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Explaining Cooperative Enterprises through Knowledge Acquisition Outcomes

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This paper develops a model of a cooperative enterprise and compares it to a vertically separated market. In our model of a multi-stage production process, agents can acquire costly knowledge to decrease production costs. Our model shows that the cooperative acquires less non-generalizable knowledge than the market, but more generalizable knowledge if the large member in the cooperative receives a sufficiently large share of the cooperative's profits. Additionally, we derive that the cooperative generates larger aggregate surplus than the market if the influence of generalizable knowledge on production costs is large. Copyright © 2012 John Wiley & Sons, Ltd.

1. INTRODUCTION

Cooperatives exist worldwide and in a broad range of sectors. The cooperative model of organization dominates many business sectors such as agriculture, financial services, housing, sports, transportation (taxis, buses, etc.), and utilities (electricity, water, gas, etc.). According to the United Nations and the International Cooperative Alliance (www.ica.coop), over 1 billion people worldwide are members of cooperatives. Despite their importance, economic explanations for their existence and widespread presence, as well as discussions of their potential advantages over other organizational arrangements, have been inconclusive.

This paper develops a theoretical model of a cooperative where members receive a share of the cooperative's profits according to their patronage. In our model of a multi-stage production process, we compare the cooperative's outcomes with the outcomes of a vertically separated market to illustrate how advantages of the cooperative form of organizing emerge. We put special emphasis on agents' decisions to acquire knowledge in the production process and in decision making about output levels because the quality of decisions in an organization depends on the relevant knowledge, and knowledge is frequently considered as the critical input in production processes (Grant, 1996).

The literature provides few and often contradictory assessments of the competitiveness of cooperatives. For example, Hansmann (1988) compares conventional investor-owned firms with cooperatives. He concludes that market contracts are costly in cases of asymmetric information or market power. Under these circumstances, a union of firms might reduce costs. Hendrikse and Veerman (2001b) analyzed the influence of the organizational structure on a cooperative's ability to attract outside equity. They show that cooperatives have a disadvantage against conventional firms with respect to access to equity funds. As a consequence, cooperatives can only prevail against conventional firms as long as the asset specificity at the processing stage of production is low.[1] Some authors point to the public support enjoyed by cooperatives in some countries and industries. For example, cooperatives

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frequently face lower taxes, subsidized interest rates, and protected markets to give cooperatives advantages via market power (Sexton and Iskow, 1993a; Cook, 1995). Hendrikse (1998) derived parameter constellations under which investor-owned firms' superior performance compared with cooperatives may be countered by the favorable public policy treatment of cooperatives. However, other authors consider these advantages as corrections of government-imposed restrictions on cooperatives' operations (Nilsson, 2001). Additionally, the variety of cooperatives that receive such favorable conditions does not allow inferences about whether public support fosters inefficiency or encourages efficient production of valuable goods.

Feng and Hendrikse (2012) developed a multi-task principal–agent model to compare cooperatives and investor-owned firms. They conclude that an interdependency between stages of production may give cooperatives a competitive advantage if there are complementarities between the production stages, and the downstream marginal product does not exceed a certain level. This implies that cooperatives outperform investor-owned firms in industries where the processing stage's contribution to the overall value of a product is not too high.

Porter and Scully (1987) and Ferrier and Porter (1991) compared the productive efficiency of cooperatives with investor-owned firms, with the conclusion that cooperatives show, among others, greater amounts of technical/X-inefficiency, that an increase in cooperative size increases the problem of control, and that cooperatives are not expected to fully realize all scale economies. In contrast, Helmberger and Hoos (1962) stated that a cooperative and an investor-owned firm face the same marginal conditions, implying identical outcomes. In their survey on the economic efficiency of cooperatives, Sexton and Iskow (1993b) find no evidence that cooperatives are less efficient than comparable investor-owned firms. In contrast to the frequent popular perception that cooperatives are less efficient, Bogetoft (2005) shows that, given particular market parameters and output characteristics, cooperatives outperform a vertically separated value chain as a consequence of information asymmetries that cause inefficiencies in vertically separated arrangements. In his model, he does not account for potential conflicts of interest among the members of the cooperative, and the model only allows outcomes where the cooperative never performs worse than an investor-owned processor. Furthermore, Bogetoft (2005) does not consider the possibility of knowledge acquisition, but focuses on a given information asymmetry.

Our article contributes to the literature by studying the interaction of organizational form and knowledge acquisition as an argument for the competitiveness of cooperatives. We show that cooperatives can have a competitive advantage over market organizations stemming from their particular allocation of ownership rights and the resulting incentives to acquire knowledge. We consider agents who can acquire knowledge, but face the costs of knowledge acquisition, with different acquisition costs depending on the type of knowledge. We distinguish between knowledge that can be generalized as opposed to knowledge that is particular for one setting, that is, idiosyncratic or non-generalizable knowledge (Jensen and Meckling, 1995; Sowell, 1996). Generalizable knowledge is valid independent of time and place. Non-generalizable knowledge, on the other hand, is situation specific. This means that the validity of non-generalizable knowledge is limited to specific circumstances and is therefore not valid across time and/or space. In the agricultural sector, typical examples for generalizable knowledge include knowledge of general agricultural principles, expertise in handling machinery, production techniques, and other inputs to agricultural production that are relatively independent of site-related, climate-related, and time-related idiosyncrasies. Examples of non-generalizable knowledge include knowledge about soil conditions, local weather characteristics, and local infrastructure quality.[2] The distinction between generalizable and non-generalizable knowledge is the most appropriate for analyzing a number of individual producers on different production sites, where the producers are confronted with issues that may be common to each individual producer and issues that are particular for each individual producer. The distinction implies that there can be significant differences between knowledge acquisition on different production sites.

In our analysis, we assume two cost components that influence production costs for the producers, a general cost component and an idiosyncratic cost component. In order to optimally adapt to these cost elements, the decision maker has to take the appropriate action, which is only possible with the relevant knowledge. This implies that judgment of the general and idiosyncratic cost elements is only possible to the extent that an agent acquires knowledge about them. Because of the nature of knowledge as a factor of production, any acquisition of generalizable knowledge and non-generalizable knowledge is an investment that cannot be recovered once undertaken (Arrow, 1962).

Furthermore, we assume a processor with market power vis-à-vis the producers. Market power is a

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frequently observed phenomenon at the processing stage, for example, in the agricultural sector. Market power in this context can have different reasons. Some authors highlight the specific investments of producers and their subsequent dependence on a processor that is located in the proximity of their production sites (see, e.g., Bonus, 1986 and Staatz, 1987).[3] Another explanation, related to the specific investment argument, could be the economic nature of processing. To process a raw input, a processing plant is necessary, which generally allows processing input at low variable costs. The combination of substantial fixed costs and small variable costs favors the emergence of market power on the side of the processor. We incorporate this aspect in our model via a single processor with fixed and variable costs.[4]

Our model allows the cooperative enterprise to exploit knowledge that reduces the cost of production to an extent that this mode of organization can generate output at lower cost and achieve higher aggregate surplus than the market form of business organization. We illustrate the influence of what Bonus (1986) calls the centripetal and centrifugal forces in cooperatives: forces that pull the members together as one organization and forces that induce the members to remain independent units because there are advantages to individual operation. We model these forces in terms of coordinated investments and of acquiring and applying knowledge in organizations.[5]

The paper is structured as follows. Section 2 introduces a model of production that includes the influence of knowledge on costs. We consider two organizational arrangements: cooperatives and markets. In Section 3, we derive knowledge acquisition behaviors and their consequences on output and profits in the two different organizational arrangements. Section 4 compares the two organizational arrangements with respect to their knowledge acquisition and aggregate surplus obtained by the processor and the producers. Section 5 summarizes the main results and concludes the paper.

