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Abstract: *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. Decentralized decision making within cooperatives may lead to quality coordination problems (free-riding on product quality), for example: whereas the individual member has to bear the full costs associated with higher quality, the benefits of delivering higher quality will be shared among all members. The present paper investigates this free-riding problem in determining product quality within a marketing cooperative in a vertically related market (food chain).*

On the basis of a mixed-oligopoly model, we show that the free-rider problem in the supply of high-quality products 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.

Keywords: product quality, cooperatives, food chain, competition

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).

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).

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; Choi and Shin 1992; Hoffmann 2005) the decisions which manufacturer actually delivers the high quality product is endogenous here. 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. 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-own 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.

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 and 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. Hoffmann (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 three organisations (firms, cooperatives and nonprofits). The problems of coordination 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 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 Karantinis 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 $s > 0$.

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:

$$u_{\tilde{\theta}} = \begin{cases} \tilde{\theta} s^g - p^g & \text{if he buys a product with quality } s^g \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

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 θ measures the degree of consumer differentiation in evaluating product quality. The inverse demand functions for high and low quality are

$$\begin{aligned} p^H &= \theta - Q^H - Q^L + (\theta - Q^H)s \\ &\text{and} \\ p^L &= \theta - Q^H - Q^L, \end{aligned} \quad (2)$$

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

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.

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

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: $\sum_{i=1}^n \omega_i s_i^s$, where ω_i

represents the weight attached to the quality of farmer i 's product delivered, with $\sum_{i=1}^n \omega_i = 1$.⁴ As the members of

the cooperative might choose different quality levels, the cooperative can produce a final good of 'mixed quality'. Consumers perceive this mixed quality as high quality (and are therefore willing to pay p^H) if there is no

product of higher quality in the market and if $\sum_{i=1}^n \omega_i s_i^s \geq s^T$, where s^T is a certain 'threshold quality' with

$s^L < s^T \leq s^H$.⁵ This specification includes an aggregation function proposed by Economides (1999), who assumes that the quality of the manufacturers' composite good is the minimum of the quality levels of its components (the inputs delivered by all individual farmers). In this case $s^T = s^H$ and the aggregation function of product quality can, alternatively, be stated in a so-called 'O-Ring' form (Kremer, 1993)⁶:

$s^s = 1 + [\prod_{i=1}^n (s_i^s - 1)]^{\frac{1}{n}}$. The multiplicative interaction between quality levels provided by the different farmers

implies that the final product will be of high quality only if all farmers deliver high quality. As soon as one farmer delivers low quality the final product will be of low quality. We start with discussing the implications of the 'O-Ring' form for the quality aggregation function, the consequences when assuming a linear aggregation function (excluding the special case of the 'O-Ring' form) will be discussed later.⁷

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 than producing low quality inputs: $c(q) = \frac{1}{2}cq^2 + f^s$ 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.⁸

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

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 weights are assumed to be $\frac{1}{n_c}$ for each member. This simplifies the analysis, as an individual farmer can affect aggregate quality only by changing his quality level and not by changing his output. The assumption is justified ex-post, because if the cooperative produces mixed quality, all farmers produce the same quantity, irrespective of their individual quality levels (as quality affects only fixed, but not variable costs; see below).

⁶ 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.

⁷ 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. In this case the threshold quality can be characterized by: $s^L < s^T \leq \sum_{j \neq i} \omega_j s_j^L + \omega_i s_i^H$. We consider this

assumption to be rather unrealistic and will not consider this case further here.

⁸ 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.

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-behaviour within the cooperative. The 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

$$\pi_c^g = p^g q_c - \frac{1}{2} c q_c^2 - f^g. \quad (3)$$

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.⁹ 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

$$\Pi_f^g = p^g Q_f - n_f \frac{1}{2} c \left(\frac{Q_f}{n_f} \right)^2 - n_f f^g \quad (4)$$

with $Q_f = n_f q_f$. Each individual farmer receives $\pi_f^g = \frac{\Pi_f^g}{n_f}$.

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 increase in order to guarantee each farmer the same level of profits (the isoprofit curves slope upwards, see proposition 1 in the appendix¹⁰). 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 .

⁹ 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).

¹⁰ The appendix is available from the authors upon request.

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 (Table 1) illustrates the decision making process according to the quality 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 >

In the first (third) line of the payoff matrix, the final product is perceived as a high (low) quality product, irrespective of the quality decision of the firm. In both situations member i will produce low quality, which reduces production costs without altering the market price ($\pi_{C,M}^L > \pi_{C,M}^{L-}$ and $\pi_{C,M}^{H+} > \pi_{C,M}^H$). Table 1 therefore suggests the possibility of two Nash equilibria in the decision making within the cooperative: It is always an equilibrium that all members produce low quality. As long as $\pi_{C,M}^L > \pi_{C,M}^H$ this is the only equilibrium and producing low quality is the dominant strategy. It can be an equilibrium that the cooperative produces a quality level that is just good enough to be perceived as a high quality product. This is the case if $\pi_{C,M}^H \geq \pi_{C,M}^L$. The indeterminacy 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 (coordination problem).

