresponding profits of individual farmers depend on parameters θ, λ, s and f, as well as on the number of firms n_C and n_F. To keep the following discussion as simple as possible and to focus on the quality decisions, we ignore the quantity coordination problem and assume $\lambda = 1$. Any difference in product quality between the cooperative and the firm are not caused by the well known 'quantity control problem' of the cooperative (described above for the monopoly case). We further restrict our attention to the 'closed membership' case where each farmer has already decided whether to deliver to the firm or to the cooperative and for simplicity we assume $n_C = n_F = \frac{n}{2}$ to be exogenously given.[13]

In contrast to the monopoly case discussed in the previous section each manufacturer now has to consider the quality decision of its rival in determining his optimal level of quality. Our main findings in a mixed duopoly setting are:

Proposition (iii): In general the quality of the composite good of the firm will be at least as high as the product of the cooperative and certainly of a higher quality in some scenarios.

Proposition (iv): If the quality of the final good is determined by the minimum quality of its components, we cannot derive clear results. We find scenarios where the firm produces higher quality or both manufacturers produce the same quality levels, but we also find scenarios where the cooperative ends up producing higher quality products than the firm.

[13] The point here is to illustrate how differences in the degree of coordination in the decision making process as well as the way in which aggregate quality is produced from the inputs delivered result in differences in strategic behavior in the final market. The explanation of how the market division is determined in the first place is not an issue here, the implications of $n_F \neq n_C$ in a mixed duopoly will be briefly discussed in the final section of the paper. A detailed analysis of the implications of different access policies for financing and growth of an open-membership cooperative is available in Rey and Tirole (2007).

The interdependence in decision making as well as the equilibrium configuration of quality levels offered by the two manufacturers is shown in Figure 2.

< Figure 2 around here >

Figure 2 shows isoprofit contours for the firm and the cooperative for given parameters (n, θ, and c). Assuming perfect coordination in output decisions within the cooperative implies that the firm and the cooperative deliver the same quantities as long as quality levels are identical. We thus find that $\pi_C^{LL} = \pi_F^{LL}$, $\pi_C^{HH} = \pi_F^{HH}$, $\pi_C^{L} = \pi_F^{L}$, and $\pi_C^{H} = \pi_F^{H}$. This implies that the isoprofit curves for the firm and the cooperative are identical: $IP_F^1 \equiv IP_C^1$ and $IP_F^2 \equiv IP_C^2$. IP_F^1 and IP_C^1 are the isoprofit curves for the firm and the cooperative respectively assuming that the rival delivers low quality, whereas IP_F^2 and IP_C^2 denote the corresponding isoprofit curves given that the rival delivers high quality. Note that $IP_F^1 > IP_F^2$ and $IP_C^1 > IP_C^2$: the decision of the firm to produce high instead of low quality reduces the incentive of the cooperative to produce high quality too, and vice versa (for a formal analysis see proposition 3 in appendix C). The two manufacturers have an incentive to differentiate vertically. It is well known from the results of 'first-quality-then-price games' (Shaked and Sutton, 1982) that vertical differentiation reduces the intensity of competition in the product market.

The model suggests three different equilibrium configurations (areas *A*, *B*, and *C*): Both manufacturers will offer low quality products in area *A*. Area *B* represents combinations of *f* and *s* where the firm produces high and the cooperative delivers low quality. In area *C* the firm will again deliver high quality products whereas the cooperative offers either high or low quality.

The quality decisions in area *A* and area *C* of the firm are easily analyzed, as they do not depend on the cooperatives choice of quality: Area *A* represents all combinations of *f* and *s* where the firm will produce low quality, whether the cooperative delivers low quality (as we are above IP_F^1) or high quality products (as we are above IP_F^2). The firm will produce low quality in area *C*, as we are below both isoprofit curves IP_F^1 and IP_F^2. The dominant strategy for the members of the cooperative in area *A* is to produce low quality. In area *C* the cooperative faces a firm producing high quality goods in any case, but although profits are higher when producing high quality products we find two Nash-equilibria in the decision making process of the members of the cooperative: either all members produce low quality or all members deliver high quality inputs. As in the monopoly case, the cooperative cannot ensure that all members deliver high quality (quality coordination problem).

In area *B* the decisions about quality are interdependent: the firm will choose to produce high quality, if the cooperative produces low quality (since we are below IP_F^1), but low quality, if the cooperative produces high quality goods (since we are above IP_F^2). The reason for this is, that the price increase, the firm can realize from producing high instead of low quality products, is smaller if the cooperative produces high quality already (see footnote 11). The cooperative's decision in turn is illustrated in the following payoff matrix.

