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Cooperatives and the Risk Aversion of Farmers

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Abstract

In this paper I explain why some marketing firms are organized as cooperatives. I construct a theoretical model which captures main features of the environment, in which agricultural marketing firms operate. These features include the presence of cooperative and non-cooperative marketing firms in the same markets, the ability of individual farmers to sell their crops to cooperatives and non-cooperatives, the use of pre-specified purchase prices in cooperatives, and the aversion toward risk among individual farmers. Based on these features, the model suggests that any marketing firm offering a pre-specified purchase (pooled) price to its suppliers without any quantity restrictions should be cooperatively owned by its suppliers.

Keywords: cooperatives, risk aversion, price pooling

1 Introduction

Although cooperatives play an important role in the US agriculture, the use of a cooperative form of ownership is not uniformly spread among all sub-sectors of the US agriculture. In general, cooperatives play an important role among agricultural marketing firms, which purchase crops from individual farmer suppliers and sell the produce either to final consumers or to processing firms. Traditionally, the term "cooperative" has been reserved for an agricultural marketing firm under a joint ownership of farmers who also supply their crops

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to the firm. Marketing firms under other forms of ownership are usually termed as non-cooperatives or as investor owned firms. Another element making a cooperative marketing firm different from other types of marketing firms is the ability of members of a cooperative to supply their crops to the cooperative at a pre-specified purchase price, which is usually fixed for a sufficiently long period of time.

In this paper I explain why some marketing firms are organized as cooperatives. I construct a theoretical model which captures main features of the environment, in which agricultural marketing firms operate. These features include the presence of cooperative and non-cooperative marketing firms in the same markets, the ability of individual farmers to sell their crops to cooperatives and non-cooperatives, the use of pre-specified purchase prices in cooperatives, and the aversion toward risk among individual farmers. Based on these features, the model suggests that any marketing firm offering a pre-specified purchase (pooled) price to its suppliers without any quantity restrictions should be cooperatively owned by its suppliers.

The supplier ownership of the marketing firm is important, because without quantity restrictions, a farmer supplier sells to the firm at the pooled price only when the outside spot price is below the pooled price and never when the outside spot price is above the pooled price. As a result, the firm cannot effectively diversify across fluctuations of outside spot prices and sustain the pooled price. The model shows that when the spot price is high, we can induce a farmer supplier to sell to the marketing firm at the pooled price by giving him an appropriate share of the firm's ownership rights and without imposing quantity restrictions. With multiple farmer suppliers this arrangement results in the emergence of a cooperative marketing firm, where ownership of the marketing firm is distributed among all suppliers of inputs having access to the pooled price. The model shows that the allocation of the firm's ownership rights among farmer suppliers can result in a sustainable pooled price only if farmer suppliers are sufficiently risk-averse.

In the rest of the introduction I cover each of the features of the agricultural marketing sector in more detail and also discuss the related literature. I first discuss the system of price pooling and other elements of a membership agreement between a cooperative marketing firm and an individual farmer supplier. Next, I discuss the accessibility to multiple markets for individual farmers and risk attitudes of farmers.

Price Pooling.

By joining a cooperative marketing firm and becoming its partial owner,

an individual farmer gains access to a number of services including grading, shipping, and processing of agricultural products. In addition to the services which increase the value added of supplied products, many marketing cooperatives also offer risk-protection mechanisms to their members. By far the most popular risk-protection mechanism is the system of price pooling. The system of price pooling is usually organized for a specific agricultural product and allows a member of a cooperative to receive a fixed purchase price for the supplied product. Usually, a member of a cooperative participating in the system of price pooling receives some payment based on the fixed purchase price at the time of the product delivery, a share of the payment as the content of the pool is being sold, and a share of the payment after the pool is closed and all costs of running the pool are deducted. The average of these payments corresponds to the average price at which the product is sold on the spot market. Non-members of a marketing cooperative do not have access to the pool price, although they can supply a cooperative on the basis of delivery contracts at spot prices.

Depending on the cooperative membership contract and a type of a cooperative, a farmer may have an obligation to sell his entire crop to the cooperative, may be required to supply some pre-specified share of his crop to the cooperative, or may be free to supply any share of his crop to the cooperative. For example, when Saskatchewan Wheat Pool was originally established in the 1920's, its members received the same pre-specified fixed price for any amount of grain supplied to the cooperative at any time of the year (Fulton and Larson 2009). On the other extreme, prior to its conversion to a publicly traded company in 2005, Diamond Walnut Growers marketing cooperative required its members to deliver all their crops to the cooperative (Hardesty 2009). However, most currently operating marketing cooperatives require their members to deliver some pre-specified share of their crops to be able to participate in the system of price pooling or to receive the value added services (USDA 1999)¹.

Single-product versus multi-product pooling.