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 all members decide to deliver high quality. In this case $s^T = s^H = \sum_{j \neq i} \omega_j s_j^H + \omega_i s_i^H$ and the first line in Table 1 does not exist. As soon as one member delivers low quality, the final product falls below the threshold will also be of low quality.

To investigate the factors influencing $\pi_{C,M}^H$ and $\pi_{C,M}^L$, we maximize profits in equation (3) with respect to q_C^g which gives $q_{C,M}^H = \frac{\theta(1+s)}{c+[n+1+\lambda(n-1)](1+s)}$ 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 $\pi_{C,M}^H = -f + \frac{\theta^2(1+s)^2\{c+2[1+\lambda(n-1)](1+s)\}}{2\{c+[n+1+\lambda(n-1)](1+s)\}^2}$ and

$\pi_{C,M}^L = \frac{\theta^2\{c+2[1+\lambda(n-1)]\}}{2\{c+n+1+\lambda(n-1)\}^2}$. 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: $IP_{F,M} = IP_{C,M}^{\lambda=1}$. In area A the cooperative acts as the firm and delivers low quality, whereas we find two Nash equilibria in area B and C: all members either produce high or low quality.

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 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: ‘pure’ high and ‘pure’ low quality.

¹¹ Note from equation (4) that $p^H - p^L = (\theta - Q^H)s$ 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, 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. The coordination problem in the ‘O-Ring’ specification is, however, not a free-riding 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 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 are similar 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 do not change. The only difference is that the cooperative will produce a mixed quality (instead of a ‘pure’ high quality as in the ‘O-Ring’ specification), just good enough to pass the threshold quality. As in the ‘O-Ring’ specification we observe a coordination problem, because even if $\pi_{C,M}^H > \pi_{C,M}^L$ we find two Nash-equilibria: The cooperative cannot ensure, that the quality of the final product will be high enough. 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 $\pi_{C,M}^{H+} > \pi_{C,M}^H$).

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).

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 2.¹²

< 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 . 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

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 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 .

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

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.

< 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 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 10). The cooperative's decision in turn is illustrated in the following payoff matrix.

< Table 3 around here >

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).

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: The first line of the payoff matrix does not exist in the ‘O-Ring’ specification (as $s^T = s^H = \sum_{j \neq i} \omega_j s_j^H + \omega_i s_i^H$), so either all members produce high quality or all members produce low quality (as $\pi_c^{LL} > \pi_c^{LL-}$ and as we are below IP_c^1 , which implies $\pi_c^H > \pi_c^{LL}$). 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 always produce high quality, irrespective of the quality decisions of the members of the cooperative. The decision making within the cooperative on the other hand is still 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 second payoff matrix in Table 3 ($f < f_2$ implies $\pi_c^{HH} > \pi_c^L$, while $\pi_c^L > \pi_c^{L-}$). 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 coordination 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.

5.2. Aggregation of product quality: the linear form

Assuming the production process for product quality to be of a linear form 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 all members of the cooperative will produce either high or low quality),¹⁴ the situation is different in area *B* in Figure 2.

If the firm delivers high quality, the dominant strategy for all members of the cooperative is to produce low quality, which corresponds to the results derived in the previous section. If the firm decides to produce low quality instead, we find two equilibria in the cooperative’s decision (see first payoff matrix in Table 3): One equilibrium is that all members produce low quality inputs (as $\pi_c^{LL} > \pi_c^{LL-}$). The second equilibrium is a mixed quality, just good enough to pass the threshold quality (as $\pi_c^H > \pi_c^{LL}$). However, 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 (as $\pi_c^{H+} > \pi_c^H$). As in the ‘O-Ring’ specification, the cooperative cannot ensure that the quality of the final product is high enough to pass the threshold. Additionally (and contrary to the O-Ring specification) some members produce high quality inputs to preserve the threshold quality, will others free-ride, produce low quality and gain higher profits.

If the cooperative produces low quality, the firm will immediately switch to high quality. 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 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’. The firm producing high and the cooperative delivering low

¹⁴ Note that all members have to produce high quality (independent of the threshold quality) in order to match the high quality product of the firm.

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 modelling framework will never deliver higher quality products than 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 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 high quantity and 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, as the cooperative faces a quality coordination problem. The problems according to quality get more severe if the members fail to coordinate their output decisions and therefore tend to overproduce (free-riding according to 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 of the '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), 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. 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.¹⁵ 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.¹⁶ 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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¹⁵ 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.

