The Efficiency of Cooperative Organizations

Preliminary draft

Helmut M. Dietl and Martin Grossmann[1]

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Abstract

Cooperative organizations are an important legal form of organization in many European countries. This paper points out the attractiveness of cooperative organizations in a specific economic setting: agents produce an intermediate product which they can either sell to a central company transforming the product into a final good or which they can sell in an outside market. The particularity of the model is that the agents have two random cost components. First, agents' costs are affected by a *common* component which influences all agents in an identical manner. This common component can be interpreted as a typical cost element in a specific industrial sector. Second, the agents' costs are affected by an *individual* component. This reflects the fact that every agent is exposed to individual circumstances in a given industrial sector. Nevertheless, the agents have the possibility to invest specifically in order to gather information about the two components and subsequently alter their effect on costs.

This paper compares agents' incentives to measure own cost characteristics depending on the organizational form. We show that a cooperative organization is more efficient than other organizational forms under specific parameter conditions in this economic setting. Primarily, a higher specificity of investments favours a cooperative solution compared to a market solution. Otherwise a commune is less efficient than a cooperative if the costs of detecting the idiosyncratic element by an agent are relatively low. Finally, other critical parameter conditions are discussed in the paper.

[1] University of Zurich, Institute of Strategy and Business Economics, Winterthurerstrasse 92, CH- 8006 Zurich, Tel: +41 (0)44 635 34 15, Fax: +41 (0)44 635 34 09, e-mail: helmut.dietl@isu.unizh.ch, martin.grossmann@isu.unizh.ch

1 Introduction

Today, many industries are dominated by firms which are organized as business corporations. Owners of these corporations are investors. However, there are other organizational forms such as cooperatives. Cooperatives are typically owned by consumers, workers or producers. The voting power varies among the different organizational forms. In a cooperative every member has a per capita voting power, whereas in a business corporation the capital investments are decisive. But which organizational form is preferable in a specific industry? Apparently, the economic environment has a tremendous impact on the efficiency of an organizational form.

In this paper we combine two topics which are often discussed separately in the literature: A cooperative as an organizational form and the characteristics of knowledge. We develop a model to compare cooperatives with other organizational forms and we simultaneously incorporate elements of idiosyncratic and general knowledge. The particularity of our model is that agents have two random cost components. First, agents' costs are affected by a *common* component which influences all agents in an identical manner. This common component could be interpreted as a typical cost element in a specific industrial sector. Second, the agents' costs are affected by an *individual* component. This reflects the fact that every agent is exposed to individual circumstances in a given industrial sector. Nevertheless, the agents have the possibility to invest specifically in order to gather information about the two components and subsequently alter their effect on costs. Hence, these investments reflect the incorporation of knowledge into the model as discussed above. We postulate that it is exactly the combination of organizational form and knowledge which induces a cooperative organization to be more efficient in specific economic environments.

There exists a broad literature both on the theory of cooperatives and knowledge. Bonus (1986) combines both topics. He describes two forces which are critical in cooperatives: On the one hand, there must be benefits of collective organization. Bonus denominates these benefits as *centripetal forces* in a cooperative. For instance, members of a specific cooperative do not purchase products on their own. Instead they jointly buy these products by their purchasing cooperative. On the other hand, there are benefits of independent operations leading to *centrifugal forces* in a cooperative. Bonus points out that economies of scale and some degree of monopoly power are often accompanying the formation of cooperatives. But these motives are not the critical sources from his point of view. He concludes that the availability of local information as well as a 'cooperative spirit' are the driving forces in order to form cooperatives. Bonus emphasizes that trust is a productive resource in a cooperative. All members know that they own the cooperative and that they depend on each other. We resume the importance of local information and knowledge in a cooperative in the next section. Other authors have discussed the particularity of cooperatives (Hausmann (1988), Enke (1945), Phillips (1953)). For instance, Hausmann (1988) describes farm supply cooperatives in the U.S. Contrary to

Bonus, he points out that market power constitutes an important stimulation to form cooperatives in farm supply business. Moreover Hausmann notes that farm supply cooperatives often have difficulties in providing capital. Porter and Scully (1987) empirically test whether plants in cooperatives are more efficient than noncooperative firms in the U.S. fluid-milk processing market. Their results indicate that self-governed plants are significantly more efficient than cooperatives.

We have already mentioned that *general* and *idiosyncratic* knowledge about firms' environments might influence the efficiency of a specific organizational form. Idiosyncratic knowledge reflects the knowledge about special circumstances in a firm. This knowledge is highly depending on individual experience and therefore cannot be communicated easily. For instance, consider a farmer managing his crops and cattle. It is nearly impossible to specify adequate behavior accounting for every possible contingency. However, an experienced farmer will know how to behave in different circumstances based on his experience. Another example has been given by Polanyi (1958) who, in a famous paper, describes the process of learning to ride a bicycle. Even if you explain the riding with physical terminology, a layman would fall from the bicycle in the beginning. Both examples emphasize the importance of experience regarding idiosyncratic knowledge. Hayek (1945) postulates that it seems to be reasonable that people working in a specific firm should get the decision rights because they best know the local conditions. He points out that general knowledge often can be communicated between firms costlessly. A further paper about specific and general knowledge is written by Jensen and Meckling (1998). They analyze how transfer costs of knowledge influence the decentralization of decision rights.

