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Decision Support

Coordination of channel members' efforts and utilities in contract farming operations

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ABSTRACT

One important driving force behind parties entering into contract farming agreements is to improve farmers' production efforts (e.g. buying agricultural machinery or using new planting techniques). In this study, we examine two widely used channel structures in contract farming operations, namely firm–farmer (FF) and firm–cooperative–farmer (FCF) structures, to assess how each contract type influences the coordination of efforts and utilities by channel members. First, we study wholesale price and cost-sharing contracts under the FF structure and find that the latter can result in a win–win outcome for both channel members when the firm's cost-sharing proportion is lower than a threshold level. We also find that cost-sharing contract effectively enlarges the opportunity of a successful FF contract farming agreement. Interestingly, we show that the purchasing price offered by the firm has a unimodal pattern in its cost-sharing proportion. Second, under the FCF structure, we consider two bargaining models based on the cooperative's commission contracts with the farmer. We find that the farmer's production effort can achieve the system optimal level, and the cooperative's high bargaining power helps ensure a steady FCF contract farming agreement. We also find that there exists a win–win–win outcome for all three channel members when the cooperative's commission ratio is higher than a threshold level.

1. Introduction

In recent decades, contract farming has become increasingly popular in developed countries/regions. More than 60 percent of large farms in the United States have used contracts, covering roughly 40 percent of the annual value of agricultural products (Key & MacDonald, 2006).

Contract farming has a number of advantages. It can help reduce supply chain risk, increase farmer's productivity, stimulate firms' marketing activities, facilitate farmers' access to higher-end markets, and boost total profits for both firms and farmers (Wang, Wang, & Delgado, 2014). Evidence supporting improvements in farmers' production efficiency when adopting contract farming has been found in the United States, Japan, France, Belgium, Canada, and United Kingdom. Wang et al. (2014), for example, find that contract farming can reduce crop yield uncertainty, facilitate the adoption of new production technologies, and increase output at a lower production cost.

Nevertheless, contract farming also has several shortcomings. First, because farmers give up their right to price their own products, they are likely to be dominated by monopolistic firms. Second, small farmers might be subject to 'unfair' contracts when dealing with powerful firms, placing them under a huge financial burden (PBS English News, 2013). Finally, a poorly functioning contract farming system might allow firms to snatch most of the benefits, but leave small farmers shouldering all the costs (Fernquest, 2012).

To address this final limitation and thus increase farmers' incentives to enter into contract farming agreements, many firms choose to share costs by providing farmers with the necessary materials such as seeds, livestock, chemicals, baby animals, feed, fertilizers, and machinery. Some firms even provide production technologies, quality control methods, and advanced training programmes as part of their initial investment (Pansin & Khamkaew, 2012). For example, Dongfanghong, one of the largest green onion packers in China, provides 60 percent of the pesticides its contract farmers need. Similarly, in order to meet the quality and food safety standards set by supermarkets and importers, it provides farmers with technical assistance (Miyata, Minot, & Hu, 2009).

Despite these inducements, however, not all farmers are willing to share such costs with firms (Curtis, 2013). In practice, a large

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number of farmers prefer to bear all such expenses by themselves and sell their products to firms at the wholesale price, under so-called wholesale price contracts (WPs). Possible reasons for their decisions include: (1) Farmers might suspect that firms' materials are of low quality; (2) The required materials offered by firms may be delayed without reason, which decreases annual production cycles and farmers' incomes; (3) Firms may provide machines that farmers do not know how to operate (Pansin & Khamkaew, 2012). In addition to these reasons, farmers may refuse to enter into cost-sharing contracts (CSs) owing to profit incentives. For example, Delforge (2007) points out that farmers' returns may be significantly lowered under a CS; however, he/she fails to provide a detailed theoretical explanation. Therefore, it is necessary to build a model to examine how contract type and key parameters such as purchasing price and retail price influence farmers' profit gains.

In addition to direct farmer–firm relations (FF structure), farmers may protect their profits by joining a farmer cooperative, yielding a firm–cooperative–farmer (FCF) structure. Such a cooperative acts as an *agent* negotiating on behalf of individual farmers with powerful firms based on its larger bargaining power. The existence of farmer cooperatives is also valuable for firms. According to Wang et al. (2014), the transaction costs of dealing with individual farmers can be reduced, and contract compliance can be improved. As a result, the number of farmer cooperatives has dramatically increased in the past 20 years, reaching nearly 600,000 in China by 2012, involving 46 million members and accounting for 18.6 percent of all farmers (Zhang & Huang, 2014).

