# Do Cooperatives Offer High Quality Products? Vertical Product Differentiation in a Mixed Oligopoly

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## Abstract:

We investigate the free-riding problem in determining product quality within cooperatives in a vertically related market. Whereas the individual member has to bear all costs associated with higher quality, the benefits of delivering higher quality will be shared among all members. On the basis of a mixed-oligopoly model, we show that the free-rider problem in the supply of high-quality products is important for the members of the cooperative and might be strong enough to ensure that cooperatives will never supply higher quality than investor-owned firms. Whether the cooperative can overcome the free-riding problem and supply a final product of high quality is shown to depend on the consumer's valuation of quality, the costs of producing high quality, the way in which the quality of the final product is determined from the quality levels of the inputs delivered, the possibilities in controlling product quantity as well as on the number of members of the cooperative.

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## 1. Introduction

Cooperatives and investor-owned firms are alternative forms of business organisation that coexist and compete in many markets. The theoretical literature has identified a number of comparative advantages and disadvantages of cooperatives (Fulton, 1995; Albaek and Schultz 1998; Karantininis/Zago 2001; Bogetoft 2005). A classical problem of traditional cooperatives is the quantity coordination problem, which arises from the decentralised decision making of the members of a cooperative (Phillips 1953). Each member (farmer) decides how much to deliver to the cooperative and the cooperative thus has no control over what is actually supplied to the market. Although an individual farmer realizes that an increase in production 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 (free-riding).[1]

Decentralized decision making within a cooperative also leads to quality coordination problems, which could be considered even more detrimental to the prosperity of cooperatives since, in contrast to quantities, the quality delivered by individual members very often is difficult to verify and might be non-contractible between independent actors. The problem of free-riding on product quality with decentralized decision making is a well-recognized problem in the literature on cooperatives (see, among others, Cook 1995 and Fulton 1995) and is nicely illustrated in Babcock and Weninger's (2004: 14) case study of the Alaskan Salmon Industry: '... suppose two fishermen deliver to a single processor. The fishermen know that part of the investment in quality that increases price will end up in the pocket of the other fisherman. The two fishermen get roughly a half-share of the benefit of quality-control efforts, yet both bear the full cost of those efforts'. Similar observations have been made for cooperatives in wine production in Germany (Dilger 2005).

The present paper investigates this free-riding problem in determining quantity and quality within a marketing cooperative in a vertically related market. In contrast to previous studies on quality competition in an oligopolistic market (Lehmann-Grube (1997), Choi and Shin (1992), Hoffmann (2005)) the decisions which firm actually delivers the high quality product

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[1] Albaek and Schultz (1998) investigate the consequences of this behaviour in a market, where the cooperative competes with an investor owned firm (mixed duopoly). The authors find that due to the decentralisation 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).

is endogenous here. Upstream firms (farmers) deliver inputs to the downstream market, where the cooperative and an investor-owned firm (mixed duopoly) use the components delivered to produce a composite good which is then sold to consumers. Whether the cooperative can overcome the free-riding (coordination) problem and supply a final product of high quality is shown to depend on the consumer's valuation of quality, the costs of producing high quality, the way in which the quality of the final product is determined from the quality levels of the inputs delivered as well as on the number of members of the cooperative. We find that the quantity- and the quality control problem are interrelated: improvements in coordinating quantity decisions between members also mitigate the free-riding problem with respect to product quality.

Section 2 provides a brief literature review on related studies. In section 3 we set up the model. Section 4 compares the quality decision of a firm and a cooperative acting as a monopolist, whereas section 5 considers a mixed oligopoly setting, where a cooperative and a firm compete with each other. Section 6 concludes.

## 2. Related literature

Since the beginning of the 1990's, a number of authors 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/Shin 1992). The decision which of the two rivals produces the higher quality product however is not derived endogenously in these studies since the duopolists typically are assumed to be identical ex ante.

In the spirit of Tirole's (1996) model of collective reputation, Winfree and McCluskey (2005) investigate the individual firms' incentive to choose quality levels. The authors assume that firms in the group share a common reputation, which is based on the groups' past average quality. It is shown that individual firms have an incentive to produce lower quality and free ride on the good group reputation. Free-riding becomes more important as the number of firms increases.

