Quality Provision and Farmer Inclusion of Agricultural Cooperatives

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Abstract

The paper aims to analyze the quality provision and inclusion of farmers by a farmer-owned cooperative (co-op) when it competes with an investor-owned firm (IOF). A model of mixed oligopsonistic competition is developed to capture the endogenous participation of farmers who are heterogeneous in their efficiency to provide quality. The results highlight an advantage of the co-op: by imposing a similar quality standard to the one imposed by the IOF, the co-op may drive the IOF out of the market. Due to this advantage, it is more likely that the co-op will set a high quality standard when the minimum quality standard is costly to farmers. This advantage, however, may induce an inefficient outcome if providing a high quality product involves a high fixed cost.

JEL classification: Q12, Q13, L1, L2

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1 Introduction

In the agro-food industry, farmers often form cooperatives (co-ops) to enhance their coordination with each other and with food processors. One important type of co-op is the marketing co-op, which forward-integrates the processing industry and competes directly with private processing firms (known as the investor-owned firms (IOF)). In many countries, co-ops hold substantial shares in the agriculture sector. In the EU, co-ops account for more than 50% of agricultural production in many member states (83% in the Netherlands, 79% in Finland, 55% in Italy and 50% in France) (EC Legal notice on cooperatives). In the US, cooperatives account for between 25% and 30% of total farm marketing and supply expenditure (Giannakas and Fulton (2005)). With increasing concerns surrounding the quality and safety of agro-food products, co-ops are orienting towards higher value-added production and controlling the quality of raw product more closely. For example, in the EU, the Committee of Professional Agricultural Organizations and the General Confederation of Agricultural Co-operatives (COPA-COGECA) recommend that farmers and their cooperatives participate in the quality assurance schemes, such as geographical indication and organic food systems, which regulate the agro-food production by means of various quality standards (COPA-COGECA (2006)). Similar quality provision schemes can also be found in the US (See Lence et.al (2007) for the provision of geographically differentiated products and Hardesty (2004) for the example of organic product provision).

Some cases have shown that co-ops exhibit an ability to compete with their IOF counterparts in providing qualities. One example is the organic co-op Valley/CROPP in the US. Started in 1988 with 7 members to market organic products and dairy products, the co-op distinguishes itself as a group of "small organic family farms". Its membership had expended to 655 producers and its sales increased from $ 15 million in 1998 to $ 122 million in 2003 (Hardesty(2004)). In contrast, the bankruptcy of some large co-ops such as the Farmland Industries, Tri Valley Growers in the US demonstrates that these co-ops experience difficulties in undertaking value-added business (Hardesty and Salgia(2004)). The report of McKinsey in 2002

even alleged that agricultural co-ops "destroy value".

Improving product quality is the most direct way to generate high value of the agro-food production chain. However, providing quality involves additional cost both for farmers who make the effort to comply with the high quality standard and for different organizations engaged in processing, administration, quality inspection and/or marketing.[1] The success of providing quality requires first that the market premium is high enough to cover the cost born by farmers and by organizations in controlling and promoting quality. Second, the policies or contracts that an organization applies to farmers should give farmers enough incentive to undertake the costly production. While the first point depends on the level of quality standard that an organization imposes to farmers, the second point relies on the payment schemes that the organization proposes to farmers. An extensively high quality standard with low compensation for farmers may discourage their participation in the organization and hence induces a failure of the quality provision, whereas raising payments to attract high quality farmers may reduce the retained profit which is required by the organization to finance its cost. At what level the quality standard is fixed? How to share the value of the production chain with farmers? These are questions depending on the organizational structure and the competition environment that the organization faces in the agro-food sector. This paper thus aims to analyze the quality provision of an agricultural co-op when it competes with an IOF counterpart in attracting high quality supply of farmers.

The debates on co-ops versus IOFs have attracted much attention in recent years. Much literature has demonstrated various advantages of the farmer-owned co-op

[1] An example is the Identity Preservation Production and Marketing (IPPM) system, which was implemented by the Canadian wheat co-op (Canadian Wheat Board) and the UK backing firm Warburtons. Wheat produced under this system can be processed into bread, which is sold at a price of 86 pence compared to the typical price of 33-39 pence in the UK. However, grain and oilseed farmers have to bear extra costs of purchasing pedigreed seeds and for storing wheat for longer periods than normal. The co-op also suffers additional expenses of administration and logistics. As a whole, the total cost of this system is 16%-18% above conventional wheat market costs. (Smyth and Philipps (2002))

versus the IOF. In a setting of mixed oligopoly competition, Tennbakk (1992) models the co-op as a vertically integrated firm which competes à la Cournot with an IOF that maximizes the downstream profit. It turns out that the co-op captures a larger market share and farmers benefit more by joining the co-op. Albeak and Schultz (1998) pointed out that the members of a co-op often over produce, which gives the co-op a credible commitment to produce large quantities when it competes with IOFs. In a setting of mixed oligopsony competition, Sexton (1990) analyzed the spatial competition between a co-op and a processing firm in purchasing raw products of farmers. He emphasized that a co-op may have a pro-competitive effect on the behavior of rival non-cooperative processors and that the presence of an open-membership co-op may mitigate the monopsony power of the for-profit firms towards farmers. Giannakas and Fulton (2001 and 2005) studied the competition between an open membership co-op and an IOF and demonstrated the advantages of co-op regarding to the member commitment and innovation, respectively. These analysis provides insights on how co-ops can succeed in competition with the IOF counterparts. However, they do not take into account the aspect of quality provision by these organizations.

Hoffmann (2005) incorporated endogenous quality choice in the model of Tennbakk (1992) and analyzed the competition between a co-op and an IOF in providing quality differentiated products at the downstream market. He showed that either the co-op or the IOF can promote higher levels of quality, depending on the structure of cost of providing quality. More precisely, in case of a fixed cost of quality, the IOF has an advantage in providing the higher quality product. However in case of variable cost of quality, it is the co-op which has the advantage. The paper only deals with the competition at the downstream level without specifying the policies or contracts that the organizations may apply to motivate the quality provision of farmers. Bontems and Fulton (2005) compared the incentive compatibility contracts that a co-op and an IOF offer to farmers in presence of imperfect information. They showed that the co-op benefits from an information cost advantage because its objective is consistent with that of farmers. Saitone and Sexton (2009) studied the

revenue pooling practice of a co-op which produces vertically differentiated products. They pointed out that the co-op pooling has two advantages: it alleviates the overproduction problem by attenuates the incentive of farmers to produce high quality products and it ensures producers against random shocks. These papers, however, do not model the competition between co-ops and IOFs.

The present paper develops a model of mixed oligopsonistic competition between a co-op and an IOF. By allowing endogenous participation of farmers, who are heterogeneous in their efficiency of providing quality, the model analyzes quality provision and farmer inclusion of the co-op when it competes with the IOF in setting quality standards and payments to farmers. The results highlight another advantage of the farmer-owned co-op: by imposing a similar quality standard to the one imposed by the IOF, the co-op may drive the IOF out of the market. This is due to the fact that a co-op is committed to repaying all vertical rents to farmers and hence provides farmers with higher payments than an IOF does if both organizations set the same quality standards. Therefore, farmers prefer to join the co-op rather than supply the IOF. Due to this advantage, the co-op can more easily implement a profitable quality standard, which induces greater participation of farmers.

In equilibrium, when the quality provision is not so profitable in the sense that the market premium on high quality product is low compared with the additional cost paid by farmers to meet the high quality standard, it is more likely that the IOF will provides the high quality product. Whereas when the market premium is high, it is more likely that the co-op will choose to produce high quality. Due to the advantage of the co-op, if a minimum quality standard (MQS) increases the cost to farmers to meet the low quality standard, it is more likely that the co-op will dominate the market by imposing a high quality standard. This advantage, however, may induce an inefficient outcome if providing a high quality product involves a high fixed cost. In order to avoid sharing the fixed cost among farmer members and to secure the participation of farmers, the co-op may choose a suboptimally low quality standard so as to drive the IOF out of the market.

The paper is organized as follows: the next section describes the basic setting. Section 3 analyzes the competition of two organizations in three scenarios: a benchmark scenario in which a regulator sets quality standards to maximize the social welfare; a scenario in which two IOFs compete and a scenario of the mixed duopsonistic competition between a co-op and an IOF. Then Section 4 analyzes and compares the farmer inclusion and welfare under different scenarios and provides some insight into the implementation of minimum quality standard. Section 5 extends the model to the case where the co-op has to share some up-front cost among farmer members before producing the high quality product. The last section gives the conclusion.

2 Basic Setting

Consider the vertical structure of a food production chain, where farmers supply raw products for processing of final products. Assume that the upstream market consists of a unit mass of farmers. Each farmer produces at most one unit of raw product.[2] The quality of raw product and production practice are controlled by a certain quality standard (denote by s), which may take two values: s_l and s_h. s_l is a loose and low quality standard, which might correspond to the mandated minimum quality standard and s_h is a stringent and high quality standard which is stipulated voluntarily by the organization.[3] In order to meet a certain quality standard, a farmer has to make an effort, which involves a cost depending on the stringency of the quality standard. Farmers differ from their ability to meet the quality standard. We use a parameter θ to capture the difference. θ is uniformly distributed in $[0, 1]$. The cost of a farmer indexed by θ to meet the standard s_i $(i = l, h)$ is $C(\theta, s_i) = \theta c_i$ with

[2]This assumption suggests that the farm production is capacity constrained, with a large number of farmers producing similar quantities of raw product. A case that corresponds to this assumption may be the EU dairy sector, where numerous small farmers produce under the constraint of milk quotas. According to the EuroStat (2008), over 80% of dairy farmers in EU-27 countries hold only less than 10 cows. The EC milk quota is distributed amongst individual producers in the member states based on their historical production.

[3]s_h can also be the mandated quality standard, stipulated by the public authority. An example is the Geographical Indication labels. However whether to apply for the label with certain production requirement is decided voluntarily by the organization.