A typical farmer cooperative is the California Canning Peach Association (CCPA). CCPA negotiates prices and terms of sales with canneries on behalf of its member growers in return for a certain percentage of the *gross value* of the sold products (see the CCPA's membership agreement at http://www.rurdev.usda.gov/rbs/pub/cir26/appenda.pdf for more details). Another typical example is the European olive oil farmers' cooperative, which provides marketing and processing services to its members and helps farmers negotiate with downstream channel members (oil bottlers and resellers), charging a proportion of farmers' *net income* in return (Bijman et al., 2012).

The distinction between the commission contracts of these two bodies (gross value-based and net income-based, termed NB-I and NB-II hereafter) provides a platform on which we can study which commission contract is better for the cooperative and examine how the choice of contract influences the production effort and utilities of firms and farmers. In this study, because the farmer's bargaining power is enhanced through the use of a cooperative, we build generalized Nash bargaining models to characterize the negotiations among the firm, cooperative, and farmer.

According to industrial observations, we assume farmers strive to increase their production quantities. For example, in European countries such as Portugal, Malta, Slovakia, Sweden, Denmark, and Finland, farmers must invest in the infrastructure, equipment, and relevant skills necessary to produce fresh milk. The introduction of contract farming in this setting reduces their investment risk and hence increases their production efficiency (Bijman et al., 2012; Key & MacDonald, 2006). In previous literature, Desai (1997), Nair and Narasimhan (2006), and Guo, Ling, Dong, and Liang (2013) have made similar assumptions. For each structure, we identify the conditions under which the channel members all participate in contract farming agreements, compute the equilibria, and then compare the utilities of channel members. We subsequently investigate the value of contract farming to a risk-averse farmer and that of introducing a farmer cooperative to all channel members.

Under the FF structure, a firm is always better off by sharing part of the farmer's production cost. The major driving force is the increase in the farmer's production effort, which guarantees a large production quantity. Correspondingly, the firm has to strive harder to sell the products, which eventually brings the firm a high return. However, we find that a CS may be detrimental to the farmer because the firm may determine a low purchasing price for its products. Thus, we identify a threshold cost-sharing proportion above which both the firm and the farmer are better off under a CS. Interestingly, we find that purchasing price in a cost-sharing scenario is unimodal in terms of cost-sharing proportion. When this proportion is small, the marginal value of effort improvement due to the firm's cost sharing is large, meaning that the firm is willing to bear an increased purchasing price. However, if the firm shares a large proportion of the farmer's cost, this generally increases its bargaining power over the farmer, allowing it to determine a low purchasing price. By contrast, since a large proportion of the farmer's total cost is shared with the firm, he/she is willing to accept this low purchasing price, too.

Under the FCF structure, the NB-1 contract cannot coordinate channel efforts, whereas NB-II contract can. This finding indicates that total profit under the latter is the largest. Nevertheless, we find that the cooperative's utility can only be improved when the revenue-sharing ratio is higher than a threshold level. In this situation, the cooperative has more incentives to negotiate a high purchasing price, which benefits both the farmer and itself. For the firm and farmer, although they have to split total profit (the firm has to pay a higher purchasing price, while the farmer has to share more net income), their utility rises because the increase in effort levels is more significant. This approach eventually results in a win–win–win outcome for all channel members.

We find that a contract farmer's risk aversion degree is crucial. When the farmer is sufficiently risk-averse, he/she is better off entering into a contract farming agreement. We also show that the farmer may be worse off in a FCF structure when he/she has to share a large proportion of net income. A further observation is that, introducing a cooperative under NB-II may not be good news for the firm.

Note that, for the ease to derive managerial insights, we start with a benchmark case where one farmer sells products to one firm. We then extend the model by considering multiple farmers. We find that our main results generated from the benchmark case qualitatively hold, so the corresponding managerial insights are robust in both one-farmer case and multiple-farmer case. We finally study a model with multi-farmer-multi-firm where firms compete in the downstream market. The main observation is that firm competition results in more system efficiency loss and hence, induces channel members to prefer contract farming agreements with better channel coordination.

The remainder of this paper is organized as follows. Section 2 reviews related studies and positions our work against the current stream of research on this topic. In Section 3, we describe the model settings and notations. Section 4 presents the main findings under the FF and FCF structures, respectively. We also discuss the spot market (SM) scenario in this section. Multi-farmer-one-firm case is investigated in Section 5, and multi-farmer-multi-firm case is investigated in Section 6. Concluding remarks and possible future research directions are provided in Section 7. All proofs are relegated to the appendix.

2. Literature review

First, our work is closely related to studies of agriculture supply chain management. Sodhi and Tang (2011), for instance, provide examples of where the poor in developing countries/regions such as Afghanistan, Africa, Bangladesh, India, Malaysia, Mexico, Nepal, Philippines, and Sri Lanka act as suppliers or distributors, thus benefiting from a higher level of market information, easier

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