Our paper is most closely related to the analysis of Hoffmann (2005) and Herbst and Prüfer (2007). Hoffmann (2005) investigates firms' price and quality choices under different ownership structures (mixed duopoly) in a vertically related market. If the downstream firm decides about product quality whereas the fixed costs of producing high quality are to be paid by the upstream supplier, the firm will underestimate the full costs of delivering high quality. If upstream suppliers also sell their products downstream through a cooperative, the fixed costs associated with higher quality are considered in the cooperative's decision about the quality of the final product. Huffmann (2005) shows that investor owned firms choose a higher level of quality than cooperatives in markets where the costs of producing high quality are fixed. On the basis of numerical calculations the author suggests that the conclusion is reversed in markets where producing high quality raises variable costs of production.

Herbst and Prüfer (2007) compare the decisions about product quality in these three organisations (firms, cooperatives and nonprofits). The problems of collective decision making within the cooperative are captured by introducing costs of collective decision making which increase with the heterogeneity of a cooperative's members. Firms are assumed to care about profits only (shareholders of a firm do not consume the good produced themselves). The pure focus on financial returns implies a perfect goal alignment among shareholders and a firm thus does not have to bear any costs of collective decision making. Members of a cooperative on the other hand are assumed to care about both: dividends as well as consumer surplus (per assumption, members also act as consumers of the products produced). If individual members' preferences for quality differ, the cooperative incurs extra costs of collective decision making. The differences in incentives as well as the costs of decision making between a firm and a cooperative also has implications for the decisions about product quality. The indirect utility of members from consuming the products produced provides an additional incentive for the cooperative to deliver products of higher quality. Herbst and Prüfer (2007) thus suggest that firms provide lower levels of quality than cooperatives. In the present paper, we will explicitly analyze the decision making of the individual members instead of trying to capture them with a rather unspecific term of 'transaction costs' ('costs of decision making'). In addition, we will specifically focus on the strategic interaction effects between a firm and a cooperative in a mixed duopoly which are neglected in Herbst and Prüfer (2007).[2]

Empirical evidence on ownership structure and product quality is scarce. Few studies have attempted to measure the market performance of cooperatives. Haller (1985) compares prices of cooperative brands relative to leading non-cooperative brands in the US and finds

[2] In Herbst and Prüfer's (2007) analysis, consumers choose between the product offered by the organisation considered (the firm, the nonprofit or the cooperative) and an imperfect substitute produced by a competitive fringe in an alternative market. The price and the quality of the substitute are exogenously given and a strategic interdependency between the suppliers thus is ignored.

significantly lower prices for cooperatives. However, 'it is not possible to determine whether the lower prices observed by cooperatives' brands were due to differences in the type of products sold by cooperatives' (p. 190). Similar findings are reported in Haller (1993) for cottage cheese for 47 US metropolitan areas. Whether lower prices in cooperatives are the result of a lower quality of their products thus is unclear.

According to our knowledge, the only direct empirical evidence on ownership structure and product quality is provided in Frick (2004) and Dilger (2005). The authors find that cooperatives in the German wine sector offer a significantly lower quality compared to investor-owned firms (farms). Dilger (2005) observes, that members of a wine cooperative are normally paid according to the quantity they deliver as long as they preserve some minimum quality requirements. Accordingly, cooperatives face a free-rider problem. Whereas the individual member has to bear all costs associated with higher quality of inputs delivered to the cooperative, the benefits of delivering higher quality have to be shared among all members.

## 3. 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. 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, he 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 centralised: 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 and the quality 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 (with $s_i^H > s_i^L$).[3] To simplify notation, we normalize $s_i^L = 1$, $s_i^H = 1 + s$ with $s > 0$.

[3] We use subscripts to denote organisational forms ($C$ and $F$) and superscripts to identify the level of product quality.

