Pooling and the Yardstick Effect of Cooperatives

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Abstract

Most agricultural markets show differentiated products and coexistence of cooperatives and investor-owned firms (IOFs). The difference between the two governance structures is that the IOF charges different procurement prices from the farmers based on their quality and maximizes its profits, whereas the cooperative pays a (partial) pooling price to all its members and retains no profits. We analyse and compare the outcome of different markets: IOF market, mixed market, and cooperative market. We show in a non-cooperative game between farmers and enterprises that governance structure choices depend crucially on the differential treatment of members regarding quality within a cooperative. The competitive yardstick effect of cooperatives arises as an externality of the governance structure choices. Both the market share of cooperatives and the extent of payment differentiation inside a cooperative have a positive effect on the prices received by farmers.

Key words: Cooperative, Quality, Pooling, Yardstick effect

1 Introduction

The changing production methods, increased concentration in supply chains, lower world prices and more international markets are threatening to small farmers (Hazell et al., 2006). Helper (1991) indicates that buyer-supplier relationships are becoming more dependent on factors such as quality, delivery performance, flexibility in contracting, and commitment to work together, as opposed to traditional relationships based on cost. Nowadays food quality and safety have become so important that suppliers have to pay more attention to them, as well as to consumers' preferences. Given the substantial heterogeneity among consumers, there are opportunities for farmers to produce differentiated products. Farmers are potentially able to grasp these opportunities because they are heterogeneous regarding educational level, experience, geographic location, market orientation, farm size, production technique, quality, risk attitude, age, non-farm incomes, etc. (Iliopoulos and Cook, 1999; Zusman, 1992). However, the rise of supermarkets and the subsequent specialized distribution centers is a challenge to small farmers (Hu et al., 2004). They can hardly deal with the private standards of these modern transaction parties, nor do they have the countervailing power to gain a reasonable share of the value added.

Competition in markets has many beneficial effects, but markets are not without problems when there are imbalances in the food chain. Examples of the problems faced by small firms are the formation of prices in markets, price instability, the provision of high quality inputs, lack of support services, exploitative grading practices, and lack of access to markets (Dunn, Ingalsbe, and Armstrong, 1979). Zusman and Rausser (1994) argue that collective action by farmers via cooperatives may solve these market failures (to a certain extent). Various efficiency enhancing features of cooperatives have been identified, like eliminating the double monopoly markup, countervailing power, economies of scale, assurance of sale, competitive yardstick, coordination, information provision, and providing member services (Hendrikse and Feng, 2013). This article highlights the competitive yardstick effect of cooperatives to improve the procurement prices received by farmers. The competitive yardstick effect refers to the fact that the presence of cooperatives in the market forces investor-owned firms to offer higher procurement prices for farmers' products. Empirical support for the competitive yardstick

is observed in the food manufacturing industry in the US (Rogers and Petraglia, 1994), the wheat market in Canada (Zhang et al., 2007), the coffee market in Chiapas, Mexico (Milford 2012), and the European dairy industry (Hanisch et al., 2012).

An agricultural cooperative is defined as an enterprise collectively owned (vertical relationship) by an association of many independent upstream parties (horizontal relationship). It is an example of a governance structure through which transactions occur (Coase, 1937). Other governance structures observed in agri-food production and marketing are contracts, contract farming, cooperatives, franchises, and networks. A governance structure can be characterized by as the allocation of decision rights and income rights over relevant assets (Hansmann, 1996). Decision rights in the form of authority and responsibility address the question 'Who has authority or control (regarding the use of assets)?', while income rights address the question 'How are benefits and costs allocated?'. The main distinction between an investor-owned firm (IOF) and a cooperative is that the decision rights reside formally with the investors in an IOF and with the input suppliers or buyers in an agricultural cooperative. An important income rights feature of cooperatives is pooling (Nilsson, 1998). It entails that the allocation of revenues as well as costs may be (partially) independent of quality and/or quantity delivered by the members.

The practice of pooling in cooperatives is commonly believed to place cooperatives at a competitive disadvantage in quality differentiated markets. Fulton and Sanderson (2002) argue that traditional cooperatives have disadvantages in meeting markets' demands for quality, due to several reasons. Firstly, revenue pooling generates adverse selection problems among heterogeneous farmers. Secondly, patronage-based financing leads to the horizon problem and underinvestment in long-term strategies that can enhance objective or perceived product quality. Thirdly, providing a "home" for member production is problematic both with respect to product quality and the potential to glut niche market. Finally, difficulties in dealing with "marginal" members lead to revenue inefficiencies of each member. The evidence regarding the relationship between governance structure and product quality in agricultural markets indicates that there are many cooperatives providing low quality products (Frick, 2004; Theodorakopoulou and Iliopoulos, 2012; Pennerstorfer and Weiss, 2012; Bijman et al., 2012).

We argue that the practice of pooling in a cooperative has also a competitive yardstick effect. The formation of a cooperative eliminates the double monopoly markup (Spengler, 1950), which increases the prices received by farmers and improves welfare. The practice of pooling in a cooperative and their zero-profit constraint have the effect of increasing the procurement prices for farmers outside the cooperative. Farmers are more likely to invest in specific assets and activities when they form a bargaining cooperative (Hendrikse, 2011).

Helmberger (1964), Cotterill (1987), and Milford (2012) establish a competitive yardstick effect in homogeneous product models without uncertainty, while Hendrikse (2007a) establishes a competitive yardstick effect by a contracting externality in a homogeneous product model with production uncertainty. Sexton (1990) and Tribl (2009) show the competitive yardstick effect in spatial models. This article addresses the outlet choice of heterogeneous farmers in terms of product quality, where the outlet choice is either an IOF or a cooperative. The distinction in terms of income rights is that an IOF charges farmers different procurement prices (based on their quality and / or production costs) and maximizes its profits, whereas the cooperative pays a (partial) pooling price to its members and retains no profits (by distributing all revenues to the members). Farmers with low quality products deliver to the cooperative due to the (partial) pooling price policy. The commitment of the cooperative to a (partial) pooling price policy is responsible for the competitive yardstick effect. It forces the IOF to increase procurement prices in order to attract farmers when it competes with a cooperative. Not only farmers delivering to the cooperative receive a higher surplus, but also the other farmers receive more than in a market with only IOFs. The competitive yardstick effect of cooperatives arises as an externality of the choice of governance structure. To be more specific, the emergence of cooperatives increases the outside option of farmers delivering to IOFs.[2]

In this article we determine the yardstick effect by comparing the outcomes of markets with only IOFs, mixed market, and markets with only cooperatives. Section 2 specifies the game between farmers and enterprises. Section 3 determines the equilibrium. We extend the model to partial pooling within cooperatives in section 4. Section 5 concludes and formulates some possibilities for future research.

2 Model

This section develops a non-cooperative game highlighting the farmers' choices of product outlet, and the pricing policies of the enterprises. The five ingredients of the game are specified, i.e. players, choices, payoffs, information structure, and the sequence of decisions.

Players

Assume that there are three farmers, two enterprises, and three consumers. Farmer 1 (2, 3) produces low (median, high) quality product. The quality produced by farmers is given exogenously. The two enterprises act as marketing organizations that purchase products from farmers and sell to consumers.