¹In general, the delivery requirement specifying the amount of product to be delivered at the pooled price or for the value added services varies by type of a cooperative with traditional cooperatives having no delivery requirements and the so called "new generation cooperatives" having strict delivery requirements. Very often the delivery rights/requirements in the "new generation cooperatives" are tied to members' ownership shares and entail fines in case of violations. For more details, see Coltrain, Barton, and Boland (2001).

Although there are instances when some cooperatives use multi-product pools, typically cooperatives set separate pools for different crops. It is common for cooperatives, which handle multiple types of crops, to establish a separate price pool for each commodity under supervision of a separate pool manager. In addition, the pool prices for the same crops are differentiated by product grade and quality (USDA 1999). As an instance, in 1963-1983 Tri Valley Growers (TVG) marketing cooperative operated a single price pool for all crops including tomatoes, peaches, olives, and other fruits and vegetable. However, after 1983 and until 2001 TVG introduced product-specific pools (Hariyoga and Sexton 2009).

The conversion to separate pools for different commodities reduces the ability of a cooperative to more effectively manage risk through cross subsidization from pooling different crops. On the other hand, the establishment of separate pools lowers transaction costs, makes cooperatives respond more readily to demand fluctuations and stay profitable. As a result, most of the currently operating cooperatives use only single-product price pools.

Spot markets.

In most industries members of cooperatives supply their crops both to their cooperatives at pooled prices, to non-cooperative marketing firms at spot prices, and directly to final consumers. The actual shares of crops going to each market vary widely across industries and products. For example, in the dairy industry in 2012 the share of nationally produced milk marketed through cooperatives reached 84%, while the share of nationally produced cheese marketed through cooperatives was only 22% (USDA 2012). According to USDA (2011), in 1978-2007 on average 5.5% of all farms in the US participated in direct sales to final consumers such as grocers and restaurants. Most of the direct sales took place in the fruit and vegetable industry where marketing cooperatives occupy a prominent position. For example, in the 1990's Ocean Spray cooperative marketed 80-85% of all cranberries produced in US (USDA 1999).

Hence, empirical evidence suggests that farmers have access to multiple markets. The choice of a market and the share of crops directed to each market depend not only on the characteristics of a crop (e.g. perishability) but also on quantity restrictions imposed by cooperatives and the ability of cooperatives to enforce these restrictions.

Risk attitudes of farmers.

Farming is a risky business. Along with the demand uncertainty, farmers also face uncertainty related to weather conditions and productivity of crops.

In addition to the risk factors affecting farming as a business activity, there is empirical evidence that US farmers themselves are relatively more risk-averse than other groups of US population. In a survey of risk preferences of farmers, non-farmer entrepreneurs, and the general population in US, Roe (2013) finds that farmers are more tolerant toward risk than the general population but less tolerant toward risk than non-farmer entrepreneurs. The lower tolerance toward risk of farmers versus non-farmer entrepreneurs is particularly strong for individuals of ages 48 and above.

There is secondary evidence that farmers are risk-averse from the survey of reasons for joining a marketing cooperative. According to Bond, Carter, and Sexton (2009), former members of Rice Growers Association cooperative listed "increased agricultural income", benefits from price pooling", and "reduced marketing risk" as the top three reasons for joining the cooperative (p. 81). Hence, the available empirical evidence suggests that risk-aversion is an important element in the farmers' decision-making process, and that farmers largely view cooperatives as a means to protect against price uncertainty.

The importance of the risk protection motive in joining a marketing cooperative suggests that a model of a marketing cooperative should be built around the system of price pooling as a risk protection mechanism². However, since the provision of the pooled price is undermined by the farmers' access to spot prices outside the marketing firm, the model relies on the ownership structure as an additional incentive for farmers to supply to the marketing firm even if the competing price outside the firm is higher. As a result, the cooperative form of ownership with ownership rights allocated among farmer suppliers can help farmers to enjoy the access to the pooled price either when quantity restrictions do not exist or when they cannot be enforced.

There are a number of alternative models of a cooperative firm. Similarly to the model in this paper, Kimball (1988) stresses the importance of the risk-protection element in the functioning of a cooperative. He views a cooperative as a collection of farmers who offer mutual risk protection. Since farmers face independently distributed output shocks, they can insure themselves by distributing payoffs from those with positive output shocks to those with negative output shocks. However, the empirical evidence suggests that

²Since the quality of crops in commodity pools is in general observable, we cannot directly apply risk-insurance (moral hazard) models of unobservable action (e.g. Stiglitz (1974), Shavell (1979)).

farmers join cooperatives to gain protection against price shocks rather than against output shocks. In addition, since most pools are single-commodity pools, members of a commodity pool face the same price shocks. Lastly, there is no explanation to why only cooperatives are able to maintain price pools. Hueth and Marcoul (2008) argue that a cooperative firm can act as a substitute for a "missing market" and offer services, which otherwise would not be offered. In particular, they view the cooperative form of ownership as an instrument to maintain sufficient monitoring efforts by investors over actions of the management board. The model in this paper is different, because I view a cooperative as an instrument to protect against demand fluctuations of risk-averse farmers rather than as a monitoring device.