This paper has the following structure: Section two presents the main assumptions and timing in the model. In the third section we solve the model in three different market environments. First, we assume that every firm does not cooperate and a central company acts self-governedly as a buyer of the firms' products. We will denote this case as the 'market solution' because all agents interact autonomously in markets. Second, we examine a market situation in which all firms are part of a cooperative. This will be called the 'cooperative solution'. Third, we consider a vertically integrated environment in which the central company owns all firms. By reason of the dominant position of the central company we will call this case as the 'commune solution'. In section four we sum up the results and compare the different results in the three economic environments.

2 The Model

2.1 The Assumptions

We consider a closed economy in which a large number of identical and (expected) profit maximizing firms have the opportunity to produce two different intermediate products using two linear production functions. The first product is produced by the linear technology $f(s_i) = s_i$ at costs $c_s(s_i) = \frac{1}{2}s_i^2$. The output s_i can be sold to a profit maximizing monopolist at a price p_1 chosen by this monopolist. The monopolist transforms the intermediate product into a final good. We assume that the monopolist neither incurs costs through this transformation nor has an outside option. Finally, the monopolist resells the final good at an exogenous world market price p_2.[2] The firms also have the possibility to produce a second intermediate product. This product could become important for a firm if the proposed price p_1 by the monopolist is too low.[3] Then, this firm could realize its profit by selling the second product in the outside market instead of selling the first product to the monopolist. Therefore, the second product can be interpreted as an investment into an outside option if there is no trade with the monopolist. We assume that a firm chooses to interact with the monopolist if this firm is indifferent between the monopolist's offer and the outside option. The technology for the second product is similar to the technology of the first product. The production function of the second product is given by $g(v_i) = v_i$. We assume that the associated convex cost function is $c_v(v_i) = \frac{1}{2}\gamma v_i^2$ with parameter $\gamma > 1$. If the firm is not satisfied with the monopolist's price p_1 the firm could sell its output on an outside market at a normalized price $p_3 = 1$. Note that firm i could either sell s_i or v_i but not both together. One intermediate product loses all of its value depending on the firm's decision on which market it wants to be active. To support this assumption, suppose that a firm's owner has a time budget constraint which allows him to sell but on one market. Nevertheless the firm is facing the two costs functions - $c_s(s_i) = \frac{1}{2}s_i^2$ and $c_v(v_i) = \frac{1}{2}\gamma v_i^2$ - independent of the decision which intermediate product will be sold in the end. Why should a firm invest into its outside option if one product loses all of its value? Consider the following argument possibly answering this question: The higher a firms' value of its outside option, the more a firm exerts pressure on the monopolist to reduce the price p_1 such that a firm favours the monopolist's offer. Hitherto we have delineated the production and part of the cost side of the economy. Next we reconsider the cost functions of the model.

The costs consist of two *components*. Firms generate the first cost component - $c_s(s_i)$ and $c_v(v_i)$ - by producing the two products as described above. The parameter γ reflects the degree of specificity of investments into the second product. A high γ implies that the marginal costs of producing the second product relatively to the first product are high. Now we add a second cost component which we have not mentioned so far. This second cost component itself contains two *elements*: The first element represents costs which influence all firms in an identical manner illustrating a common cost factor. The second element depicts a firm specific idiosyncratic cost. The firms have the opportunity to cancel one or both of the two cost elements by investing an exogenous

[2] Thus, the monopolist acts as a price taker with respect to the world market but simultaneously the monopolist sets a price p_1 in the "inside" market as a price setter.

[3] Too low means that the firm gets higher profits on the outside market compared to a trade with the monopolist on the inside market.

amount k_θ and/or k_ε. As an example for the second cost component, consider a farmer (representing a firm) working on his farmland. The harvest is influenced both by the climate (common cost factor) which affects all farmers in an identical manner and by the quality of the soil (idiosyncratic cost) which is different between the farmlands. Now a farmer has the opportunity to invest into a technology to detect the characteristics of his farmland and/or he could buy some information about weather forecast or the climate at a research institute such that he could optimally (re-)act to the characteristics of his farmland and/or to weather changes. We formalize the second cost component by the following expression:

$$c_i = (\theta + \varepsilon_i - x_i)^2$$

We assume that θ and ε_i are independent, continuously distributed random variables with a first moment equal to zero and a finite second moment $\sigma_\theta^2 > 0$ and $\sigma_{\varepsilon_i}^2 = \sigma_\varepsilon^2 > 0\ \forall i$. At first, both variables are not observed by firms. The variable θ reflects the common effect on firms. Therefore there is no firm specific subscript i whereas ε_i is a firm specific random variable with subscript i. The variable x_i indicates a choice variable for firm i. Suppose that the firm has no information about the realized variables θ and ε_i. Minimizing the expected costs $E[c_i] = E[(\theta + \varepsilon_i - x_i)^2]$ implies setting $x_i^* = 0$ because both variables have an expected value of zero and are independent of each other. Then, we get expected costs of $E[c_i] = \sigma_\theta^2 + \sigma_\varepsilon^2$. Otherwise we could invest an exogenous amount k_θ and/or k_ε such that we receive informations about the realized values of θ and/or ε_i. Afterwards a firm could adjust its choice variable x_i to minimize its expected costs. Suppose that a firm invests k_θ (but not k_ε) to learn the value θ (but not ε_i). Thus, we get an optimal choice of $x_i^* = \theta$. In the next section we consecutively describe the different stages of the model.

2.2 The Timing

We model four stages in this economy. In the first stage nature determines θ and ε_i unobserved by all firms. In stage two, firm i chooses both s_i and v_i after having observed the exogenous values $p_2, p_3 = 1, k_\theta, k_\varepsilon, \sigma_\theta^2, \sigma_\varepsilon^2$. Moreover firm i decides whether to invest the amounts k_θ and/or k_ε to discover the values θ and/or ε_i. In the third stage the monopolist sets a price p_1 after having observed the chosen values s_i and v_i and the exogenous variables $p_2, p_3 = 1, k_\theta, k_\varepsilon, \sigma_\theta^2, \sigma_\varepsilon^2$. In the last period firm i decides whether to sell the product to the monopolist or to take its outside option at price $p_3 = 1$. Ultimately the payoffs are realized.