< Table 3 around here >

If the firm produces high quality (the situation described in the second payoff-matrix), the dominant strategy for the members of the cooperative is to produce low quality (as $\pi_C^L > \pi_C^{L-}$ and as we are above IP_C^2, which implies $\pi_C^L > \pi_C^{HH}$). If, on the other hand, the firm offers low quality (the situation described in the first payoff-matrix), Table 3 suggests the existence of two Nash-equilibria: Either all members produce low quality (as $\pi_C^{LL} > \pi_C^{LL-}$) or the cooperative produces mixed quality (as we are below IP_C^1, which implies $\pi_C^H > \pi_C^{LL}$). The cooperative will never produce a final product of 'pure' high quality, as some members can save production costs without altering the market price by producing low quality (free-riding problem, as $\pi_C^{H+} > \pi_C^H$).

Both Nash-equilibria in the decision making process within the cooperative (producing low quality or producing mixed quality) turns out to be inconsistent with a Nash-equilibrium in the game between the firm and the cooperative: If the cooperative produces low quality, the firm will immediately switch to high quality (as we are below IP_F^1 in area *B*). But how would the firm respond to the decision of the cooperative to supply 'mixed quality'? Note, that a 'mixed quality' of the cooperative implies that the firms' product would be of higher (lower) quality than the cooperatives' product if the firm decides to produce high (low) quality. The firm is indifferent between high and low quality if $\pi_F^H = \pi_F^L$. All combinations of *f* and *s* where $\pi_F^H = \pi_F^L$ are represented by the isoprofit contour IP_F^3 in Figure 2. Proposition 4 in appendix C shows that $IP_F^3 > IP_F^1$, which implies that it is always attractive for the firm to produce high quality if the cooperative delivers 'mixed quality'. The firm producing high and the cooperative delivering low quality products is therefore the only remaining equilibrium in area *B*. In markets, where the average quality of the inputs determines the quality of the final product, the free-riding problem within the cooperative implies that the cooperative in our modeling framework will never deliver higher quality products than the firm, and certainly lower quality products in a number of scenarios (see proposition (iii)).

Under the assumption that the quality of the composite good is determined by the lowest quality of inputs, the results for the areas *A* and *C* are identical to the previous analyses. For area *B* the analysis is different. If the firm produces low quality, there are two Nash-equilibria within the cooperative: Either all members produce low quality inputs, or all members deliver high quality products. Producing high quality goods is also consistent with a Nash-equilibrium in the game between the firm and the cooperative.

When the quality is determined by the minimum quality, the cooperative still faces a coordination problem with respect to the quality of the inputs supplied by its members. But there is no possibility for any member to free-ride on the quality delivered by the other farmers: As soon as one farmer delivers inputs of low quality, the composite good is of a low quality (and each member receives the market price for the low quality product). This type of quality aggregation (aggregate quality is determined by the minimum quality of inputs) improves the situation for the cooperative, whereas it does not alter the firm directly, as the firm is not plagued by free-riding problems. The coordination problem of the cooperative alone is not strong enough to ensure that firms will always deliver a quality that is at least as high as the quality supplied by the cooperative (see proposition (iv)).

The present model also includes the results derived in Albaek and Schultz (1998) as a special case. Ignoring differences in product quality, the quantity coordination problem of the cooperative turns out to be a comparative advantage and all farmers should become members of the cooperative in an open-membership equilibrium. Assuming $s = 0$, $f = 0$, and $\lambda = 0$ we find that the profit of cooperative members always exceed those of farmers delivering to the firm as long as $n_F > 1$ (see proposition 5 in appendix C). The present analysis however suggests that the superior performance of cooperatives suggested in Albaek and Schultz will disappear in markets where consumers care about product quality ($s > 0$). A deeper examination of an open membership setting in this case is beyond the scope of this paper.

Conclusions and extensions

The present paper investigates the incentives to supply high quality products in a vertically related industry. Quality choices of an investor-owned firm and a producer cooperative are analyzed within a monopoly as well as a mixed duopoly framework. Assuming that the members of the cooperative independently decide about the quantity and the quality they deliver (decentralized decision making) there is a strong incentive to free-ride and to deliver high quantity and low quality (quantity and quality coordination problem). The investor-owned firm on the other hand is characterized by a centralized decision making process and, by assumption, is not plagued by a coordination problem.