To determine the quality of the final (manufacturers') product $s^g$ we distinguish between two cases. In the first, we follow Economides (1999) and assume that the quality of the manufacturers' composite good is the minimum of the quality levels of its components (the inputs delivered by the individual farmer *i*). The aggregation function of product quality thus has the so-called 'O-Ring' form (Kremer, 1993)[4]: $s^g = 1 + [\prod_{i=1}^{n}(s_i^g - 1)]^{\frac{1}{n}}$. The multiplicative interaction between quality levels provided by the different farmers implies that the final product will be of high quality if all farmers deliver high quality. As soon as one farmer delivers low quality the final product will be of low quality. Alternatively, the quality of the final product could be determined as the (weighted) average of the quality of inputs delivered by farmers. This assumption would be represented by a linear aggregation function for product quality: $s^g = \sum_{i=1}^{n} \omega_i s_i^g$, where $\omega_i$ represent the weight attached to the quality of farmer *i*'s product delivered.[5] We start with discussing the implications of the 'O-Ring' form for the quality aggregation function, the consequences when assuming a linear aggregation function will be discussed later.

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 $f^H = f \geq 0$. For a given product quality, all farmers have the same production technology.[6]

4 The failure of the launching of the space shuttle was entirely due to the malfunctioning of a small component, the 'O-Ring'. Kremer (1993) analyses the implications of an O-Ring production function for economic development. In an industrial organization framework, 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.

5 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. Finally one could consider the implications of a third form of the quality aggregation function which assumes that the quality of the final product is determined by the highest quality of the inputs delivered. We consider the last assumption to be rather unrealistic and will not consider this case further here.

6 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 heterogenous farmers and investigate, which type of farmer delivers to the cooperative and the firm respectively. Karantinides and Zago (2001) investigate this issue in more detail.

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 $\lambda$ as the outcome of some unknown game, $\lambda = 1$ would imply perfect coordination, $\lambda = 0$ corresponds to Cournot-behaviour within the cooperative. The cooperative also retains no profit. The unit price paid to the farmer either is $p^H$, if the product is of higher quality than the competing firms’ product, or $p^L$, in the case where the cooperative offers the product with the lower quality. Depending on the prices received, an individual members’ profit is

$$\pi_C^g = p^g q_C - \frac{1}{2} c q_C^2 - f^g . \tag{1}$$

The firm on the other hand is characterised by ‘centralised’ 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 behaviour can be described as if it maximises the vertically integrated profit of itself and its suppliers. In order to facilitate comparison with the behaviour 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.[7] 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

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

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

[7] 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).

Finally, it remains to describe consumer behaviour. 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. The consumer indexed by the parameter $\tilde{\theta}\in[\theta-1,\theta]$ maximizes the following utility function:

$$u_{\tilde{\theta}}=\begin{cases}\tilde{\theta}s^{g}-p^{g} & \text{if he buys a product with quality } s^{g}\\ 0 & \text{otherwise}\end{cases} \tag{3}$$

All consumers prefer higher quality at a given price, but a consumer with higher $\tilde{\theta}$ is willing to pay more for higher quality. The parameter $\theta$ measures the degree of consumer differentiation in evaluating product quality. The inverse demand functions for high and low quality are

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

$$\text{and} \tag{4}$$

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

where $Q^{H}$ and $Q^{L}$ is the aggregate quantity of the high and low quality product respectively.

## 4. The cooperative and the firm as monopolists

This section compares the behaviour of the firm and the cooperative in a situation, where there is only one manufacturer (the cooperative or the firm) and all $n$ farmers in the market sell their products via this monopolist. Consider the situation of a profit maximising firm first. Maximizing profits in (2) 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 $\pi_{F,M}^{L}=\frac{\theta^{2}}{2c+4n}$, respectively. The firm decides to produce high quality if $\pi_{F,M}^{H}>\pi_{F,M}^{L}$. Quality choices can be illustrated by means of an 'isoprofit' contour ($IP_{F,M}$ in Figure 1).

< 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 ($f$) increases, the consumers' willingness to pay for higher quality ($s$) also has to increases in order to guarantee each farmer the same level of profits (the isoprofit curves slope upwards, see proposition 1 in the appendix). If, for a given $s = s_1$, the additional costs of 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*.

Now compare this situation to a market in which a cooperative is the only manufacturer (monopolist). Decentralised 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 illustrates the decision making process within the cooperative.