2. MODEL

We develop a simple theoretical model of the production of a good and the transaction of it from the producers to a processor, where both producers and processor are risk neutral. We consider two types of producers, with each producer operating an independent production site. The producers differ in their marginal costs of production. After production, the producers sell their output to a processor, who transforms the raw product into the final product and sells it to end consumers in a competitive market.[6] The organization of the individual sites and their relationship to the processor determine production and transaction costs. We assume that the production technology is identical for all forms of organization. First, we present the model of a cooperative enterprise, where two producers jointly own the processor. In the second arrangement, the two producers act autonomously as independent firms. That is, they do not cooperate, and the market is vertically separated. The processor also acts as a self-governed buyer of the output of the producers. We will call this case the market form of business organization because all interactions of agents are bilateral and autonomous.

We assume that P is the price at which producer i's output $q_i \geq 0$ is sold on a competitive market with $i \in \{1,2\}$. The function $C_e(q_i,q_j) \in C^1$ characterizes the cost of processing and marketing the aggregate output $Q = q_i + q_j$, and $F > 0$ is the associated sunk fixed costs.[7] The function $C_\gamma(\gamma) \in C^1$ represents the cost of acquiring generalizable knowledge, which depends on the amount γ of the acquired generalizable knowledge. Similarly, $C_v(v_i) \in C^1$ is the cost function of acquiring non-generalizable knowledge, which depends on amount v_i of the acquired non-generalizable knowledge. $C_i(q_i,\gamma,v_i) \in C^1$ is the production cost function of producer i. To make our model tractable, we impose the following assumptions that hold throughout the paper:

- A1. Marginal knowledge-acquisition costs are linear with $\partial C_\gamma(\gamma)/\partial \gamma = \gamma$ and $\partial C_v(v)/\partial v = v$.
- A2. The cost of production for producer i is given by $C_i(q_i,\gamma,v) = \frac{c_i}{2} f(\gamma,v) q_i^2$, where $f(\gamma,v) \in C^1$ is a cost-reducing function with $\partial f(\gamma,v)/\partial \gamma = f_\gamma(\gamma,v) < 0$, and $\partial f(\gamma,v)/\partial v = f_v(\gamma,v) < 0$. Moreover, $c_i > 0$ reflects a cost parameter for producer i.
- A3. Marginal processing and marketing costs are constant with $\partial C_e(q_i,q_j)/\partial q_i = r$. To guarantee non-negative profits, we assume that $P - r > 0$.
- A4. We consider a setting where we can analyze the influence of generalizable and non-generalizable knowledge on production costs separately. We therefore assume that $f(\gamma,v)$ has the following properties:[8]

$$\frac{f_\gamma(\gamma,v)}{f(\gamma,v)^2} = -\alpha \quad \text{and} \quad \frac{f_v(\gamma,v)}{f(\gamma,v)^2} = -(1-\alpha).$$

The parameter $\alpha \in [0,1]$ in A4 can be interpreted as a measure for the relative importance of generalizable knowledge in the production function. That is, a higher

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α implies that the cost-reducing effect of generalizable knowledge on production costs increases. At the same time, the relative importance of non-generalizable knowledge decreases, that is, the effect of a higher v on production costs is smaller.[9]

The chronological order of events in the model is as follows. At the first stage, the efficient (i.e., the surplus maximizing) governance structure is chosen. At the second stage, given the governance structure, agents decide how much generalizable and non-generalizable knowledge to acquire in order to adapt their decisions regarding output levels and pricing. At the third stage, production takes place, and each producer chooses the quantity that maximizes the producer's objective function. At the fourth stage, the price at which the processor acquires the total amount of output from the producers is determined. The processor then processes and markets the producers' output, and payoffs are realized at the processor and the producer level.

First, we analyze an organizational arrangement in which all upstream producers align with each other in a cooperative. The suppliers are also the owners of the downstream processor. Under such a cooperative structure, the producers themselves hold the residual rights to the processor's profits, and they receive these profits in the form of patronage returns. We consider a cooperative with two members, which can be considered as an identical number of two different member types, which are homogeneous within each type, but heterogenous between types. Member types differ with regard to their marginal cost of production, $c_i > 0$, and patronage, $\mu_i \in [0,1]$, with $\mu_j = 1 - \mu_i$. Member patronage determines the fraction μ_i of the cooperative's profits that member i obtains.[10] To impose more structure on individual member profits, we assume that if $c_i > c_j$, then $\mu_i < \mu_j$, which implies that the member with lower costs of production assumes higher patronage of the cooperative. That is, the low-cost member represents the 'large' member in the cooperative.[11] Following convention, our model considers a setting in which the members deliver their entire production to the cooperative and the cooperative accepts each member's output. We also consider delivery rights as non-tradable with outsiders. According to these preliminaries, the profit function for the cooperative enterprise is

$$\pi^{c} = P\cdot\left(q_i + q_j\right) - C_e\left(q_i, q_j\right) - C_\gamma(\gamma) - F,$$

where member i's individual profit yields

$$\pi_i^{c} = \mu_i \pi^{c} - C_i(q_i, \gamma, v_i) - C_v(v_i),$$

with $i \in \{1,2\}$. Aggregate surplus in the cooperative is thus given by

$$\Pi^{c} = \pi_i^{c} + \pi_j^{c}. \tag{1}$$

Second, we characterize the market form of business organization as an arrangement, where each producer is organized as an independent firm that maximizes its profits individually. One important characteristic of this organizational arrangement is that there is no coordination among single firms. The producers interact with the processor and transact their output individually. Additionally, producers do not share common costs. We set up the model of this vertically separated organizational form by including a price for the product, at which each producer sells to the processor. We assume that the processor can rule out the option of side-trading among the producers. As introduced earlier, we model a monopsony processor, where the processor exercises market power vis-à-vis the producers via the price for the output that it pays to the producers. Market power on the side of the processor results in a price P_i^{m} with $P_i^{m} < P$.

The profit function of the processor in the market form of business organization is given by

$$\pi^{m} = \left(P - P_i^{m}\right)q_i + \left(P - P_j^{m}\right)q_j - C_e\left(q_i, q_j\right) - F,$$

where P_i^{m} represents the price, at which producer $i \in \{1,2\}$ sells q_i to the processor. We consider the fixed costs of processing and marketing as sunk, resembling, for example, planning and set-up costs for the transaction between the processor and each producer i. These costs enter the processor's profit as well as its threat point in the bargaining process.

The profit function of producer i is given by

$$\pi_i^{m} = P_i^{m} q_i - C_i(q_i, \gamma_i, v_i) - C_\gamma(\gamma_i) - C_v(v_i).$$

Aggregate surplus in the market is given by

$$\Pi^{m} = \pi^{m} + \pi_i^{m} + \pi_j^{m}. \tag{2}$$

3. EQUILIBRIUM

In this section, we derive equilibrium outcomes for knowledge acquisition, outputs, and the resulting profits in the multi-stage production model introduced in Section 2. We apply backwards induction to determine optimum choices for the processor and the producers in both the cooperative and the market form of business organization.

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3.1. Cooperative Form of Business Organization

To determine the members' decisions in the cooperative form of business organization, we first have to look at the transaction between the cooperative and its members. Because the full profits of the cooperative go to the members according to their patronage, the problem at stage 4, that is, the transaction between the cooperative and its members, directly translates into the individual members' production decisions at stage 3. Member $i \in \{1,2\}$ of the cooperative chooses its output q_i to maximize its individual profit and thus solves the maximization problem $\max_{q_i \geq 0} \pi_i^c$ at stage 3. We derive the following first-order condition, which implicitly defines the production decision by member i:[12]

$$\frac{\partial \pi_i^c}{\partial q_i} = \mu_i \cdot \left(P - \frac{\partial C_e\left(q_i^c, q_j^c\right)}{\partial q_i} \right) - \frac{\partial C_i\left(q_i^c, \gamma, v_i\right)}{\partial q_i} = 0.$$

Lemma 1:
Under A1–A3, the optimal (anticipated) level of production of member i for stage 3 in the cooperative is given by

$$q_i^c(\gamma, v_i) = \frac{\mu_i(P-r)}{c_i f(\gamma, v_i)}. \tag{3}$$

Proof
Straightforward by noting that under A1–A3, the first-order condition is given by $\frac{\partial \pi_i^c}{\partial q_i} = \mu_i(P-r) - c_i f(\gamma, v_i) q_i^c = 0$. ■

We derive that the anticipated level of production, $q_i^c(\gamma, v_i)$, increases with a higher investment level in both types of knowledge. These results follow from the decreasing effect of knowledge on production costs, which induces members to increase their output. Moreover, we find that increasing member i's share μ_i of the cooperative profit increases the anticipated level of production $q_i^c(\gamma, v_i)$, which is due to the higher fraction of marginal profits that member i obtains.