$c_l < c_h$. Furthermore, for notation convenience, we denote by $\sigma = \frac{c_l}{c_h}$ ($\sigma \in (0,1]$), the relative cost of a farmer to meet the low quality standard and the high quality standard. Thus the smaller σ, the larger incremental cost for a farmer to provide higher quality product. In return for complying the quality standard, farmers receive a payment for its unit production under the standard s_i (we denote by w_i). The utility function of a farmer indexed by θ is thus

$$v(s_i, w_i; \theta) = w_i - \theta c_i \tag{1}$$

The quality of raw product has a direct relationship to the quality of the final output. We assume that one unit of raw product under quality standard s_i ($i = l, h$) can be processed into one unit of final product and then sold at a price p_i in the final market[4], with $p_l < p_h$. implying a more stringent quality standard for raw product results in a higher market price for final product. Furthermore, we denote by $\rho = \frac{p_l}{p_h}$ ($\rho \in (0,1]$) the relative price of final products produced with the low quality input and the high quality input. Thus the smaller ρ, the higher incremental benefit accruing from the high quality output. The variable cost of processing is assumed to be zero.[5] However, in order to process and promote the high quality final product (which is produced by using the raw product produced under standard (s_h)), a fixed cost g is involved at the processing and marketing stage.

The processing and marketing of final products are undertaken by different organizations in the market. In order to control the quality of supply and participation of farmers, an organization announces its policy towards farmers, which specifies the quality requirement and the payment scheme associated with the quality. The

[4]we assume that organizations are price-takers of p_i, in the sense that it cannot influence the price by adjusting its production. An example of this is the provision of the Geographical Indication labels or common labels. Once the label is established by a group of producers, other producers complying with the quality requirements can not be excluded from using the label. Therefore, the competition in the downstream final product market is so intensive that each organization can hardly influence the market price. (See Moschini et al. (2008))

[5]This assumption can be relaxed to the case where the cost of processing is a linear function in quantity of final product. In this case, $p(s)$ can be interpreted as the revenue gained from a unit sale of final product.

type of a farmer (θ) is not observable for the organizations, but the quality of raw product is verifiable. Therefore we assume that an organization provides a uniform policy to farmers which can be specified by a contract (s, w).[6] [7] In this paper, we are interested in the incentive of quality provision by an organization, when it competes with another organization. Therefore we assume that there are potentially two organizations in the market.

Note that each farmer produces one unit of raw product, which can be processed into one unit of final product. To this extent, the production of each organization is directly linked to the participation of farmers. We assume that a farmer supply only for one organization. Which organization will be chosen by a farmer depends on the comparison of utilities that the farmer gains from supplying for the two organizations. We denote by $\hat{\theta}_i = \{\theta | v(s_i, w_i; \hat{\theta}) = 0\}$ the marginal farmer who is indifferent to staying inactive and participating in the organization setting quality standard s_i. The farmer indexed by θ with $\theta < \hat{\theta}_i$ prefers to supply to the organization with standard s_i rather than to stay inactive. In order to analyze the participation of farmers, we assume that $\hat{\theta}_i < 1$ for $i = l, h$ so that the market is not covered and some farmers stay outside the market. Furthermore if the two organizations apply respectively the policies (s_l, w_l) and (s_h, w_h) to farmers, there exists a marginal farmer $\tilde{\theta} = \{\theta | v(s_l, w_l; \theta) = v(s_h, w_h; \theta)\}$, who is indifferent to participating in either of the two organizations. Thus the farmers indexed by θ with $\theta < \tilde{\theta}$ prefers to supply to the organization with standard s_h. Therefore, for given policies of the two organizations, three cases may occur:

1. if $w_l \geq w_h$ ($\tilde{\theta} \leq 0$), the organization with standard s_l monoposonizes the

[6] In some cases, an organization discriminates farmers by offering premium to farmers who provide higher quality raw products. In this paper, we assume that in order to provide a final product with certain quality characteristics, all farmers who participate in the delivery should comply with the same quality standard. An example of this is the application of common label or Geographical Indication label. In order to obtain the label, all producers participating in the program have to comply with the mandated quality standard, which is uniform for all participators.

[7] Since we assume that a farmer produces at most one unit of raw product, the payment for each farmer is just the price for its unit production.

market ($q_h = 0$). The supply of farmers is

$$q_l^m(w_l) = \hat{\theta}_l = \frac{w_l}{c_l} \tag{2}$$

2. if $\sigma w_h < w_l < w_h$ ($0 < \tilde{\theta} < \hat{\theta}_h < \hat{\theta}_l$), the two organizations coexist in the market. The supply functions are respectively

$$q_l^d(w_l, w_h) = \hat{\theta}_l - \tilde{\theta} = \frac{w_l}{c_l} - \frac{w_h - w_l}{c_h - c_l} \tag{3}$$

$$q_h^d(w_l, w_h) = \tilde{\theta} = \frac{w_h - w_l}{c_h - c_l} \tag{4}$$

3. if $w_l < \sigma w_h$ ($\tilde{\theta} > \hat{\theta}_h > \hat{\theta}_l$), the organization with standard s_h monopsonizes the market ($q_l = 0$). The supply is

$$q_h^m(w_h) = \hat{\theta}_h = \frac{w_h}{c_h} \tag{5}$$

Organizations can take either of the two forms: a farmer-owned cooperative (co-op) or an investor-owned firm (IOF). Due to the different ownership structure, co-op and IOF control the participation of farmers in a different way.[8] A co-op is owned by farmers. Its objective is to maximize the total welfare of farmer members.[9] In order to analyze the participation of farmers, we assume that the co-op applies an open-membership policy, which implies that the co-op can not reject the participation of farmers who satisfy the production requirement. All revenue and cost accruing in the processing and marketing stage are shared among farmer members by means of the payment w. In contrast, an IOF aims to maximize the profit at the processing

[8]The fact that organizations can not observe the type of farmers implies that they have no other means to exclude the participation of farmers except the policy (s, w). In this sense, the co-op can be seen as a kind of "open-membership co-op", which accepts all delivery of farmers, but with restrictions on quality. The firm has all bargaining power over the individual farmers. Its policy can be seen as an "leave-it-or-take-it" offer.

[9]A cooperative can have various objectives. According to Tennbackk (1992), A co-op might 1) maximizes the profit of the cooperative firm by outsourcing input; 2) maximizes the total profit of members and the cooperative plant; 3) maximizes the throughput or production 4) maximizes the membership and 5) maximizes the patronage refunds per unit without considering the cost. In the present paper, we take the "cooperative as a firm" approach, which is frequently employed by Sexton (1990), Tennbakk (1995) Albeak and Schultz (1998) etc. and assume the objective 2)

and marketing stages regardless of the interest of farmers. The IOF bears the fixed cost but leaves as low as possible rent to farmers. Therefore, in our context, the co-op and the IOF differ in two aspects: the objective functions and the cost and revenue sharing rules. In order to distinguish the two aspects, we first analyze the case where there is no fixed cost in providing the high quality product (Section 3). Then we extend the analysis to the case with fixed cost (Section 5).

3 Competition between two organizations

In this section, we assume that the cost of providing high quality accrues only at the farming stage. Thus in order to attract high quality supply of farmers, the two organizations have to compensate farmers with high payment. Assume that the two organizations compete in a two-stage game: in the first stage, they decide simultaneously their respective quality standards (s_l or s_h) and commit to the standards in the following stage of the game. In the second stage, they announce simultaneously their respective payments (prices of raw product) to farmers. Farmers then choose either to participate in an organization or to stay inactive.

In this paper, we focus on the mixed oligopsonistic competition between a ccop and an IOF. Two questions may arise: first, which organization is more likely to impose a high quality standard in equilibrium of competition? Second, does the mixed oligoposonistic competition results in an efficient outcome compared to the other types of competition such as the pure oligopsonistic competition? Or equivalently, is the presence of a co-op in place of an IOF in the competition socially desirable? To answer these questions, we analyze three scenarios, among which the first two scenarios serve as comparison: 1)a benchmark case in which the total welfare is maximized under two quality standards s_l and s_h. 2) the pure duoposonistic competition between two IOFs 3) the mixed duopsonistic competition between a co-op and an IOF.

3.1 Benchmark case

We assume that a regulator with complete information aims to maximize the total social welfare. With two quality standards available for the regulator[10], its problem is to decide which farmer follows which level of quality standard. Lemma 1 shows the optimal inclusion of farmers under two quality standards.

Lemma 1 *It is optimal for the regulator to implement both s_l and s_h if and only if $\rho > \sigma$. Otherwise, it is optimal to implement only s_h. In the former case, there are two thresholds $\tilde{\theta}^* = \frac{p_h - p_h}{c_l - c_h}$, $\theta_l^* = \frac{p_l}{c_l}$ such that*

- *farmers with $\theta \in [0, \tilde{\theta}^*]$ follow standard s_h.*
- *farmers with $\theta \in [\tilde{\theta}^*, \theta_l^*]$ follow standard s_l.*
- *The other farmers do not participate in the production.*

Proof If the regulator chooses two quality standards, it is not optimal to leave some efficient farmers inactive while letting less efficient ones produce (i.e. there is no $\tilde{\theta}$ such that farmers with $\theta < \tilde{\theta}$ do not produce while those with $\theta > \tilde{\theta}$ produce). Nor is it optimal to let less efficient farmers follow standard s_h and the more efficient ones produce quality s_l (i.e. if $\theta_1 < \theta_2$ it is not optimal that a farmer indexed by θ_1 produces for standard s_l and θ_2 produces for s_h). Therefore, the regulator sets two threshold $\tilde{\theta}$ and θ_l, such that farmers with $\theta < \tilde{\theta}$ produce under standard s_h and those with $\tilde{\theta} < \theta < \theta_l$ follow standard s_l. The problem of the regulator is described as follows:

$$\max_{\tilde{\theta}, \theta_l} W \equiv p_h \tilde{\theta} - c_h \int_0^{\tilde{\theta}} \theta d\theta + p_l(\theta_l - \tilde{\theta}) - c_l \int_{\tilde{\theta}}^{\theta_l} \theta d\theta \tag{6}$$

Solve the program, we derive the optimal thresholds as defined in the lemma. The optimal social welfare is thus:

$$W^* = \frac{p_h^2}{c_h}\left(\frac{\sigma - 2\rho\sigma + \rho^2}{2\sigma(1-\sigma)}\right) \tag{7}$$

If only one quality standard is imposed, the social welfare is maximized as if farmers face a co-op.[11] Thus we have $W_i = \pi^{mc}(s_i) = \frac{p_i^2}{2c_i}$. Compared with the case with two standards, $W^* > \pi^{mc}(s_l)$ for $\forall \rho \in (0,1), \sigma \in (0,1)$. However $W^* > \pi^{mc}(s_h)$ only if $\rho > \sigma$. Q.E.D.