Comparing the behavior of the two organisations (cooperative and firm) in a monopolistic market position we find that a cooperative will never produce higher quality than an investor-owned firm, as the cooperative faces a quality coordination problem. The quality coordination problem gets even more severe if the members fail to coordinate their output decisions and therefore overproduce (free-riding on quantity).

In a mixed duopoly setting the incentives for the competitors to supply higher-quality products depend on the way in which the quality of the final product is determined from the inputs delivered by upstream firms (farmers). In a general setting, where the quality of the final product is the average of the quality of inputs delivered by farmers, the free-riding problem is strong enough to ensure that the quality of the cooperative's final product will never be above the quality of the firm's composite good. In the special case that the quality of the manufacturers' composite good is the minimum of the quality levels of its components, the free-riding problem is mitigated, as one member cannot receive the market price for high quality products without delivering high quality inputs himself. Despite the coordination problem, the cooperative's product can be of higher quality than the product supplied by the firm.

The theoretical analysis further suggests that the quantity and quality control problem within the cooperative are interrelated. Introducing measures to coordinate quantity decisions of members helps to mitigate the coordination and free-riding problem with respect to product quality within the cooperative. In situations, where the quality of inputs supplied to the cooperative is more difficult to verify than the quantity delivered (in practice, the quality of inputs might be non-contractible between independent members of the cooperative), any attempt to coordinate quantities will be a suitable second best choice which indirectly also contributes to a higher level of product quality of the cooperative's product.

Whether the firm and the cooperative will offer high or low quality in equilibrium will also depend on factors which are not explicitly included in this model. It is well known that repeated interaction between members helps to achieve a cooperative outcome. The equilibrium outcome might be determined by the visibility of cheating (free-riding) and on the possibility of punishment. For example, Winfree and McCluskey (2005) show in an extension of Tirole's (1996) model of collective reputation that there exists an incentive for a single firm to free-ride when the market price depends on the reputation of a producer group (or cooperative), which is based on past quality provided by the group. They show that in a repeated game the threat of punishment (by other members providing low quality) might be strong enough to achieve a sustainable equilibrium with high quality products. In addition, free-riding could be reduced if the cooperative improves in assessing the product quality of its members. Pouliot and Sumner (2008) show that an increase in the traceability to upstream suppliers (farmers) has positive effects on the quality (safety) of the raw materials provided. The results obtained further are likely to be sensitive to our assumptions about the specification of consumer preferences with respect to quality (Tirole, 1988:101) as well as on the assumptions concerning the cost of quality (Hoffmann, 2005). In addition, the extent to which the degree of competition between manufacturers influences the quality decisions in a mixed duopoly has not yet been investigated in detail.

Finally, our results are derived under the assumption that the number of upstream firms (farmers) patronizing one of the two manufacturers is exogenously given (closed membership). In contrast, an open-membership model would determine the share of farmers delivering to the cooperative and to the firm endogenously: this share will depend on the relative level of profits associated with supplying one of the two manufacturers. A detailed analysis of quantity and quality decisions in an open-membership model is beyond the scope of the present paper.[14] Our result, however, that members of the cooperative tend to supply products of lower quality (and thus realize lower profits) causes doubts upon the finding of Albaek and Schultz (1998), who conclude that 'in the long run all farmers would be members of the cooperative' (Albaek and Schultz, 1998:401). Our model suggests that the profitability of cooperatives depends on consumers' preferences for quality, as well as the way in which the aggregate quality is produced from the individual inputs delivered. These characteristics need not be identical for all products and might also differ between individual countries.[15] We hope that our paper will spur further theoretical and empirical research on the issue of product quality supplied by different organizations along these lines.

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[14] Following Tennbakk (1995), an additional option for those farmers patronising the firm would be to establish a second cooperative. Tennbakk (1995) discusses the implications of this strategy in the case of a duopoly model with homogenous products.

[15] As documented by Hansmann (1996) cooperatives figure prominently in some industries, such as agriculture, credit cards, electricity, and the financial sector. Focussing on the agri-food sector, Hendrikse (1998) finds substantial differences in the success of cooperatives between products and countries. While cooperatives have large market shares in some countries and some markets (e.g. milk production in Ireland) they are virtually non-existent in other markets (e.g. beef production in Belgium or Greece). Within a particular country (e.g. Denmark), the market shares of cooperatives vary between 0 % (poultry and sugar beet) and 97 % (pork), and within a specific market (e.g. vegetables), market shares differ between 8 % (Ireland) and 90 % (Denmark). For the U.S.A., Cook (1995) observes that the market share of cooperatives in the market for milk production in the US increased steadily from 46 % in 1951 to 85 % in 1993. The market shares in other markets remained fairly stable (e.g. fruits and vegetables) or even declined slightly (e.g. livestock).