In a next step, we distinguish the optimal decision about acquiring knowledge at stage 2 according to the two types of knowledge that we examine, generalizable and non-generalizable knowledge. At stage 2, member i chooses the optimal acquisition level of non-generalizable knowledge to maximize its profits. Plugging the anticipated level of production, $q_i^c(\gamma, v_i)$, into the profit function π_i^c yields the maximization problem $\max_{v_i \geq 0} \pi_i^c\left(q_i^c, q_j^c\right)$ for member i at stage 2. The first-order condition for member i is then given by[13]

$$\frac{\partial \pi_i^c}{\partial v_i} = \mu_i \cdot \left(P - \frac{\partial C_e}{\partial q_i^c} \right) \frac{\partial q_i^c}{\partial v_i} - \left(\frac{\partial C_i}{\partial q_i^c} \frac{\partial q_i^c}{\partial v_i} + \frac{\partial C_i}{\partial v_i} \right) - \frac{\partial C_v}{\partial v_i} = 0 \tag{4}$$

and implicitly defines member i's optimal acquisition level v_i^c of non-generalizable knowledge. We identify the following effects on the first-order condition of an increase in the acquisition of non-generalizable knowledge:

(i) The profit effect is given by $\mu_i \left(P - \frac{\partial C_e}{\partial q_i^c} \right) \frac{\partial q_i^c}{\partial v_i}$: that is, a higher v_i^c implies higher anticipated output q_i^c, which increases processing and marketing costs. At the same time, it also increases revenues. As $P - \frac{\partial C_e}{\partial q_i^c} \overset{A3}{=} P - r > 0$, revenues increase more than costs such that profits of the cooperative will increase, yielding a positive sign for the profit effect.

(ii) The production cost effect is given by $\frac{\partial C_i}{\partial q_i^c} \frac{\partial q_i^c}{\partial v_i} + \frac{\partial C_i}{\partial v_i}$ and is composed of two different effects: (a) the indirect production cost effect is given by $\frac{\partial C_i}{\partial q_i^c} \frac{\partial q_i^c}{\partial v_i} > 0$: that is, a higher v_i^c implies higher anticipated output q_i^c, which increases production costs and therefore has a negative effect on the first-order condition (4). (b) The direct production cost effect is given by $\frac{\partial C_i}{\partial v_i} < 0$: that is, a higher v_i^c implies lower production costs for each level of anticipated output q_i^c, which has a positive effect on the first-order condition (4). Under A1–A4, the indirect production cost effect dominates the direct production cost effect such that overall production costs increase through a higher investment level in non-generalizable knowledge.

(iii) The knowledge cost effect is given by $\frac{\partial C_v}{\partial v_i} > 0$ and describes the fact that investments in non-generalizable knowledge are costly.

It is important to mention that member i does not receive the full marginal return from a higher investment level v_i^c in non-generalizable knowledge because it obtains only share μ_i of the cooperative's profits. On the other hand, it must bear the full investment costs in this type of knowledge and the knowledge-induced higher production costs.

Regarding the acquisition of generalizable knowledge, we assume that the cooperative's members make a collective decision and choose the optimal acquisition level γ to maximize aggregate surplus

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given by Equation (1).[14] Plugging the anticipated level of production $q_i^c(\gamma, v_i)$ into the profit function yields the maximization problem $\max_{\gamma \geq 0} \Pi^c\left(q_i^c, q_j^c\right)$ for the cooperative in stage 2. The first-order condition for the cooperative yields

$$\begin{aligned}\frac{\partial \Pi^c}{\partial \gamma} &= \left(P - \frac{\partial C_e}{\partial Q^c}\right)\frac{\partial\left(q_i^c + q_j^c\right)}{\partial \gamma} \\ &\quad - \left(\frac{\partial C_i}{\partial q_i^c}\frac{\partial q_i^c}{\partial \gamma} + \frac{\partial C_i}{\partial \gamma}\right) - \left(\frac{\partial C_j}{\partial q_j^c}\frac{\partial q_j^c}{\partial \gamma} + \frac{\partial C_j}{\partial \gamma}\right) \\ &\quad - \frac{\partial C_\gamma}{\partial \gamma} = 0,\end{aligned} \tag{5}$$

and implicitly defines the cooperative's optimal acquisition level γ^c of generalizable knowledge. Similar to non-generalizable knowledge, we identify a profit effect, a production cost effect, and a knowledge effect on the first-order condition of an increase in the acquisition of generalizable knowledge. From (4) and (5), we derive the following results.

Lemma 2:
Under A1–A4, the stage 2 equilibrium levels for knowledge acquisition of member i are given by

$$v_i^c = \frac{1-\alpha}{c_i}\frac{\mu_i^2 (P-r)^2}{2} \quad \text{and}$$

$$\gamma^c = \alpha \cdot \left(\frac{(2-\mu_i)\mu_i}{c_i} + \frac{(2-\mu_j)\mu_j}{c_j}\right)\frac{(P-r)^2}{2},$$

with $i, j \in \{1,2\}$ and $i \neq j$.

Proof
See Appendix A.1. ■

We derive from this lemma that the large member acquires more non-generalizable knowledge than the small member. The difference stems from the nature of generalizable and non-generalizable knowledge and the cooperative's nature of allocating its profits according to patronage. The members of the cooperative bear the costs of acquiring non-generalizable knowledge individually. This implies that a member that receives a larger share in the cooperative's profits will also acquire more non-generalizable knowledge, because, via the higher patronage returns, this type of knowledge is more profitable for the large member. Substituting the equilibrium acquisition levels of knowledge into (3) yields equilibrium output of member i in the cooperative as $\hat{q}_i^c = \frac{\mu_i(P-r)}{c_i f\left(\gamma^c, v_i^c\right)}$.

To derive the comparative statics of knowledge acquisition with respect to μ_i, we assume without loss of generality that member 1 has lower marginal production costs than member 2, that is, $c_1 < c_2$, and therefore, $\mu_1 > \mu_2 = 1 - \mu_1$ holds.

Lemma 3:
(i) Regarding non-generalizable knowledge, we derive $\frac{\partial v_1^c}{\partial \mu_1} > 0$, $\frac{\partial v_2^c}{\partial \mu_1} < 0$, and $\frac{\partial\left(v_1^c + v_2^c\right)}{\partial \mu_1} > 0$.
(ii) Regarding generalizable knowledge, we derive $\frac{\partial \gamma^c}{\partial \mu_1} > 0 \Leftrightarrow \mu_1 < \frac{c_2}{c_1 + c_2}$.

Proof
Straightforward by calculating the partial derivatives. ■

It is straightforward to see that increasing member 1's share of the cooperative's profit induces this member to increase its acquisition level v_1^c of non-generalizable knowledge, because marginal revenue increases. Simultaneously, incentives for member 2 decrease. The increase compensates for the decrease such that the aggregate acquisition level $v_1^c + v_2^c$ increases.