Choices

An enterprise $e\ (=1,2)$ takes two decisions. First, it has to make entry decision. If an enterprise chooses to enter the market, then a fixed cost F is incurred. This fixed cost is sunk (Sutton, 1991). There are no costs when there is no entry. Second, each enterprise chooses between two governance structures, investor-owned firm (IOF) and open-membership cooperative. An open-membership cooperative entails that farmers can join in the cooperative without limitation or any cost. An IOF can reject farmers to deliver to it, whereas a cooperative can't. An IOF chooses a differentiated markup pricing policy, whereas a cooperative chooses a pooling price policy. Each enterprise having two governance structure possibilities implies that there are three possible compositions of the market, i.e. two IOFs, an IOF and a cooperative, and two cooperatives.

A farmer chooses where to deliver and each farmer produces either nothing or one unit of product. Let q_j^{eg} be the delivery and output choice of farmer $j\ (=1,2,3)$ to enterprise $e\ (=1,2)$ with governance structure $g\ (=I,C)$, where $I\ (C)$ is an IOF (a cooperative). $q_j^{eg}=1(0)$ when farmer j delivers (does not deliver) a unit of the product to enterprise e with governance structure g. Consumer 1 (2, 3) buys either nothing or one unit of the product.

Payoffs

IOFs and cooperatives are characterized by different payment schemes. An IOF prices products on the basis of quality when purchasing inputs from farmers. It earns the difference between the input price and the sales price. A cooperative pools inputs of

differentiated qualities and pays farmers a pooling price. It distributes all revenues to members. Both an IOF and a cooperative price their products discriminatorily when selling products in the final product market, depending on the quality of products. The pricing policy of the IOF is known as double markup or double marginalization (Spengler, 1950), where markup refers to the difference between the price and the marginal cost in each stage of production (Carlton and Perloff, 1990, p526).[3]

Define R_j as the reservation price of a consumer for product j. Notice that j usually describes a particular farmer, but we will use it also for the product of this farmer. Consumers attach value to quality, i.e. $R_1 < R_2 < R_3$. The production costs of producing one unit of product j by farmer j are c_j $(j = 1, 2, 3)$, where c_j is increasing in j. Production costs are zero when the farmer does not produce. Reservation prices are assumed to be larger than the production cost, i.e. $c_j < R_j$ for $j = 1, 2, 3$.

Enterprises earn the difference between revenues and costs. Let p_{jb}^{eg} be the procurement price that enterprise e with governance structure g pays when buying (b) product j and p_{js}^{eg} be the sales price that enterprise e with governance structure g receives for selling (s) product j to a consumer. Notice that there are two markups, i.e. $p_{jb}^{eI} - c_j$ and $p_{js}^{eI} - p_{jb}^{eI}$, when there is an IOF, while there is only a single markup when there is a cooperative. The payoff of enterprise e with governance structure g is $\sum_{j=1}^{3} q_j^{eg} p_{js}^{eg} - \sum_{j=1}^{3} q_j^{eg} p_{jb}^{eg} -$ F, where $\sum_{j=1}^{3} q_j^{eg} p_{js}^{eg}$ is the total revenue that enterprise e with governance structure g earns, $\sum_{j=1}^{3} q_j^{eg} p_{jb}^{eg}$ refers to what enterprise e with governance structure g pays to farmers. The revenue of farmer j is p_{jb}^{eg} when he delivers to enterprise e with governance structure g and zero if he doesn't produce. Assume that members of a cooperative shoulder production costs individually and share the entry cost equally. Farmer j delivering to an IOF earns $p_{jb}^{eI} - c_j$, while he earns $p_{jb}^{ec} - c_j - F / \sum_{j=1}^{3} q_j^{eC}$ when delivering to a cooperative.

Denote the payoff of enterprise e with governance structure $\alpha (= I, C)$, competing with an enterprise with governance structure $\beta (= I, C)$, as $\pi_e^{\alpha\beta}$. Define the payoff of farmer j in an enterprise with governance structure α competing with an enterprise with governance structure β as $F_j^{\alpha\beta}$.

Information structure

Product quality, product production cost, consumers' reservation prices, the enterprises' pricing policy and income rights distribution strategy are common knowledge.

Sequence of decisions

The game consists of four stages. At stage one, each enterprise decides regarding entry. At stage two, each enterprise chooses its governance structure to be an IOF or a cooperative, i.e. price policy. Governance structure choices are made simultaneously.[4] At stage three, farmers choose the outlet of their products. The three farmers act simultaneously. At stage four, farmers decide about their level of output, i.e. to produce one unit of product or not to produce.

3 Equilibrium

The game will be solved by the method of backward induction. Section 3.1 presents the Nash equilibrium choices in each market. The competitive yardstick effect is determined in section 3.2. The equilibrium governance structure choices are presented in 3.3.

3.1 Outlet and production choices in each market

Three cases have to be distinguished: an IOF market, a mixed duopoly market, and a cooperative market.

IOF market

Suppose that there are two IOFs in the market and that they decide prices simultaneously. Since producers are assumed to know the preferences of each consumer, the entire consumer surplus will be extracted away by the enterprises (Grossman 1981). Prices that the IOFs charge consumers are $p_{js}^{eI} = R_j$. There is price competition between the two IOFs to attract farmers. The IOFs overbid each other as long as they earn a non-negative payoff. Input prices of the two IOFs tend to $p_{jb}^{eI} = R_j - \varepsilon$, where ε is a small positive number. Both IOFs will earn a negative profit due to the sunk cost F of entry.

The positive sunk cost F for entering the market results in a monopolistic market due to the IOFs anticipating the consequences of a contestable market. Assume that enterprise 1 is the monopolist. The monopolist will maximize its payoff by pricing inputs at marginal

costs, i.e. $p_{jb}^{1I} = c_j + \varepsilon$, and selling the outputs at $p_{js}^{1I} = R_j$. Equilibrium price policies, outlet choices, and production decisions in the IOF market are presented in table 1.

Table 1 Equilibrium in the IOF market

j	p_{jb}^{1I}	p_{js}^{1I}	q_j^{1I}	q_j^{2I}
1	$c_1 + \varepsilon$	R_1	1	0
2	$c_2 + \varepsilon$	R_2	1	0
3	$c_3 + \varepsilon$	R_3	1	0

Payoffs of the market participants in the IOF market are presented in table 4. The payoff of the IOF is $\pi^I = \sum_{j=1}^{3} R_j - \sum_{j=1}^{3} c_j - F - 3\varepsilon$ and each farmer earns ε.

Proposition 1: All farmers deliver to one IOF and earn almost nothing in a market with only IOFs.

Mixed duopoly

A cooperative distributes its revenues equally among its producer members. It entails that a cooperative has zero profits. Farmer *j* delivering to the cooperative therefore earns $p_{jb}^{eC} = \frac{\sum_{j=1}^{3} q_j^{eC} p_{js}^{eC} - F}{\sum_{j=1}^{3} q_j^{eC}}$.