Appendix A

The utility function of a consumer is characterized by equation (1):

$$u_{\tilde{\theta}} = \begin{cases} \tilde{\theta}(1+s) - p^H & \text{if he buys a product of high quality} \\ \tilde{\theta} - p^L & \text{if he buys a product of low quality} \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

The consumer who is indifferent between buying a product of low quality and not buying at all is characterized by a parameter value θ', and the consumer who is indifferent between buying a low or a high quality product is denoted by a parameter value of θ'', with $\theta - 1 < \theta' < \theta'' < \theta$. The threshold quality levels with respect to prices are:

$$0 = \theta' - p^L \Leftrightarrow \theta' = p^L$$

and

$$\theta'' - p^L = \theta''(1+s) - p^H \Leftrightarrow \theta'' = \frac{p^H - p^L}{s}$$

The producer of low quality products captures all consumers with $\theta' \leq \tilde{\theta} < \theta''$ and the producer of high quality products gets all consumers with $\theta'' \leq \tilde{\theta} \leq \theta$.[16] Assuming a uniform distribution of consumers over the interval $[\theta - 1, \theta]$ with unit density, the demand for low (Q^L) and high quality (Q^H) is:

$$Q^L = \theta'' - \theta' = \frac{p^H - p^L}{s} - p^L$$

$$Q^H = \theta - \theta'' = \theta - \frac{p^H - p^L}{s}$$

Solving for p^H and p^L gives the inverse demand functions as stated in equation (2):

$$p^H = \theta - Q^H - Q^L + (\theta - Q^H)s$$

and (2)

$$p^L = \theta - Q^H - Q^L$$

[16] We assume that the indifferent consumer buys the product of higher quality, for convenience.

Appendix B

The firm as a monopolist:

Maximizing profits in equation (4) with respect to Q_F gives $q_{F,M}^H = \frac{Q_{F,M}^H}{n} = \frac{\theta s}{c+2n(1+s)}$ for high quality and $q_{F,M}^L = \frac{Q_{F,M}^L}{n} = \frac{\theta}{c+2n}$ for low quality products. The corresponding profit for each individual farmer is $\pi_{F,M}^H = \frac{\theta^2 s^2}{2c+4n(1+s)} - f$ and $\pi_{F,M}^L = \frac{\theta^2}{2c+4n}$.

The cooperative as a monopolist:

Maximizing profits in equation (3) with respect to q_C^g which gives $q_{C,M}^H = \frac{\theta(1+s)}{c+\left[n+1+\lambda(n-1)\right](1+s)}$ for high quality products and $q_{C,M}^L = \frac{\theta}{c+n+1+\lambda(n-1)}$ for low quality products. The corresponding levels of profits are $\pi_{C,M}^H = -f + \frac{\theta^2(1+s)^2\left\{c+2\left[1+\lambda(n-1)\right](1+s)\right\}}{2\left\{c+\left[n+1+\lambda(n-1)\right](1+s)\right\}^2}$ and $\pi_{C,M}^L = \frac{\theta^2\left\{c+2\left[1+\lambda(n-1)\right]\right\}}{2\left[c+n+1+\lambda(n-1)\right]^2}$.

The cooperative and the firm in a mixed duopoly:

The corresponding levels of profits for the individual members of the cooperative as well as for the farmers supplying the firm for all combinations of quality levels are listed below. Note that we denote both manufacturers delivering the same quality with superscript *LL* (for low quality) and superscript *HH* (for high quality). One superscript indicates that we observe product differentiation with respect to product quality: The superscript *L* (*H*) denotes that this manufacturer produces low (high) quality whereas the quality of the rival's product is of high (low) quality.

$$\pi_C^{LL} = \frac{\theta^2\left[2+c+2\lambda(n_C-1)\right](c+n_F)^2}{2\left[c^2+(2+n_C)n_F+c(1+n_C+2n_F)+\lambda(n_C-1)(c+2n_F)\right]^2}$$

$$\pi_C^H = -f + \frac{\theta^2\left\{c+2(1+s)\left[1+\lambda(n_C-1)\right]\right\}\left[c(1+s)+n_F(1+2s)\right]^2}{2\left\{c^2+2cn_F+n_Cn_Fs+c(1+n_C)(1+s)+n_F(2+n_C)(1+s)+\lambda(1+s)(n_C-1)(c+2n_F)\right\}^2}$$