On the other hand, the cooperative's acquisition level of generalizable knowledge follows an inverted U-shaped pattern in μ_1. That is, if the large member's share of the cooperative's profits is small, increasing μ_1 induces the cooperative to acquire more generalizable knowledge until $\mu_1 = \frac{c_2}{c_1 + c_2}$. Increasing the large member's share above this threshold decreases the cooperative's acquisition level of generalizable knowledge. The intuition behind this result is as follows. An increase in the share μ_1 of member 1 has two effects on the cooperative's first-order condition given by (5). It has a positive effect through a higher anticipated output q_1^c of member 1, but simultaneously, it has a negative effect through a lower anticipated output q_2^c of member 2. The effect on aggregate anticipated output depends on the cost heterogeneity between the members. High heterogeneity strengthens the positive effect and diminishes the negative effect. The negative effect on the cooperative's first-order condition decreases with a higher heterogeneity between members in terms of costs because member 2's anticipated output q_2^c is a decreasing function in c_2.[15] As a result, the threshold $\frac{c_2}{c_1 + c_2}$ increases with a higher cost heterogeneity between the members. Hence, in the limiting case where c_2 goes to infinity, the positive effect on the cooperative's first-order condition dominates the negative effect, and the cooperative always increases γ^c if the large member's share μ_1 increases.

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3.2. Market Form of Business Organization

At stage 4, the processor and the individual producers bargain over the price P_i^{m}, at which producer i sells its output to the processor.[16] We assume that the processor and producer i bargain in bilateral Nash bargaining fashion over price P_i^{m} (e.g., Nash, 1950; Binmore *et al.*, 1986). The underlying optimization problem then is

$$\widetilde{P}_i^{\mathrm{m}}(q_i) = \arg\max_{P_i^{\mathrm{m}} \geq 0} \left\{ \left(\pi_i^{\mathrm{m}} - t_i\right)^{\rho} \left(\hat{\pi}_i^{\mathrm{m}} - T_i\right)^{1-\rho} \right\},$$

where $\rho \in (0,1)$ is producer i's level of bargaining power and $(t_i, T_i) = (0, -F_i)$ stands for the threat points of producer i and the processor, respectively, in case the bargaining does not result in an exchange.[17] In the case that there is no exchange between the processor and producer i, the producer makes zero profit, that is, $t_i = 0$, and the processor has to bear the sunk fixed costs F_i, that is, $T_i = -F_i$. The processor's profit realized with producer i is given by $\hat{\pi}_i^{\mathrm{m}} = \left(P - P_i^{\mathrm{m}}\right)q_i - C_e(q_i) - F_i$. We further assume that the producer and the processor have equal bargaining power, that is, $\rho = 1/2$.

By computing the first-order condition and solving for the optimal transfer price $\widetilde{P}_i^{\mathrm{m}}$, the solution to the preceding optimization problem is given as follows. For a given anticipated output q_i, the Nash bargaining solution for the transfer price is $\widetilde{P}_i^{\mathrm{m}}(q_i) = (1/2)[P - C_e(q_i)/q_i] + (1/2)\left[1/q_i\left(C_i(q_i, \gamma_i, v_i) + C_\gamma(\gamma_i) + C_v(v_i)\right)\right]$. Plugging $\widetilde{P}_i^{\mathrm{m}}(q_i)$ into the profit function π_i^{m}, we derive producer i's profit as

$$\pi_i^{\mathrm{m}} = \frac{1}{2}\left[Px_i - C_e(q_i) - C_i(q_i, \gamma_i, v_i) - C_\gamma(\gamma_i) - C_v(v_i)\right]. \tag{6}$$

The processor's profit stemming from its transaction with producer i equals producer i's profit, except for the sunk fixed costs of processing and marketing the processor has to bear because of its transaction with producer i.

At stage 3, producer i solves the maximization problem $\max_{q_i \geq 0} \pi_i^{\mathrm{m}}$, where π_i^{m} is given by (6). As the related first-order conditions, we obtain[18]

$$\frac{\partial \pi_i^{\mathrm{m}}}{\partial q_i} = \frac{1}{2}\left(P - \frac{\partial C_e\left(q_i^{\mathrm{m}}\right)}{\partial q_i} - \frac{\partial C_i\left(q_i^{\mathrm{m}}, \gamma_i, v_i\right)}{\partial q_i}\right) = 0.$$

Lemma 4:
Under A1–A3, the optimal (anticipated) level of production of producer i for stage 3 in the market is given by

$$q_i^{\mathrm{m}}(\gamma_i, v_i) = \frac{(P - r)}{c_i f(\gamma_i, v_i)}. \tag{7}$$

Proof
Straightforward by noting that under A1–A3, the first-order condition is given by $\frac{\partial \pi_i^{\mathrm{m}}}{\partial q_i} = \frac{1}{2}\left(P - r - c_i f(\gamma_i, v_i) q_i^{\mathrm{m}}\right) = 0$. ■

The optimal output level of a producer in the market form of business organization is characterized by the price on the competitive market, the marginal costs of processing and marketing, and the cost of production of q. The producers in the market can appropriate the full profit they generate in exchange with the processor, up to the extent determined by the bargaining outcome. The processor and the producers bargain over the transfer price P^{m}, which leads to the direct influence of the cost of processing and marketing on producer output. Additionally, producers independently acquire generalizable and non-generalizable knowledge, which yields a direct effect of the individually acquired knowledge on output.

At stage 2, the producers decide how much generalizable and non-generalizable knowledge to acquire. Plugging $q_i^{\mathrm{m}}(\gamma_i, v_i)$ into the profit function π_i^{m} yields the maximization problem $\max_{(\gamma_i, v_i) \geq 0} \pi_i^{\mathrm{m}}\left(q_i^{\mathrm{m}} q_j^{\mathrm{m}}\right)$ for each producer i. The corresponding first-order conditions are given by

$$\frac{\partial \pi_i^{\mathrm{m}}}{\partial \kappa_i} = \frac{1}{2}\left[\left(P - \frac{\partial C_e}{\partial q_i^{\mathrm{m}}}\right)\frac{\partial q_i^{\mathrm{m}}}{\partial \kappa_i} - \left(\frac{\partial C_i}{\partial q_i^{\mathrm{m}}}\frac{\partial q_i^{\mathrm{m}}}{\partial \kappa_i} + \frac{\partial C_i}{\partial \kappa_i}\right) - \frac{\partial C_{\kappa_i}}{\partial \kappa_i}\right] = 0, \tag{8}$$

where $\kappa_i \in \{\gamma_i, v_i\}$.

The first-order conditions show that the profit effect in the market form of organization, $\left(P - \frac{\partial C_e}{\partial q_i^{\mathrm{m}}}\right)\frac{\partial q_i^{\mathrm{m}}}{\partial \kappa_i} > 0$, incorporates that producer i obtains the full return on its transaction with the processor. The production cost effect with respect to generalizable knowledge, given by $\frac{\partial C_i}{\partial q_i^{\mathrm{m}}}\frac{\partial q_i^{\mathrm{m}}}{\partial \gamma_i} + \frac{\partial C_i}{\partial \gamma_i}$, depends only on individual knowledge acquisition; and analogous to the knowledge cost effect, $\frac{\partial C_{\kappa_i}}{\partial \gamma_i} > 0$ denotes that there are no collective investments.

Lemma 5:
Under A1–A4, the stage 2 equilibrium levels for knowledge acquisition of producer i are given by

$$v_i^{\mathrm{m}} = \frac{1 - \alpha}{c_i}\frac{(P - r)^2}{2} \quad \text{and} \quad \gamma_i^{\mathrm{m}} = \frac{\alpha}{c_i}\frac{(P - r)^2}{2}.$$

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Proof

See Appendix A.2. ■

The outcomes for the stage 2 equilibrium levels of knowledge acquisition of producer i are independent for the two producers, that is, the producers' acquisition decisions do not influence each other. We also observe that the large producer will always acquire more generalizable and non-generalizable knowledge.

Substituting the equilibrium acquisition levels of knowledge into (7) yields equilibrium output of producer i in the market organization as $\hat{q}_i^{\mathrm{m}}\left(\gamma_i^{\mathrm{m}}, v_i^{\mathrm{m}}\right) = \frac{(P-r)}{c_i f\left(\gamma_i^{\mathrm{m}}, v_i^{\mathrm{m}}\right)}$. Similarly, we obtain the aggregate surplus in the market form of organization, that is, profits of the processor and the producers, of $\Pi^{\mathrm{m}} = \pi^{\mathrm{m}} + \pi_1^{\mathrm{m}} + \pi_2^{\mathrm{m}}$.