There are two markups for product *j* ($j = 1, 2, 3$) delivered by the IOF. One markup arises when the IOF buys from farmer *j*. The other markup arises when the IOF sells product *j* to a consumer. Thus the IOF chooses two sets of prices, i.e. the procurement prices and the sales prices. The IOF earns the difference between the procurement price and the sales price. Suppose that the entry cost F is sufficiently small to not deter production by farmers.

The cooperative is not able to attract high quality farmers in equilibrium due to the collective pooling price. The IOF tailors its pricing policy to individual farmers. The IOF chooses a procurement price $p_{jb}^{1I} = R_1 - F - \varepsilon$ to deter farmer 1 from delivering to the IOF. If the IOF chooses $p_{jb}^{1I} = R_1 - F$, then farmer 1 is indifferent in delivering to the IOF and the cooperative. The IOF has to choose $p_{2b}^{1I} = R_2 - F$ and $p_{3b}^{1I} = R_3 - F$ in order to attract farmer 2 and farmer 3 when $p_{jb}^{1I} = R_1 - F$. The IOF therefore chooses a

lower procurement price for the low quality product in order to establish lower opportunity costs for farmer 2 and farmer 3. The IOF chooses $p_{jb}^{1I} = R_1 - F - \varepsilon$. It chooses $p_{2b}^{1I} = (R_1 + R_2)/2 - F/2 + \varepsilon$ in order to prevent that farmer 2 goes to the cooperative. It chooses $p_{3b}^{1I} = (R_1 + R_3)/2 - F/2 + \varepsilon$ to prevent that farmer 3 goes to the cooperative. Farmer 1 delivers to the cooperative. The pooling price policy of the cooperative causes adverse selection of farmer 2 and farmer 3. It is more attractive for them to deliver to the IOF. Table 2 presents the equilibrium price policies, outlet choices, and production decisions when parameter values are such that producing one unit of product results in a non-negative payoff for each farmer.

Table 2 Equilibrium in the mixed duopoly

j	p_{jb}^{1I}	p_{js}^{1I}	p_b^{2C}	p_s^{2C}	q_j^{1I}	q_j^{2C}
1	-	-	R_1	R_1	0	1
2	$\frac{R_1+R_2}{2} - \frac{F}{2} + \varepsilon$	R_2	-	-	1	0
3	$\frac{R_1+R_3}{2} - \frac{F}{2} + \varepsilon$	R_3	-	-	1	0

Payoffs of the players in the mixed market are presented in table 4. Farmer 1 earns $R_1 - F - c_1$ by delivering to the cooperative. Farmer 2 receives $(R_1 + R_2)/2 - F/2 + \varepsilon$ from the IOF and earns $(R_1 + R_2)/2 - F/2 - c_2 + \varepsilon$. The IOF earns $(R_2 - R_1)/2 + F/2 - \varepsilon$ from the marketing of the medium quality product. Farmer 3 receives $(R_1 + R_3)/2 - F/2 + \varepsilon$ from the IOF and earns $(R_1 + R_3)/2 - F/2 - c_3 + \varepsilon$. The IOF earns $(R_3 - R_1)/2 + F/2 - \varepsilon$ from the marketing of the high quality product. All farmers earn more in the mixed duopoly than in the IOF market.

Proposition 2 states that the pooling function of a cooperative discourages farmers with high quality products from joining the cooperative. It entails adverse selection, which is a widely recognized problem regarding cooperatives (Fulton and Sanderson, 2002; Saitone and Sexton, 2009). Farmers providing low quality products are willing to deliver to the cooperative because they benefit from the elimination of the double markup. The IOF is in the high reservation price market niches.

Proposition 2: The low quality farmer delivers to the cooperative whereas the farmers producing medium and high quality products deliver to the IOF.

Cooperative market

Cooperatives are characterized by a price policy based on pooling. There is no Nash equilibrium in pure strategies in a market with only cooperatives. Low quality farmers like to deliver to the cooperative where high quality farmers deliver, in order to benefit from pooling. However, high quality farmers leave the cooperative where low quality farmers deliver and join the other cooperative. The choices of farmers therefore result in a mixed strategy equilibrium. Suppose that parameter values are such that all three farmers produce one unit of product. The calculation of the mixed strategy equilibrium in this case is provided in the Appendix. The equilibrium mixed strategy of each farmer is to choose enterprise 1(2) with probability 0.5(0.5). Table 3 presents the equilibrium price policies, outlet choices, and production decisions. All farmers produce one unit of product when $(R_1 + R_2)/2 > c_2$, $(R_1 + R_2 + R_3)/3 > c_3$, and $(R_1 + R_3)/2 > c_3$.[5]

Table 3 Equilibrium in the cooperative market

j	p_{jb}^{1C}	p_{js}^{1C}	p_b^{2C}	p_s^{2C}	q_j^{1C}	q_j^{2C}
1	$\frac{14R_1+5R_2+5R_3}{24} - \frac{2}{3}F$	R_1	$\frac{14R_1+5R_2+5R_3}{24} - \frac{2}{3}F$	R_1	0.5	0.5
2	$\frac{5R_1+14R_2+5R_3}{24} - \frac{2}{3}F$	R_2	$\frac{5R_1+14R_2+5R_3}{24} - \frac{2}{3}F$	R_2	0.5	0.5
3	$\frac{5R_1+5R_2+14R_3}{24} - \frac{2}{3}F$	R_3	$\frac{5R_1+5R_2+14R_3}{24} - \frac{2}{3}F$	R_3	0.5	0.5

The equilibrium payoffs in the cooperative market are presented in table 4. The membership size of each cooperative is 1.5. Each farmer earns the purchasing price deducted by the individual production cost. Payoffs of three farmers are therefore $(14R_1 + 5R_2 + 5R_3)/24 - c_1 - 2F/3$, $(5R_1 + 14R_2 + 5R_3)/24 - c_1 - 2F/3$, and $(5R_1 + 5R_2 + 14R_3)/24 - c_1 - 2F/3$ respectively.

3.2 Yardstick effect

The relationship between the price paid to farmers and the market share of cooperatives, i.e. the competitive yardstick effect, is determined. The table 1, 3, and 5 show that the three markets are efficient, but the equilibrium farmer payoffs differ substantially

between markets. In the IOF market all the farmers deliver to one IOF. The IOF prices inputs at marginal costs. Each farmer earns a small profit. In the mixed duopoly market, the pooling policy of the cooperative results in adverse selection. Only farmers producing the lowest quality products deliver to the cooperative, whereas the other farmers deliver to the IOF. However, the prices received by farmers are much higher. The commitment of the cooperative to a pooling price policy forces the IOF to pay higher prices to farmers. Figure 1 depicts the relationship between the cooperative market share and the procurement prices.