A number of studies of agricultural cooperatives focus on different aspects of the cooperatives' operations without necessarily explaining why cooperatives persist. For example, Vercammen, Fulton, and Hyde (1996) study efficient pricing rules in agricultural cooperatives, while Sexton (1990) concentrates on pro-competitive effects of cooperatives in agricultural markets. Albaek and Shultz (1997) focus on investment decisions in cooperatives, and Hendrikse and Bijman (2002) study the effect of ownership structure on investment decisions in cooperatives. In contrast to these papers, I do not concentrate on investment or pricing decisions in cooperatives. Instead I attempt to justify the use of a cooperative form of ownership as a possible solution to the failure of a non-cooperative marketing firm to provide price insurance to risk-averse farmers.

In the rest of the paper I introduce the general setup of the model, discuss the case when a farmer supplier has no ownership of the marketing firm, and discuss the case when a farmer owns a share of the marketing firm. In the last section I extend the model by introducing two farmers with heterogeneous attitude toward risk.

2 Model Setup

Consider a farmer with a utility function $U(\cdot)$. Under the assumption that the farmer is risk-averse, I assume that U is increasing at a decreasing rate. The farmer has access to two outlets and allocates his output between a spot market and a marketing firm. The share of the output allocated to the marketing firm in state $j \in \{H, L\}$ is $q_j \in [0, 1]$ and the share of the output allocated to the spot market in state j is $(1 - q_j)$. For simplicity I assume

that the farmer does not incur any costs of production.

The farmer's allocation decision depends on the price on the spot market, $P \in \{P_H, P_L\}$, where $P_H > P_L$, and the price offered by the marketing firm, P_C . In state $j = H$, the price on the spot market is high and $P = P_H$, and in state $j = L$, the price on the spot market is low and $P = P_L$. The probability of state $j = H$ is $\pi \in (0, 1)$ and the probability of state $j = L$ is $1 - \pi$. The farmer has a choice to make an allocation decision after the uncertainty on the spot market is realized. As a result, when $j = H$ and the spot market price is high, the farmer sells on the spot market a $(1 - q_H)$ share of the output, and when $j = L$ and the spot price is low, the farmer sells on the spot market a $(1 - q_L)$ share of the output.

The marketing firm sets the purchase (pooled) price P_C prior to the realization of the uncertainty on the spot market and sells her output on the spot market at the same realized spot price $P \in \{P_H, P_L\}$. I assume that the marketing firm is risk-neutral and does not create any value added services. Further, I assume that the marketing firm offers P_C , if the following ex ante non-negative profit condition holds.

$$\pi(P_H - P_C)q_H + (1 - \pi)(P_L - P_C)q_L \geq 0$$

The firm's ex ante non-negative profit condition implies that the marketing firm offers P_C , if the expected profit from offering P_C to the farmer is weakly above zero. The expected profit is an expected sum of the firm's payoffs occurring in both states. In particular, when the realized spot price is P_H , the firm's payoff is $(P_H - P_C)q_H$, since the marketing firm buys a q_H share of the farmer's output at price P_C and sells the same amount on the spot market at price P_H . Similarly, when the realized spot price is P_L , the firm's payoff is $(P_L - P_C)q_L$, since the marketing firm buys a q_L share of the farmer's output at price P_C and sells it on the spot market at price P_L .

The farmer agrees to sell to the marketing firm at price P_C before the realization of the spot market price, if the farmer's ex ante participation constraint holds,

$$U(P_C) \geq \pi U(P_H) + (1 - \pi)U(P_L).$$

This condition states that the farmer has an ex ante incentive to supply to the marketing firm at price P_C , if the farmer's utility from accepting P_C weakly exceeds the expected utility from selling only on the spot market.

Further, this condition implies that $P_C > P_L$, which together with the non-negative profit condition implies that $P_C < P_H$. Hence, the farmer's ex ante participation constraint and the firm's ex ante non-negative profit condition imply that $P_H > P_C > P_L$.

The timing of the model is following. The firm and the farmer sign a contract which specifies the firm's purchase price P_C and the farmer's right to supply any amount of his output to the firm at any point in time. After the contract is signed, the price on the spot market is realized and the farmer decides how much of his output to supply to the marketing firm and how much to sell on the spot market.

In the model I make four important assumptions. First of all, I assume that the farmer has no obligation to deliver a pre-specified quantity of his output to the firm conditional on the realized spot price. Although marketing firms usually sign contracts, which specify quantities to be delivered, I give reasons why it can be impossible to draft or enforce quantity restrictions conditional on realized market prices. First, since contracts are signed prior to the realization of the market uncertainty, the marketing firm and the farmer may be unable to draft a complete contract with quantities conditional on realized prices, because it is either impossible to specify all realized prices or because the farm output cannot be conditioned on a realized price. Second, even if the firm and the farmer can write a complete contract, such a contract is very hard to implement due to asymmetric information. In particular, the farmer can manipulate the timing of delivery of the contracted output, since the firm has no first-hand information about the actual timing of production of crops.