3 The Solution of the Model

We consider the optimal behavior of firms and the monopolist in three different market environments. In the first environment, all firms act autonomously. They do not cooperate and the market is vertically separated. Thus, the monopolist also acts self-governed. Second, we examine the optimal performance in a cooperative. There, we assume that the firms together "own" the monopolist and they share the monopolist's profit which has to be nonnegative. In addition, we assume that the firms have the opportunity to detect the common cost effect θ once only because the information about θ can circulate between the cooperative firms without costs. In a third case, we analyze a vertically integrated market. In this setting, a firm acts as a monopolist's employee. This structure implies that the monopolist owns all downstream firms. It is important to note that we just focus on the producer side in this model. We abstract from consumer surplus. Thus, in this paper efficiency refers to the aggregate profits of firms.

3.1 The Market Solution

Consider a situation where every firm individually maximizes its profit. The monopolist also acts autonomously. We solve this model by applying backward induction.

Stage 4 and 3:

In the last period firm i sells its product to the monopolist at price p_1 if and only if expected profits are at least as high as expected profits generated in the outside option. Note that in stage four the firm's costs represent sunk costs because s_i and v_i already were chosen in stage two. The monopolist anticipates this reaction one period earlier. Furthermore the monopolist bears in mind that its own outside option is zero. Thus, the monopolist offers a value p_1 (if $p_1 \leqslant p_2$) such that firm i is just indifferent between its outside option and selling the product to the monopolist. So the monopolist maximizes the sum of revenues $p_2 s_i$ minus costs $p_1 s_i$ over all firms $i \in 1, ..., I$ with respect to p_1 under the restriction that all firms prefer this offer to the outside option:

$$\max_{p_1} \sum_{i=1}^{I} (p_2 s_i - p_1 s_i)$$

$$s.t.\ p_1 s_i - \underbrace{\left(\frac{1}{2}\gamma v_i^2 + \frac{1}{2}s_i^2\right)}_{\text{first cost component}} - \underbrace{E[(\theta + \varepsilon_i - x_i)^2]}_{\text{second cost component}} \quad \geq \quad p_3 \cdot v_i - \left(\frac{1}{2}\gamma v_i^2 + \frac{1}{2}s_i^2\right)$$
$$-E[(\theta + \varepsilon_i - x_i)^2]\ \forall i$$

We solve this problem by introspection. The monopolist chooses the minimum value p_1 such that every firm is just indifferent between this offer and its outside option.[4] The optimal choice of p_1 is $\frac{v_i}{s_i}$ if the monopolist's profit is

[4] Remark: We already have assumed that a firm chooses the monopolist's offer if the firm is indifferent.

positive.[5] Otherwise the monopolist offers $p_1 = 0$.[6] The monopolist's reaction function is given by

$$p_1^*(s_i, v_i) = \begin{cases} \frac{v_i}{s_i} & \text{if } p_2 \geqslant \frac{v_i}{s_i} \\ 0 & \text{if } p_2 < \frac{v_i}{s_i} \end{cases} .$$

Stage 2:

In the second period, firm i chooses s_i and v_i anticipating the monopolist's reaction function. We apply two steps to solve the firms' optimal behavior because the monopolist's price setting includes a case differentiation as mentioned above. In the first step we focus on a situation where the monopolist has an incentive to set a positive price p_1. Thus, the monopolist gets positive profits. The second step computes a solution under the assumption that the monopolist sets its price $p_1^*(s_i, v_i) = 0$.

Step 1

Firm i maximizes its expected profits ($E[\pi_i] = p_1^*(s_i, v_i)s_i - \frac{1}{2}s_i^2 - \frac{1}{2}\gamma v_i^2 - E[(\theta + \varepsilon_i - x_i)^2]$) under the following constraint: The monopolist has to get nonnegative profits ($p_2 s_i - p_1^*(s_i, v_i)s_i \geqslant 0$). Otherwise the monopolist would set $p_1 = 0$. Thus, firm i compares the generated profit with the profit it would get by the outside option. We get the following maximization problem:[7]

$$\max_{s_i, v_i} \mathcal{L} = p_1^*(s_i, v_i)s_i - \frac{1}{2}s_i^2 - \frac{1}{2}\gamma v_i^2 - E[(\theta + \varepsilon_i - x_i)^2] + \lambda[p_2 s_i - p_1^*(s_i, v_i)s_i]$$

$$\Leftrightarrow \max_{s_i, v_i} \mathcal{L} = v_i - \frac{1}{2}s_i^2 - \frac{1}{2}\gamma v_i^2 - E[(\theta + \varepsilon_i - x_i)^2] + \lambda[p_2 s_i - v_i]$$

In the last line we have replaced $p_1^*(s_i, v_i)s_i$ by v_i anticipating the optimal behavior of the monopolist. The first term in the maximization problem represents firm i's revenue. The second and third term stand for the costs of producing s_i and v_i (first cost component). Finally, the forth term indicates the expected costs from the second cost component. The variable λ represents the marginal increase in profits by relaxing the constraint $p_2 s_i - p_1^*(s_i, v_i)s_i \geqslant 0$ infinitesimally. We get the following results after taking the FOCs with respect to s_i and v_i :

$$s_i : \lambda = \frac{s_i}{p_2}$$

[5] Note that both cost components cancel each other in the constraint and that we have normalized $p_3 = 1$. Furthermore we concentrate on a symmetric equilibrium. Hence, every firm produces the same amount s_i and v_i.