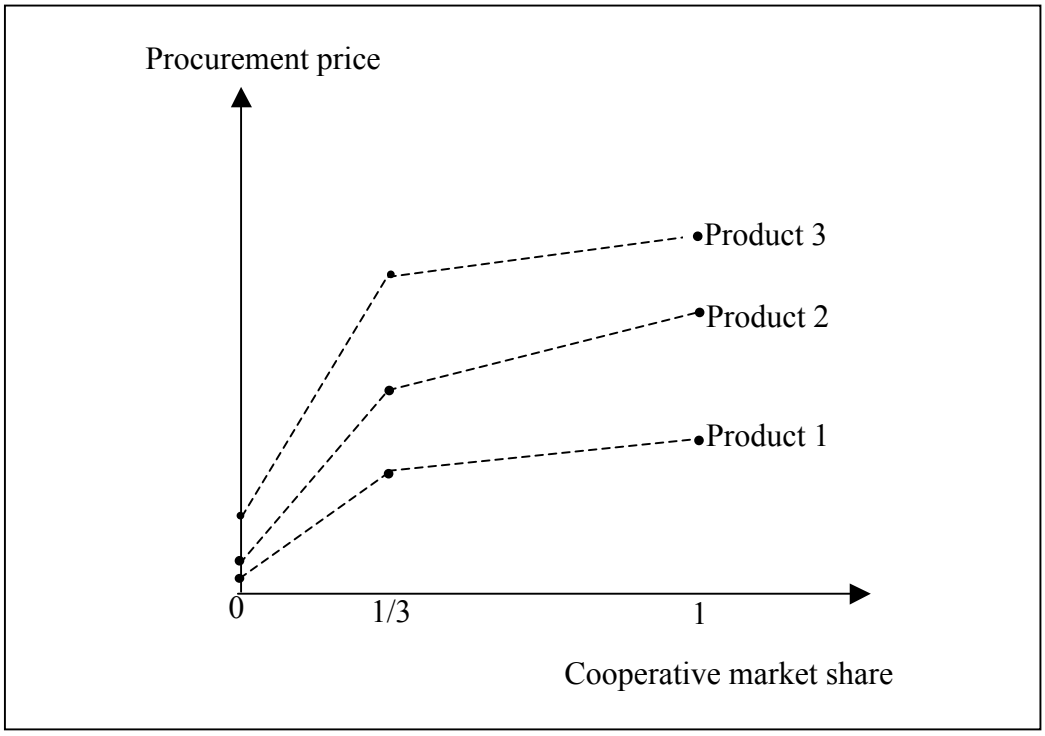

Figure 1. Market structure and procurement prices

Define the yardstick effect of market structure as the difference between the procurement price paid to farmers in the market when cooperatives are present and the price when there is no cooperative. The presence of a cooperative in the mixed duopoly has a yardstick effect. Not only farmers delivering to the cooperative are better off, but also farmers delivering to the IOF earn more revenues than those in a pure IOF market. All the

farmers are even better off in the cooperative market than the mixed market when F is small. This result is summarized in proposition 3.

Proposition 3: The presence of cooperatives in the market has a yardstick effect and the effect increases as the market share of cooperatives increases.

The competition between established firms and potential entrants is similar to the practice of limit pricing. Limit pricing entails setting a high output level, or a low price, to deter new firms from entering industries (Milgrom and Roberts, 1982; Sexton and Sexton, 1987). The potential entrants expect existing firms to maintain their pre-entry output or price after entry. This makes it less attractive for potential firms to enter the market. Our model shows the reverse effect in an intermediate product market. The presence of cooperatives in the market increases the price(s) at which farmers are able to sell their products. The yardstick effect of cooperatives is to increase the procurement prices paid to farmers.

3.3 Governance structure choice

This section determines the equilibrium industry structure. Table 4 presents the farmer and enterprise payoffs in alternative markets. In each cell of the table, a vector $\left(\left[\left(F_1^{\alpha\beta}, F_2^{\alpha\beta}, F_3^{\alpha\beta}\right);\ \pi_1^{\alpha\beta}\right], \left[\left(F_1^{\beta\alpha}, F_2^{\beta\alpha}, F_3^{\beta\alpha}\right);\ \pi_2^{\beta\alpha}\right]\right)$ is listed. It reflects the payoff of farmer j in enterprise e with governance structure α facing competition of an enterprise with governance structure β, as well as the payoff of the enterprises.

Table 4 Market structure and farmer payoffs

$e=2$ / $e=1$	**IOF**	**Coop**
IOF	$\left(\begin{bmatrix}\varepsilon\\ \varepsilon\\ \varepsilon\\ \sum_{j=1}^{3} R_j - \sum_{j=1}^{3} c_j - 3\varepsilon\end{bmatrix}, \begin{bmatrix}0\\0\\0\\0\end{bmatrix}\right)$	$\left(\begin{bmatrix}0\\ \frac{R_1+R_2}{2} - \frac{F}{2} - c_2 + \varepsilon\\ \frac{R_1+R_3}{2} - \frac{F}{2} - c_3 + \varepsilon\\ \frac{R_3+R_2-2R_1}{2} - 2\varepsilon\end{bmatrix}, \begin{bmatrix}R_1 - F - c_1\\0\\0\\0\end{bmatrix}\right)$
Coop	$\left(\begin{bmatrix}R_1 - F - c_1\\0\\0\\0\end{bmatrix}, \begin{bmatrix}0\\ \frac{R_1+R_2}{2} - \frac{F}{2} - c_2 + \varepsilon\\ \frac{R_1+R_3}{2} - \frac{F}{2} - c_3 + \varepsilon\\ \frac{R_3+R_2-2R_1}{2} - 2\varepsilon\end{bmatrix}\right)$	$\left(\begin{bmatrix}\frac{14R_1+5R_2+5R_3}{24} - \frac{2F}{3} - c_1\\ \frac{5R_1+14R_2+5R_3}{24} - \frac{2F}{3} - c_2\\ \frac{5R_1+5R_2+14R_3}{24} - \frac{2F}{3} - c_3\\0\end{bmatrix}, \begin{bmatrix}\frac{14R_1+5R_2+5R_3}{24} - \frac{2F}{3} - c_1\\ \frac{5R_1+14R_2+5R_3}{24} - \frac{2F}{3} - c_2\\ \frac{5R_1+5R_2+14R_3}{24} - \frac{2F}{3} - c_3\\0\end{bmatrix}\right)$

In an IOF duopoly, the IOF prices inputs at marginal costs of production. Farmers therefore receive hardly any payoff. They will respond by starting a cooperative. Not only farmers delivering to the cooperative are better off, but also farmers delivering to the IOF earn more revenues than those in the IOF market. The presence of a cooperative has a competitive yardstick effect. The IOF earns a positive payoff due to the double markup. Farmers earn even more when they leave the IOF and start a second cooperative. The mixed IOF-cooperative duopoly market is therefore also not stable. A cooperative market is the equilibrium industry composition. All the value-added product is obtained by farmers.

4 Partial pooling

Although equal distribution of revenues in terms of quality used to be the basic principle of cooperatives, many cooperatives nowadays choose alternative payment schemes due to changed market conditions. Differential pricing is important for a cooperative's stability and optimal production decisions when member heterogeneity is increasing (Sexton, 1986; Staatz, 1984). Take for example the Dutch cooperative Coforta (Hendrikse, 2011). High quality members left the cooperative due to the pooling strategy. However, high quality farmers returned to the cooperative when policies were more tailored to the high quality members. Many cooperatives therefore grade members' products and pay differential prices based on quality. We therefore extend the model by relaxing the assumption of complete pooling. The interactions between farmers' outlet choice and partial pooling based on sales price is examined in this section.