< Table 1 around here >

Our choice of the 'O-Ring' specification for the aggregation of product quality implies that the final product of the cooperative will be of high quality only if <u>all</u> members decide to deliver high quality. In this case, profits are $\pi_{C,M}^{H}$. As soon as one member delivers low quality, the final product will also be of low quality. Here profits are $\pi_{C,M}^{L}$ for members delivering low quality and $\pi_{C,M}^{L-}$ for those delivering high quality (with $\pi_{C,M}^{L} > \pi_{C,M}^{L-}$, since producing high quality is costly). Table 1 suggests that the question whether the cooperative ends up producing high or low quality depends on the comparison between $\pi_{C,M}^{H}$ and $\pi_{C,M}^{L}$. If $\pi_{C,M}^{L} > \pi_{C,M}^{H}$, the dominant strategy for all members is to deliver low quality. If on the other hand $\pi_{C,M}^{H} > \pi_{C,M}^{L}$, Table 1 suggests the existence of two Nash equilibria in the decision making within the cooperative: either all members produce high quality or all members produce low quality. Delivering high quality <u>can</u> be a Nash-equilibrium for a cooperative. The indeterminancy of the equilibrium in the quality decisions within the cooperative however implies that the cooperative could also end up producing the low quality product even if producing high quality would generate higher profits for all members ($\pi_{C,M}^{H} > \pi_{C,M}^{L}$),

To investigate the factors influencing $\pi_{C,M}^{H}$ and $\pi_{C,M}^{L}$, we maximizes profits in equation (1) 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 $\pi_{C,M}^{L} = \frac{\theta^2\left\{c+2\left[1+\lambda(n-1)\right]\right\}}{2\left[c+n+1+\lambda(n-1)\right]^2}$. 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 $\pi_{C,M}^{g} = \pi_{F,M}^{g}$). Assuming away the quantity control problem within the cooperative implies that the isoprofit curve for the cooperative, which represents all combinations of *f* and *s* for which $\pi_{C,M}^{H} = \pi_{C,M}^{L}$ is identical to the isoprofit curve for the firm in Figure 1: $IP_{F,M} = IP_{C,M}^{\lambda=1}$.

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,[8] which reduces $\pi_{C,M}^{H}$ relative to $\pi_{C,M}^{L}$. We thus find that $IP_{F,M} > IP_{C,M}^{\lambda<1}$ (see proposition 2 in the appendix). 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: all members either produce high or low quality.

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8 Note from equation (4) that $p^H - p^L = \left(\theta - Q^H\right)s$ is a decreasing function of $Q^H$.

Note that an increase in the number of farmers delivering to the manufacturer (*n*) reduces the incentive to supply high quality. For both manufacturers acting as monopolists the aggregate output increases with *n* (although output per member declines with *n*), since production costs per unit decline. The price increase which is associated with delivering high instead of low quality declines with aggregate quantity. Supplying high quality thus becomes less attractive.

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 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. The results further suggest that the coordination problem 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.

These results remain unchanged if the quality of the final product is assumed to be the weighted average of the quality of the inputs. As the profit levels for a member of the cooperative ($\pi_{C,M}^{H}$ and $\pi_{C,M}^{L}$) are independent of the two different aggregation functions discussed, the isoprofit curves in Figure 1 are the same in both cases. The specific form in which the quality of inputs is aggregated is more important in situations where the cooperative and the firm compete in the downstream market (mixed duopoly).

## 5. The cooperative and the firm in a mixed duopoly

Assume that the firm and the members of the cooperative 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 behaviour between the cooperative and the firm ($\frac{\partial Q_F}{\partial q_C} = \frac{\partial q_C}{\partial Q_F} = 0$) the optimal quantities 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 summarized in Table 2.[9]

< Table 2 around here >

The choice of quality levels and the corresponding profits of individual farmers depend on parameters $\theta$, $\lambda$, $s$ and $f$, as well as on the number of firms $n_C$ and $n_F$. The implications of the quantity coordination problem within the cooperative ($\lambda < 1$) as well as the effects of changes in the number of upstream firms ($n$) have already been described in the previous section. 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 (closed membership) and for simplicity assume $n_F = n_C$ to be exogenously given.[10]

### 5.1. Aggregation of product quality: 'O-Ring form'

In this scenario, the quality of the manufacturers' composite good is determined by the minimum of the quality levels of the inputs delivered by the individual farmers: $s^g = 1 + [\prod_{i=1}^{n} (s_i^g - 1)]^{\frac{1}{n}}$. In contrast to the monopoly case discussed in section 4, each manufacturer now has to consider the quality decision of its rival in determining his optimal level of quality. This interdependence in decision making as well as the equilibrium configuration of quality levels offered by the two manufacturers is shown in Figure 2.