4. EFFICIENT GOVERNANCE STRUCTURE

In this section, we determine the efficient, that is, the surplus maximizing, governance structure. In a first step, we compare the relative levels of generalizable and non-generalizable knowledge acquired in the cooperative enterprise with the outcomes in the market. We then proceed by comparing aggregate surplus in both organizational arrangements.

The next proposition summarizes the comparison with respect to knowledge acquisition. Recall that member 1 has lower marginal production costs than member 2, that is, $c_1 < c_2$. Consequently, $\mu_1 > \mu_2 = 1 - \mu_1$ holds.

Proposition 1:

Under A1–A4, we derive the following results:

(i) Member i in the cooperative acquires less non-generalizable knowledge than producer i in the market, that is, $v_i^{\mathrm{c}} < v_i^{\mathrm{m}}$.

(ii) The cooperative always acquires more generalizable knowledge than the small producer in the market, that is, $\gamma^{\mathrm{c}} > \gamma_2^{\mathrm{m}}$.

(iii) The cooperative acquires more generalizable knowledge than the large producer in the market only if the large member in the cooperative receives a sufficiently large share of the cooperative's profits, that is, $\gamma^{\mathrm{c}} > \gamma_1^{\mathrm{m}} \Leftrightarrow \mu_1 > \mu_1^*(c_1, c_2) \equiv \frac{c_2 - c_1}{c_1 + c_2}$.

Proof

It is straightforward to show that $v_i^{\mathrm{c}} = \frac{1-\alpha}{c_i}\frac{\mu_i^2 (P-r)^2}{2} < v_i^{\mathrm{m}} = \frac{1-\alpha}{c_i}\frac{(P-r)^2}{2}$ with $\mu_i \in [0,1]$. Moreover, $\gamma^{\mathrm{c}} > \gamma_2^{\mathrm{m}}$ always holds, whereas $\gamma^{\mathrm{c}} > \gamma_1^{\mathrm{m}} \Leftrightarrow \mu_1 > \frac{c_2 - c_1}{c_1 + c_2}$. ■

The proposition shows that, compared with a cooperative, the market has an advantage in acquiring non-generalizable knowledge, but can have a disadvantage in acquiring generalizable knowledge. To understand the intuition behind the result about non-generalizable knowledge in part (i), notice that increasing the investment level in this type of knowledge triggers a positive profit effect and a negative production cost effect in both organizational forms. Because member i only receives share μ_i of the cooperative's profit, the anticipated output in stage 2 is lower in the cooperative than in market, that is, $q_i^{\mathrm{c}} < q_i^{\mathrm{m}}$. It follows that the (positive) profit effect is stronger in the market than in the cooperative. At the same time, the (negative) production cost effect is also stronger in the market than in the cooperative. However, the profit effect is the dominant effect, that is, the difference between the profit effects in the market and the cooperative always outweighs the difference between the production cost effects such that producer i acquires more non-generalizable knowledge than member i, that is, $v_i^{\mathrm{m}} > v_i^{\mathrm{c}}$. It immediately follows that aggregate costs to acquire non-generalizable knowledge are higher in the market than in the cooperative, that is, $C_v^{\mathrm{m}} = C_v\left(v_1^{\mathrm{m}}\right) + C_v\left(v_2^{\mathrm{m}}\right) > C_v^{\mathrm{c}} = C_v\left(v_1^{\mathrm{c}}\right) + C_v\left(v_2^{\mathrm{c}}\right)$. According to Lemma 3, the aggregate acquisition level $v_1^{\mathrm{c}} + v_2^{\mathrm{c}}$ increases in μ_1 in the cooperative such that the difference $C_v^{\mathrm{m}} - C_v^{\mathrm{c}}$ will decrease in μ_1. Moreover, the difference $C_v^{\mathrm{m}} - C_v^{\mathrm{c}}$ will also decrease in α because incentives to acquire non-generalizable knowledge decrease more steeply in the market than in the cooperative if the relative importance α of generalizable knowledge increases, that is, $\partial v_i^{\mathrm{m}}/\partial\alpha < \partial v_i^{\mathrm{c}}/\partial\alpha < 0$.

Parts (ii) and (iii) show that the cooperative always acquires more generalizable knowledge than the small producer in the market, whereas the cooperative acquires more generalizable knowledge than the large producer in the market only if the large member's share μ_1 of cooperative's profit is above a threshold given by μ_1^*. If the members in the cooperative are sufficiently homogeneous, that is, $c_2 \in (c_1, 3c_1)$, the cooperative always acquires more generalizable knowledge than the large producer in the market independent of the large member's share. In the case of sufficiently heterogeneous members, that is, $c_2 > 3c_1$, it depends on the share μ_1 that the large member receives from the cooperative's profit, whether the cooperative acquires more generalizable knowledge than the large producer.[19] Similarly, an increase in generalizable knowledge

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triggers a positive profit effect and a negative production cost effect. However in comparison with the market, the cooperative takes into account the effect of a higher level of generalizable knowledge on aggregate output. Additionally, the cooperative has to bear these knowledge costs only once, whereas each producer in the market incurs the full investment costs.

In the next proposition, we compare the aggregate surplus (i.e., profits of the two producers and the processor) in the cooperative given by Equation (1) with the corresponding surplus in the market given by Equation (2). To make the comparison tractable, we henceforth assume that the cost-reducing function yields $f(\gamma,v)=(\alpha\gamma+(1-\alpha)v)^{-1}$ (A4 ′).[20]

Proposition 2:
Under A1–A4′, the aggregate surplus is higher in the cooperative than in the market if the relative importance of generalizable knowledge is sufficiently high, that is, $\Pi^{c}>\Pi^{m}\Leftrightarrow\alpha>\alpha_{\pi}(\mu_1,c_1,c_2)$. Necessary conditions for this result to hold are

(i) members in the cooperative are sufficiently similar in terms of their cost structure, that is, $\frac{c_2}{c_1}<c^{\pi}$;
(ii) the member patronage of cooperative is sufficiently homogeneous, that is, $\mu_1\in(\underline{\mu}_1^{\pi},\bar{\mu}_1^{\pi})$.

Proof
See Appendix A.3. ∎

The proposition shows that the cooperative can have an advantage over the market in terms of profits if the relative importance α of generalizable knowledge for the cost of production is sufficiently high. The higher the α, the more the cooperative can capitalize its ability to collectively acquire generalizable knowledge. This holds only to the extent that the difference in cost structure and patronage between the members does not become too large. When members are very unequal in terms of their cost structure, and/or the large member receives too large a share of the cooperative's profit, the aggregate surplus in the market is higher than in the cooperative. The cooperative can only achieve higher profits than the actors in the market form of business organization, if the cooperative's members can exploit their advantage in acquiring generalizable knowledge. This advantage is more pronounced for converging patronage levels between the large and the small member, in particular, when $\mu_1\in(\underline{\mu}_1^{\pi},\bar{\mu}_1^{\pi})$, that is, members receive a similar share in the cooperative's profits. The advantage also is more pronounced if the cost heterogeneity between the members in the cooperative is small. From the cooperative's decision regarding the acquisition of generalizable knowledge, we know that more similar cost structures lead to more knowledge acquisition in the cooperative than in the market, which in turn enhances the cooperative's advantage.

To observe the intuition behind Proposition 2, we analyze the difference in aggregate surplus $\Delta\Pi=\Pi^{c}-\Pi^{m}$ between the cooperative and the market:

$$\Delta\Pi=\Delta R-\Delta C_k, \tag{9}$$

where $\Delta R=(P-r)(Q^{c}-Q^{m})-\left[C_1^{c}+C_2^{c}-\left(C_1^{m}+C_2^{m}\right)\right]$ is the difference in gross revenue (i.e., revenue minus production costs) and $\Delta C_k=(C_{\gamma}^{c}+C_{v}^{c})-(C_{\gamma}^{m}+C_{v}^{m})$ is the difference in knowledge costs for acquiring both types of knowledge between the cooperative and the market. We establish some useful properties in the next lemma.