The second assumption implies that the firm does not provide any value added services aside from offering the pooled price P_C . It is straightforward to relax this assumption by introducing some positive constant m to be added to sale prices $\{P_H, P_L\}$ of the marketing firm. The size of m then captures the increase in the market value of the final product from these value added services. Since the introduction of the value added services does not change main results of the model, I omit this component from further discussion.

The third assumption suggests that the firm and the farmer sell their products on the same market. In other words, I assume that prices and the probability distribution of prices facing the firm and the farmer are the same. I make this assumption for the ease of exposition, although this assumption can be easily relaxed by making prices facing the firm and the farmer different and by introducing some dependence structure on probability distributions

of prices in markets accessible to the firm and to the farmer.

Lastly, I assume that the farmer produces a single kind type of output of a homogeneous quality and the marketing firm offers a single purchase price P_C . This assumption reflects the ability of agricultural marketing firms to set purchase prices conditional on product quality and the dominance of single-commodity pools in the US agricultural sector.

3 Non-integration

In this section I consider the case when the farmer has no ownership of the marketing firm and show that in this case the firm cannot sustain the purchase price P_C . Recall that the marketing firm offers the purchase price P_C , if the ex ante non-negative profit condition is satisfied. To capture the dependence of the firm's expected profit on the farmer's allocation decision, I transform the ex ante non-negative profit condition in the following way,

$$\frac{q_H}{q_L} \geq \frac{1 - \pi}{\pi} \frac{P_C - P_L}{P_H - P_C} > 0.$$

The transformed ex ante non-negative profit condition implies that the marketing firm operates on the market, if the ratio of the farmer's output allocated to the firm under different realizations of the spot price, $\frac{q_H}{q_L}$, exceeds a strictly positive cutoff value $\frac{1 - \pi}{\pi} \frac{P_C - P_L}{P_H - P_C}$. The cutoff value is a function of probabilities of each state and differences between realized spot prices P_H and P_L and the purchase price P_C .

To calculate the ratio $\frac{q_H}{q_L}$ when the farmer does not have ownership of the marketing firm, let's consider the farmer's allocation decision when the realized spot prices are high and low. If the realized spot price is P_H , the farmer chooses q_H to maximize his utility of $U(P_H(1 - q_H) + P_C q_H)$, where $P_H(1 - q_H) + P_C q_H$ is the farmer's payoff from selling a $(1 - q_H)$ share of output on the spot market at P_H and a q_H share to the marketing firm at price P_C . Since $U(\cdot)$ is strictly increasing and $P_H > P_C$, the optimal q_H^* is equal to 0, so that $q_H^* = 0$. Similarly, if the realized spot price is P_L , the farmer chooses q_L to maximize $U(P_L(1 - q_L) + P_C q_L)$. Since $U(\cdot)$ is strictly increasing and $P_L < P_C$, the optimal q_L^* is equal to 1, and $q_L^* = 1$. Hence, the ratio of optimal allocation decisions is equal to zero, $\frac{q_H^*}{q_L^*} = 0$, and the non-negative profit condition is never satisfied.

Result 1: *The marketing firm cannot sustain the pooled price P_C , if the farmer has no ownership of the marketing firm.*

This result means that if the farmer can sell to the firm at price P_C without quantity restrictions conditional on realized spot prices or without an obligation to sell before the realization of the market uncertainty, the farmer never trades with the firm when the spot price is high and supplies all his output to the firm when the realized spot price is low. As a result, the firm's expected profit is always negative, and the firm does not offer P_C . Hence, unless the firm is able to contractually specify the purchase price P_C along with the pair of allocations q_H and q_L such that $\frac{q_H}{q_L} \geq \frac{1-\pi}{\pi} \frac{P_C-P_L}{P_H-P_C}$ and enforce these contractual terms, the marketing firm never offers the pooled price P_C .

4 Integration: General Case

In this section I extend the basic model and make the farmer a partial owner of the marketing firm. To introduce the farmer ownership of the firm, I assume that the farmer obtains the $\frac{1}{n}$ share of the firm's value V and the $\frac{1}{n}$ share of the firm's profit from offering the purchase price P_C . The parameter n takes values from 1, if the farmer is the sole owner of the marketing firm, to $n \rightarrow \infty$, if the farmer has no ownership of the marketing firm. Hence, $n \in [1, \infty)$. The parameter $V > 0$ represents the farmer's ownership payoff in addition to the profit arising from offering P_C ³.

I assume that the farmer's utility from partial ownership of the firm and from selling his output is additively separable. This assumption reflects the fact that the farmer receives payoffs from his ownership share and from his allocation decision at different moments in time. For example, in agricultural cooperatives, where farmer suppliers jointly own their marketing firms, farmers usually receive ownership dividends at the end of the fiscal year while the payoffs from selling their crops are spread throughout the whole crop season.