$$\pi_C^L = \frac{\theta^2\left[2+c+2\lambda(n_C-1)\right]\left[c+n_F(1+s)\right]^2}{2\left[-n_Cn_F+c\left[c+2n_F(1+s)\right]+\left[1+\lambda(n_C-1)+n_C\right]\left[c+2n_F(1+s)\right]\right]^2}$$

$$\pi_C^{HH} = -f + \frac{\theta^2 (1+s)^2 \left\{c + 2\left[1+\lambda(n_C - 1)\right](1+s)\right\}\left[c + n_F (1+s)\right]^2}{2\left\{c^2 + c(1+s)(1+n_C+2n_F) + (2+n_C) n_F (1+s)^2 + \lambda(n_C-1)\left[c(1+s) + 2n_F (1+s)^2\right]\right\}^2}$$

$$\pi_F^{LL} = \frac{\theta^2 (c+2n_F)\left[1+c+\lambda(n_C-1)\right]^2}{2\left[c^2 + (2+n_C) n_F + c(1+n_C+2n_F) + \lambda(n_C-1)(c+2n_F)\right]^2}$$

$$\pi_F^{L} = \frac{\theta^2 (c+2n_F)\left\{c + \left[1+\lambda(n_C-1)\right](1+s)\right\}^2}{2\left\{c^2 + 2cn_F + n_C n_F s + c(1+n_C)(1+s) + n_F (2+n_C)(1+s) + \lambda(1+s)(n_C-1)(c+2n_F)\right\}^2}$$

$$\pi_F^{H} = -f + \frac{\theta^2 \left[c+2n_F(1+s)\right]\left\{n_C s + (1+s)\left[1+c+\lambda(n_C-1)\right]\right\}^2}{2\left[-n_C n_F + c\left[c+2n_F(1+s)\right] + \left[1+\lambda(n_C-1)+n_C\right]\left[c+2n_F(1+s)\right]\right]^2}$$

$$\pi_F^{HH} = -f + \frac{\theta^2 (1+s)^2 \left[c+2n_F(1+s)\right]\left\{c + (1+s)\left[1+\lambda(n_C-1)\right]\right\}^2}{2\left\{c^2 + c(1+s)(1+n_C+2n_F) + (2+n_C) n_F (1+s)^2 + \lambda(n_C-1)\left[c(1+s) + 2n_F (1+s)^2\right]\right\}^2}$$

Appendix C

Proposition 1:

The iso-profit contours ($IP_{C,M}^{\lambda<1}$, $IP_{F,M} = IP_{C,M}^{\lambda=1}$, $IP_F^1 = IP_C^1$, $IP_F^2 = IP_C^2$, IP_F^3) slope upwards in the *f/s* space for $s > 0$, $n \geq 1$, and for $\lambda \in [0,1]$ (for $IP_{C,M}^{\lambda<1}$) and for $\lambda = 1$ (for all other contours). $n_F = n_C = \frac{n}{2}$ for all iso-profit contours in the mixed duopoly setting (for the contours IP_F^1, IP_C^1, IP_F^2, IP_C^2, IP_F^3).

Proof:

We compute the relevant iso-profit contour by setting $\pi_F^g - \pi_C^g = 0$ and solving for *f*. We show that the derivative with respect to *s* is positive.

$$IP_{C,M}^{\lambda<1} = \frac{\theta^2}{2}\left(-\frac{2+c+2\lambda(n-1)}{\left[1+c+\lambda(n-1)+n\right]^2} + \frac{(1+s)^2\left\{c+2\left[1+\lambda(n-1)\right](1+s)\right\}}{\left\{c+\left[1+\lambda(n-1)+n\right](1+s)\right\}^2}\right)$$

$$\frac{\partial IP_{C,M}^{\lambda<1}}{\partial s} = \frac{\theta^2(1+s)\left\{c^2+3c\left[1+\lambda(n-1)\right](1+s)+\left[1+\lambda^2(n-1)^2+n+\lambda\left(-2+n+n^2\right)\right](1+s)^2\right\}}{\left\{c+\left[1+\lambda(n-1)+n\right](1+s)\right\}^3} > 0$$

$$IP_{F,M} = IP_{C,M}^{\lambda=1} = \frac{\theta^2 s\left[2n(1+s)+c(2+s)\right]}{2(c+2n)\left[c+2n(1+s)\right]}$$

$$\frac{\partial IP_{F,M}}{\partial s} = \frac{\partial IP_{C,M}^{\lambda=1}}{\partial s} = \frac{\theta^2(1+s)\left[c+n(1+s)\right]}{\left[c+2n(1+s)\right]^2} > 0$$