9 In the following we denote the farmers' profits with $\pi^{LL}$ and $\pi^{HH}$ when both manufacturers deliver low quality (superscript *LL*) or high quality (superscript *HH*). Farmers' profits are $\pi^{L}$ ($\pi^{H}$) when they supply a manufacturer whose product is of low (high) quality whereas the quality of the rival's product is of high (low) quality.

10 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).

< Figure 2 around here >

Figure 2 shows isoprofit contours for the firm and the cooperative for given parameters ($n_C$, $n_F$, $\theta$, 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 incentives of the cooperative to produce high quality too, and vice versa (for a formal analysis see proposition 3 in the appendix). 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 either the firm or the cooperative delivers high quality and the rival will prefer to produce low quality. Finally, the firm will deliver high quality products whereas offering high or low quality can both be a Nash-equilibrium in the decision making process within the cooperative in area *C*.

To discuss these results in more detail, assume $s = s_1 > 0$. If the additional costs of producing high quality (*f*) are large enough ($f > f_1$), the dominant strategy of all members of the cooperative as well as the firm is to supply low quality. Area *A* in Figure 1 represents all combinations of *f* and *s* where both the firm and the cooperative deliver low quality.

As *f* decreases below $f_1$ (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 the firm will opt for low quality, if the cooperative produces high quality (since we are above $IP_F^2$). The reason 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 8). Area *B* (the area between $IP_F^1$ and $IP_F^2$) represents all combinations of *f* and *s* where it is profitable for the firm to produce high quality, given that the cooperative offers low quality products. The cooperative's decision in turn is illustrated in the following payoff matrix.

< Table 3 around here >

If the firm produces low quality (the situation described in the right payoff-matrix), the dominant strategy for the members of the cooperative is to produce low quality. This follows from $\pi_C^L > \pi_C^{L-}$ as well as the fact that in area *B* the fixed costs associated with high quality are too high and thus $\pi_C^L > \pi_C^{HH}$. If, on the other hand, the firm offers high quality (the situation described in the left payoff-matrix), Table 3 suggests the existence of two Nash-equilibria: either all members produce high quality or all members produce low quality (since $\pi_C^H > \pi_C^{LL} > \pi_C^{LL-}$). Note however, that the second Nash-equilibrium in the decision making process within the cooperative (producing low quality) turns out to be inconsistent with a Nash-equilibrium in the game between the firm and the cooperative: as argued above the firm would not want to produce low quality in area *B* if the product of the cooperative is of low quality. We can thus conclude that the behaviour of the two rivals for all combinations of *f* and *s* in area *B* will be characterised by vertical product differentiation: the two manufacturers supply different levels of quality.

As the fixed costs associated with producing high quality further decrease and $f < f_2$, the incentive for the firm to produce high quality is strong enough to guarantee that the firm will <u>always</u> produce high quality, irrespective of the quality decisions of the members of the cooperative. The decision making within the cooperative on the other hand still is characterised by the existence of two Nash-equilibria, one in which all members of the cooperative produce high quality and a second one, where all members deliver low quality. This can be seen from the right payoff matrix in Table 3. Note that $f < f_2$ implies $\pi_C^{HH} > \pi_C^L$. Area *C* in Figure 1 thus represents combinations of *s* and *f* where the firm produces high quality and the cooperative offers either high or low quality.

Under the assumption of the ‘O-Ring’ technology for the aggregation of product quality, the present analysis does not provide a general prediction as to the whether the firm or the cooperative provides higher quality. The free-rider problem in the supply of high-quality products, although important for the members of the cooperative, 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. In contrast to the monopoly situation described in section 4 we now find cases where the cooperative delivers high quality products and the firm decides to offer products of low quality. The extent of the free riding problem however crucially depends on the way in which the quality of the final (manufacturers’) product is determined from the inputs of the farmers. In the present case, the free-rider problem is mitigated since a reduction of the quality of inputs delivered by one member immediately leads to a reduction in the quality of the final product. Any cost savings associated with lower quality have to be weighted against the losses from a price reduction. In an alternative scenario, where the quality of the final product is the (weighted) average of the quality of inputs delivered by farmers, free-riding will have more severe consequences for the cooperative.