The timing of the model with farmer ownership remains the same with an addition of the ownership payoff stage. As before, initially the firm and the farmer sign a contract which specifies the firm's purchase price P_C without any quantity restrictions. After the contract is signed, the price on the spot

³In particular, V can represent the value of the firm's stock or the value of the firm's capital owned by the farmer.

market is realized and the farmer sells his output to the firm and on the spot market. After selling his output, the farmer receives his payoff from ownership of the firm.

Under additive separability, the farmer obtains utility from allocating his output between the spot market and the marketing firm and utility from appropriating the $\frac{1}{n}$ share of the firm's value V and the $\frac{1}{n}$ share of the firm's profit from offering P_C . Since the farmer is free to make an allocation decision after the realization of the price uncertainty, the farmer's optimal allocation decision depends on the realized spot price. In particular, if the realized spot price is P_H , the farmer's allocation decision q_H maximizes the payoff of $U(P_H(1 - q_H) + P_C q_H) + U(\frac{1}{n}V + \frac{1}{n}(P_H - P_C)q_H)$. If the realized spot price is P_L , the farmer's allocation decision q_L maximizes the payoff of $U(P_L(1 - q_L) + P_C q_L) + U(\frac{1}{n}V + \frac{1}{n}(P_L - P_C)q_L)$. Since $U(\cdot)$ is concave, the farmer's optimal allocation decisions \bar{q}_H^* and \bar{q}_L^* are unique and are characterized by a pair of first-order conditions,

$$\begin{aligned} \frac{1}{n}U'(\frac{1}{n}V + \frac{1}{n}(P_H - P_C)\bar{q}_H^*) &= U'(P_H(1 - \bar{q}_H^*) + P_C\bar{q}_H^*), \\ U'(P_L(1 - \bar{q}_L^*) + P_C\bar{q}_L^*) &= \frac{1}{n}U'(\frac{1}{n}V + \frac{1}{n}(P_L - P_C)\bar{q}_L^*). \end{aligned}$$

The first condition implies that when the realized spot price is high, the farmer's optimal allocation decision \bar{q}_H^* equalizes the farmer's marginal benefit from partial ownership of the firm (the left-hand side) and the farmer's marginal cost from selling to the firm at price P_C rather than on the spot market at price P_H (the right-hand side). Similarly, the second condition implies that when the realized spot price is low, the farmer's optimal allocation decision \bar{q}_L^* equalizes the marginal benefit from selling to the firm at price P_C rather than on the spot market at price P_L (the left-hand side) and the marginal cost from partial ownership of the firm (the right-hand side).

Whether optimal allocation decisions \bar{q}_H^* and \bar{q}_L^* satisfy the firm's non-negative profit condition depends on the shape of the utility function $U(\cdot)$, the farmer's ownership share $\frac{1}{n}$ and values of realized spot prices $\{P_H, P_L\}$. However, as opposed to Result 1 in the non-integration case, where I show that the purchase price P_C is never sustainable under any conditions, the result of this section suggests that the firm's purchase price P_C is sustainable for a certain range of parameters.

Result 2. *The marketing firm can sustain the pooled price P_C , if the*

farmer is sufficiently risk-averse and has an appropriate ownership share of the marketing firm.

Before I proceed further with a particular utility function, I discuss the role of the risk-aversion assumption in the farmer's optimal allocation decisions \bar{q}_H^* and \bar{q}_L^* . Let's consider the case when the farmer is risk-neutral, so that $U(x) = x$. Then, if the realized spot price is P_H , the farmer's allocation decision q_H maximizes the payoff of $P_H - \frac{n-1}{n}(P_H - P_C)q_H + \frac{1}{n}V$. Since $n \geq 1$, the payoff is maximized at $\bar{q}_H^* = 0$. Similarly, if the realized spot price is P_L , the farmer's allocation decision q_L maximizes the payoff of $P_L + \frac{n-1}{n}(P_C - P_L)q_L + \frac{1}{n}V$, and the payoff is maximized at $\bar{q}_L^* = 1$. Hence, under farmer's risk-neutrality, the ratio of optimal allocation decisions is $\frac{\bar{q}_H^*}{\bar{q}_L^*} = 0$, so that the firm's ex ante non-negative profit condition is never satisfied. As a result, unless the farmer is the sole owner of the firm ($n \rightarrow \infty$), the firm cannot sustain the purchase price P_C under any partial ownership of the farmer.

Result 3. *The marketing firm cannot sustain the pooled price P_C under any partial ownership of the farmer, if the farmer is risk-neutral.*

The case with the risk-neutral farmer illustrates the key role of the risk-aversion assumption in the firm's ability to sustain P_C . In the model, the farmer obtains utility from two sources: (1) from selling his output to the firm at price P_C and on the spot market and (2) from obtaining the $\frac{1}{n}$ share of the firm's value and profit given his own allocation decision. Further, the farmer's allocation decision, which increases the firm's profit, simultaneously lowers the farmer's payoff from selling to the firm and on the spot market, and vice versa. A risk-neutral farmer with a partial ownership of the firm always gets a higher marginal payoff (and, equivalently, utility) from exploiting the pooled price P_C than from increasing the firm's profit, given that he receives only a share of the firm's profit. As a result, the risk-neutral farmer fully exploits the pooled price P_C and sells his output to the firm only when the spot price is low. Consequently, the firm is unable to sustain P_C .