¹⁶ 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).

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

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

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

		Firm produces low quality	
		Member i	
		H	L
All other members	$s^T \leq \sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^L$	π_C^H	$\pi_{C,M}^{H+}$
	$\sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^L < s^T \leq \sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^H$	π_C^H	π_C^{LL}
	$s^T < \sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^H$	π_C^{LL-}	π_C^{LL}

		Firm produces high quality	
		Member i	
		H	L
All other members	$s^H = \sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^H$	π_C^{HH}	π_C^L
	$\sum_{j \neq i} \omega_j s_j^g + \omega_i s_i^H < s^H$	π_C^{L-}	π_C^L

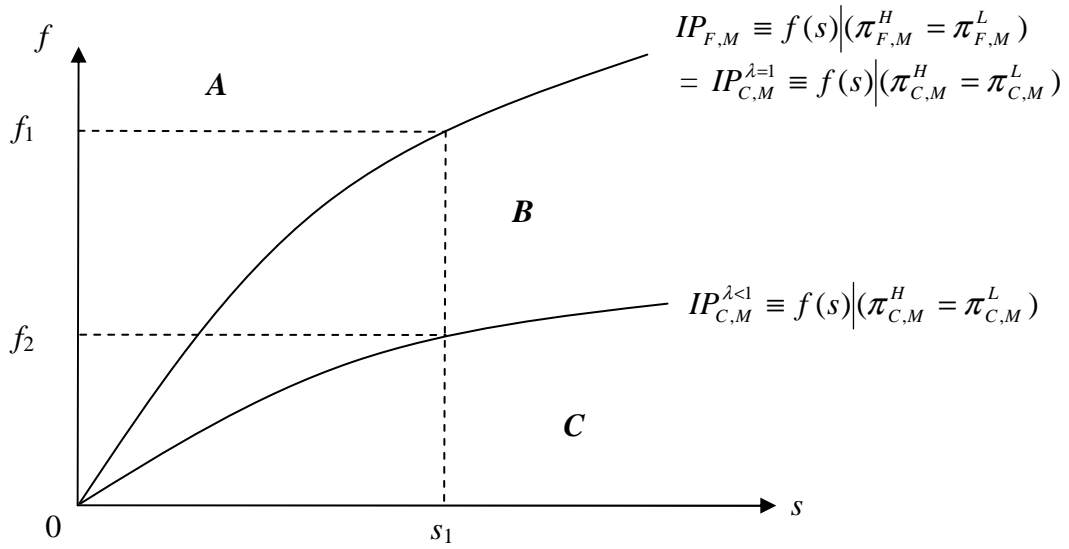


Figure 1: Isoprofit curves of the firm and the cooperative in a monopoly market

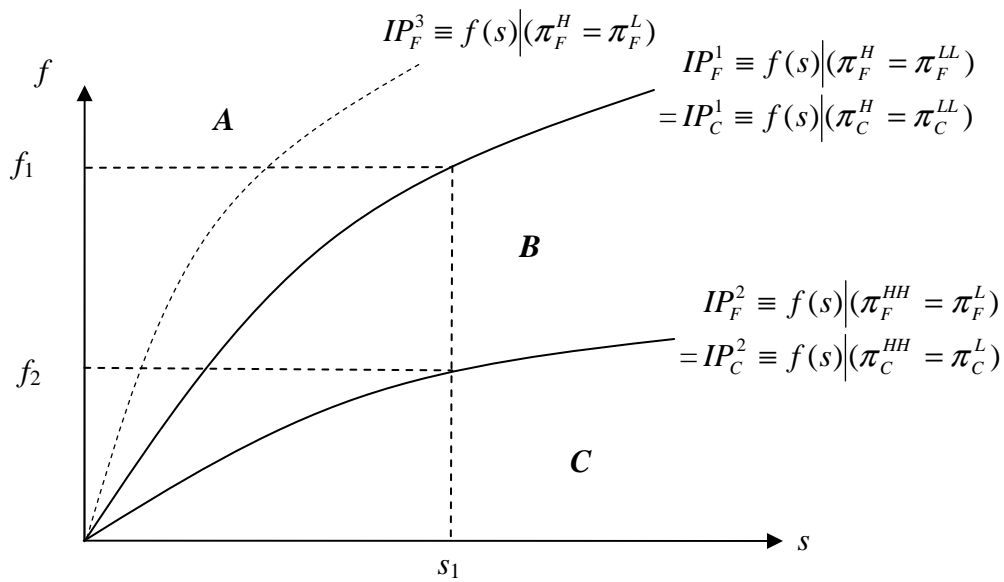


Figure 2: Isoprofit curves of the firm and the cooperative in a mixed duopoly

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

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