### 5.2. Aggregation of product quality: the linear form

Assuming the production process for product quality to be of a linear form ( $s^g = \sum_{i=1}^{n} \omega_i s_i^g$ ) has important consequences for the equilibrium quality decisions of the rivals. Whereas the equilibrium configuration is unchanged in area *A* (both rivals prefer to produce low quality) and area *C* (the firm delivers high quality and the cooperative will produce either high or low quality), the situation is different in area *B* in Figure 1.

If the firm delivers high quality, the dominant strategy for all members of the cooperative is to produce low quality, which again corresponds to the results derived in the previous section. Consider now the case where the firm decides to produce low quality. Given the way the quality of the final product is determined from the inputs delivered, the cooperative will produce higher quality (as the firm) as soon as one member of the cooperative delivers high quality. The following payoff matrix illustrates whether the members of the cooperative have an incentive to do so.

< Table 4 around here >

If farmer *i* delivers low quality whereas all other farmers deliver high quality, the cooperative still produces higher quality than the firm and thus realises the high market price. Since farmer *i* saves production costs, his profits will be larger $\pi_C^{H+} > \pi_C^H$. Farmers delivering high quality thus provide a positive externality, which is not internalised in the decision making process. In area *B* we also have $\pi_C^H > \pi_C^{LL}$. Table 4 suggests the existence of two Nash equilibria in the decision making within the cooperative, either member *i* produces low quality whereas all other members produce high quality, or farmer *i* delivers high quality while all other members produce low quality. In both cases we find 'heterogeneous quality levels' within the cooperative where some members free ride and produce low quality.[11] Despite free riding, the quality of the cooperative's final product ('mixed quality') will still be higher than the quality of the firm's product given that the firm produces low quality.

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 1. Proposition 4 in the appendix 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'. A linear representation of the production process of aggregate product quality aggravates the free-riding problem within the cooperative.

The firm producing low and the cooperative producing high quality will not be a Nash-equilibrium. The only remaining equilibrium is area *B* thus has the firm producing high and the cooperative delivering low quality. 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 modelling framework will never deliver higher quality products then the firm.

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

[11] Note the difference to the results obtained from assuming an 'O-Ring' technology for the aggregation of product quality. With an 'O-Ring' technology the result that farmer *i* delivers a different quality level than all other members of the cooperative ('mixed quality') can never be an equilibrium outcome, since farmer *i* (or all other farmers) can save production costs without negative consequences on revenue.

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 the appendix). 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.

## 6. 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 mixed duopoly framework.

Assuming that the members of the cooperative independently decide about the quantity and the quality they deliver (decentralised decision making) there is a strong incentive to free-ride and to deliver low quality (quantity and quality coordination problem). The investor-owned firm on the other hand is characterised by a centralised decision making process and, by assumption, is not plagued by a coordination problem.

Comparing the behaviour 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. Members of a cooperative tend to free-ride with respect to the supply of quality.

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). Assuming an ‘O-Ring form’ in the production process of aggregate quality (which implies that the quality of the manufacturers’ composite good is the minimum of the quality levels of its components), we find that the free-riding problem among the members of the cooperative in the supply of high-quality products may not be strong enough to ensure that firms will always supply higher quality than cooperatives. Despite free-riding, the cooperative’s product can be of higher quality than the product supplied by the firm. In an alternative scenario, in which the quality of the final product is the (weighted) average of the quality of inputs delivered by farmers, free-riding will have more severe consequences for the cooperative: the quality level delivered by the cooperative will never be above that of 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 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. The equilibrium outcome might be determined by the visibility of cheating (free-riding) and on the possibility of punishment. It is well known that repeated interaction between members helps to achieve a cooperative outcome. The results obtained further are likely to be sensitive to our assumptions about the specification of consumer preferences with respect to quality (Tirole, 1988, p. 101) as well as on the assumptions concerning the cost of quality (Huffman, 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) patronising 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.[12] 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' (p. 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.[13] We hope that our paper will

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[12] 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 duopoly model with homogenous products.

[13] 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

spur further theoretical and empirical research on the issue of product quality supplied by different organizations along these lines.

(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

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.

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

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

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

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

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

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

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

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

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

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

<u>Proposition 2:</u>

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.

<u>Proof:</u>

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

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

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

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

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

<u>Proposition 3:</u>

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 $s > 1$.