Lemma 6:
Under A1–A4′, the following inequalities are true: $\Delta R>0\Leftrightarrow\alpha>\alpha_r(\mu_1,c_1,c_2)$ and $\Delta C_k>0\Leftrightarrow\alpha>\alpha_k(\mu_1,c_1,c_2)$ with $\alpha_r<\alpha_k$.

Proof
See Appendix A.4. ∎

The lemma shows that gross revenues are larger in the cooperative than in the market if the relative importance of generalizable knowledge is sufficiently high, that is, $\alpha>\alpha_r$. Moreover, aggregate knowledge acquisition costs are higher in the cooperative than in the market if the relative importance of generalizable knowledge is larger than another threshold α_k.

We illustrate these thresholds for α, which are functions of μ_1, c_1, and c_2, by fixing $(c_1,c_2)=(0.1,0.5)$ and varying μ_1 in Figure 1. The figure shows the ranges of (α,μ_1), for which the two components in Equation (9) are positive or negative. To illustrate the specific thresholds and the related ranges, we consider the relative importance of generalizable knowledge as fixed at $\alpha=\alpha'=0.85$, and the large member's share μ_1 as varying, starting at $\mu_1=0.7$.

Area *A* represents the parameter constellation where all components are lower in the cooperative than in the market. Augmenting μ_1 increases the aggregate acquisition level of non-generalizable and generalizable knowledge in the cooperative, yielding higher knowledge costs but also a knowledge-induced reduction in production costs. At the same time, aggregate output increases, entailing higher aggregate

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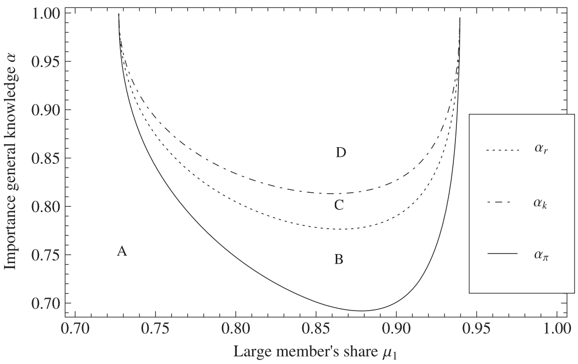

Figure 1. Comparison of cooperative and market.

production costs. If μ_1 is sufficiently large, that is, $\mu_1 \gtrapprox 0.75$, then $(\alpha',\mu_1) \in B$. The knowledge-induced reduction in the production costs, in addition to the increase in output, implies a higher aggregate surplus in the cooperative than in the market. Figure 2 illustrates this case by depicting the aggregate surplus in the cooperative and market, respectively, as a function of μ_1 for fixed parameters $\alpha = 0.85$, $c_1 = 0.1$, and $c_2 = 0.5$. However, in area B, gross revenues and knowledge acquisition costs remain lower in the cooperative than in the market. If μ_1 further increases, that is, $\mu_1 \gtrapprox 0.76$, then $(\alpha',\mu_1) \in C$. Both aggregate surplus and gross revenues are higher in the cooperative, but knowledge acquisition costs remain lower than in the market. If $\mu_1 \gtrapprox 0.77$, then $(\alpha',\mu_1) \in D$, and the cooperative acquires knowledge to such an extent that the corresponding acquisition costs are higher than in the market. However, the knowledge-induced reduction in the production costs is sufficiently strong that it compensates for the higher knowledge costs, such that profits are higher in the cooperative compared with those in the market. If μ_1 further increases, that is, $\mu_1 \gtrapprox 0.92$, then $(\alpha',\mu_1) \in C$. In this case, the knowledge costs in the cooperative are lower than in the market because the cooperative's acquisition level of generalizable knowledge follows an inverted U-shaped pattern in μ_1 (Lemma 3). However, gross revenues and the aggregate surplus remain higher in the cooperative than in the market. If $\mu_1 \gtrapprox 0.93$, then $(\alpha',\mu_1) \in B$. Even though output further increases in the cooperative, gross revenue is lower than in the market because of the increase in production costs. Finally, if $\mu_1 \gtrapprox 0.94$, then $(\alpha',\mu_1) \in A$, and all components are lower in the cooperative than in the market.

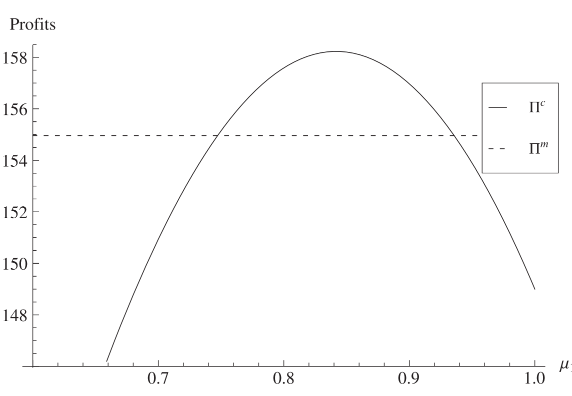

Figure 2. Comparison of profits in cooperative and market.

5. CONCLUSION

The cooperative enterprise is a widespread form of business organization. Despite cooperatives' global influence and their presence in a large variety of sectors, research of cooperatives has not yet established a conclusive understanding of why cooperatives are competitive organizations in so many different fields. We contribute to research on the competitiveness of cooperatives by setting up a simple model of a cooperative and illustrating how advantages of the cooperative form of organizing emerge. A cooperative can provide an organizational structure for production and processing activities, which, compared with other organizational arrangements, namely the organization via a vertically separated market, enhances knowledge acquisition and enables higher total surplus. From our model, we infer that the cooperative acquires less non-generalizable knowledge than the market, but more generalizable knowledge than the market if the large member in the cooperative receives a sufficiently large share of the cooperative's profits. Additionally, we find that cooperatives generate larger aggregate surpluses than the market form of business organization if the influence of generalizable knowledge on production costs is large. This result is true under the assumption that the difference in cost structure and patronage between the cooperative members is not too large.

The proposed model intends to explain why cooperatives are such a widespread form of organizing transactions and frequently coexist with other forms of business organization. The model should pose a starting point for further analysis of the specific organizational features of cooperatives. For example, an extension of our model should provide more detailed analysis of the effect of the problems of vaguely defined property rights and the control problems frequently associated with cooperatives (Nilsson, 1997). The influence of these problems may be further assessed to obtain insights on what organizational attributes have to be adapted to address the problems, and what effects this generates for the competitive advantage of cooperatives.[21]

Our theoretical analysis of cooperatives can serve as a basis for empirical testing. For example, the importance of generalizable knowledge compared with non-generalizable knowledge could be determined for different sectors. Our theory predicts that sectors, in which generalizable (non-generalizable) knowledge is important in the production process, should display a stronger presence of cooperatives (market organizations). In the case that empirical testing confirms our propositions, measures to foster the cooperative advantage and to mitigate the problems related to cooperatives could be established for the respective sectors.