Define the payment differentiation parameter θ as the extent of differentiation regarding the distribution of revenues in terms of sales prices. $\theta = 0$ entails complete pooling, or the equality principle regarding the distribution of revenues, while $\theta = 1$ entails no pooling, or distribution of revenues based entirely on sales prices. Suppose farmer j delivering to a cooperative receives a payment comprised of the pooling price and a differential price based on the sales price, i.e. $p_{jb}^{ec} = (1-\theta)\sum_{j=1}^{3} p_{js}^{ec} q_j^{ec} / \sum_{j=1}^{3} q_j^{ec} + \theta p_{js}^{ec}$.

Consider first the mixed duopoly market. When $0 \leq \theta < 1$, the outlet choices of farmers and the governance structure choices are the same as in the case of complete pooling. Farmer 1 delivers to the cooperative, whereas farmer 2 and farmer 3 deliver to the IOF. Though the payment differentiation regarding quality in the cooperative offers an incentive to farmer 2 and farmer 3 to join the cooperative, the IOF is able to attract farmer 2 and farmer 3 by increasing the procurement price. The procurement prices that various farmers receive are $p_1^M = R_1$, $p_2^M = (1-\theta)(R_1 + R_2)/2 + \theta R_2 - F/2 + \varepsilon$, and $p_3^M = (1-\theta)(R_1 + R_3)/2 + \theta R_3 - F/2 + \varepsilon$. As θ increases, the IOF facing competition from the cooperative has to increase the procurement prices to attract farmers. The procurement prices paid to medium and high quality farmers therefore increase as well. When $\theta = 1$, the prices paid by the cooperative are $p_1^M = R_1$, $p_2^M = R_2$, and $p_3^M = R_3$. The IOF will earn nothing if it pays farmers the same prices as the cooperative does. It is not able to attract farmers. All the farmers deliver to the cooperative rather than to the IOF in the mixed duopoly market.

Assume that the equilibrium θ is determined by majority voting of the membership of the cooperative (Hart and Moore, 1996; Zago, 1999). Farmer 3 prefers a high differentiation parameter and votes for $\theta = 1$. Farmer 2 is aware that farmer 3 delivers to the cooperative only when $\theta = 1$. He would then choose $\theta = 1$ to escape from the pooling with the low quality farmer. Farmer 1 is indifferent regarding the value of θ, because he realizes that neither farmer 3 nor farmer 2 will deliver to the cooperative when θ is smaller than 1. The equilibrium in the mixed duopoly is that the cooperative sets $\theta = 1$ and all farmers join the cooperative. Each farmer earns the sales price of his product.

Although partial pooling based on sales price doesn't result in different outlet choices of farmers, it affects the yardstick effect of the cooperative. The procurement prices for both farmer 2 and farmer 3 delivering to the IOF increase as the price differentiation parameter θ increases. There are more incentives for high quality farmers to join the cooperative when θ increases. As the differentiation in the cooperative' pricing policy for differentiated qualities increases, the procurement prices that the IOF has to pay to farmer 2 and farmer 3 are increasing as well in order to prevent them from leaving. This drives the procurement price in the markets towards the sales prices. This result is summarized in proposition 4 and depicted in figure 2.

Proposition 4: There is a positive relationship between the degree of payment differentiation regarding product quality within a cooperative and the yardstick effect.

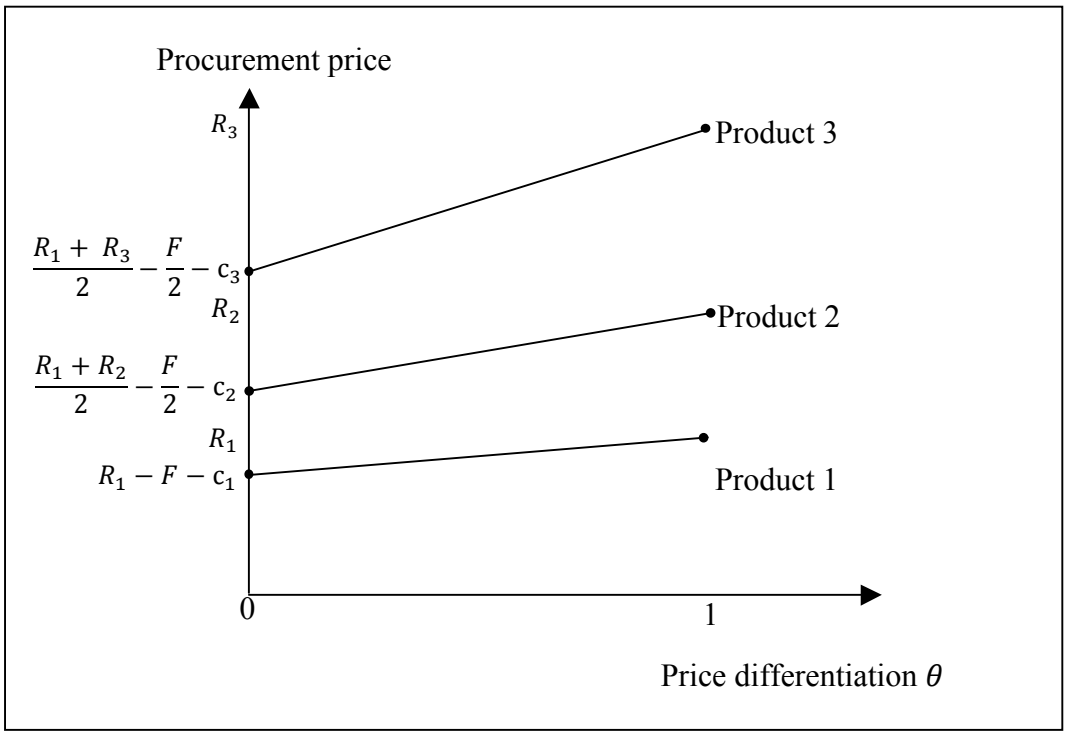

Figure 2. Yardstick effect and partial pooling

In the cooperative market, farmers' outlet choices are dependent on the degree of differentiation of the two cooperatives. Assume that the two cooperatives are identical regarding θ. There is no Nash equilibrium in pure strategies. Each farmer chooses cooperative 1(2) with probability 0.5(0.5). Farmer j earns $5\theta(3R_j - \sum_{j=1}^{3} R_j)/24 + 9R_j + 5\sum_{j=1}^{3} R_j/24 - 3F/2$.

Consider again the choice of θ by the membership. Farmer 3 votes for $\theta = 1$, while farmer 1 will vote for $\theta = 0$. Farmer 2's choice regarding θ depends on the value of R_2 and $(R_1 + R_3)/2$. If $R_2 > (R_1 + R_3)/2$, farmer 2 votes for $\theta = 1$. Otherwise farmer 2 votes for $\theta = 0$. When $R_2 > (R_1 + R_3)/2$, cooperatives choose $\theta = 1$ and each farmer receives a price equal to the sales price of his product. When $R_2 < (R_1 + R_3)/2$, cooperatives set $\theta = 0$ and the expected price of farmer 1 (2, 3) in the mixed strategy equilibrium, is $(14R_1 + 5R_2 + 5R_3)/24$ ($(5R_1 + 14R_2 + 5R_3)/24$, $(5R_1 + 5R_2 + 14R_3)/24$).