[10] Assume it is costless for the regulator to verify the two quality standards

[11] In this paper we do not consider the consumer surplus. Therefore the social welfare is just the sum of downstream profit of firm and the welfare of individual farmers who are active in the market.

Intuitively, a farmer indexed by θ contributes $p_h - \theta c_h$ to the social welfare for its unit production if it is assigned to meet standard s_h, while it contributes $p_l - \theta c_l$ if it produces under standard s_l. Therefore, the farmer should be assigned to produce quality s_h if $p_h - \theta c_h > p_l - \theta c_l$ and $p_h - \theta c_h > 0$, which leads to $\theta < \tilde{\theta}^* = \frac{p_h - p_l}{c_h - c_l}$ and $\theta < \theta_h = \frac{p_h}{c_h}$. It can be verified that $\tilde{\theta}^* < \theta_h < \theta_l$ for $\rho > \sigma$. In this case, farmers with $\theta > \tilde{\theta}^*$ should follow the standard s_l if $p_l - \theta c_l > 0$. If on the other hand $\rho < \sigma$ ($\tilde{\theta}^* > \theta_h > \theta_l$.), the price incremental of the high quality product is larger than the cost incremental of meeting the high quality standard. It is optimal to make all farmers with $\theta < \theta_h$ meet the standard s_h and the rest inactive. In this case, only one quality standard is implemented.

Note that when two quality standards are implemented, the social optimum can be realized by two co-ops who impose s_l and s_h, respectively. In order to redistribute the retained earning, the two co-ops pay each member p_l and p_h respectively. The farmer indexed by $\tilde{\theta}^*$ is indifferent from participating in either of the two co-ops. The farmer with $\theta < \tilde{\theta}^*$ participates in the co-op with s_h and gains $p_h - \theta c_h$, while that with $\theta_l^* < \theta < \tilde{\theta}^*$ produces for the co-op with s_l and receives $p_l - \theta c_l$.

3.2 Competition between 2 IOFs

When two IOFs are present in the market, if both implement the same quality standards, they face intensive competition in quoting price to attract farmers. By raising the purchasing price slightly above its rival's, an IOF can attract all farmers who are active in the market and hence drive its rival out of the market. The same strategy is applied by the rival firm, leading to a high purchasing price ($w = p_i$ at standard s_i) such that no firm earns positive profit. Therefore in order to avoid the intensive competition, the two IOFs try to differentiate their quality standards. Thus, their policies are respectively (s_l, w_l) and (s_h, w_h). We denote by "Firm L" and "Firm H", the IOFs with standard s_l and s_h, respectively. Furthermore, we superscript the equilibrium variables by "ff". The equilibrium of the second stage competition is summarized in Lemma 2:

Lemma 2 *The equilibrium of competition between two IOFs in quoting the prices of raw products depends on the relative market price ρ and the relative cost σ:*

i if $\rho > \frac{\sigma}{2-\sigma}$, the two firms coexist in equilibrium ($0 < \tilde{\theta} < \theta_l$) and their prices are respectively:

$$w_l^{ff} = p_h \frac{2\rho + \sigma}{4 - \sigma} \tag{8}$$

$$w_h^{ff} = p_h \frac{2 + \rho}{4 - \sigma} \tag{9}$$

The two thresholds are respectively $\tilde{\theta}^{ff} = \frac{p_h}{c_h} \frac{2-\rho-\sigma}{(1-\sigma)(4-\sigma)}$ and $\theta_l^{ff} = \frac{p_h}{c_h} \frac{2\rho+\sigma}{\sigma(4-\sigma)}$

ii if $\frac{\sigma}{2} \leq \rho \leq \frac{\sigma}{2-\sigma}$, Firm H just "monopsonizes" the market ($\tilde{\theta} = \theta_l = \theta_h$). Its price for farmer is

$$w_{rh}^{ff} = p_h \frac{\rho}{\sigma} \tag{10}$$

iii if $\rho \leq \frac{\sigma}{2}$, Firm H is a pure monopsony in equilibrium ($\tilde{\theta} > \theta_l$). Its price for farmer is

$$w_{mh}^{ff} = \frac{p_h}{2} \tag{11}$$

Proof: In the second stage of the game, the two firms decide simultaneously the prices of raw products so as to maximize their profits, anticipating the participation of farmers. Their profits are defined as follows:

$$\pi_l^{ff} = (p_l - w_l) q_l(w_l, w_h) \tag{12}$$

$$\pi_h^{ff} = (p_h - w_h) q_h(w_l, w_h) \tag{13}$$

where $q_l(w_l, w_h)$ and $q_h(w_l, w_h)$ are defined by conditions (2)-(5). Providing that $w_h \leq \frac{p_l}{\sigma}$, the best response function for Firm L ($BR_l(w_h)$) is

$$BR_l(w_h) = \begin{cases} \frac{p_l}{2} & \text{if } w_h < \frac{p_l}{2} \\ w_h & \text{if } \frac{p_l}{2} \leq w_h \leq \frac{p_l}{2-\sigma} \\ \frac{p_l + \sigma w_h}{2} & \text{if } \frac{p_l}{2-\sigma} < w_h \leq \frac{p_l}{\sigma} \end{cases} \tag{14}$$

The first line corresponds to the case in which Firm L sets $w_l > w_h$ so as to monoposonize the upstream market. The third line reflects the strategy of Firm L to coexist with Firm H. There is an intermediate case, in which $\frac{p_l}{2} \leq w_h \leq \frac{p_l}{2-\sigma}$. In this case, if Firm L coexists with Firm H by setting $w_l = \frac{p_l + \sigma w_h}{2}$, one can verify that $w_l > w_h$. Thus the price is so

high that Firm H is pushed out of the market. Therefore, the profit of Firm L is not maximized at this price. On the other hand, if Firm L chooses to monopolize the market by setting $w_l = \frac{p_l}{2}$, one can verify that $w_l < w_h$, which induces entry of Firm H. Thus the monopsony price fails to capture the monopsony profit. In order to maximize profit, Firm L chooses $w_l = w_h$ so as to just cover the most efficient farmer ($\tilde{\theta} = 0$) and to just force Firm H to exit.

Analogously, giving w_l ($w_l < p_l$), we derive the best response function for Firm H ($BR_h(w_l)$) as follows:

$$BR_h(w_l) = \begin{cases} \frac{p_h}{2} & \text{if } w_l < \frac{\sigma p_h}{2} \\ \frac{w_l}{\sigma} & \text{if } \frac{\sigma p_h}{2} \leq w_l \leq \frac{\sigma p_h}{2-\sigma} \\ \frac{p_h + w_l}{2} & \text{if } \frac{\sigma p_h}{2-\sigma} < w_l \leq p_l \end{cases} \tag{15}$$

Thus the first line corresponds to the case where Firm H monopsonizes the upstream market. The last line is the response of Firm H when it coexists with Firm L. The second line reflects the restricted monopsony case where Firm H just drives firm L out of the market, i.e. $\tilde{\theta} = \theta_l = \theta_h$.

The equilibrium price pair lies in the intersection of the best response curves, which can be illustrated by Figure 1 From the figure, $BR_l(w_h)$ intersects with $BR_h(w_l)$ at the part

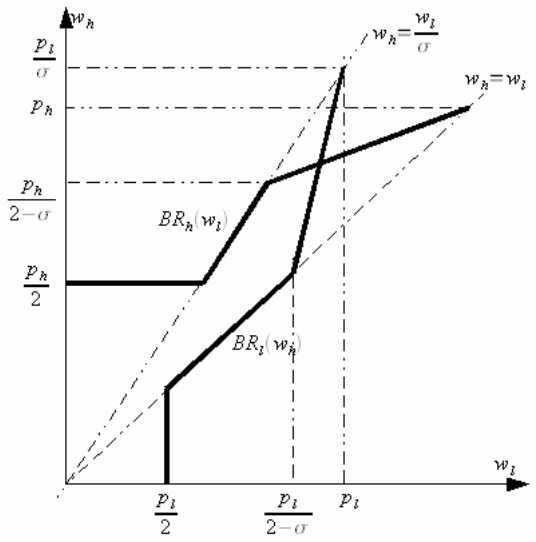

Figure 1: Best response function of under two-firm competition

where the two organizations coexist if

$$\frac{p_l}{\sigma} > \frac{p_h}{2-\sigma}$$

which leads to $\rho > \frac{\sigma}{2-\sigma}$. In this case, the equilibrium prices (8) and (9) in item i are decided by combining the two best response functions:

$$w_l = \frac{p_l + \sigma w_h}{2} \qquad w_h = \frac{p_h + w_l}{2}$$

Thus we derive the equilibrium threshold levels by inserting the two prices into the thresholds functions $\tilde{\theta} = \frac{w_h - w_l}{c_h - c_l}$ and $\theta_l = \frac{w_l}{c_l}$. Thus we have item i in the lemma.

The two respond functions intersect at the part that firm H just monopsonizes the market if

$$\frac{p_h}{2-\sigma} \geq \frac{p_l}{\sigma} \geq \frac{p_h}{2}$$

which leads to $\frac{\sigma}{2-\sigma} \geq \rho \geq \frac{\sigma}{2}$. The equilibrium price for the restricted monopsony firm w_{rh}^{ff} in condition(10) is defined by combining conditions

$$w_h = \frac{w_l}{\sigma} \qquad w_l = p_l$$

Thus we have item *ii* in the lemma. If $p_l < \frac{p_h}{2}$, Firm H captures all farmers even with the monopsony price, which is derived by maximizing the monopsony profit (13) with $q_h(w_l, w_h) = q_h^m = \frac{w_h}{c_h}$. Thus there is only one firms in the market which imposes the high quality standard. (item *iii*) Q.E.D.