$$IP_F^1 = IP_C^1$$
$$= \frac{2\theta^2 s\left[(2c+n)^2(2c+3n)\left(4c^2+10cn+7n^2\right)+4(c+n)(2c+n)\left(2c^3+13c^2n+24cn^2+14n^3\right)s+4n(c+n)^2(2c+3n)^2 s^2\right]}{(2c+3n)\left[4c^2+4cn(2+s)+n^2(3+4s)\right]^2}$$

$$\frac{\partial IP_F^1}{\partial s} = \frac{\partial IP_C^1}{\partial s}$$
$$= \frac{2\theta^2\left[2c+n+2(c+n)s\right]\left[(2c+n)^2\left(4c^2+10cn+7n^2\right)+2n(c+n)(2c+n)(6c+7n)s+8n^2(c+n)^2 s^2\right]}{\left[4c^2+4cn(2+s)+n^2(3+4s)\right]^3} > 0$$

$$IP_F^2 = IP_C^2 = \frac{\theta^2(2c+n+ns)^2}{8}\left(\frac{16(1+s)^2(c+n+ns)}{(2c+n+ns)^2\left[2c+3n(1+s)\right]^2} - \frac{16(c+n)}{\left[4c^2+4cn(2+s)+n^2(3+4s)\right]^2}\right)$$

$$\frac{\partial IP_F^2}{\partial s} = \frac{\partial IP_C^2}{\partial s} = \frac{\theta^2(2c+n+ns)}{4}\left(\frac{8(1+s)\left[4c^2+6cn(1+s)+3n^2(1+s)^2\right]}{(2c+n+ns)\left[2c+3n(1+s)\right]^3} + \frac{16n(c+n)(2c+n)^2}{\left[4c^2+4cn(2+s)+n^2(3+4s)\right]^3}\right) > 0$$

$$IP_F^3 = \frac{2\theta^2 s\left[2c+n+(c+n)s\right]}{4c^2+4cn(2+s)+n^2(3+4s)}$$

$$\frac{\partial IP_F^3}{\partial s} = \frac{2\theta^2\left[(2c+n)^2(2c+3n)+2(c+n)(2c+n)(2c+3n)s+4n(c+n)^2 s^2\right]}{\left[4c^2+4cn(2+s)+n^2(3+4s)\right]^2} > 0$$

Proposition 2:

If the quantity decisions within the cooperative (acting as a monopolist in the downstream market) are not perfectly coordinated ($\lambda < 1$) the incentive to produce high quality products declines.

Proof:

For $\lambda = 1$ we have $IP_{F,M} = IP_{C,M}$. We need to show that $\frac{\partial IP_{C,M}}{\partial \lambda} > 0$ for $s > 0$ and $n > 1$. To compute $IP_{C,M}$, we set $\pi_{C,M}^H - \pi_{C,M}^L = 0$ and solve for *f*. This gives:

$$IP_{C,M} = \frac{\theta^2}{2}\left(-\frac{2+c+2\lambda(n-1)}{\left[1+c+\lambda(n-1)+n\right]^2} + \frac{(1+s)^2\left\{c+2\left[1+\lambda(n-1)\right](1+s)\right\}}{\left\{c+\left[1+\lambda(n-1)+n\right](1+s)\right\}^2}\right)$$

$$\begin{aligned}
\frac{\partial IP_{C,M}}{\partial \lambda} &= (n-1)\theta^2\left(\frac{2+c+2\lambda(n-1)}{\left[1+c+\lambda(n-1)+n\right]^3} - \frac{1}{\left[1+c+\lambda(n-1)+n\right]^2}\right. \\
&\qquad \left. - \frac{(1+s)^3\left\{c+2\left[1+\lambda(n-1)\right](1+s)\right\}}{\left\{c+\left[1+\lambda(n-1)+n\right](1+s)\right\}^3} + \frac{(1+s)^3}{\left\{c+\left[1+\lambda(n-1)+n\right](1+s)\right\}^2}\right) \\
&= (1-\lambda)(n-1)^2\theta^2\left(-\frac{1}{\left[1+c+\lambda(n-1)+n\right]^3} + \frac{(1+s)^4}{\left\{c+\left[1+\lambda(n-1)+n\right](1+s)\right\}^3}\right) \\
&= (1-\lambda)(n-1)^2\theta^2\left(-\frac{1}{\left[1+c+\lambda(n-1)+n\right]^3} + \frac{1}{\left\{1+\frac{c}{(1+s)}+\lambda(n-1)+n\right\}^3}\frac{(1+s)^4}{(1+s)^3}\right) > 0
\end{aligned}$$

Proposition 3:

In the mixed duopoly setting, it is always more profitable to switch to high quality if the rivalling manufacturer produces low quality, compared to a situation when the rivalling manufacturer produces high quality, as long as $s > 0$ and $n > 2$.