[6] We could solve this optimization problem by the Kuhn-Tucker approach as well.

[7] Technical remark: The constraint is qualified.

$$v_i : \lambda = 1 - \gamma v_i$$

Next we have to check whether the constraint is binding or not. We distinguish two cases. In case 1 we suggest that $p_2 s_i - p_1^*(s_i, v_i)s_i > 0$ so that $\lambda = 0$. In the second case we examine a binding constraint. Therefore λ is nonnegative.

Case 1: $p_2 s_i > v_i \Rightarrow \lambda = 0$

$$s_i^* = 0$$

$$v_i^*(\gamma) = \frac{1}{\gamma}$$

But this is not consistent with the constraint $p_2 s_i - v_i > 0$. Therefore this is not a solution.

Case 2: $p_2 s_i = v_i \Longrightarrow \lambda \geqslant 0$

Thus, the constraint is binding and the monopolist receives zero profits. We get the following optimal choice of s_i and v_i:

$$s_i^*(p_2, \gamma) = \frac{p_2}{1 + \gamma p_2^2}$$

$$v_i^*(p_2, \gamma) = p_2 s_i^* = \frac{p_2^2}{1 + \gamma p_2^2}$$

Putting these optimal values into the firm's profit equation we get firm i's expected profit in a market solution denoted by $E[\pi_i^m]$.[8]

$$E[\pi_i^m] = \frac{1}{2}\frac{p_2^2}{1 + \gamma p_2^2} - E[(\theta + \varepsilon_i - x_i)^2]$$

$$\Leftrightarrow E[\pi_i^m] = \begin{cases} \frac{1}{2}\frac{p_2^2}{1+\gamma p_2^2} - \sigma_\theta^2 - \sigma_\varepsilon^2 & \text{if } k_\theta > \sigma_\theta^2 \text{ and } k_\varepsilon > \sigma_\varepsilon^2 \\ \frac{1}{2}\frac{p_2^2}{1+\gamma p_2^2} - k_\theta - k_\varepsilon & \text{if } k_\theta \leqslant \sigma_\theta^2 \text{ and } k_\varepsilon \leqslant \sigma_\varepsilon^2 \\ \frac{1}{2}\frac{p_2^2}{1+\gamma p_2^2} - \sigma_\theta^2 - k_\varepsilon & \text{if } k_\theta > \sigma_\theta^2 \text{ and } k_\varepsilon \leqslant \sigma_\varepsilon^2 \\ \frac{1}{2}\frac{p_2^2}{1+\gamma p_2^2} - k_\theta - \sigma_\varepsilon^2 & \text{if } k_\theta \leqslant \sigma_\theta^2 \text{ and } k_\varepsilon > \sigma_\varepsilon^2 \end{cases}$$

In the last line we included the optimal investment choices in detecting θ and ε_i depending on investment costs k_θ and k_ε as well as on the variances σ_θ^2 and σ_ε^2. Therefore we have to distinguish four cases as indicated above.

Step 2

[8] Note that the superscript m in π_i^m stands for market.

We compute firm i's (expected) profit taking directly its outside option. The expected profit in a market solution where a firm just takes its outside option is denoted by $E[\pi_i^{m,o}]$.[9] In such a setting, firm i obviously sets $s_i = 0$.[10] We get the following maximization problem:

$$\max_{v_i} \mathcal{L} = v_i - \frac{1}{2}\gamma v_i^2 - E[(\theta + \varepsilon_i - x_i)^2]$$

The optimal choice of v_i is $v_i^*(\gamma) = \frac{1}{\gamma}$. Thus, we get the following expected profit for firm i :

$$E[\pi_i^{m,o}] = \frac{1}{2}\frac{1}{\gamma} - E[(\theta + \varepsilon_i - x_i)^2] = \begin{cases} \frac{1}{2}\frac{1}{\gamma} - \sigma_\theta^2 - \sigma_\varepsilon^2 & \text{if } k_\theta > \sigma_\theta^2 \text{ and } k_\varepsilon > \sigma_\varepsilon^2 \\ \frac{1}{2}\frac{1}{\gamma} - k_\theta - k_\varepsilon & \text{if } k_\theta \leqslant \sigma_\theta^2 \text{ and } k_\varepsilon \leqslant \sigma_\varepsilon^2 \\ \frac{1}{2}\frac{1}{\gamma} - \sigma_\theta^2 - k_\varepsilon & \text{if } k_\theta > \sigma_\theta^2 \text{ and } k_\varepsilon \leqslant \sigma_\varepsilon^2 \\ \frac{1}{2}\frac{1}{\gamma} - k_\theta - \sigma_\varepsilon^2 & \text{if } k_\theta \leqslant \sigma_\theta^2 \text{ and } k_\varepsilon > \sigma_\varepsilon^2 \end{cases}$$

Firm i compares the two possible profits in step 1 and step 2 and chooses the related values for s_i and v_i to maximize its profits. So firm i favours its outside option if

$$E[\pi_i^m] = \frac{1}{2}\frac{p_2^2}{1+\gamma p_2^2} - E[(\theta + \varepsilon_i - x_i)^2] < \frac{1}{2}\frac{1}{\gamma} - E[(\theta + \varepsilon_i - x_i)^2] = E[\pi_i^{m,o}]$$

$$\Leftrightarrow \frac{p_2^2}{1+\gamma p_2^2} < \frac{1}{\gamma}$$

$$\Leftrightarrow \gamma p_2^2 < 1 + \gamma p_2^2$$

This is true for all values of γ.[11] Thus, the outside option is preferable for all firms. No firm will invest in s_i anticipating that its profits out of a trade with the monopolist would be lower compared to profits in the outside option. The intuition behind this result is the following: The firm's revenue is independent of the choice s_i because the monopolist sets a price such that the firm is indifferent. But the firm's costs are increasing in s_i.