Therefore, in equilibrium only Firm H has possibility to monopsonize the upstream market but not Firm L. Note that $\frac{\sigma}{2-\sigma}$ and $\frac{\sigma}{2}$ are increasing with σ. Thus the larger σ compared to ρ, the more likely that Firm H drives Firm L out of the market. This is intuitive since the lager relative cost of Firm L compared to its relative gain , the less competitive is Firm L compared to Firm H. In case of coexistence of the two firms (item i), other things equal, the larger the relative cost, the higher purchasing prices are paid by the two organizations. In fact, $\sigma = \frac{c_l}{c_h}$ captures the similarity of the two quality standards in eye of farmers. Thus a large σ implies intensive upstream competition between the two organizations in attracting farmers' supply. As a result input prices are higher in equilibrium.

In the first stage, the two IOFs choose either to set standard s_l or s_h, simultaneously. There are two symmetric pure strategy equilibria, in which either IOF applies the high quality standard s_h to farmers. The other IOF applies either the low standard s_l if $\rho > \frac{\sigma}{2-\sigma}$ or quits the market otherwise.

3.3 Mixed duopsonistic competition

In this scenario, we focus on the competition between a co-op and an IOF. Starting from the second stage of the game, where the two organizations compete in quoting raw product prices to farmers, we analyze first two cases: the competition between a co-op setting standard s_l (denote by Coop L) and Firm H and the reverse case. By comparing profits they obtain in the two cases, we derive the equilibria of the first-stage game, where the two organizations compete in setting quality standards.

3.3.1 Coop sets s_l and IOF sets s_h

When Firm H competes with Coop L, the equilibrium of the second-stage competition is summarized in Lemma 3.

Lemma 3 *Coop L always sets $w^c = p_l$. The strategy of Firm H depends on the comparison of ρ and σ:*

- *if $\rho > \frac{\sigma}{2-\sigma}$, both organizations coexist ($0 < \tilde{\theta} < \theta_l$). Firm H will purchase at price*

$$w_h^{df} = p_h \frac{1+\rho}{2}$$

The two thresholds are $\tilde{\theta}^{cf} = \frac{p_h}{c_h}\frac{1-\rho}{2(1-\sigma)}$ and $\theta_l^{cf} = \frac{p_l}{c_l}$. Coop obtains

$$\pi_l^{dc} = \frac{p_h^2}{c_h}\frac{\big(2\rho - \sigma(1+\rho)\big)^2}{8\sigma(1-\sigma)^2} \tag{16}$$

- *if $\frac{\sigma}{2} \leq \rho \leq \frac{\sigma}{2-\sigma}$, Firm H just monopsonizes the market ($\tilde{\theta} = \theta_l$) and prices at*

$$w_h^{df} = p_h \frac{\rho}{\sigma}$$

- *if $\rho \leq \frac{\sigma}{2}$, Firm H monopsonizes the market ($\tilde{\theta} > \theta_l$) and sets*

$$w_h^{mf} = \frac{p_h}{2}$$

Proof: Coop L decides its payment to farmers based on the patronage of farmers, that is, the payment to a member is in proportion to the volume of its production. By assumption, each farmer produces one unit of raw product and the co-op sets a uniform price to call for supply of farmers. Therefore, in order to distribute all vertical profit to farmer members, the co-op raises the payment up to the level of the market price, i.e. $w^c = w_l = p_l$. Thus, if both Coop L and Firm H are present in the market, the "profit" of the co-op, i.e. the total welfare of co-op members π_l^{dc} is thus

$$\pi_l^{dc} = p_l q_l^d(w_l, w_h) - c_l \int_{\tilde{\theta}}^{\theta_l} \theta d\theta \tag{17}$$

where $q_l^d(w_l, w_h)$ is defined in condition (3). Taking into account the participation of farmers defined in conditions (2)-(5), Firm H decides the raw product price so as to maximize its profit which is defined in condition (13). Thus we have $w_h^{df} = BR_h(p_l)$, which gives the three prices as well as the threshold levels in the three items of Lemma 3. By inserting the equilibrium prices in the objective function of Coop L (17), we derive the equilibrium profit of Coop L as defined in condition (16). Q.E.D.

The price offered by Firm H is obviously larger than the one in the two-firm case (condition (9)). The intuition is straightforward: as the co-op repays farmers with all the vertical profit, which gives it a commitment to fix a high price for farmers, the IOF has to respond with a higher payment so as to capture some supply of farmers. To this extent, the organizational structure of co-op gives it advantage in the second-stage price competition.

3.3.2 Coop sets s_h and firm sets s_l

When Firm L competes with Coop H, the equilibrium of price competition is summarized in Lemma 4

Lemma 4 *When Firm L competes with Coop H, Coop H always sets $w^c = p_h$. The strategy of Firm L depends on the comparison of ρ and σ*

- *if $\sigma < \rho < 1$, Firm L coexists with Coop H and sets*

$$w_l^{df} = p_h \frac{\rho + \sigma}{2}$$

the two thresholds are $\tilde{\theta}^{fc} = \frac{p_h}{c_h}\frac{2-\rho-\sigma}{2(1-\sigma)}$; $\theta_l^{fc} = \frac{p_h}{c_h}\frac{\rho+\sigma}{2\sigma}$ *Coop h obtains:*

$$\pi_h^{dc} = \frac{p_h^2}{c_h}\frac{(2-\rho-\sigma)(2+\rho-3\sigma)}{8(1-\sigma)^2} \tag{18}$$

- *if* $\rho < \sigma$*, Firm L is out of the market.*

Proof Similar to the former case, Coop H will distribute its profit to farmer members by setting $w^c = w_h = p_h$. Thus if both organizations are present in the market, the total welfare for farmers participating in Coop H π_h^{dc} is

$$\pi_h^{dc} = p_h q_h^d(w_l, p_h) - c_h \int_0^{\tilde{\theta}} \theta d\theta \tag{19}$$

where $q_h^d(w_l, p_h)$ is defined in condition (4). Again, taking into account the participation of farmers defined in conditions (2)-(5), Firm L decides the raw product price so as to maximize its profit (condition (12)). In equilibrium, it will respond according to the best response function (14). Thus we have $w_l^{df} = BR_l(p_h)$, which gives the equilibrium price and thresholds defined in the Lemma. The equilibrium profit for Coop H is derived by inserting the equilibrium variables in condition (19). Q.E.D.

Compared with the price in the two-firm case (condition (8)), the price of Firm L is higher, suggesting that the commitment of the co-op to repay farmers with the market price forces the IOF to raise its payment. Furthermore, the condition that Firm L is inactive ($\rho < \sigma$) is less stringent than that in the two-firm case ($\rho < \frac{\sigma}{2}$), implying that Firm L is more likely to exit when competing with a co-op than with another IOF.

3.3.3 Equilibrium of competition in setting quality standards

Anticipating the outcome of price competition in the second stage, in the first stage, the co-op and the IOF decide their respective quality standard. Proposition 1 summarizes the equilibrium:

Proposition 1 *When a co-op competes with an IOF in choosing quality standard, there exists two increasing functions* $\rho_l^{dc}(\sigma)$ *and* $\rho_h^{dc}(\sigma)$ *(*$1 > \rho_l^{dc}(\sigma) > \rho_h^{dc}(\sigma) > \sigma$ *for* $\sigma \in (0,1)$*) such that*

1. *If $\rho \geq \rho_l^{dc}(\sigma)$, there is one pure strategy equilibrium in which the IOF chooses s_h and the co-op chooses s_l.*

2. *If $\rho_l^{dc}(\sigma) > \rho > \rho_h^{dc}(\sigma)$, There is no pure strategy equilibrium. The IOF always wants to differentiate the standard, but the co-op always chooses the same standard as that of the IOF.*

3. *If $\rho_h^{dc}(\sigma) > \rho \geq \sigma$, there is one pure strategy equilibrium in which the IOF chooses s_l and co-op chooses s_h.*

4. *If $\rho \leq \sigma$, the co-op "monopsonizes" the market with standard s_h.*

Proof: To derive the equilibrium of competition, we first specify the response of each organization. As has mentioned in section 3.2, the IOF has no incentive to impose the same quality standard as its rival's. Therefore, providing that the co-op sets a standard s^c, the IOF always imposes a different standard $s^f \neq s^c$. Such reasoning, however, does not hold for the co-op. Providing that the IOF sets s^f, the co-op can impose either a different standard $s^c \neq s^f$ or the same standard as that of the IOF $s^c = s^f$. In the former case, the co-op coexists with the IOF and obtains the "duopsonistic" profit. In the latter case, the IOF is driven out of the market because it receives no profit if it raises its price above that of the co-op ($w^c = p_i$), while the co-op receives a monopsony profit. The normal form of the game is represented in the table. Where π_l^{dc} and π_h^{dc} are defined by conditions (16) and

Table 1: Mixed duopsonistic competition

	Coop	
IOF	s_l	s_h
s_l	$0, \pi_l^{mc}$	π_l^{df}, π_h^{dc}
s_h	π_h^{df}, π_l^{dc}	$0, \pi_h^{mc}$

(19), respectively. $\pi_i^{mc} = \frac{p_i^2}{2c_i}$ are the monopsony profit that the co-op obtain by imposing quality standard s_i $(i = l, h)$. Whether the co-op chooses a different quality standard or the same standard as that of the IOF depends on the comparison of profits that the co-op obtains in the two cases. More precisely, if the firm chooses the standard s_h, co-op chooses

s_l and coexists with the IOF if $\pi_l^{dc} > \pi_h^{mc}$, which leads to

$$\rho > \rho_l^{dc}(\sigma) = \frac{(\sigma + 2\sqrt{\sigma}(1-\sigma))}{2-\sigma}$$

otherwise, the co-op chooses s_h, which drives the IOF out of the market. Thus we have item 1 in the proposition. Analogously, if the IOF sets s_l, the co-op coexists with the IOF if $\pi_h^{dc} > \pi_l^{mc}$, which gives

$$\rho < \rho_h^{dc}(\sigma) = \frac{\sigma^2 + 2\sqrt{(1-\sigma)^3\sigma(4-3\sigma)}}{4+\sigma(-7+4\sigma)}$$

Thus we have item 3. It can be verified that $\rho_l^{dc}(\sigma) > \rho_h^{dc}(\sigma)$ for $\sigma \in (0,1)$. Thus when $\rho_l^{dc}(\sigma) > \rho > \rho_h^{dc}(\sigma) > \sigma$, the IOF always wants to differentiate its quality standard, whereas the co-op always chooses the same standard as that of the IOF. There is no pure strategy equilibrium for this range of parameters (item 2). If $\rho < \sigma$, the co-op chooses s_h, while the IOF can only choose s_l. However, by Lemma 4, Firm L can not attract the supply of farmers. Therefore, Coop H totally "monopsonizes" the upstream market (item 4). Q.E.D.