Proof:

To show that $IP_F^1 = IP_C^1 > IP_F^2 = IP_C^2$ for $\lambda = 1$, $n_C = n_F = \frac{n}{2}$ and $s > 0$ we compute $IP_F^1 - IP_F^2$ ($= IP_C^1 - IP_C^2$) and show that this is positive. Using the levels of profits shown in Table 2 we set $\pi_F^H - \pi_F^{LL} = 0$ and $\pi_F^{HH} - \pi_F^L = 0$ and solve for *f* which gives the equation for IP_F^1 and IP_F^2 as well as $IP_F^1 - IP_F^2$:

$$IP_F^1 - IP_F^2 = IP_C^1 - IP_C^2$$
$$= \frac{\theta^2}{2}\left\{ -\frac{c+2n}{(c+3n)^2} + \frac{(c+n+cs+2ns)^2\left[c+2n(1+s)\right]}{\left[c^2+2cn(2+s)+n^2(3+4s)\right]^2} - \frac{(c+n+ns)^2(1+s)^2\left[c+2n(1+s)\right]}{\left[c^2+4cn(1+s)+3n^2(1+s)^2\right]^2} + \frac{(c+n+ns)^2(c+2n)}{\left[c^2+4cn(1+s)+3n^2(1+s)^2\right]^2} \right\}$$

After rearranging we get:

$$IP_F^1 - IP_F^2 = IP_C^1 - IP_C^2 = \frac{\theta^2(c+n+ns)^2 nsK}{2(c+3n)^2\left[c^2+4cn(1+s)+3n^2(1+s)^2\right]^2\left[c^2+2cn(2+s)+n^2(3+4s)\right]^2} > 0$$

$$\begin{aligned} K = {} & 2c^6\left(1+3s+s^2\right)+18n^6(1+s)^2\left(6+25s+20s^2\right)+c^5n\left(26+85s+56s^2+9s^3\right) \\ & +2c^4n^2\left(68+247s+232s^2+70s^3+5s^4\right)+2c^3n^3\left(182+747s+896s^2+389s^3+50s^4\right) \\ & +2c^2n^4\left(261+1225s+1791s^2+1011s^3+185s^4\right)+3cn^5\left(126+679s+1184s^2+831s^3+200s^4\right) > 0 \end{aligned}$$

<u>Proposition 4:</u>

It is always profitable for the firm to produce high quality if the cooperative delivers 'mixed quality'.

<u>Proof:</u>

We need to show that $IP_F^3 > IP_F^1 = IP_C^1$ if $\lambda = 1$, $n_C = n_F = \frac{n}{2}$ and $s > 0$. To compute IP_F^3 and IP_F^1, we set $\pi_F^H - \pi_F^L = 0$ and $\pi_F^H - \pi_F^{LL} = 0$ from Table 2 and solve for *f*. This gives

$$IP_F^3 = \frac{2s\left[c(2+s)+n(1+s)\right]\theta^2}{4c^2+4cn(2+s)+n^2(3+4s)}$$

$$IP_F^1 = IP_C^1 = \frac{2\left[c+n(1+s)\right]\left[2c(1+s)+n(1+2s)\right]^2\theta^2}{\left[4c^2+4cn(2+s)+n^2(3+4s)\right]^2} - \frac{2(c+n)\theta^2}{(2c+3n)^2}$$

After rearranging, we get:

$$IP_F^3 - IP_F^1 = IP_F^3 - IP_C^1 = \frac{2ns\left(2c^2+3cn+n^2\right)\left[8c^2+2cn(8+3s)+n^2(6+7s)\right]\theta^2}{(2c+3n)^2\left[4c^2+4cn(2+s)+n^2(3+4s)\right]^2} > 0$$

Proposition 5:

The profit of farmers delivering to the cooperative exceeds those patronising the firm if $s=0$, $f=0$, and $\lambda=0$ as long as $n_F > 1$ (the result obtained in Albaek and Schultz, 1998).

Proof:

Profits of farmers from Table 2 simplify to $\pi_C^g = \frac{(2+c)(c+n_F)^2\,\theta^2}{2\left[c^2+(2+n_C)n_F+c(1+n_C+2n_F)\right]^2}$ and

$\pi_C^g = \frac{(1+c)^2\,(c+2n_F)\theta^2}{2\left[c^2+(2+n_C)n_F+c(1+n_C+2n_F)\right]^2}$ $s=0$, $f=0$, and $\lambda=0$. From this we find that

$\pi_C^g > \pi_F^g$ if $n_F > 1$.