In the IOF market all the farmers deliver to one IOF. The IOF prices inputs at marginal costs. Each farmer earns a small profit.

Equilibrium farmer payoffs in different markets when $R_2 > (R_1 + R_3)/2$ are summarized in table 5. In each cell of the table, a vector $\left(\left[\left(F_1^{\alpha\beta}, F_2^{\alpha\beta}, F_3^{\alpha\beta}\right);\ \pi_1^{\alpha\beta}\right], \left[\left(F_1^{\beta\alpha}, F_2^{\beta\alpha}, F_3^{\beta\alpha}\right);\ \pi_2^{\beta\alpha}\right]\right)$ is listed. In the mixed duopoly market, the cooperative chooses a complete differentiation pricing policy to attract farmers. All the farmers deliver to the cooperative. In the cooperative market, there is a mixed strategy equilibrium. Cooperatives choose the complete differentiation pricing policy and farmers are indifferent in choosing either cooperative. Only the IOF market is not an equilibrium market structure. The equilibrium in a mixed market consists of either one cooperative with all farmers, or two cooperatives.

Table 5 Market structure and farmer payoffs when partial pooling is based on sales price and $R_2 > (R_1 + R_3)/2$

$e = 2$ / $e = 1$	IOF	Coop
IOF	$\left(\begin{bmatrix}\varepsilon\\ \varepsilon\\ \varepsilon\\ \sum_{j=1}^{3} R_j - \sum_{j=1}^{3} c_j - 3\varepsilon\end{bmatrix}, \begin{bmatrix}0\\0\\0\\0\end{bmatrix}\right)$	$\left(\begin{bmatrix}0\\0\\0\\0\end{bmatrix}, \begin{bmatrix}R_1 - \frac{F}{3} - c_1\\ R_2 - \frac{F}{3} - c_2\\ R_3 - \frac{F}{3} - c_3\\ 0\end{bmatrix}\right)$
Coop	$\left(\begin{bmatrix}R_1 - \frac{F}{3} - c_1\\ R_2 - \frac{F}{3} - c_2\\ R_3 - \frac{F}{3} - c_3\\ 0\end{bmatrix}, \begin{bmatrix}0\\0\\0\\0\end{bmatrix}\right)$	$\left(\begin{bmatrix}\frac{14R_1+5R_2+5R_3}{24} - \frac{F}{3} - c_1\\ \frac{5R_1+14R_2+5R_3}{24} - \frac{F}{3} - c_2\\ \frac{5R_1+5R_2+14R_3}{24} - \frac{F}{3} - c_3\\ 0\end{bmatrix}, \begin{bmatrix}R_1 - c_1\\ R_2 - c_2\\ R_3 - c_3\\ 0\end{bmatrix}\right)$

Equilibrium farmer payoffs in the different markets when $R_2 < (R_1 + R_3)/2$ are summarized in table 6. In the mixed duopoly market, the cooperative chooses a complete differentiation pricing policy to attract farmers. All the farmers deliver to the cooperative. In the cooperative market, there is a mixed strategy equilibrium. Cooperatives choose the complete pooling pricing policy and farmers are indifferent in choosing either cooperative. Since $R_2 < (R_1 + R_3)/2$, the mixed market is comprised of one cooperative (and an empty IOF) is the equilibrium outcome.

Table 6 Market structure and farmer payoffs when partial pooling is based on sales

price and $R_2 < (R_1 + R_3)/2$

$e=2$ / $e=1$	**IOF**	**Coop**
IOF	$\left(\begin{bmatrix}\varepsilon\\ \varepsilon\\ \varepsilon\\ \sum_{j=1}^{3} R_j - \sum_{j=1}^{3} c_j - 3\varepsilon\end{bmatrix}, \begin{bmatrix}0\\0\\0\\0\end{bmatrix}\right)$	$\left(\begin{bmatrix}0\\0\\0\\0\end{bmatrix}, \begin{bmatrix}R_1 - \frac{F}{3} - c_1\\ R_2 - \frac{F}{3} - c_2\\ R_3 - \frac{F}{3} - c_3\\ 0\end{bmatrix}\right)$
Coop	$\left(\begin{bmatrix}R_1 - \frac{F}{3} - c_1\\ R_2 - \frac{F}{3} - c_2\\ R_3 - \frac{F}{3} - c_3\\ 0\end{bmatrix}, \begin{bmatrix}0\\0\\0\\0\end{bmatrix}\right)$	$\left(\begin{bmatrix}\frac{14R_1+5R_2+5R_3}{24} - \frac{2F}{3} - c_1\\ \frac{5R_1+14R_2+5R_3}{24} - \frac{2F}{3} - c_2\\ \frac{5R_1+5R_2+14R_3}{24} - \frac{2F}{3} - c_3\\ 0\end{bmatrix}, \begin{bmatrix}\frac{14R_1+5R_2+5R_3}{24} - \frac{2F}{3} - c_1\\ \frac{5R_1+14R_2+5R_3}{24} - \frac{2F}{3} - c_2\\ \frac{5R_1+5R_2+14R_3}{24} - \frac{2F}{3} - c_3\\ 0\end{bmatrix}\right)$

5 Conclusion and further research

This article examines farmers' outlet and production choices in a differentiated product market. Enterprises in the market choose to adopt either an IOF or a cooperative governance structure. An IOF prices products differentially and earns the difference between input prices and output prices. A cooperative adopts a (partial) pooling price policy and distributes all revenues to members. In the mixed duopoly, farmers with low quality products deliver to the cooperative, whereas farmers with high quality products deliver to the IOF. The presence of the cooperative in the market has a competitive yardstick effect. An IOF is forced to increase the procurement prices in order to attract farmers when it competes with a cooperative. The commitment of the cooperative to a (partial) pooling price policy is responsible for this effect. Not only farmers delivering to the cooperative receive a higher surplus, but also the other farmers receive more compared to the IOF market. The yardstick effect becomes stronger when the cooperative adopts a more differentiated price policy. The differentiation in pricing provides incentives for high quality farmers to join the cooperative. The IOF has to respond with paying higher procurement prices to attract farmers. It therefore forces the market towards higher procurement prices.

There are various possibilities for further research. We mention two possibilities. First, we have highlighted the relationship between the structure of income rights and the yardstick effect, which determines the quality of products provided by cooperatives.

Complete as well as partial pooling results in cooperatives attracting the low quality farmers. However, pooling can also bring advantages (Saitone and Sexton, 2009; Hendrikse, 2011). It attenuates the incentive of farmers to overproduce high quality products, insures risk-averse farmers against stochastic variation in quality levels, and creates countervailing power. A richer structure of the income rights may attract therefore only the high quality farmers, i.e. it has to be determined that cooperatives are not bound to low quality. Hoffman (2005) is an example highlighting various cost structures regarding quality. Second, the role of ownership rights in terms of a constitutional rule consisting of majority voting has been addressed, but the role of decision rights has not been addressed (Bijman, et al. 2013). This may turn out to be important for the provision of quality by cooperatives because the distinction in a cooperative between ownership of the members and control by managers is important for the viability of the cooperative due to their diverging focus and interests.