A risk-averse farmer with a concave utility function strives to equalize utilities from these two sources. Formally, this means that the risk-averse farmer receives a higher marginal utility from a lower payoff. As a result, the risk-averse farmer has a stronger incentive to increase the firm's profit at the expense of an additional payoff arising from exploitation of the pooled price P_C . Consequently, for a sufficiently high partial ownership share, only

a sufficiently risk-averse farmer can make an allocation decision $\{\bar{q}_H^*, \bar{q}_L^*\}$ allowing the marketing firm to sustain the pooled price P_C .

Naturally, a risk-averse farmer with a larger ownership share obtains a larger marginal utility from increasing the firm's profit, and therefore, has a weaker incentive to exploit the pooled price P_C . In the rest of the paper, I explore this point in more detail using a specific utility function.

4.1 Integration: CRRA Utility Function

The solution to the system of first-order conditions in the previous section depends on the curvature of the concave utility function $U(\cdot)$ and parameter values. In this sub-section I use CRRA (Constant Relative Risk Aversion) utility function to study the farmers' allocation decision when the farmer's ownership share is $\frac{1}{n}$, $n \in [1, \infty)$.

Suppose that $U(x) = \begin{cases} \frac{x^{1-\sigma}}{1-\sigma}, & \text{if } 0 < \sigma < 1 \\ \ln(x), & \text{if } \sigma = 1 \end{cases}$, where σ is the constant relative risk aversion coefficient. Then, the farmer's optimal allocation decision $\{\bar{q}_H^*, \bar{q}_L^*\}$ takes the following form:

$$\begin{aligned}\bar{q}_H^* &= \frac{P_H - Vn^{\frac{1-\sigma}{\sigma}}}{(P_H - P_C)(1 + n^{\frac{1-\sigma}{\sigma}})}, \\ \bar{q}_L^* &= \frac{Vn^{\frac{1-\sigma}{\sigma}} - P_L}{(P_C - P_L)(1 + n^{\frac{1-\sigma}{\sigma}})}.\end{aligned}$$

Aside from the farmer's ex ante participation constraint, $P_C^{1-\sigma} \geq \pi P_H^{1-\sigma} + (1 - \pi)P_L^{1-\sigma}$, there are no additional restrictions on the parameters of the model. Assume that $0 \leq P_H - Vn^{\frac{1-\sigma}{\sigma}} \leq (P_H - P_C)(1 + n^{\frac{1-\sigma}{\sigma}})$ and $0 \leq Vn^{\frac{1-\sigma}{\sigma}} - P_L \leq (P_C - P_L)(1 + n^{\frac{1-\sigma}{\sigma}})$, so that $\bar{q}_H^*, \bar{q}_L^* \in [0, 1]$. Then, we can define conditions under which the firm is able to sustain the pooled price P_C .

Recall that the marketing firm offers P_C , if the inequality $\frac{q_H}{q_L} \geq \frac{1-\pi}{\pi} \frac{P_C - P_L}{P_H - P_C}$ holds. Plugging in the optimal allocations \bar{q}_H^* and \bar{q}_L^* in the inequality, we obtain that the marketing firm offers price P_C if the following condition holds:

$$\frac{P_H - Vn^{\frac{1-\sigma}{\sigma}}}{Vn^{\frac{1-\sigma}{\sigma}} - P_L} \geq \frac{1 - \pi}{\pi}.$$

Whether this inequality holds or not depends on the farmer's ownership share indicated by the size of n , the constant relative risk-aversion coefficient σ , realized spot prices and the probability distribution of spot prices. However, without imposing any specific values, we can see that for any $\sigma \in (0, 1)$, a reduction in the farmer's ownership share $\frac{1}{n}$ leads to the decrease in the left-hand side of the inequality. Similarly, for any $n \in [1, \infty)$, an increase in the risk-aversion coefficient $\sigma \in (0, 1)$ leads to the increase in the left-hand side of the inequality. As a result, we can conclude that there is a direct trade-off between the risk-aversion parameter and the farmer's ownership share. More precisely, holding the firm's ability to sustain the pooled price P_C constant, a more risk-averse farmer requires a lower ownership share and vice versa.

It is instructive to test how the condition $\frac{P_H - Vn^{\frac{1-\sigma}{\sigma}}}{Vn^{\frac{1-\sigma}{\sigma}} - P_L} \geq \frac{1-\pi}{\pi}$ behaves for extreme values n and σ . Consider the case when the farmer is risk-neutral and $\sigma = 0$. Then, for any $n \in [1, \infty)$, the left-hand side of the condition approaches -1 , the condition never holds, and the marketing firm cannot sustain the purchase price P_C . Next, consider the case when the farmer has no ownership of the marketing firm and $n \rightarrow \infty$. Then, for any $\sigma \in (0, 1)$, the left-hand side of the inequality is always negative, the condition never holds, and the marketing firm cannot sustain the purchase price P_C . Both these cases illustrate the more general conclusion about the critical role of the risk-aversion assumption and the farmer ownership for the specific CRRA utility function.