3.2 The Cooperative Solution

In this section we consider the case where all firms could align in a cooperative. In this case, the cost of observing the common factor θ has to be paid once only.

[9] Note that the superscript m in $\pi_i^{m,o}$ stands for market and the superscript o stands for outside option.

[10] Step 2 is connected with case 1 in step 1. We perceive in case 1 in step 1 that the constraint could not be fulfilled. Therefore we would have a situation in step 1 where $p_1^* = 0$ so that it is optimal to set $s_i^* = 0$. Thus, case 1 in step 1 without the constraint is equivalent to step 2.

[11] Recall that $\gamma > 1$.

The realized θ is communicated to all firms without any additional costs if k_θ is paid once by the cooperative. Of course, this is not possible concerning the individual factor ε_i. Nevertheless, every firm can detect ε_i at cost k_ε as in the market solution. In a cooperative it is not evident how the price p_1 is determined. A committee would have to set this price. We do not consider the price-setting mechanism. Instead, we assume that p_1 is chosen as high as possible such that the firms get the highest profits but under the condition that the cooperative itself makes nonnegative profits. The cooperative's profit is the number of firms I times the revenue per firm minus a possible payment of k_θ for observing θ. We have to distinguish three cases depending on the profitability of investing k_θ. In the first case we assume that $\frac{k_\theta}{I} < k_\theta \leq \sigma_\theta^2$. In this case every single firm has an incentive to pay k_θ in a market situation because $k_\theta \leq \sigma_\theta^2$. Moreover the cooperative also pays k_θ in a cooperative environment because $\frac{k_\theta}{I} < \sigma_\theta^2$. The second case examines the parameter condition $\frac{k_\theta}{I} \leq \sigma_\theta^2 < k_\theta$. Note that in this case just the cooperative invests k_θ but no firm invests k_θ in a market solution. We consider a third situation where no firm has an incentive to invest k_θ in both organizational forms. Thus, we analyze a parameter constellation in case 3 where $\sigma_\theta^2 < \frac{k_\theta}{I} < k_\theta$.

Case 1

Suppose that the cooperative makes zero profits[12] and it is profitable to invest k_θ in both organizational forms. Formally, this is the case if $\frac{k_\theta}{I} < k_\theta \leq \sigma_\theta^2$. In such a constellation, all firms know the variable θ. The next lines figure out the optimal actions of firms. Afterwards we compare the firms' profits in a cooperative organization with the firms' profits generated by the market solution and we present necessary parameter conditions such that a cooperative solution is more efficient than a market solution (and vice versa). In the following we start with the zero profit condition (and henceforth we assume a symmetric behavior of the firms so that $s_i = s\ \forall i$):[13]

$$\pi^g = I \cdot (p_2 s_i - p_1 s_i) - k_\theta = 0$$

$$\Longleftrightarrow p_1(p_2, k_\theta, s_i, I) = p_2 - \frac{k_\theta}{I \cdot s_i}$$

We notice that a higher exogenous price p_2, I or s_i implies a higher price p_1 while still satisfying the zero profit condition. Moreover a higher k_θ implies a lower p_1. Unlike the results above p_1 does not depend on v_i. This is of capital importance in the following. Firm i chooses s_i and v_i anticipating the price function $p_1(p_2, k_\theta, s_i, I)$.

$$\max_{s_i, v_i} \mathcal{L} = p_1(p_2, k_\theta, s_i, I)s_i - \frac{1}{2}\gamma v_i^2 - \frac{1}{2}s_i^2 - E[(\varepsilon_i - \tilde{x}_i)^2]$$

[12] The cooperative's profit is denoted by π^g.

[13] Note that k_θ is paid once only by the cooperative.

$$\Leftrightarrow \max_{s_i,v_i} \mathcal{L} = (p_2 - \frac{k_\theta}{I \cdot s_i})s_i - \frac{1}{2}\gamma v_i^2 - \frac{1}{2}s_i^2 - E[(\varepsilon_i - \tilde{x}_i)^2]$$

In the last line we have replaced $p_1(p_2, k_\theta, s_i, I)$ by $p_2 - \frac{k_\theta}{I \cdot s_i}$. Notice that θ does not appear in the term $E[(\varepsilon_i - \tilde{x}_i)^2$. The realization of this variable is already incorporated in the optimal choice of the variable $x_i \equiv \tilde{x}_i + \theta$. The cooperative has paid k_θ and distributed the information about θ over all firms.[14] We get the following optimal choices of the variables v_i^* and s_i^*:

$$v_i^* = 0$$

$$s_i^*(p_2) = p_2$$

Thus, putting the optimal choice of s_i into the function determining the price p_1, we get $p_1(p_2, k_\theta, s_i^*(p_2), I) = p_2 - \frac{k_\theta}{I \cdot p_2}$. Furthermore we compute the expected profits for firm i denoted by $E[\pi_i^c]$:[15]

$$E[\pi_i^c] = \frac{1}{2}p_2^2 - \frac{k_\theta}{I} - E[(\varepsilon_i - \tilde{x}_i)^2] = \begin{cases} \frac{1}{2}p_2^2 - \frac{k_\theta}{I} - \sigma_\varepsilon^2 & \text{if } k_\varepsilon > \sigma_\varepsilon^2 \\ \frac{1}{2}p_2^2 - \frac{k_\theta}{I} - k_\varepsilon & \text{if } k_\varepsilon \leqslant \sigma_\varepsilon^2 \end{cases}$$