References

Bijman, J., Hendrikse, G.W.J., van Oijen, A.A.C.J., 2013. Accommodating two worlds in one organization: Changing board models in agricultural cooperatives. Managerial and Decision Economics. 34, 204-217.

Bijman, J., Iliopoulos, C., Poppe, K.J., Gijselinckx, C., Hagendorn, K., Hanisch, M., Hendrikse, G.W.J., Kühl, R., Ollila, P., Pyykkonen, P., van der Sangen. G., 2012. Support for Farmers' Cooperatives, Final report. Wageningen: Wageningen UR.

Carlton, D.W., JPerloff, M., 1990. Modern Industrial Organization. Scott, Foresman/Little, Brown High Education.

Coase, R.H., 1937. The nature of the firm. Economica 4(16), 386-405.

Cotterill, R.W., 1987. Agricultural cooperatives: A unified theory of pricing, finance and investment', in J.S. Royer (Eds.), Cooperative Theory: New Approaches. ASC Service Reports 18, US Department of Agriculture, Washington D.C., pp171-258.

Dunn, J.R., Ingalsbe, G., Armstrong, J.H., 1979. Cooperatives and the structure of US agriculture, in Structure Issues of American Agriculture. Agr. Econ. Report No 438, USDA/ESCS, Washington, DC, pp. 241-248.

Frick, B., 2004. Does ownership matter? Empirical evidence from the German wine industry. Kyklos. 57, 357-386.

Fulton, M., Sanderson, K., 2002. Co-Operatives and farmers in the new agriculture. working paper, Centre for the Study of Co-operatives, University of Saskatchewan.

Grossman, S.J., 1981. The informational role of warranties and private disclosure about product quality. Journal of Law and Economics. 24(3), 461-483.

Hanisch M., Rommel, J., Müller. M., 2012. Variation in farm gate milk prices and the cooperative yardstick revisited – Panel evidence from the European dairy sectors. A report for the project Support for Farmers' Cooperatives'.

Hansmann, H., 1996. The ownership of enterprise. Harvard University Press.

Hart, O., Moore, J., 1996. The governance of exchanges: members' cooperatives versus outside ownership. Oxford Review of Economic Policy. 12(4), 53-69.

Hazell, P., Poulton, C., Wiggins, S., Dorward A., 2006. The future of small farms: synthesis paper. Presented at Research Workshop organized by IFPRI, ODI and Imperial College, Wye.

Helmberger, P.G., 1964. Cooperative enterprise and organization theory. Journal of Farm Economics. 44, 275-290.

Helper, S., 1991. How much has really changed between U.S. manufactures and their suppliers?. Sloan Management Review. 32(4), 15-28.

Hendrikse, G.W.J., 2007. On the co-existence of spot and contract markets: The delivery requirement as contract externality. European Review of Agricultural Economics. 34(2), 257-282.

Hendrikse, G.W.J., 2011. Pooling, access, and countervailing power in channel governance. Management Science. 57(9), 1692-2002.

Hendrikse, G.W.J., Feng, L., 2013. Interfirm Cooperatives, in Grandori A. (Eds.), Handbook of Economic Organization: Integrating Economic and Organization Theory. Edward Elgar Publishing, pp501-521.

Hoffmann, R., 2005. Ownership structure and endogenous quality choice: cooperatives versus investor-owned firms. Journal of Agricultural & Food Industrial Organization. 3(8), 1-24.

Hu, D., Reardon, T., Rozelle, S., 2004. The emergence of supermarkets with Chinese characteristics: Challenges and opportunities for China's agricultural development. Development Policy Review. 22(5), 557-586.

Iliopoulos, C., Cook. M.L., 1999. The efficiency of internal resource allocation decisions in customer-owned firms: The influence costs problems. Paper presented at the third Annual Conference of the International Society for New Institutional Economics, Washington, D.C., September 16-18.

Milford, A., 2012. The pro-competitive effect of coffee cooperatives in Chiapas, Mexico. Journal of Agricultural & Food Industrial Organization. 10(1), 1362.

Milgrom, P.R., Roberts J., 1982. Limit pricing and entry under incomplete information: An equilibrium analysis. Econometrica, 50(2), 443-459.

Nilsson, J., 1998. The emergence of new organizational models for agricultural cooperatives. Swedish Journal of Agricultural Research. 28(1), 39-47.

Pennerstorfer, D., Weiss. C.R., 2012. Product quality in the agri-food chain: Do cooperatives offer high-quality wine?. European Review of Agricultural Economics 1: 1-20.

Rogers, R.T., Petraglia. L.M., 1994. Agricultural cooperatives and market performance in food manufacturing: Implications for Market Performance. Journal of Agricultural Cooperation. 9, 1-12.

Saitone, T.L., and Sexton R.J. 2009. Optimal cooperative pooling in a quality-differentiated market. Paper presented at International Conference Rural Cooperative in the 21st Century: Lessons from the Past, Pathways to the Future, 14-17, June, The Hebrew University of Jerusalem, Israel.

Sexton, R.J., 1986. The formation of cooperatives: a game-theoretic approach with implications for cooperatives. Giannini Foundation Information Series No. 88-3, University of California.

Sexton, R.J., 1990. Imperfect competition in agricultural markets and the role of cooperatives: a spatial analysis. American Journal of Agricultural Economics. 72(3), 709-720.

Sexton, R.J., Sexton T.A., 1987. Cooperatives as an entrant. The RAND Journal of Economics. 18(4), 581-595.

Spengler J.J., 1950. Vertical integration and antitrust policy. Journal of Political Economy. 58(4), 347-352.

Staatz, J.M., 1984. A Theoretical Perspective on the Behavior of Farmers' Cooperatives. Ph.D. Dissertation, Department of Agricultural Economics, Michigan State University, USA.

Sutton J., 1991. Sunk Costs and Market Structure. The MIT Press Cambridge, Massachusetts: London, England.

Theodorakopoulou, I. liopoulos. C., 2012. Support for farmers' cooperatives: Sector report wine. Wageningen: Wageningen UR.

Tribl, C., 2009. Spatial competition of food processing cooperatives in a mixed market–the case of uniform delivered pricing. Working paper, Federal Institute of Agricultural Economics, Austria.

Zago, A.M., 1999. Quality and self-regulation in agricultural markets: How do producer organizations make the rules? European Review of Agricultural Economics. 26(2), 199-218.

Zusman, P., 1992. Constitutional selection of collective-choice rules in a cooperative enterprise. Journal of Economic Behavior and Organization. 17, 353-362.

Zusman, P., Rausser, G.C., 1994. Intraorganizational influence relations and the optimality of collective action. Journal of Economic Behavior & Organization. 24 (1), 1-17.

Zhang, J., Goddard, E., Lerohl, M., 2007. Estimating pricing games in the Wheat-handling market in Saskatchewan: The role of a major cooperate, in Novkovic, S., Dena, V., (Eds.), Cooperative Firms in Global Markets. Emerald Group Publishing Limited, pp151-182.