<u>Proof:</u>

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 $IP_F^1 - IP_F^2$:

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

After rearranging we get:

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

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

<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:

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

<u>Proposition 5:</u>

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

<u>Proof:</u>

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 $n_F > 0$.

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

| | | Member *i*: *H* | Member *i*: *L* |
|---|---|---|---|
| All other members | *H* | $\pi_{C,M}^{H}\ \pi_{C,M}^{H}$ | $\pi_{C,M}^{L-}\ \pi_{C,M}^{L}$ |
| | *L* | $\pi_{C,M}^{L}\ \pi_{C,M}^{L-}$ | $\pi_{C,M}^{L}\ \pi_{C,M}^{L}$ |

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

Firm produces high quality

| | | Member *i*: *H* | Member *i*: *L* |
|---|---|---|---|
| All other members | *H* | $\pi_{C}^{H}\quad \pi_{C}^{H}$ | $\pi_{C}^{LL-}\quad \pi_{C}^{LL}$ |
| | *L* | $\pi_{C}^{LL}\quad \pi_{C}^{LL-}$ | $\pi_{C}^{LL}\quad \pi_{C}^{LL}$ |

Firm produces low quality

| | | Member *i*: *H* | Member *i*: *L* |
|---|---|---|---|
| All other members | *H* | $\pi_{C}^{HH}\quad \pi_{C}^{HH}$ | $\pi_{C}^{L-}\quad \pi_{C}^{L}$ |
| | *L* | $\pi_{C}^{L}\quad \pi_{C}^{L-}$ | $\pi_{C}^{L}\quad \pi_{C}^{L}$ |

Table 4: Payoff matrix for members of the cooperative if the firm produces low quality

| | | Member *i*: *H* | Member *i*: *L* |
|---|---|---|---|
| All other members | *H* | $\pi_{C}^{H}\quad \pi_{C}^{H}$ | $\pi_{C}^{H}\quad \pi_{C}^{H+}$ |
| | *L* | $\pi_{C}^{H+}\quad \pi_{C}^{H}$ | $\pi_{C}^{LL}\quad \pi_{C}^{LL}$ |

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

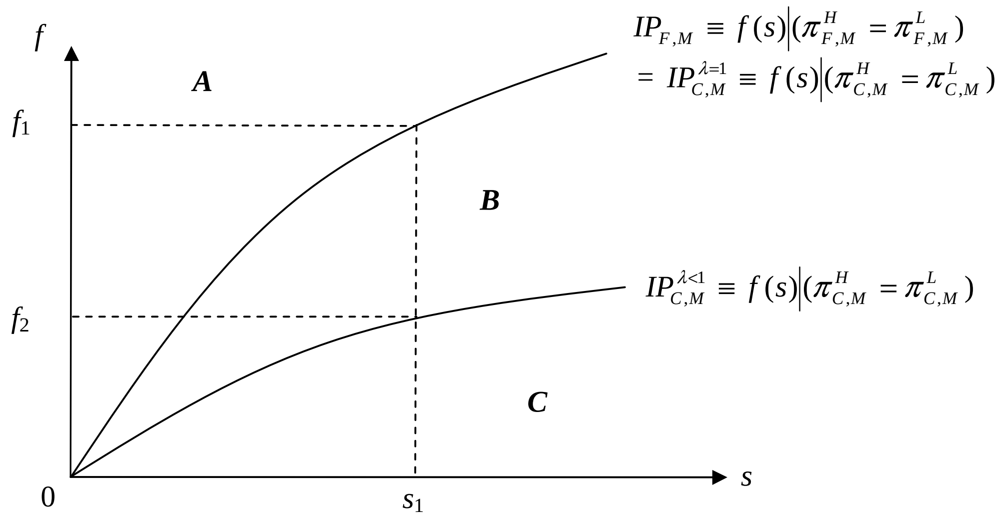
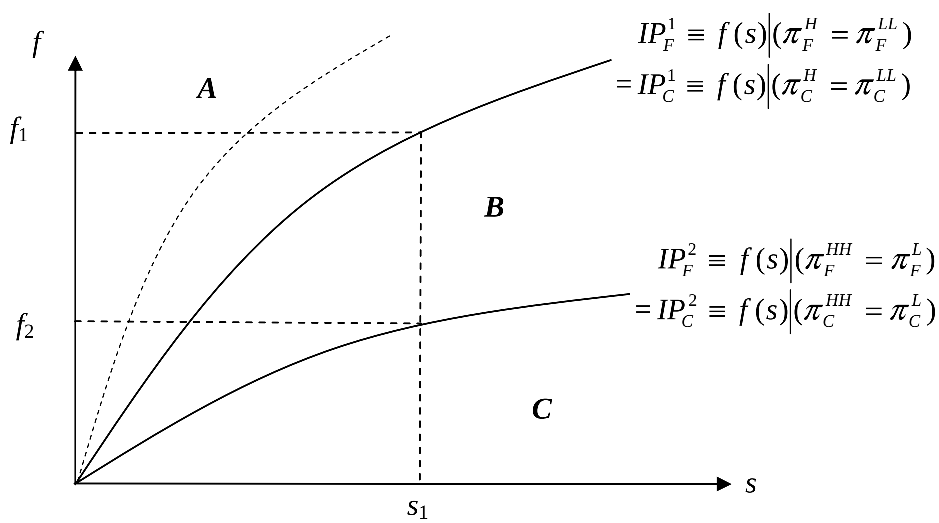