Next, we compare the firm's profit in the cooperative with the firm's profit in the market case:[16]

$$E[\pi_i^c] = (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - \min\{k_\varepsilon, \sigma_\varepsilon^2\}) \gtreqless (\frac{1}{2}\frac{1}{\gamma} - k_\theta - \min\{k_\varepsilon, \sigma_\varepsilon^2\}) = E[\pi_i^{m,o}]$$

$$\Longleftrightarrow 2 \cdot k_\theta[\frac{I-1}{I}] \gtreqless \frac{1}{\gamma} - p_2^2$$

Thus, the cooperative solution generates higher profits for the firms compared to the market solution if the following parameter conditions hold: First of all, a relatively high k_θ implies that a cooperative is more efficient because the total costs of k_θ are spread over all firms in contrast to the market solution where every firm has to pay k_θ. An increase in k_θ by one unit decreases a firm's profit one-to-one in the market solution whereas the firm's profit just reduces by $\frac{1}{I}$ in a cooperative. A relatively high number of firms implies that a cooperative is more profitable. The intuition behind this result is analogical to the former discussion about k_θ. The cost per firm decreases in the parameter

[14] Confer the zero profit condition.

[15] Note that the superscript c in $E[\pi_i^c]$ stands for cooperative.

[16] Remark: In this section we compare the expected profits of an arbitrary firm i. But this is the same as comparing the sum of all profits of every firm $i = 1, ..., I$ because of the firms' symmetry . Moreover we could add the profits of the cooperative denoted by π^g (in the cooperative solution) resp. the monopolist's profit (in the market case) to get the aggregate profits. Nothing would change because both the cooperative profit and the monopolist's profit are zero. We indicate this by reason that in section 3.3 we compare aggregate profits.

I in the cooperative case but remains constant in a market solution. Another interesting parameter is γ. The parameter γ determines the difference of the marginal costs between product one and product two. An increasing γ implies that the marginal costs producing the second product increase. A higher γ (ceteris paribus) reduces the revenue in a market solution because a firm's incentive to invest in v_i decreases in γ whereas a higher γ does not influence the profit in a cooperative organization. Finally, a relatively high exogenous price p_2 leads to a situation where a cooperative is more efficient. A marginal increase in p_2 increases the marginal revenue in a cooperative but does not alter the profits in a market solution.

Case 2

In case 2 we assume that $\frac{k_\theta}{I} \leq \sigma_\theta^2 < k_\theta$. Thus, we have to examine the following profits:

$$E[\pi_i^c] = (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - \min\{k_\varepsilon, \sigma_\varepsilon^2\}) \gtreqqless (\frac{1}{2}\frac{1}{\gamma} - \sigma_\theta^2 - \min\{k_\varepsilon, \sigma_\varepsilon^2\}) = E[\pi_i^{m,o}]$$

On the left hand side we have firm i's expected profits in a cooperative as in case 1. On the right hand side firm i's expected profits differ from the expected profits in case 1 because $\sigma_\theta^2 < k_\theta$. The above inequality is rewritten as

$$\underbrace{\sigma_\theta^2 - \frac{k_\theta}{I}}_{\geq 0} \gtreqqless \frac{1}{2}\left[\frac{1}{\gamma} - p_2^2\right].$$

We conclude that a high firm's cost difference of the factor θ (which is reflected by the term $\sigma_\theta^2 - \frac{k_\theta}{I}$) implies that the cooperative is more efficient than the market solution. The other parameters have a similar effect as in case 1.

Case 3

In case 3 we have the parameter condition $\sigma_\theta^2 < \frac{k_\theta}{I} < k_\theta$. Therefore the cooperative prefers not to invest k_θ. The cooperative's zero profit condition then reduces to

$$\pi^g = I \cdot (p_2 s_i - p_1 s_i) = 0$$

Therefore the cooperative sets its price p_1 equal to the world market price p_2:

$$p_1(p_2) = p_2$$

Now firm i chooses s_i and v_i anticipating the price function $p_1(p_2)$:

$$\max_{s_i,v_i} p_1(p_2)s_i - \frac{1}{2}\gamma v_i^2 - \frac{1}{2}s_i^2 - E[(\theta+\varepsilon_i - x_i)^2]$$

$$\Leftrightarrow \max_{s_i,v_i} p_2 s_i - \frac{1}{2}\gamma v_i^2 - \frac{1}{2}s_i^2 - E[(\theta+\varepsilon_i - x_i)^2]$$

We get the following optimal choices of the variables v_i^* and s_i^*:

$$v_i^* = 0$$

$$s_i^* = p_2$$

Furthermore we compute the expected profits for firm i:

$$E[\pi_i^c] = p_2^2 - \frac{1}{2}p_2^2 - E[(\theta+\varepsilon_i - x_i)^2]$$

$$\Leftrightarrow E[\pi_i^c] = \begin{cases} \frac{1}{2}p_2^2 - \sigma_\theta^2 - \sigma_\varepsilon^2 & \text{if } k_\theta > \sigma_\theta^2 \text{ and } k_\varepsilon > \sigma_\varepsilon^2 \\ \frac{1}{2}p_2^2 - \sigma_\theta^2 - k_\varepsilon & \text{if } k_\theta > \sigma_\theta^2 \text{ and } k_\varepsilon \leqslant \sigma_\varepsilon^2 \end{cases}$$