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Table 1: Payoff matrix for members of the cooperative (monopolist)

(Quality perception of consumers in brackets; arrows denote strategies that are always more profitable)

		Member i: H		Member i: L
All other members	$s^T \leq \sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^L$	$\pi_{C,M}^{H}$ (high)	→	$\pi_{C,M}^{H+}$ (high)
	$\sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^L < s^T \leq \sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^H$	$\pi_{C,M}^{H}$ (high)		$\pi_{C,M}^{L}$ (low)
	$s^T > \sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^H$	$\pi_{C,M}^{L-}$ (low)	→	$\pi_{C,M}^{L}$ (low)

Table 2: Profits for individual farmers delivering to the cooperative or to the firm

		Cooperative: Low Quality	Cooperative: High Quality
Firm	Low Quality	π_C^{LL}, π_F^{LL}	π_C^{H}, π_F^{L}
Firm	High Quality	π_C^{L}, π_F^{H}	π_C^{HH}, π_F^{HH}

Table 3: Payoff matrix for members of the cooperative if the firm produces low quality and high quality

(Quality perception of consumers in brackets; arrows denote strategies that are always more profitable)

Firm produces low quality

		Member i: H		Member i: L
All other members	$s^T \le \sum_{j \ne i} \omega_j s_j^g + \omega_i s_i^L$	π_C^H (high)	→	$\pi_{C,M}^{H+}$ (high)
	$\sum_{j \ne i} \omega_j s_j^g + \omega_i s_i^L < s^T \le \sum_{j \ne i} \omega_j s_j^g + \omega_i s_i^H$	π_C^H (high)		π_C^{LL} (low)
	$s^T > \sum_{j \ne i} \omega_j s_j^g + \omega_i s_i^H$	π_C^{LL-} (low)	→	π_C^{LL} (low)

Firm produces high quality

		Member i: H		Member i: L
All other members	$s^H = \sum_{j \ne i} \omega_j s_j^g + \omega_i s_i^H$	π_C^{HH} (high)		π_C^L (low)
	$\sum_{j \ne i} \omega_j s_j^g + \omega_i s_i^H < s^H$	π_C^{L-} (low)	→	π_C^L (low)

Figure 1: Isoprofit curves of the firm and the cooperative in a monopoly market

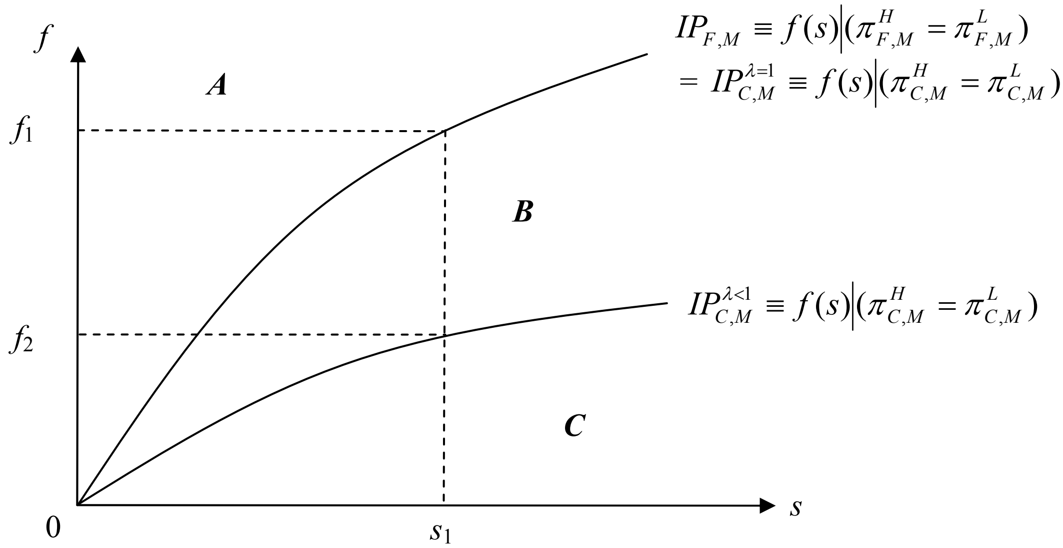

Figure 2: Isoprofit curves of the firm and the cooperative in a mixed duopoly