Appendix

This appendix will determine the equilibrium mixed strategy of each farmer when $\frac{R_1+R_2}{2} > c_2$, $\frac{R_1+R_2+R_3}{3} > c_3$, and $\frac{R_1+R_3}{2} > c_3$, i.e. all farmers produce one unit of product. Farmers shoulder their individual production cost and share the sunk cost F of entry equally. Suppose that farmer j delivers to cooperative 1(2) with probability q_j $(1 - q_j)$. The payoffs of each farmer in each of the eight cases are presented in table A-1.

We show that only two cases have to be distinguished regarding the Nash equilibrium. Consider the choices of the farmers 2 and 3 when the outlet choice of farmer 1 is Cooperative 1, i.e. the left branch in table A-1. Farmer 2 prefers to deliver to Cooperative 2 above Cooperative 1 when farmer 3 delivers to cooperative 2, regardless the level of F. Similarly, farmer 3 prefers to deliver to Cooperative 2 above Cooperative 1 when farmer 2 delivers to Cooperative 2, regardless the level of F. If farmer 2 (3) prefers to deliver to Cooperative 2 above Cooperative 1 when farmer 3 (2) delivers to Cooperative 1, then the unique payoff-maximizing choices or the farmers 2 and 3 is to deliver to Cooperative 2 when farmer 1 delivers to Cooperative 1. This occurs when $2F < 2R_3 - R_1 - R_2$. If this inequality does not hold, i.e. $2F \geq 2R_3 - R_1 - R_2$, then there are two pure Nash equilibria and one mixed strategy Nash equilibrium, given the choice of farmer 1 to deliver to Cooperative 1. The analysis of the payoff maximizing choices of the farmers 2 and 3 when the outlet choice of farmer 1 is Cooperative 2 is identical because the payoffs are symmetric. The farmers 2 and 3 deliver to Cooperative 1 when $2F < 2R_3 - R_1 - R_2$, given that farmer 1 delivers to cooperative 2. There are three Nash equilibria when this inequality does not hold, given that farmer 2 does deliver to Cooperative 2.

The Nash equilibrium of the case $2F < 2R_3 - R_1 - R_2$ will be analyzed because there is only one Nash equilibrium, and it includes the case which is highlighted in the article, i.e. each farmer receives a non-negative payoff when one unit of the product is produced. The unique equilibrium in this case is a mixed strategy Nash equilibrium. This can be explained as follows. Suppose that the farmers 2 and 3 deliver to Cooperative 2, then 1 prefers to join Cooperative 2 above delivering to Cooperative 1 because $R_1 + R_2 + R_3 - F > 3(R_1 - F)$. However, the above has shown that the farmers 2 and 3 leave Cooperative 2 when farmer 1 delivers to Cooperative 2. Similarly, if the farmers 2 and 3 deliver to Cooperative 1, then farmer 1 prefers to join Cooperative 1 above delivering to

Cooperative 2 because $R_1 + R_2 + R_3 - F > 3(R_1 - F)$. However, the farmers 2 and 3 leave Cooperative 1 when farmer 1 delivers to Cooperative 1. The conclusion is therefore that there is not a Nash equilibrium in pure strategies, the equilibrium is therefore a mixed strategy Nash equilibrium. The computation of this mixed strategy Nash equilibrium will be provided now.

The expected payoff that farmer 1 receives is

$$F_1^{CC} = q_1\left[q_2q_3(\frac{R_1+R_2+R_3}{3} - c_1 - \frac{F}{3}) + q_2(1-q_3)(\frac{R_1+R_2}{2} - c_1 - \frac{F}{2}) + (1-q_2)q_3(\frac{R_1+R_3}{2} - c_1 - \frac{F}{2}) + (1-q_2)(1-q_3)(R_1 - c_1 - F)\right] + (1-q_1)\left[q_2q_3(R_1 - c_1 - F) + q_2(1-q_3)(\frac{R_1+R_3}{2} - c_1 - \frac{F}{2}) + (1-q_2)q_3(\frac{R_1+R_2}{2} - c_1 - \frac{F}{2}) + (1-q_2)(1-q_3)(\frac{R_1+R_2+R_3}{3} - c_1 - \frac{F}{3})\right].$$

The expected payoff that farmer 2 receives is

$$F_2^{CC} = q_1\left[q_2q_3(\frac{R_1+R_2+R_3}{3} - c_2 - \frac{F}{3}) + q_2(1-q_3)(\frac{R_1+R_2}{2} - c_2 - \frac{F}{2}) + (1-q_2)q_3(R_2 - c_2 - F) + (1-q_2)(1-q_3)(\frac{R_2+R_3}{2} - c_2 - \frac{F}{2})\right] + (1-q_1)\left[q_2q_3(\frac{R_2+R_3}{2} - c_2 - \frac{F}{2}) + q_2(1-q_3)(R_2 - c_2 - F) + (1-q_2)q_3(\frac{R_1+R_2}{2} - c_2 - \frac{F}{2}) + (1-q_2)(1-q_3)(\frac{R_1+R_2+R_3}{3} - c_2 - \frac{F}{3})\right].$$

The expected payoff that farmer 3 receives is

$$F_3^{CC} = q_1\left[q_2q_3(\frac{R_1+R_2+R_3}{3} - c_3 - \frac{F}{3}) + q_2(1-q_3)(R_3 - c_3 - F) + (1-q_2)q_3(\frac{R_1+R_3}{2} - c_3 - \frac{F}{2}) + (1-q_2)(1-q_3)(\frac{R_2+R_3}{2} - c_3 - \frac{F}{2})\right] + (1-q_1)\left[q_2q_3(\frac{R_2+R_3}{2} - c_3 - \frac{F}{2}) + q_2(1-q_3)(\frac{R_1+R_3}{2} - c_3 - \frac{F}{2}) + (1-q_2)q_3(R_3 - c_3 - F) + (1-q_2)(1-q_3)(\frac{R_1+R_2+R_3}{3} - c_3 - \frac{F}{3})\right].$$

To maximize F_j by letting $\frac{dF_j}{dq_j} = 0$. We have

$$\begin{cases} (q_2+q_3-1)\frac{R_1+R_2+R_3}{3} + (q_3-q_2)\frac{R_2+R_3}{2} + (1-q_2-q_3)R_1 + (q_2+q_3-1)\frac{2F}{3} = 0 \\ (q_1+q_3-1)\frac{R_1+R_2+R_3}{3} + (q_3-q_1)\frac{R_2+R_3}{2} + (1-q_1-q_3)R_1 + (q_1+q_3-1)\frac{2F}{3} = 0 \\ (q_1+q_2-1)\frac{R_1+R_2+R_3}{3} + (q_2-q_1)\frac{R_2+R_3}{2} + (1-q_1-q_2)R_1 + (q_1+q_2-1)\frac{2F}{3} = 0. \end{cases}$$

These equations are satisfied when $q_1 = q_2 = q_3 = 0.5$. The expected membership size of each cooperative is 1.5. Payoffs of three farmers in the cooperative market are therefore $F_1^{CC} = \frac{14R_1+5R_2+5R_3}{24} - c_1 - \frac{2F}{3}$, $F_2^{CC} = \frac{5R_1+14R_2+5R_3}{24} - c_2 - \frac{2F}{3}$, and $F_3^{CC} = \frac{5R_1+5R_2+14R_3}{24} - c_3 - \frac{2F}{3}$.