Again, we compare firm i's profit in the cooperative with firm i's profit in the market case:

$$E[\pi_i^c] = (\frac{1}{2}p_2^2 - \sigma_\theta^2 - \min\{k_\varepsilon, \sigma_\varepsilon^2\}) \gtreqless (\frac{1}{2}\frac{1}{\gamma} - \sigma_\theta^2 - \min\{k_\varepsilon, \sigma_\varepsilon^2\}) = E[\pi_i^{m,o}]$$

$$p_2^2 \gtreqless \frac{1}{\gamma}$$

Thus, the cooperative model is preferable if there is a relative high parameter p_2 and/or a relative high γ (and vice versa). What is the economic intuition behind these interrelations? In a cooperative, a high world market price p_2 is carried forward to the firms by increasing the price p_1 whereas in the market solution the world market price does not influence firms' profit. Moreover, a high γ reduces the incentive to produce in the market solution. In case 3, the possibility of communicating θ without costs in a cooperative has no influence because there do not exist any incentives to invest k_θ.

3.3 The Commune Solution

In this section, we suppose that there is a central company which owns all firms. Hence, we analyze a vertically integrated market structure. Firms become the central company's subsidiaries and do not have any outside option since they are property of the central company. In this setting, the central company is able to dictate each subsidiary's output s_i. In return, the central company pays a constant amount w if subsidiary i produces the demanded amount s_i^*.[17] We assume that the central company receives the subsidiary's whole profit including its costs except a possible investment of k_ε.[18] So the company asks $s_i^* = p_2$ $\forall i$.[19] Moreover, the company has to decide whether to pay k_θ for observing the realized variable θ. If the central company invests this amount it could communicate θ to all subsidiaries. Therefore k_θ has to be paid once only as in the cooperative case. The company invests k_θ if $\frac{1}{I}k_\theta \leq \sigma_\theta^2$. Regarding individual cost component, note first of all that a subsidiary gets w minus a possible investment k_ε. As the wage w does not have any incentive effects to detect ε_i a subsidiary will not invest k_ε. Thus, the central company obtains expected costs of σ_ε^2 per subsidiary. The central company gets an expected profit $E[\pi^p] = I \cdot (p_2 s_i - \frac{1}{2}s_i^2 - \sigma_\varepsilon^2 - w) - k_\theta$ where s_i is optimally chosen as described above and under the condition that $\frac{1}{I}k_\theta \leq \sigma_\theta^2$.[20] If $\frac{1}{I}k_\theta > \sigma_\theta^2$ then $E[\pi^p] = I \cdot (p_2 s_i - \frac{1}{2}s_i^2 - \sigma_\varepsilon^2 - \sigma_\theta^2 - w)$. Plugging in the optimal $s_i^* = p_2$ we get the central company's profit function:

$$E[\pi^p] = \begin{cases} I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2 - w) - k_\theta & \text{if } \frac{1}{I}k_\theta \leq \sigma_\theta^2 \\ I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2 - \sigma_\theta^2 - w) & \text{if } \frac{1}{I}k_\theta > \sigma_\theta^2 \end{cases}$$

We notice that the wage payment just has distributional effects between subsidiaries and the central company. The sum of all subsidiaries' profits and the company's profit which is denoted by $E[\pi^{vi}]$ (where vi stands for 'vertically integrated') does not change with a varying w:

$$E[\pi^{vi}] \equiv E[\pi^p] + \sum_{i=1}^{I} E[\pi_i] = \begin{cases} I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2) - k_\theta & \text{if } \frac{1}{I}k_\theta \leq \sigma_\theta^2 \\ I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2 - \sigma_\theta^2) & \text{if } \frac{1}{I}k_\theta > \sigma_\theta^2 \end{cases}$$

Next, we compare aggregate profits in the cooperative case to aggregate profits in the commune case. We follow the structure in section 3.2 and distinguish three cases, again. In the first case we assume that $\frac{k_\theta}{I} < k_\theta \leq \sigma_\theta^2$. The second case examines the parameter condition $\frac{k_\theta}{I} \leq \sigma_\theta^2 < k_\theta$. We analyze a parameter constellation $\sigma_\theta^2 < \frac{k_\theta}{I} < k_\theta$ in case 3.

Case 1

In case 1 we begin with the parameter condition $\frac{k_\theta}{I} < k_\theta \leq \sigma_\theta^2$. Expected aggregate profits in the cooperative case (denoted by $E[\pi^c]$) are the sum of all

[17] We simplify the problem here by neglecting the possibility of optimal contracting in hidden actions situations. See, for example, Hart and Holmström (1987) for a broad discussion about this topic.

[18] We justify this assumption by taking into account that k_ε represents private monetary costs while the costs σ_ε^2, for instance, indicate losses in physical harvest. This physical loss is carried forward from a subsidiary to the central company.

[19] The central company maximizes $I \cdot (p_2 s_i - \frac{1}{2}s_i^2 - \kappa) - \mu$ with respect to s_i where κ and μ contain cost components (such as w) which are independent of s_i. Therefore, we get $s_i^* = p_2$.