ENDNOTES

1. See also Hendrikse and Veerman (2001a), who formulate a theory with respect to the choice of governance structure in an agricultural production chain on the basis of an incomplete contracting framework.
2. In any agricultural sector, both non-generalizable and generalizable knowledge are usually required. However, non-generalizable knowledge about, for example, the site-related soil condition, is more important in the wine industry than in the dairy industry. As a result, production in the dairy industry is less influenced by site-related idiosyncrasies than that in the wine industry.
3. On the basis of an incomplete contracting, property rights model with two upstream suppliers and one downstream party, Hendrikse (2011) analyzed the interactions between two income rights and one decision right on investment incentives and investigates the efficiency of five different governance structures.
4. See Sexton (1986) for the relevance of this approach. In contrast, for example, Bogetoft (2005) considers a cooperative, where the processor does not face any costs. Moreover, Karantininis and Zago (2001) developed a model to study the choice of producers to sell their products to an investor-owned firm or to join a cooperative. In their model, the members of the cooperative have different costs.
5. By using modern concepts of the theory of the firm, Feng and Hendrikse (2008) formulated these forces within a system of attributes framework.
6. See Hendrikse (2007) for an analysis of the interaction between an upstream party and a downstream party, and the coexistence of different forms of governing the resulting transactions.
7. As $C_e(q_i,q_j)$ reflects costs for the processing enterprise, we use the subscript e.
8. This assumption allows us to draw conclusions for a broad set of functional forms for $f(\gamma,v)$ and enables us to compare outcomes among different organizational arrangements. For example, this property is fulfilled for $f(\gamma,v)=(\alpha\gamma+(1-\alpha)v)^{-1}$.
9. Note that the producers' investments in the two different types of knowledge in this setting show characteristics adjacent to the concept of asset specificity. Competition at the processing stage would reduce this adjacency as the acquired knowledge has impact on production costs independent of which processor the raw output is sold to after production.
10. See, for example, Cook and Chaddad (2004), for a characterization of different cooperative models and related patronage definition. An alternative modeling approach is patronage depending on the volume of delivery of a producer to the cooperative; see, for example, Phillips (1953) and Trifon (1961). Moreover, the parameter μ_i can be interpreted as an example of income rights. We are grateful to an anonymous referee who pointed this out. According to Feng and Hendrikse (2008), 'income rights specify the rights to receive the benefits, and obligations to pay the costs, that are associated with the use of an asset, thereby creating the incentive system faced by decision makers.'
11. This implies that members consider their patronage as exogenously given and that, with regard to their patronage, they consider their contribution to cooperative profits as negligible (Helmberger and Hoos, 1962). This modeling approach also incorporates the possibility that members purchase shares on the basis of projected output and then consider their patronage as fixed (Harris *et al.*, 1996). In general, our approach embodies the assumption that the divergence in marginal costs affects patronage to the extent that lower production costs imply higher use of the cooperative enterprise.
12. It can be easily verified that the second-order conditions for a maximum are satisfied.
13. Note that the optimal (anticipated) level of production q_j^c of member j does not depend on the acquisition level of non-generalizable knowledge v_i of member i because non-generalizable knowledge is particular for one setting and therefore is irrelevant for the other member.
14. We are grateful to an anonymous referee who suggested modeling the acquisition of generalizable knowledge at the cooperative level.
15. The larger the heterogeneity between members in terms of costs, the higher the c_2 and/or the lower the c_1.
16. This bargaining process incorporates both the processor's and individual producer's propensity to appropriate available rents. By threatening not to be willing to meet an agreement, each bargaining party can improve its bargaining power, to the extent where a failure of the bargaining process leads to no transaction. Note the resemblance of this bargaining situation to a hold-up problem, where the investment in generalizable, and non-generalizable knowledge resembles non-redeemable costs and, apart from decreasing the cost of production of output q, does not have alternative use once undertaken (Klein *et al.*, 1978; Gibbons, 2005).
17. We denote fixed costs of processing and marketing per producer i as F_i, with $F_i+F_j=F$.
18. That the second-order conditions for a maximum are satisfied can be easily verified.
19. The threshold μ_1^* is an increasing function in c_2, that is, an increasing member heterogeneity implies that the

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critical share, which member 1 must receive, increases. If the members in the cooperative are sufficiently homogeneous, that is, $c_2 \in (c_1, 3c_1)$, then $\mu_1^* < 1/2$, and hence, $\mu_1 > \mu_1^*$ is fulfilled for all feasible $\mu_1 \in (1/2, 1)$.
20. Note that this function satisfies A4.
21. See Chaddad and Cook (2004) for a typology of currently existing organizational designs of cooperatives.
22. Formally, the equation $\Pi^c - \Pi^m = 0$ has two roots a_1 and a_2. However, we can rule out one root.

APPENDIX A

A.1. Proof of Lemma 2

First, we compute the stage 2 equilibrium levels for non-generalizable knowledge acquisition. From the first-order conditions (4), we derive

$$\begin{aligned} v_i^c &= \mu_i(P-r)\frac{\mu_i(P-r)[-f_{v_i}(\gamma,v_i)]}{c_i f(\gamma,v_i)^2} \\ &-\left[\frac{\mu_i^2(P-r)^2[-f_{v_i}(\gamma,v_i)]}{c_i f(\gamma,v_i)^2}+\frac{c_i f_{v_i}(\gamma,v_i)}{2}\left(\frac{\mu_i(P-r)}{c_i f(\gamma,v_i)}\right)^2\right] \\ &= \frac{[-f_{v_i}(\gamma,v_i)]}{f(\gamma,v_i)^2}\frac{\mu_i^2(P-r)^2}{2c_i} = \frac{1-\alpha}{c_i}\frac{\mu_i^2(P-r)^2}{2}. \end{aligned}$$

Second, we compute the stage 2 equilibrium levels for generalizable knowledge acquisition. From the first-order condition (5), we derive

$$\begin{aligned} \gamma^c &= (P-r)\left(\frac{\mu_i(P-r)[-f_\gamma(\gamma,v_i)]}{c_i f(\gamma,v_i)^2}+\frac{\mu_j(P-r)[-f_\gamma(\gamma,v_j)]}{c_j f(\gamma,v_j)^2}\right) \\ &-\left[\frac{\mu_i^2(P-r)^2[-f_\gamma(\gamma,v_i)]}{c_i f(\gamma,v_i)^2}+\frac{c_i f_\gamma(\gamma,v_i)}{2}\left(\frac{\mu_i(P-r)}{c_i f(\gamma,v_i)}\right)^2\right] \\ &-\left[\frac{\mu_j^2(P-r)^2[-f_\gamma(\gamma,v_j)]}{c_j f(\gamma,v_j)^2}+\frac{c_j f_\gamma(\gamma,v_j)}{2}\left(\frac{\mu_j(P-r)}{c_j f(\gamma,v_j)}\right)^2\right] \\ &= \left(\frac{(2-\mu_i)\mu_i[-f_\gamma(\gamma,v_i)]}{c_i f(\gamma,v_i)^2}+\frac{(2-\mu_j)\mu_j[-f_\gamma(\gamma,v_j)]}{c_j f(\gamma,v_j)^2}\right)\frac{(P-r)^2}{2} \\ &= \alpha\cdot\left(\frac{(2-\mu_i)\mu_i}{c_i}+\frac{(2-\mu_j)\mu_j}{c_j}\right)\frac{(P-r)^2}{2}. \end{aligned}$$

It can be easily verified that the corresponding second-order conditions for a maximum are satisfied.

A.2. Proof of Lemma 5

First, we compute the stage 2 equilibrium levels for non-generalizable knowledge acquisition. From the first-order conditions (8), we derive

$$\begin{aligned} v_i^m &= \left(P-\frac{\partial C_e}{\partial q_i^m}\right)\frac{\partial q_i^m}{\partial v_i}-\left[\frac{\partial C_i}{\partial q_i^m}\frac{\partial q_i^m}{\partial v_i}+\frac{\partial C_i}{\partial v_i}\right] \\ &= -\frac{(P-r)^2 f_{v_i}(\gamma_i,v_i)}{2c_i f(\gamma_i,v_i)^2} = \frac{1-\alpha}{c_i}\frac{(P-r)^2}{2}. \end{aligned}$$

Second, we compute the stage 2 equilibrium levels for generalizable knowledge acquisition. From the first-order conditions (8), we derive

$$\begin{aligned} \gamma_i^m &= \left(P-\frac{\partial C_e}{\partial q_i^m}\right)\frac{\partial q_i^m}{\partial \gamma_i}-\left(\frac{\partial C_i}{\partial q_i^m}\frac{\partial q_i^m}{\partial \gamma_i}+\frac{\partial C_i}{\partial \gamma_i}\right) \\ &= -\frac{(P-r)^2 f_{\gamma_i}(\gamma_i,v_i)}{2c_i f(\gamma_i,v_i)^2} = \frac{\alpha}{c_i}\frac{(P-r)^2}{2}. \end{aligned}$$

It can be easily verified that the corresponding second-order conditions for a maximum are satisfied.