Lastly, I define the optimal purchase price P_C^* for the case when the non-negative profit condition is satisfied and the conditions guaranteeing that $\bar{q}_H^*, \bar{q}_L^* \in [0, 1]$ hold. First of all, observe that the firm's expected profit given the farmer's optimal allocation decision $\{\bar{q}_H^*, \bar{q}_L^*\}$ is $\pi(P_H - P_C)\bar{q}_H^* + (1 - \pi)(P_L - P_C)\bar{q}_L^* = \frac{\pi(P_H - Vn^{\frac{1-\sigma}{\sigma}}) - (1-\pi)(Vn^{\frac{1-\sigma}{\sigma}} - P_L)}{(1+n^{\frac{1-\sigma}{\sigma}})}$, and it doesn't depend on the price P_C ⁴. Hence, an optimal purchase price P_C^* is any price satisfying the farmer's ex ante participation constraint $U(P_C^*) \geq \pi U(P_H) + (1 - \pi)U(P_L)$ or, equivalently, $P_C^* \geq (\pi P_H^{1-\sigma} + (1 - \pi)P_L^{1-\sigma})^{\frac{1}{1-\sigma}}$. Together with the restriction that $P_H > P_C^* > P_L$, we obtain that the optimal purchase price P_C^*

⁴The independence of the firm's expected profit from price P_C arises from the assumption that the farmer and the firm sell their output at the same prices on the spot market and the CRRA utility function. If we assume that the firm provides value added services, so that the firm's sale prices are $P_H + m$ and $P_L + m$ and the farmer's sale prices are P_H and P_L , the firm's profit function is no longer independent of P_C .

is any price satisfying the following condition: $P_H > P_C^* \geq (\pi P_H^{1-\sigma} + (1 - \pi)P_L^{1-\sigma})^{\frac{1}{1-\sigma}}$.

To conclude the discussion in this section I present an example with specific parameter values. Suppose that $P_H = 2$, $P_L = 1$, the probability of the spot price P_H is $\pi = 0.5$, and the firm's value is $V = \frac{5}{8}$. In addition, I assume that the farmer's coefficient of constant relative risk aversion is $\sigma = 0.5$ and the farmer's ownership share is $\frac{1}{n} = \frac{1}{2}$. Then the pooled price $P_C^* = 1.5$ satisfies the farmer's ex ante participation constraint, since $P_C^* = 1.5 > (\pi P_H^{1-\sigma} + (1 - \pi)P_L^{1-\sigma})^{\frac{1}{1-\sigma}} = 1.46$. Given these parameter values, the farmer's optimal allocation decision is $\bar{q}_H^* = 0.167$ and $\bar{q}_L^* = 0.056^5$. Further, note that the ratio $\frac{\bar{q}_H^*}{\bar{q}_L^*} = 2.98$ exceeds the cutoff value $\frac{1-\pi}{\pi} \frac{P_C^* - P_L}{P_H - P_C^*} = 1$, implying that the pooled price $P_C^* = 1.5$ is sustainable.

4.2 Farmer Heterogeneity and Free-riding

In this sub-section I modify the model and introduce farmer heterogeneity. In particular, I consider the case with two farmers, each with a different risk-aversion coefficient. I leave all other features of the basic model intact.

Consider the case with two farmers, where farmer i , $i \in \{1, 2\}$, has the constant coefficient of risk aversion of σ_i , $0 < \sigma_{i=1} < \sigma_{i=2} < 1$. Assume that the farmers are the same in all other respects and produce an equal amount of identical output. For now assume that both farmers have the same ownership share of $\frac{1}{n}$. Given these assumptions, farmer i 's optimal allocation decision in both states is the pair $\{\bar{q}_{H,i}^* = \bar{q}_H^*(\sigma_i), \bar{q}_{L,i}^* = \bar{q}_L^*(\sigma_i)\}$, $i \in \{1, 2\}$.