[20] Note that the superscript p in $E[\pi^p]$ stands for the central company.

profits of the firms plus the profit of the cooperative which is zero as described in footnote 16. Hence,

$$E[\pi^c] \equiv I \cdot E[\pi_i^c] + \underbrace{\pi^g}_{=0} = \begin{cases} I \cdot (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - \sigma_\varepsilon^2) & \text{if } k_\varepsilon > \sigma_\varepsilon^2 \\ I \cdot (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - k_\varepsilon) & \text{if } k_\varepsilon \leqslant \sigma_\varepsilon^2 \end{cases}$$

On the contrary the expected aggregate profits in the commune case are $E[\pi^{vi}]$:

$$E[\pi^{vi}] \equiv E[\pi^p] + \sum_{i=1}^{I} E[\pi_i] = I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2) - k_\theta$$

If we want to compare these profits we have to distinguish two conditions in addition compared to the cooperative versus market comparison:[21]

Henceforth, in a) we assume that $k_\varepsilon \leqslant \sigma_\varepsilon^2$ whereas in b) we consider a parameter condition $k_\varepsilon > \sigma_\varepsilon^2$:

a)

$$E[\pi^{vi}] = I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2) - k_\theta \gtreqless I \cdot (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - k_\varepsilon) = E[\pi^c]$$

$$\Leftrightarrow k_\varepsilon \gtreqless \sigma_\varepsilon^2$$

We know from the above assumption in a) that $k_\varepsilon \leqslant \sigma_\varepsilon^2$. Hence, the cooperative structure is at least as efficient as the commune solution. The economic intuition for this result lies in the fact that subsidiaries do not invest k_ε in the vertically integrated case even if it were efficient in the aggregate.

b)

$$E[\pi^{vi}] = I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2) - k_\theta \gtreqless I \cdot (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - \sigma_\varepsilon^2) = E[\pi^c]$$

In this case both market structures generate the same aggregate profits.

Case 2

In case 2 we consider a parameter condition $\frac{k_\theta}{I} \leq \sigma_\theta^2 < k_\theta$. Again, we distinguish between a) where $k_\varepsilon \leqslant \sigma_\varepsilon^2$ and b) where $k_\varepsilon > \sigma_\varepsilon^2$:

a) Comparing the two profits we get the following interrelation:

$$E[\pi^{vi}] = I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2) - k_\theta \gtreqless I \cdot (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - k_\varepsilon) = E[\pi^c]$$

$$\Leftrightarrow k_\varepsilon \gtreqless \sigma_\varepsilon^2$$

[21] This is necessary because now we have incentive distortions with respect to the detection of ε_i in the commune solution.

We know from the above assumption in a) that $k_\varepsilon \leqslant \sigma_\varepsilon^2$. Hence, the cooperative structure is at least as efficient as the commune solution. The intuition for this result lies in the fact that the subsidiaries do not invest k_ε in the vertically integrated case even if it were efficient in the aggregate.

b)

$$E[\pi^{vi}] = I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2) - k_\theta \gtreqless I \cdot (\frac{1}{2}p_2^2 - \frac{k_\theta}{I} - \sigma_\varepsilon^2) = E[\pi^c]$$

In this case both market structures generate the same aggregate profits. Thus, no organizational form is preferable.

Note that the results in case 2 are identical to case 1.

Case 3

In case 3 we examine a parameter condition $\sigma_\theta^2 < \frac{k_\theta}{I} < k_\theta$. Furthermore in a) we assume $k_\varepsilon \leqslant \sigma_\varepsilon^2$ and in b) we consider $k_\varepsilon > \sigma_\varepsilon^2$.

a) Again, we compare the two profits:

$$E[\pi^{vi}] = I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2 - \sigma_\theta^2) \gtreqless I \cdot (\frac{1}{2}p_2^2 - \sigma_\theta^2 - k_\varepsilon) = E[\pi^c]$$

$$\Leftrightarrow k_\varepsilon \gtreqless \sigma_\varepsilon^2$$

We know from the above assumption in a) that $k_\varepsilon \leqslant \sigma_\varepsilon^2$. Hence, the cooperative structure is at least as efficient as the commune solution.

b)

$$E[\pi^{vi}] = I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2 - \sigma_\theta^2) \gtreqless I \cdot (\frac{1}{2}p_2^2 - \sigma_\varepsilon^2 - \sigma_\theta^2) = E[\pi^c]$$

In this case both market structures generate the same aggregate profits.

We notice that all results in case 1, two and three are identical. Therefore we just have to distinguish the parameter cases $k_\varepsilon \leqslant \sigma_\varepsilon^2$ and $k_\varepsilon > \sigma_\varepsilon^2$ comparing the commune and cooperative cases. If the first condition holds then the cooperative structure is (weakly) preferable. Otherwise if $k_\varepsilon > \sigma_\varepsilon^2$ then both structures generate the same expected aggregate profits.

4 Conclusion

In this paper we compare the efficiency of three different organizational forms in a specific economic setting. We show that idiosyncratic and general knowledge have important influences on aggregate profit of firms in our model. Comparing a commune to a cooperative solution we notice that a commune is less efficient if the costs of detecting the idiosyncratic element in the subsidiary is low relatively to the expected costs of doing nothing (e.g. having not invested into this detection). In that case the inefficiency stems from the fact that in a commune the individually subsidiaries do not have an incentive to produce optimally. Centralization leads to a situation where subsidiaries do not bear the costs of being inefficient. We believe that in many industries cooperatives are often formed in order to prevent these inefficiencies. In fact we agree with Bonus (1986) that idiosyncratic knowledge might be an important ingredient affecting a firm's success. Dictating instructions by a central company in a commune could destroy firm- or labour-specific knowledge based on experience. Comparing a market organization to a cooperative model we have distinguished three cases. It is of significance whether firms prefer to learn common environmental factors. In a cooperative the common factors will be distributed over all firms whereas in a market organization the firms do not cooperate with each other. Thus, efficiency strongly depends on the costs of (not) detecting the common factors. In addition, a relative high specificity of investment and a relative high number of firms imply to favour a cooperative solution.

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