Figure 2 illustrates the equilibrium competition structures under different parameter ranges.

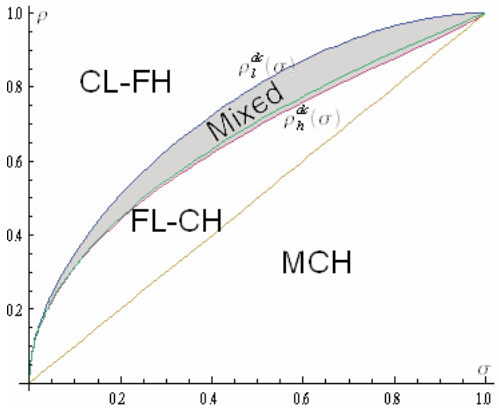

Figure 2: Equilibrium competition pattern

Note that a large ρ compared to σ implies that the relative rise in market price due to the high quality standard is small compared to the incremental in the cost of meeting the high standard. Therefore, the low quality standard is an attractive strategy for both organizations. Due to the advantage of the co-op in setting the

same standard as that of the IOF, the co-op is more competitive in the market of the low quality standard. Providing that the IOF always differentiates its quality standard with that of its rival, the competition results in a Coop L and a Firm H. The same reasoning holds for the case where the relative price is similar compared to the relative cost. The competition leads to a Coop H versus a Firm L. If the incremental of price due to the high quality standard totally exceeds the cost incremental, the co-op totally monopsonizes the market with a high standard. To sum up, when the quality provision is not so profitable in the sense that the market premium on high quality product is low compared with the additional cost paid by farmers to meet the high quality standard, it is more likely that the IOF will provides the high quality product. Whereas when the market premium is high, it is more likely that the co-op will choose to produce high quality.

4 Welfare Analysis and Policy Implication

4.1 Farmer inclusion and welfare

So far we have derived the equilibrium of competition between the co-op and the IOF. A question arises about whether the equilibrium outcome is socially desirable or alternatively, whether the co-op and the IOF include farmers in a socially efficient way. To provide some insight into the question, we focus on the two equilibrium cases in which the co-op and the IOF coexist (the case of competition between Coop L and Firm H in item 1 of proposition 1 and the case of competition between Coop H and Firm L in item 3). Each case is compared with three scenarios: 1) competition between two IOFs 2) the benchmark case 3) the case where there is only one co-op. Figure 3 illustrates the spread of individual farmers' welfare under different scenarios. The left (right) panel of the figure compares the welfare of each farmer when the price incremental of the high quality product is small relative to (similar to) the cost incremental of meeting the high quality standard . Curve ABC corresponds to the benchmark case which is equivalent to the case where two co-ops with different quality standards set $w_i = p_i$. Curve DEC (ADE) plots the equilibrium welfare

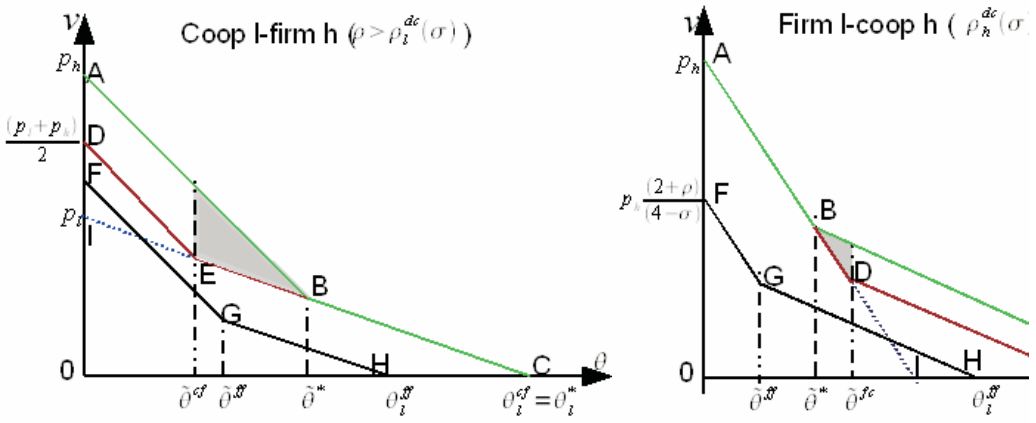

Figure 3: Welfare of individual farmers

of individual farmers under the mixed duopsonistic competition. Curve FGH plots the case of competition between two firms and Curve IC (AI) is the case that a co-op monopsonizes the upstream market.

Compared the mixed duopsonistic competition with the scenario of two-firm competition, a straightforward observation is that the welfare of each farmer is improved (or at least the same) if a co-op is present in place of a firm (both Curve DEC in the left panel and Curve ADE in the right panel are higher than Curve FGH). In the left panel, by imposing the low standard s_l, Coop L not only includes the low efficient farmers which are inactive in the two-firm scenario (i.e. those with $\theta \in (\theta_l^{ff}, \theta_l^{cf})$), but also attracts some more efficient farmers who supply for the high quality firm in the two-firm scenario (i.e. those with $\theta \in (\tilde{\theta}^{cf}, \tilde{\theta}^{ff})$). In the right panel, Coop H includes the middle efficient farmers who are supposed to produce under the low quality standard under the two-firm scenario (i.e. those with $\theta \in (\tilde{\theta}^{ff}, \tilde{\theta}^{fc})$). Therefore, in both cases of the mixed duopsonistic competition, the IOF accounts for a lower market share than the co-op rival. It produces even less than the quantity it might produce when facing competition with another IOF.

Compared with the benchmark scenario (Curve ABC in both panels), the mixed duopsonistic competition induces a misallocation of farmers in providing the two different qualities. For example, in the left panel where the co-op is engaged in the

low value-added production, the farmers with middle level of efficiency ($\theta \in [\tilde{\theta}^{cf}, \tilde{\theta}^{*}]$) are induced to participate in Coop L while it is optimal that they produce the high quality product. In the right panel, where Firm L competes with Coop H, the middle efficient farmers $\theta \in (\tilde{\theta}^{*}, \tilde{\theta}^{fc})$ join Coop H and the low efficient farmers $\theta \in (\theta_l^{fc}, \theta_l^{*})$ are excluded out of the market. However it is optimal that these farmers produce under the low quality standard. Such inefficiencies are due to the interplay of two factors: the monopsony power of the IOF which entails an exlusion of the less efficient farmers and the intensive competition triggered by the co-op which erodes the supply base of the IOF. Thus, in equilibrium, the co-op tends to over-include farmers while the IOF induces too little supply of farmers. The grey areas of in the two panels show the deadweight loss due to the mixed duopsonistic competition.

Although the presence of the IOF in competing with the co-op induces inefficiency, the absence of the IOF is not socially desirable neither. Compared the mixed duopsonistic competition with the one co-op scenario, farmers are better off (or at least the same) when participating in the IOF. Indeed, by introducing a different quality standard, the IOF provide its participators higher welfare than a monopsony co-op does. By upgrading their product quality and supplying to Firm H (see the left panel), the efficient farmers ($\theta \in [0, \tilde{\theta}^{cf}]$) receive a higher rent than they would gain by supplying for the monopsony Coop L (line DE is higher than line IE). Similarly, if the price incremental is similar compared with the cost incremental (see the right panel), the less efficient farmers($\theta \in [\tilde{\theta}^{fc}, \theta_l^{fc}]$) benefit from supplying to Firm L instead of participating in a co-op with the high quality standard (line DE is higher than line DI). This is due to the fact that farmers with different abilities to produce quality are more efficient to produce two qualities instead of a uniform one. The presence of an IOF serves as a way to introduce another quality standard, which raise the efficiency of farmers.[12] The above comparison can be summarized in Proposition 2:

Proposition 2 *In the mixed duopsonistic competition, if the co-op and the IOF*

[12]This is under assumption that $\rho > \sigma$ so that two quality is better than one from the social welfare point of view. (see Lemma 1)

coexist, the co-op always includes more farmers than an IOF does when competing with another IOF. Compared to the benchmark case, the IOF always induces insufficient supply while the co-op always over-includes farmers. However the competition results in higher welfare than the case with only one co-op in the market.

4.2 Minimum quality standard

The above analysis provides some insights into the effect of raising minimum quality standard (MQS). With increasing concern on food safety, the public authorities are tightening the production requirements and creating new control procedures, new labelling strategies to farmers and their organizations. For example, the on-going EU Common Agricultural Policy reform stipulates that in order to receive a direct payment, farmers have to comply with rules relating to basic standards for environment, food safety, animal and plant health and animal welfare, as well as standards aimed at the maintenance of land in good agricultural and environmental condition (EC report (2008)). Naturally, a stricter quality control makes the production of farmers more costly. However, it is not necessary that a higher quality standard induces also a higher market premium. As is reported by Marette (2005), the market premium is quite low for products with ethical characteristics, animal welfare and environmental attributes. To this extent, imposing a MQS mainly involves high costs for farmers relative to the market premium it might generate. In the model, this feature can be captured by an increase in σ (or equivalently an increase in c_l) while keeping other variables unchanged.