A.3. Proof of Proposition 2

Aggregate surplus in the cooperative $\Pi^c = \pi_1^c + \pi_2^c$ is given by

$$\begin{aligned} \Pi^c &= \frac{(P-r)^2}{2}\left[\frac{\mu_1(2-\mu_1)}{c_1 f(\gamma^c,v_1^c)}+\frac{\mu_2(2-\mu_2)}{c_2 f(\gamma^c,v_2^c)}\right] \\ &-\frac{(P-r)^4}{4}\left[\alpha^2\cdot\left(\frac{(2-\mu_1)\mu_1}{c_1}+\frac{(2-\mu_2)\mu_2}{c_2}\right)^2\right. \\ &\left.+(1-\alpha)^2\left(\frac{c_2^2(\mu_1^2)^2+c_1^2(\mu_2^2)^2}{c_1^2c_2^2}\right)\right]-F \end{aligned} \tag{10}$$

with $f(\gamma^c, v_i^c) = (\alpha\gamma^c + (1-\alpha)v_i^c)^{-1}$.

Aggregate surplus in the market $\Pi^m = \pi^m + \pi_1^m + \pi_2^m$ is given by

$$\begin{aligned} \Pi^m &= \frac{(P-r)^2}{2}\left[\frac{1}{c_1 f(\gamma_1^m,v_1^m)}+\frac{1}{c_2 f(\gamma_2^m,v_2^m)}\right] \\ &-\frac{(P-r)^4}{2}\left[\frac{\alpha^2}{4}\left(\frac{1}{c_1^2}+\frac{1}{c_2^2}\right)+\frac{(1-\alpha)^2}{4}\left(\frac{1}{c_1^2}+\frac{1}{c_2^2}\right)\right]-F \end{aligned}$$

with $f(\gamma_i^m, v_i^m) = (\alpha\gamma_i^m + (1-\alpha)v_i^m)^{-1}$.

After some algebraic manipulations, we derive[22]

$$\begin{aligned} &\Pi^c > \Pi^m \Leftrightarrow \alpha > \alpha_\pi \\ &\equiv \frac{1}{1+\left(\frac{\tau_1'+2c_1c_2\mu_1\mu_2(\mu_1-2)(\mu_2-2)+\tau_2'}{\tau_1+\tau_2}\right)^{1/2}}, \end{aligned}$$

with $\tau_i = c_i^2[\mu_j^3(3\mu_j-4)+1] > 0$, and $\tau_i' = c_i^2\mu_i^2(\mu_j(\mu_j-2)-1)$, $i,j \in \{1,2\}$, $i \neq j$.

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It follows that $\alpha_\pi \in [0,1]$. However, it is not guaranteed that $\alpha_\pi \in [0,1]$ exists because $\Gamma = \frac{\tau_1' + 2c_1c_2\mu_1\mu_2(\mu_1-2)(\mu_2-2)+\tau_2'}{\tau_1+\tau_2}$ can be negative. We derive that α_π exists only if (i) members in the cooperative are sufficiently similar in terms of their cost structure, that is, $\frac{c_2}{c_1} < c^\pi$; and (ii) the large member does not receive too large a share of the cooperative's profit, that is, $\mu_1 \in (\underline{\mu}_1^\pi, \bar{\mu}_1^\pi)$. For example, if $c_1 = c_2 = c$, we obtain

$$\Gamma = \frac{-5 + 24\mu_1\mu_2}{1 + 6\mu_1^2\mu_2^2} > 0 \Leftrightarrow \mu_1 \in \left(\underline{\mu}_1, \bar{\mu}_1\right) = \left(1 - \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right).$$

That is, μ_1 has to be in a certain interval to guarantee the existence of α_π. If $c_1 \neq c_2$, it can be shown that an increasing cost heterogeneity $\frac{c_2}{c_1}$ shrinks the interval $(\underline{\mu}_1^\pi, \bar{\mu}_1^\pi)$. That is, for a given c_1, it holds $\frac{\partial \underline{\mu}_1^\pi}{\partial c_2} > 0$ and $\frac{\partial \underline{\mu}_2^\pi}{\partial c_2} < 0$. If the cost heterogeneity is sufficiently large with $\frac{c_2}{c_1} > c^\pi$, then no μ_1 exists such that $\Gamma > 0$. In this case, $\Pi^c < \Pi^m \ \forall \alpha \in (0,1)$.

A.4. Proof of Lemma 6

With $f\left(\gamma^c, v_i^c\right) = \left(\alpha\gamma^c + (1-\alpha)v_i^c\right)^{-1}$ and $f\left(\gamma_i^m, v_i^m\right) = \left(\alpha\gamma_i^m + (1-\alpha)v_i^m\right)^{-1}$, we derive the following results.

(i) Gross revenues $R = (P-r)Q - (C_1 + C_2)$ in the cooperative and market are given by

$$R^c = (P-r)\left(\frac{\mu_1}{c_1 f\left(\gamma^c, v_1^c\right)} + \frac{\mu_2}{c_2 f\left(\gamma^c, v_2^c\right)}\right) - \frac{(P-r)^2}{2}\left(\frac{\mu_1^2}{c_1 f\left(\gamma^c, v_1^c\right)} + \frac{\mu_2^2}{c_2 f\left(\gamma^c, v_2^c\right)}\right) \quad (11)$$

$$R^m = (P-r)\left[\frac{1}{c_1 f\left(\gamma_1^m, v_1^m\right)} + \frac{1}{c_2 f\left(\gamma_2^m, v_2^m\right)}\right] - \frac{(P-r)^2}{2}\left(\frac{1}{c_1 f\left(\gamma_1^m, v_1^m\right)} + \frac{1}{c_2 f\left(\gamma_2^m, v_2^m\right)}\right) \quad (12)$$

We compute

$$R^c > R^m \Leftrightarrow \alpha > \alpha_r(\mu_1, c_1, c_2) \equiv \frac{1}{1 + \left(\frac{\tau_1' + 2c_1c_2\mu_1\mu_2(\mu_1-2)(\mu_2-2) + \tau_2'}{\tau_1 + \tau_2}\right)^{1/2}}$$

with $\tau_i = c_i^2\left[\mu_j^3(\mu_j - 2) + 1\right]$ and $\tau_i' = c_i^2\mu_i^2\left(\mu_j(\mu_j-2) - 1\right)$.

(ii) Aggregate knowledge acquisition costs in the cooperative and market are given by

$$C_k^c = C_\gamma(\gamma^c) + C_v\left(v_1^c\right) + C_v\left(v_2^c\right) = \frac{(P-r)^4}{4}\left[\alpha^2 \cdot \left(\frac{(2-\mu_1)\mu_1}{c_1} + \frac{(2-\mu_2)\mu_2}{c_2}\right)^2 + (1-\alpha)^2\left(\frac{c_2^2\left(\mu_1^2\right)^2 + c_1^2\left(\mu_2^2\right)^2}{c_1^2c_2^2}\right)\right]$$

$$C_k^m = C_\gamma\left(\gamma_1^m\right) + C_\gamma\left(\gamma_2^m\right) + C_v\left(v_1^m\right) + C_v\left(v_2^m\right) = \frac{(P-r)^4}{8}\left[\alpha^2\left(\frac{1}{c_1^2} + \frac{1}{c_2^2}\right) + (1-\alpha)^2\left(\frac{1}{c_1^2} + \frac{1}{c_2^2}\right)\right]. \quad (13)$$

We compute

$$C_k^c > C_k^m \Leftrightarrow \alpha > \alpha_k(\mu_1, c_1, c_2) \equiv \frac{1}{1 - \left(\frac{\tau_1' + 2c_1c_2\mu_1\mu_2(\mu_1-2)(\mu_2-2) + \tau_2'}{\tau_1 + \tau_2}\right)^{1/2}}$$

with $\tau_i = c_i^2\left(1 - \mu_j^4\right)$ and $\tau_i' = c_i^2\mu_i^2\left(\mu_j(\mu_j - 2) - 1\right)$.

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