Figure 2: Isoprofit curves of the firm and the cooperative in a mixed duopoly



<u>Table 2:</u> Profits for individual farmers delivering to the cooperative or to the firm

| Firm | | Cooperative: Low Quality | Cooperative: High Quality |
|---|---|---|---|
| Firm | Low Quality | $\pi_C^{LL} = \frac{\theta^2 [2+c+2\lambda(n_C-1)](c+n_F)^2}{2[c^2+(2+n_C)n_F+c(1+n_C+2n_F)+\lambda(n_C-1)(c+2n_F)]^2}$<br>$\pi_F^{LL} = \frac{\theta^2 (c+2n_F)[1+c+\lambda(n_C-1)]^2}{2[c^2+(2+n_C)n_F+c(1+n_C+2n_F)+\lambda(n_C-1)(c+2n_F)]^2}$ | $\pi_C^{H} = -f + \frac{\theta^2 \{c+2(1+s)[1+\lambda(n_C-1)]\}[c(1+s)+n_F(1+2s)]^2}{2\{c^2+2cn_F+n_C n_F s+c(1+n_C)(1+s)+n_F(2+n_C)(1+s)+\lambda(1+s)(n_C-1)(c+2n_F)\}^2}$<br>$\pi_F^{L} = \frac{\theta^2 (c+2n_F)\{c+[1+\lambda(n_C-1)](1+s)\}^2}{2\{c^2+2cn_F+n_C n_F s+c(1+n_C)(1+s)+n_F(2+n_C)(1+s)+\lambda(1+s)(n_C-1)(c+2n_F)\}^2}$ |
| Firm | High Quality | $\pi_C^{L} = \frac{\theta^2 [2+c+2\lambda(n_C-1)][c+n_F(1+s)]^2}{2[-n_C n_F+c[c+2n_F(1+s)]+[1+\lambda(n_C-1)+n_C][c+2n_F(1+s)]]^2}$<br>$\pi_F^{H} = -f + \frac{\theta^2 [c+2n_F(1+s)]\{n_C s+(1+s)[1+c+\lambda(n_C-1)]\}^2}{2[-n_C n_F+c[c+2n_F(1+s)]+[1+\lambda(n_C-1)+n_C][c+2n_F(1+s)]]^2}$ | $\pi_C^{HH} = -f + \frac{\theta^2 (1+s)^2 \{c+2[1+\lambda(n_C-1)](1+s)\}[c+n_F(1+s)]^2}{2\{c^2+c(1+s)(1+n_C+2n_F)+(2+n_C)n_F(1+s)^2+\lambda(n_C-1)[c(1+s)+2n_F(1+s)^2]]\}^2}$<br>$\pi_F^{HH} = -f + \frac{\theta^2 (1+s)^2 [c+2n_F(1+s)]\{c+(1+s)[1+\lambda(n_C-1)]\}^2}{2\{c^2+c(1+s)(1+n_C+2n_F)+(2+n_C)n_F(1+s)^2+\lambda(n_C-1)[c(1+s)+2n_F(1+s)^2]]\}^2}$ |