In this paper, consumer surplus is not taken into account. If imposing the MQS merely raises the cost of farmers in meeting the low quality standard, it is not surprising that the welfare, including the total farmer utilities and the profit of the IOF, decreases with the MQS.[13] In this section, we focus on the effect of the MQS

[13]It can be verified that even if the competition pattern changes, the welfare is reduced as well. More precisely, if the MQS leads to the change of equilibrium structure from the competition between Coop L and Firm H to the competition between Coop H and Firm L, it can be verified that the welfare in the former case is larger than that in the later case.

on the quality provision and farmer inclusion in the context of mixed duopsonistic competition. From Figure 2, for given ρ, if σ increases from a small level to a large level, the co-op first provides low quality product, then high quality one and finally dominates the market. To this extent, a stringent MQS makes it more likely for the co-op to undertake the high quality business. The intuition comes from the fact that the rise in cost of meeting the MQS makes the high quality business more attractive than the low quality one for both the co-op and the IOF. Due to the advantage of the co-op in setting the same standard as that of the IOF, the co-op wins the high efficient farmers by setting the high quality standard.

The MQS affects also the participation decision of individual farmers. From Lemma 3 and Lemma 4, in either case of competition between the co-op and the IOF, the total participation of farmers θ_l^j, (j = cf or fc) is decreasing with σ, while the number of farmers to meet the high quality standard ($\tilde{\theta}^j$) is increasing with σ. Therefore, if the competition pattern does not change, the MQS induces more farmers to choose the organization with the high quality standard and less farmers to follow the MQS. The latter effect dominates the former, leading to a reduction in the total number of active farmers. The impact of the MQS on the welfare of individual farmers varies with their levels of efficiency. For efficient farmers which always participate in the organization with high quality standard, the MQS does not change the level of their utility if the competition pattern does not change. However if the co-op replaces the IOF to produce the high quality product, the high efficient farmers benefit from joining the co-op. For the less efficient farmers, they switches to produce for the high quality organizations when the MQS increases. The level of their utilities decline accordingly. Finally, for the low efficient farmers, their utility is reduced with the MQS. The change of the competition pattern induces more farmers to shift out of the market.

The effect of MQS has been widely analyzed in Ronnen (1991), Crampes and Hollander (1995), Ecchia and Lambertini (1997), Scarpa (1998) etc. Based on the pure oligopolistic competition framework with vertical product differentiation, these

literatures share some common results: the MQS reduces the distance between the quality levels of two firms, which induces more intense price competition. The profit of the low quality firm rises while that of the high quality one declines. These works focus on the competition between firms in attracting the purchase of consumers without taking into account the competition in pursuing input. In the present setting, two organizations compete for attracting the supply of farmers. An increase in MQS also intensifies the competition between the co-op and the IOF, since it makes the standards of the two organizations more similar in eye of farmers. However, the low quality organization is worsen off as the MQS raises the cost of farmers to meet the standard. On the contrary, the high quality organization is better off (so long as the two organization coexist) since the MQS leads to a greater farmer participation in the organization.

5 Fixed cost of processing

In this section, we extend our model by allowing some fixed cost to occur at the processing or marketing stage.[14] Because the difference in the ownership structures, the co-op and the IOF treat the fixed cost differently. For the IOF, the fixed cost is born by the investors. Once the fixed cost takes place, it is sunk for the IOF and will not affect its decision on the payment policy to farmers. Whereas for the co-op, the fixed cost is shared among farmer-members.[15] Therefore the payment policy of the co-op depends on the level of the fixed cost. This may affect their decision on quality standard and hence influence the equilibrium competition pattern as well as the welfare of farmers. To formalize this idea, we assume that an organization

[14]At the processing stage, cost occurs because of management, settling plant and equipment, administration etc. In the marketing stage, in order to inform the buyers (either consumers or retailers), the investment are involved on certification, advertising, promotion etc.

[15]Because of the portfolio problem (the farmer-members are not able to correctly adjust their investment portfolio due to the lack of transferability, liquidity and appreciation mechanisms for the exchange of residual claims) and the horizon problem (members are impatient to share the current benefits rather than to invest for higher future returns) (see Cook and Iliopoulos (2000)), which discourage the outside investors, it is difficult for a co-op to obtain external funds. Therefore, the traditional co-op always has the self-financing problem.(see also Rey and Tirole (2007))

announcing quality standard s_i, has to bear a fixed cost g_i in order to process and sell its product at price p_i. For simplicity, we assume that $g_l = 0$ and $g_h = g > 0$. Furthermore, for notation convenience, we use $\gamma = g/\frac{p_h^2}{4c_h}$ to measure the fixed cost. Note that the denominator $\frac{p_h^2}{4c_h}$ is just the monopsony profit of Firm H when the fixed cost is not taken into account.[16] Therefore γ is just the fixed cost relative to the maximum profit that Firm H can obtain. We assume that $0 < \gamma < 1$, which is a necessary but not sufficient condition for the IOF to be active in the market.

In presence of the fixed cost, the two-stage game is redescribed as follows: in the first stage, the co-op and the IOF decide their respective quality standards (s_c and s_f), simultaneously. Once the standard is settled, they bear the fixed cost g_i. In the second stage, the co-op and the IOF set their respective purchasing prices (w_c and w_f) simultaneously, anticipating the effect of these prices on the participation of farmers. Farmers then decide whether to join the co-op or the IOF or to stay inactive.

Note that the game is based on the context that a preexisting open-membership co-op and an IOF bear upfront cost before production of raw products takes place. For the IOF, the cost is sunk once the quality standard is fixed. Therefore, the second-stage decision of w by the IOF is the same as in the case without the fixed cost (see section (3.2) for the response functions of IOFs). Hence the second-stage equilibrium of competition between two IOFs is the same as that in the case without fixed cost (subsection 3.2). As for the co-op, there is no fixed cost if it sets quality standard s_l ($g_l = 0$). Thus the second-stage equilibrium of competition between Coop L and Firm H is also the same as in subsection (3.3.1). However, for the co-op with standard s_h, the payment at the second-stage plays two roles: to share the fixed cost and the revenue generated by the high quality standard and to control the participation of farmers. Therefore, unlike in the case without cost sharing (the co-op sets $w_i = p_i$), with cost-sharing, the co-op decides w according to its

[16]The monopsony profit of Firm H is derived by maximizing the profit defined in condition (13) with the supply function expressed by $q_h(w_l, w_h) = q_h^m(w_h) = \frac{w_h}{c_h}$. Thus the monopsony price for the Firm H is $w_h^{mf} = \frac{p_h}{2c_h}$, which leads to the monopsony profit $\pi_h^{mf} = \frac{p_h^2}{4c_h}$.

anticipation of the payment set by the rival firm and of the participation of farmers. In the following analysis, we first derive the second-stage equilibrium of competition between Coop H and Firm L. Then, combined the equilibrium of competition with Coop L and Firm H, we analyze the decisions of the two organizations on quality standard in the first-stage.

5.1 Competition between Coop H and Firm L

5.1.1 The second-stage response functions

In the second-stage competition, providing that the Firm L sets $w^f = w_l$, Coop H sets w_h to share the retained profit equally among its members. The cost-sharing rule is expressed by

$$w_h = p_h - \frac{g}{q_h} \tag{20}$$

The right-hand-side term represents the unit rent that Coop H can offer to its members. The payment is less than p_h implying that Coop H has a fixed-cost disadvantage in the second stage competition. Note that the larger membership of the co-op (q_h is large), the lower cost is born by each member and hence the higher rent that a farmer can benefit from participating in the co-op. To this extent, in order to provide a high quality product, the co-op has to attract a sufficiently large number of farmers so as to cover the fixed cost.

In order to control the participation of farmers q_h, the co-op sets payment w_h, which depends on the payment of Firm L w_l. First, note that if w_l is too small such that $w_l < \sigma w_h$, the co-op totally monopsonizes the market. Therefore $q_h = q_h^{mc} = \frac{w_h}{c_h}$. Inserting this into the cost-sharing rule (20), we have $w^c = w_h^{mc} = p_h \frac{1+\sqrt{1-\gamma}}{2}$.[17] This defines a threshold of $\underline{w_l}$, which makes Coop H just monopsonize the market.

$$\underline{w_l} = \sigma w_h^{mc} = p_h \frac{\sigma(1+\sqrt{1-\gamma})}{2}$$

Thus if $w_l < \underline{w_l}$, Firm L is out of the market.

[17] We take the larger root to ensure the stability of the equilibrium. The choice of the root is discussed in the following analysis.

Second, if w_l is not too small, Coop H coexists with Firm L by producing $q_h = q_h^d(w_l, w_h) = \frac{w_h - w_l}{c_h - c_l}$. The decision of payment can be illustrated by the left panel of Figure 4. The payment paid by Coop H is determined by the intersection of the

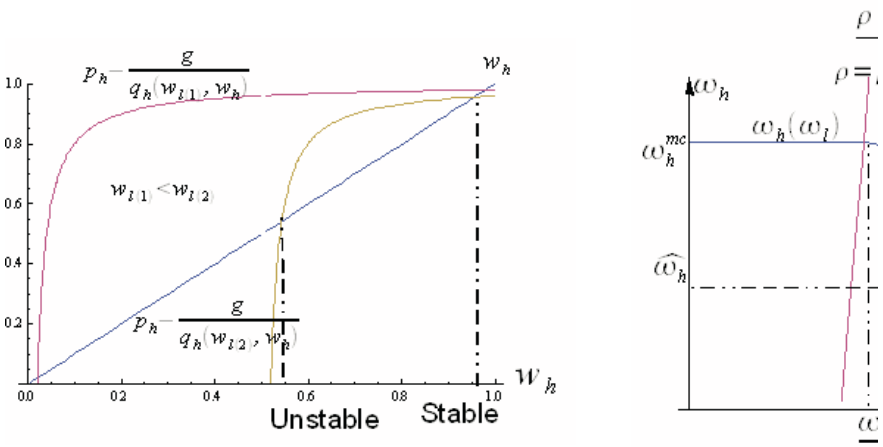

Figure 4: Decision of w by Coop H

curve of the unit rent $p_h - \frac{g}{q_h^d(w_l, w_h)}$ and the curve of the unit payment w_h. Note that the former curve shifts downwards as w_l increases. Therefore, if w_l is so large that the unit rent curve lies below the unit payment curve, there is no intersection. In this case, whatever the payment that the co-op offers to farmers, the unit rent is lower than the payment required to induce sufficient participation of farmers. Therefore, Coop H is driven out of the market due to the high level of w_l. From the figure, one can find a w_l that makes the unit rent curve just tangent with the unit payment curve. We denote this threshold by $\hat{w}_l$. It is derived by solving the cost-sharing rule for w_h and letting the discriminant of quadratic equation to be zero: $\Delta = 0$. Thus we have

$$\hat{w}_l = p_h(1 - \sqrt{\gamma(1-\sigma)})$$

The Coop H is out of the market if $w_l > \hat{w}_l$.