Further, assume that the marketing firm makes zero profit by offering the price P_C only to farmer $i = 2$. Then, we have that $\frac{\bar{q}_{H,2}^*}{\bar{q}_{L,2}^*} = \frac{1-\pi}{\pi} \frac{P_C^* - P_L}{P_H - P_C^*}$. Since farmer $i = 1$ also has the firm's ownership share of $\frac{1}{n}$ the right to sell at \bar{P}_C , when the spot price is high, the sum of output shares supplied to the firm is $\bar{q}_{H,1}^* + \bar{q}_{H,2}^*$. Similarly, when the spot price is low, the sum of output shares supplied to the marketing firm is $\bar{q}_{L,1}^* + \bar{q}_{L,2}^*$. Since $\frac{\partial \bar{q}_{H,i}^*}{\partial \sigma} > 0$ and $\frac{\partial \bar{q}_{L,i}^*}{\partial \sigma} < 0$, we have that $\bar{q}_{H,1}^* < \bar{q}_{H,2}^*$ and $\bar{q}_{L,1}^* > \bar{q}_{L,2}^*$ and $\frac{\bar{q}_{H,2}^*}{\bar{q}_{L,2}^*} = \frac{1-\pi}{\pi} \frac{\bar{P}_C - P_L}{P_H - \bar{P}_C} > \frac{\bar{q}_{H,1}^* + \bar{q}_{H,2}^*}{\bar{q}_{L,1}^* + \bar{q}_{L,2}^*}$. As a result, the firm cannot sustain the pooled price \bar{P}_C .

⁵Note that for the given parameter values the farmer allocates more to the firm when the spot price is high and less when the spot price is low, since $\bar{q}_H^* > \bar{q}_L^*$. This is the direct consequence of the risk-aversion, as the farmer prefers to lower his payoff from selling on the spot market to increase his utility from sharing the firm's profit.

This example illustrates three important points. The first point is that an increase in the number of farmers with partial ownership (equivalently, an increase in the number of cooperative members) does not necessarily improve the ability of the marketing firm to sustain the pooled price. In fact, as the example shows, an increase in the number of owners from one to two undermines the firm's ability to do so.

The second point is related to the issue of free-riding. Note that given the same ownership shares of $\frac{1}{n}$ and an access to the purchase price \overline{P}_C , the less risk-averse farmer $i = 1$ obtains a strictly higher payoff than the more risk-averse farmer $i = 2$. To see this note that when the realized spot price is P_H , the less risk-averse farmer $i = 1$ obtains $\overline{q}_{H,1}^* \overline{P}_C + (1 - \overline{q}_{H,1}^*) P_H$, which strictly exceeds the payoff of the more risk-averse farmer $i = 2$ of size $\overline{q}_{H,2}^* \overline{P}_C + (1 - \overline{q}_{H,2}^*) P_H$. Similarly, when the realized spot price is P_L , the less risk-averse farmer $i = 1$ obtains $\overline{q}_{L,1}^* \overline{P}_C + (1 - \overline{q}_{L,1}^*) P_L$, which strictly exceeds the payoff of the more risk-averse farmer $i = 2$ of size $\overline{q}_{L,2}^* \overline{P}_C + (1 - \overline{q}_{L,2}^*) P_L$. Hence, given the same ownership shares, the less risk-averse farmer obtains a strictly higher payoff than the more risk-averse farmer both from allocating output between the marketing firm and the spot market and from sharing the firm's profit. This is a manifestation of the free-riding issue, since one member of the cooperative with equal ownership rights exploits the use of the cooperative services at the expense of the firm's ability to operate on the market and remain profitable.

The issue of free-riding brings up the third point, which is the optimal size of an ownership share. As the previous discussion suggests there is a trade-off between the size of an ownership share and the degree of risk-aversion. In particular, a less risk-averse farmer with a larger ownership share can be induced to make an allocation decision similar to that of a more risk-averse farmer with a smaller ownership share. In relation to the example with two heterogeneous farmers in this sub-section, the free-riding of farmer $i = 1$ can be alleviated or altogether eliminated if the less risk-averse farmer $i = 1$ were assigned a larger ownership share than the more risk-averse farmer $i = 2$.

The example in this sub-section illustrates essential problems, which persist when we introduce heterogeneous farmers. In addition, the example in this sub-section shows how the basic model can be extended to a more general case with multiple heterogeneous farmers.

5 Conclusion

In this paper I study a simple model of a cooperative firm, which produces only the risk-protection service by offering a pooled price to its members. The main goal of the paper is to demonstrate how the cooperative form of ownership can allow the marketing firm to sustain the pooled price. The results in the paper are derived under the assumption that the firm cannot enforce price contingent quantity supplies from farmers. This assumption may appear unrealistic, since cooperative membership agreements usually specify quantity restrictions. However, there is no evidence that these quantity restrictions are made conditional on market prices.

The model in the paper relies on farmers' attitude toward risk both as the main motivation for joining a cooperative and as a source of farmer heterogeneity. Naturally, individual risk preferences are unobservable parameters and cannot be directly used in drafting membership agreements or designing internal structure of cooperative firms. Hence, a direct extension of the model is to consider a modification, where farmers have to reveal their attitude toward risk by choosing from a menu of membership agreements.

The model in the paper omits many aspects of cooperatives' operations. In particular, I do not study two important topics: investment decisions and relationships between owners and management in a cooperative firm. Although these topics occupy an important place in the literature on cooperatives, I leave these topics aside to keep the model in the simplest and the most general form. This way I attempt to show the model's tractability and its potential use as a basic platform for studying more complicated issues including the omitted topics.

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