Finally, if $\underline{\omega_l} < \omega_l \leq \hat{\omega}_l$, the unit rent curve intersects with the unit payment curve at two points, which corresponds to two roots for the equation of the cost-sharing rule (20).

$$w_h^{dc}(w_l) = \frac{1}{2}\left(p_h + w_l \pm \sqrt{(p_h - w_l)^2 + p_h^2(\sigma - 1)\gamma}\right)$$

If the co-op chooses the smaller root, a slight reduction of w_h from the smaller root will induce a lower rent for the marginal farmer $\tilde{\theta}$ than the level of payment that is required to make it produce for the high quality standard ($p_h - \frac{g}{q_h^d(w_l,w_h)} < w_h$). Therefore, fewer farmers participate in the co-op and hence the existing members bear larger cost, which in turn, results in a further exit of members. Eventually, no farmer would participate in the co-op. Thus Coop H is out of the market. On the other hand, if w_h is increased slightly above the level of the smaller root, the unit rent is greater than what the marginal farmer needs to cover its cost ($p_h - \frac{g}{q_h^d}(w_l, w_h) > w_h$). Therefore, more farmers will participate in the co-op until the available rent and payment re-balance again, i.e. until the rent reaches the level of the larger root. Therefore, the smaller root is not a stable equilibrium. In the following analysis, we keep the larger root as the payment decided by Coop H in response to the payment of the IOF (w_l).[18]

For notation convenience, we divide all price variables w_i ($i = l, h$) by p_h and denote by $\omega_i = \frac{w_i}{p_h}$. Then the response function of Coop H given that Firm L sets ω_l is thus

$$\omega_h(\omega_l) = \begin{cases} \text{out} & \text{if } \omega_l > \hat{\omega}_l \quad \text{ML by IOF} \\ \frac{1}{2}\left(1 + \omega_l + \sqrt{(1-\omega_l)^2 + (\sigma-1)\gamma}\right) & \text{if } \underline{\omega_l} < \omega_l \leq \hat{\omega}_l \quad \text{Coexistance} \\ \omega_h^{mc} & \text{if } \omega_l \leq \underline{\omega_l} \quad \text{MH by Coop} \end{cases} \tag{21}$$

The response function of the Firm L is the same as condition (14). Dividing by p_h, the response function becomes

$$\omega_l(\omega_h) = Br(\omega_h) = \begin{cases} \frac{\rho}{2} & \text{if } \omega_h < \frac{\rho}{2} \\ \omega_h & \text{if } \frac{\rho}{2} \leq \omega_h \leq \frac{\rho}{2-\sigma} \\ \frac{\rho+\sigma\omega_h}{2} & \text{if } \frac{\rho}{2-\sigma} < \omega_h \leq \frac{\rho}{\sigma} \end{cases} \tag{22}$$

It can be verified that the response function of Coop H $\omega_h(\omega_l)$ cuts the response function of Firm L $\omega_l(\omega_h)$ at the part in which $\omega_l(\omega_h) = \frac{\rho+\sigma\omega_h}{2}$ (if the intersection

[18]The larger root satisfies the Marshallian Stability, which views the quantity change in response to a change in price. Such criteria is also used in Moschini et al. (2008) and Fontaine et al.(2008)

exists). This implies that if Firm L is present in the market, it coexists with Coop H. The two response curves are plotted by the right panel of Figure 4.

5.1.2 Equilibrium of competition between Coop H and Firm L

The equilibrium lies in the intersections of the two response functions. According to the range of parameters, there may be three cases which is summarized in Lemma 5

Lemma 5 *When Firm L competes with Coop H in setting unit payment to farmers,*

- *Firm L monopsonizes the market if* $\omega_l(\hat{\omega}_h) > \hat{\omega}_l$*, which gives*

$$\rho > \hat{\rho} = 2 - \sigma - \left(2 - \frac{\sigma}{2}\right)\sqrt{\gamma(1-\sigma)}$$

- *Firm L is out of the market if* $\omega_l(\omega_h^{mc}) \leq \underline{\omega_l}$*, which gives*

$$\rho \leq \rho_l^{df} = \frac{1}{2}\left(1 + \sqrt{1-\gamma}\right)\sigma$$

  Under this condition, Coop H sets the monopsony price $\omega^c = \omega_h^{mc} = \frac{1+\sqrt{1-\gamma}}{2}$ *and earns the monoposony profit:* $\pi_h^{mc} = \frac{p_h^2}{2c_h}\left(\frac{1+\sqrt{1-\gamma}}{2}\right)^2$.

- *Firm L and Coop H coexist, if* $\rho_l^{df} < \rho \leq \hat{\rho}$.[19] *The equilibrium payments* $(\omega_h^{dc}, \omega_l^{df})$ *solve the following equations:*

$$\begin{aligned} \omega_h &= \frac{1}{2}\left(1 + \omega_l + \sqrt{(1-\omega_l)^2 + (\sigma-1)\gamma}\right) \\ \omega_l &= \frac{\rho + \sigma\omega_h}{2} \end{aligned}$$

Therefore, the second-stage equilibrium is similar as in the case without cost-sharing in the sense that the larger the price incremental of the high quality product (i.e. the smaller ρ), the more likely that Coop H enjoys a large membership and Firm L looses the upstream market. However, with cost-sharing, Coop H has a fixed-cost disadvantage, which prevents it from offering high payment to farmers when the participation is low. Particularly when providing high quality induces small price incremental ($\rho > \hat{\rho}$), Coop H may be driven out of the market by Firm L. In this case, it is more likely that the co-op will choose the same standard as that of the IOF, i.e. the low quality standard, so as to secure its market position. The next subsection deals with this problem.

[19] $\hat{\rho} > \rho_l^{df}$ for $\gamma < \frac{4(1-\sigma)}{(2-\sigma)^2}$. In this case, the quantity of the IOF $q_l^{df} > \hat{q}_l = q_l(\hat{\omega}_l, \hat{\omega}_h) \geq 0$.

5.2 Equilibrium of quality standard competition

In the first-stage competition, the strategies of the two organizations are similar to that in the case without fixed cost (subsection 3.3.3): the IOF always prefers to differentiate its quality standard from that of the co-op, whereas the co-op can either differentiate its quality standard or to set the same standard as that of the IOF.[20] Therefore, the choice of quality standard by a co-op depends on the comparison of its profits under the two strategies, i.e. providing that the IOF chooses s_j ($j = l$ or h), the co-op compares the two profits: π_i^{dc} if it chooses $s_i \neq s_j$ and π_j^{mc} if it chooses $s_i = s_j$. In the presence of fixed cost γ, many cases may occur in equilibrium depending the relationship of parameters ρ, σ and γ. Figure 5 plots the equilibrium competition pattern in a $\sigma - \rho$ space for $\gamma = 0.5$.[21]

Compared with the case without fixed cost, the regions in which the two organizations coexist are "shrunk" in the presence of fixed cost. Particularly for the competition between Coop L and Firm H, (region $CL - FH$) the equilibrium exists only if ρ is at the intermediate level and σ is small. Outside this range, either the price incremental of the high quality product is too small ($\rho > \rho_h^{df}$) for the IOF to cover its fixed cost ($\pi_h^{df} < 0$) or the price incremental is large and the cost incremental of producing the high standard is small ($\rho < \rho_l^{dc}$) which induces the co-op to set the high quality standard and hence drive Firm H out of the market ($\pi_l^{dc} < \pi_h^{mc}$).

[20] Note that the co-op in this model is a vertically integrated organization, which always obtains a larger "profit" than its IOF counterpart does. Therefore, if the co-op cannot cover the fixed cost when setting s_h, neither can the IOF. However, the reverse statement is not true. To this extent, if the co-op trigger the price competition with the IOF by setting the same quality standard as that of the IOF. the co-op can always offer farmers higher payments than the IOF does, which drives the IOF out of the market.

[21] The threshold functions in the graphic are defined respectively by the following conditions:

$$\rho_h^{df} : \pi_h^{df} = 0; \quad \rho_l^{dc} : \pi_l^{dc} = \pi_h^{mc}; \quad \rho_{hl}^{mc} : \pi_h^{mc} = \pi_l^{mc}; \quad \rho_h^{dc} : \pi_h^{dc} = \pi_l^{mc};$$

In equilibrium, Coop L and Firm H coexist if $\rho_l^{dc} < \rho_h^{df}$; Firm L and Coop H coexist if $\rho_l^{df} < \rho < \min\{\rho_h^{dc}, \hat{\rho}\}$; in case of one co-op in the market, it prefers s_h to s_l if $\rho < \rho_{hl}^{mc}$.

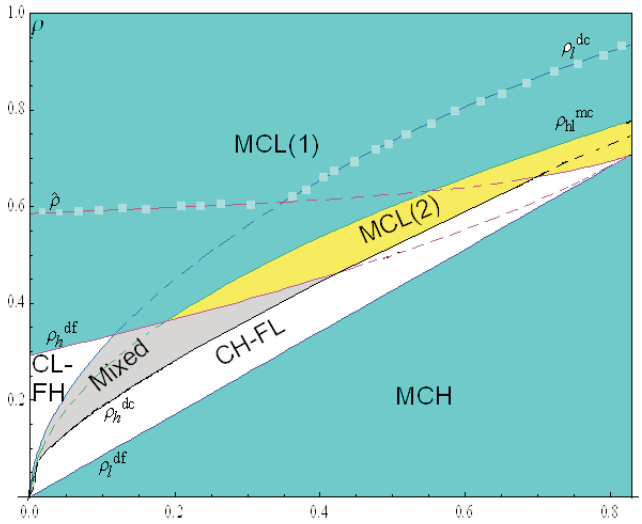

Figure 5: Equilibrium competition pattern with cost-sharing ($\gamma = 0.5$)

In order to investigate the effect of fixed cost, we focus on the shift of the equilibrium competition structure with γ for given levels of ρ and σ. As an illustration, Figure 6 plots the variation of the profits of the organizations and the welfare (denoted by W) under different competition patterns when ρ and σ are at similarly high levels. γ. Therefore, when the fixed cost γ is small, it is more likely that the co-op produces the high quality product. Thus we have "FL-CH" in equilibrium. If the fixed cost is high enough, the co-op may compete intensively with the IOF in the low standard market. Note that when γ ranges in $[\gamma_h^{dc}, \gamma_{hl}^{mc}]$, which corresponds to the region "MCL(2)" in Figure 5, the co-op dominates the market with standard s_l. In this range of parameter, if there is no competition from the IOF, the co-op prefers s_h to s_l ($\pi_l^{mc} < \pi_h^{mc}$). However, in presence of the Firm L, the co-op with standard s_h receives less profit than it would obtain by setting standard s_l ($\pi_h^{dc} < \pi_l^{mc}$). Whereas the IOF can not survive by setting s_h, since it earns a negative profit in case "CL-FH" ($\pi_h^{df} < 0$), nor can it coexist with Coop L by setting s_l. To this extent, the co-op strategically chooses the low quality standard so as to enjoy the monopsony position in the upstream market.

The strategy of the co-op leads to inefficient outcome. The lower panel of Figure 6 compares the welfare under different competition patterns. In the region "MCL(2)",

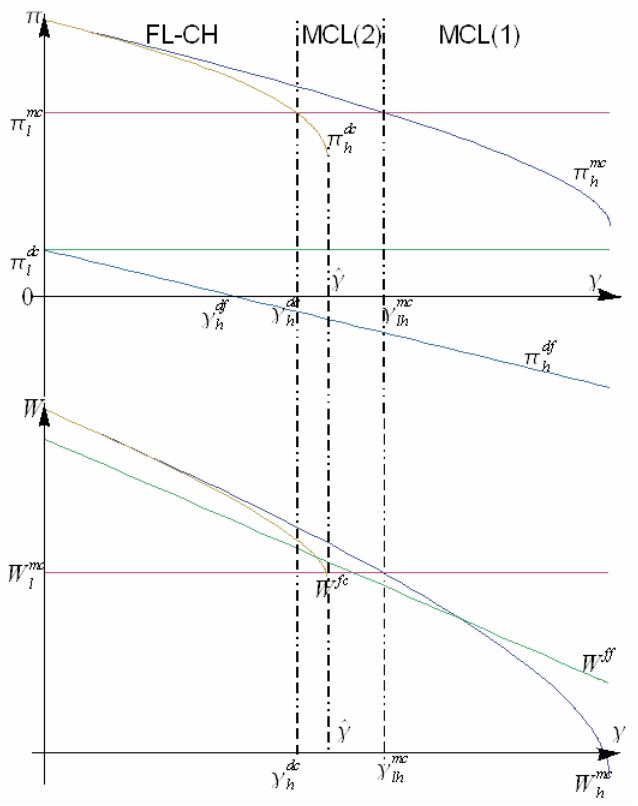

Figure 6: Effect of fixed cost ($\rho = \sigma = \frac{2}{3}$)

the equilibrium welfare is W_l^{mc}, which is lower than that in the case of monopsony co-op H (W_h^{mc}). When γ approaches the level of γ_h^{dc}, which is derived by solving $\rho = \rho_h^{dc}(\sigma, \gamma)$, the equilibrium welfare is even lower than that in the case where Firm L and Coop H coexist (W^{fc}) and in the two-firm case (W^{ff}). To this extent, the introduction of the high quality standard, either by the co-op or by the IOF, induces a high welfare compared to the case in absence of the high standard. Due to the advantage of the co-op in setting the quality standard, the mixed duopsonistic competition may lead to inefficient outcome compared to the pure duopsonistic competition between two IOFs. Indeed, in order to avoid the "high" fixed cost of improving quality and to enjoy the monopsony position in the upstream market, the co-op chooses a too low quality standard compared to the socially desired level.

6 Conclusion and remarks

This paper analyzes the quality provision of a farmer-owned cooperative (co-op) when it competes with a private-owned firm (IOF) in setting quality standard and quoting raw product prices. By developing a model of mixed duopsonistic competition, which allows endogenous participation of farmers, the paper derives the conditions under which a particular competition pattern occurs. The result shows that whether a co-op provides high quality depends on the comparison of costs and benefits of raising the quality standard. Particularly, when the incremental of market price due to the high quality product is large compared to the incremental of cost for a farmer to meet the high standard, the co-op can totally monopsonize the upstream market by setting the high quality standard. On the other hand, if the price incremental is low or the high quality production involves large fixed cost at the processing stage, the co-op dominates the market by setting the low quality standard. Only if the price incremental ranges at some intermediate level, can the co-op and the IOF coexist and implement different quality standards.

The analysis highlights another advantage of the co-op in competing with the IOF: by imposing the same quality standard as that of the IOF, the co-op triggers intensive competition with the IOF in quoting raw product price. In equilibrium, the co-op enjoys large participation of farmers and leaves little supply for the IOF. This can be a reason for a co-op to launch the high value-added business even if the production requirement is stringent for farmers.

The advantage of the co-op in setting the quality standard may, however, be socially undesirable, especially when producing the high quality product requires a high up-front fixed cost. In this case, even if the co-op can set a high quality standard and coexists with the IOF, it may strategically choose a low standard so as to attract all active farmers. This might be a reason why the traditional cooperatives suffer from a reputation of low quality production. (Zago (2006))

The paper also sheds some light on the impact of the minimum quality standard (MQS). A stringent MQS imposed by the public authority implies that the difference between the high and the low quality standards is reduced. Therefore, the two organizations becomes more similar in eye of farmers and hence their competition for farmers are more intensive. However, because of the advantage of the co-op to set the same quality standard as that of the IOF, the MQS makes the co-op more likely to dominate the market. From a farmer welfare point of view, the MQS raises the cost of meeting the low quality standard. More farmers switch to produce the high quality product and some low efficient farmers quit the market. The total welfare of farmers decline in favor of organization with high quality standard.

References

[1] Albeak and Schultz(1998) On the Relative Advantage of Coops, *Economics Letters* 59,pp.397-40

[2] Cramp, C. and Hollander, A. (1995), Duopoly and Quality Standards, *European Economic Review* 39, pp. 71-82

[3] Cook, M.L., and C. Iliopoulos, (2000), "Ill-defined property rights in collective action: the case of US agricutrual cooperatives" *Institutions, Contracts and Organizations: perspectives from New Institutional Economics*. Ménard, Cheltenham: Edward Elgar.

[4] Fulton and Sanderson (2002), Cooperatives and Farmers in the New Agriculture, report prepared for the cooperatives secretariat agriculture and agri-food Canada.

[5] Giannakas, K. and Fulton, M. (2001) Organizational Commitment in a Mixed Oligopoly: Agricultural Cooperatives and Investor-Owned Firms, *Amer. J. Agr. Econ. 83(5)* 1258-65

[6] Giannakas, K. and Fulton, M. (2005) Process innovation activity in a mixed oligopoly: The role of Cooperatives. *Amer. J. Agr. Econ.87(2)* 406Ű422

[7] Hardesty, Shermain (2004), Positioning California's Agricultural Cooperatives for the Future, working paper of *Giannini Foundation of Agricultural Economics*

[8] Hayes D.J.,Sergio H.Lence and A. Stoppa (2004), Farmer-owned brands?, *Agribusiness*, 20(3), 269-285.

[9] Hoffmann, R. (2005) Ownership Structure and Endogenous Quality Choice: Cooperatives versus Investor-Owned Firms, *Journal of Agricultural and Food Industrial Organization* Vol 3, article 8.

[10] Karantininis and Nielsen (2004), Hold-up and the implementation of "Code of Practice" by agri-food cooperatives, 6 th International Conference On Chain and Network Management in Agribusiness and the Food Industry

[11] MacDonald,Perry *et al.* (2004), Contracts, markets and prices: organizing the production and use of agricultrual commodities, *USDA, Agricultural economic report # 837*

[12] Rey, P. and Tirole, J. (2007), Financing and access in cooperatives, *International Journal of Industrial Organization*, vol 25, 1061-1088.

[13] Ronnen (1991) Minimum quality standard, fixed cost and competition, *Rand Journal of Economics*, Vol 22. No.4

[14] Saitone, T.L. and Sexton, R.J. (2009), Optimal Cooperative Pooling in a Quality-Differentiated Market, Conference paper at 2009 Annual AEA Meeting.

[15] Sexton, R. and Sexton, T(1987), Cooperative as Entrant, *Rand Journal of Economics*, Vol 18, N.4

[16] Sexton, R. (1990) Imperfect Competition in Agricutural Market and the Role of Co-ops, A Spatial Analysis, *American Journal of Agricultural Economics* 72. pp.709-720

[17] Spence A.M.(1975), Monopoly, quality and Regulation, *Bell Journal of Economics*, Vol 6. pp 417-429

[18] Sykuta and Cook (2001), A New Institutional Economics Approach to Contracts and Cooperatives, *American Journal of Agricultural Economics*, 83(5)

[19] Smyth, S and Phillips, P.W.B. (2002), Product differentiation alternatives: identity preservation, segregation, and traceability. *AgBioForum*, 5(2), 30-42.

[20] Tennbakk, Berit (1992), The Case of Cooperative Mixed Duopoly, Institute for Research on Labor and Employment Working Paper Series. Paper iirwps-044-92. http://repositories.cdlib.org/iir/iirwps/iirwps-044-92

[21] Zago (2006), The design of quality pricing in procurement setting via technology estimation, Mimeo.