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How upstream cooperatives limit downstream holdups

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In this paper, we consider a downstream firm negotiating with an upstream firm, and we investigate the impact of the organizational form of the upstream firm. We show that if the upstream firm is organized like a traditional cooperative, where the members have free delivery rights and where surplus is shared in proportion to the deliveries, the downstream firm is less subject to a holdup. The cooperative form makes it possible for the upstream firm to credibly commit to deliveries.

Traditional cooperatives are often considered as suffering from a volume management problem, which leads to excessive deliveries. Remedying this problem is the objective of the so-called new generation cooperatives. In a supply chain context, however, this problem may actually be beneficial. Specifically, it limits the upstream firm's ability to hold up the downstream firm, which in turn makes possible specific downstream investments that are closer to first best.

Our model lends structure to several real-world phenomena, including the apparent success of marketing cooperatives in farming, the success of open-end mutual funds, and the organization of aggregators in the new economy.

Key words: Cooperative, Volume Control, Holdup. JEL: L22, L23, Q13, Q42

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1. Introduction

Cooperative undertakings account for a substantial share of developed market economies, and that share is likely to grow with the advent of the new economy (Rey and Tirole (2007)). As documented by Hansmann (1996), even in the United States, cooperatives dominate or figure prominently in a number of industries, such as agriculture, credit cards, hardware, moving companies, electricity and the financial sector. Cooperatives may become even more prominent in the new economy. It is not obvious whether networks, standards, data, patent pools, etc., are best controlled by a single user or by a community of users.

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In a traditional marketing cooperative, the members are the primary producers and the joint owners of the cooperative. A salient feature of most traditional cooperatives is a high level of autonomy for members, the producers. In traditional marketing cooperatives, members can decide their production levels individually, and they have a right to sell their products at the average price of all similar products marketed by the cooperative. The cooperative therefore cannot use quantity control to increase prices in the downstream market. The cooperative cannot coordinate production levels as in a cartel. From an organizational perspective, this is usually considered a deficiency of the cooperative form and has been termed the quantity control problem or the volume management problem.

In this article, we examine whether this so-called volume management problem is necessarily a disadvantage. We show that in certain contexts, member autonomy can actually be an advantage in that it affects the way the company acts in the market.

We look at a situation where an upstream company "U(pstream)" sells to a downstream investor-owned company "D(ownstream)" and to a less attractive competitive commodity market "B(ulk)". For example, we can think of U as a dairy group, D as a supermarket chain and B as the market for milk powder. If D faces a specific investment, the holdup threat typically leads to underinvestment; the question we address now is what the ownership form of U means. We show that in this setting, the cooperative ownership of U can be an advantage in that it can reduce the holdup threat faced by D.

Therefore, in this paper, we study how ownership and governance structure at one stage of a supply chain affects another part of the supply chain. The paper is not one of optimal mechanism design. We do not optimize the ownership structure but compare familiar institutions such as an investor-owned corporation and a traditional nondiscriminatory cooperative.

The outline of the article is as follows: Section 2 provides a short introduction to cooperatives and cooperative sharing rules. Section 3 introduces the basic model, and Sections 4-6 characterize the solutions that result in the cases of vertical integration, an investor-owned upstream firm, and a cooperatively owned upstream firm, respectively. The solutions are compared in Section 7, in which we also provide a numerical example. Finally, different applications are discussed in Section 8, and conclusions are provided in Section 9.

2. Background and literature

Cooperatives come in many forms both nationally and internationally and it is therefore not easy to provide a universal definition of these organizations (cf. also Bogetoft and Olesen (2007)). A *pragmatic* definition of a cooperative is a firm that is owned and controlled by its users (instead of being owned and controlled by investors). To introduce slightly more *institutional details*, one can rely on the ICA (International Cooperative Alliance), a worldwide umbrella organization for cooperatives. The ICA revises the principles of cooperatives over time. However, from an economic point of view, the most important principles are still related to

1. *Membership*: This is voluntary and open to all who have an obvious interest in the activities of the cooperative.
2. *Decision-making rights*: Member control is democratic, based on the principle of one-person-one-vote.
3. *Capital*: Members' equity capital (the common assets) yields no return or only a minimal return. The members are jointly liable for the debts of the cooperative, often with limited liability.
4. *Earnings*: These are allocated to members according to their physical or monetary turnover with the cooperative.

Apart from loose adherence to the four general principles above, most cooperatives have a number of bylaws with a decisive influence on the activities of the business and with more or less direct linkages to the above principles. Two common provisions are

5. *The right to supply*: Members are entitled to supply all of their production to the cooperative.
6. *Equality*: Members shall be treated equally.

The exact meaning of the equality principle varies over time as well as from cooperative to cooperative. One of the most common features is, however, that the earnings of a supplier/marketing cooperative are allocated in proportion to the amount of products supplied by the members. Specifically, if member i produces q^i and all members produce the same homogeneous good, member i will be paid

$$x^i = \frac{q_i}{\sum\limits_{j \in J} q_j} R(\sum_{j \in J} q_j) = q_i \bar{p}$$

where $R(\cdot)$ is the cooperative net revenue after processing and marketing costs and $\bar{p}$ is the cooperative average net earning per unit of the product.

In a cooperative, the individual members retain a relatively high degree of *autonomy*, in the sense that important decisions, e.g., on production levels, are decentralized among the individual members. This is also the background of what is commonly considered an important challenge for cooperatives, namely, *the quantity control problem*, which refers to the fact that the total production quantity is not necessarily optimal. Problems of overproduction typically occur in cooperatives selling in imperfectly competitive ('thin') market, where increased production leads to lower unit prices. Additionally, overproduction may occur when there are decreasing returns to scale in processing, such that extra units are processed at higher marginal costs. The proportional allocation rule and the free right to supply means that a producer will not herself bear all the costs of increased production. If a producer increases its supplies to the cooperative, this will reduce average earnings via a price fall in the market for final goods or a cost increase in processing. However, the producer in question only bears part of this fall in average earnings. The reduced average earnings also affect the other members. The result of "forgetting" the negative spillover effect is overproduction. Everyone could be better off if production were reduced.

The theoretical literature has identified a series of additional *cooperative shortcomings* (cf., e.g., Albaek and Schultz (1998), Fulton (1995), and Hansmann (1996)).They include the free-rider problem, arising from the ability of new members to benefit frominvestments by old members, and the associated horizon problem, arising from the lack of interest in long-term investments with benefits realized over horizons exceeding the membership period. Additionally, the costs of democratic control have been discussed. The root of many of these problems lies in the (incomplete) allocation of property rights. A member of a cooperative does not receive all the benefits nor does it face all the costs of its activities. Part of the motivation for the development of so-called new generation cooperatives is to remedy these disadvantages by introducing closed memberships and tradable production rights (cf. Harris et al. (1996)).

The dominant role of cooperatives in some industries and the coexistence of cooperatives and investor-owned companies in others (cf. also Henrikse (1998)) suggest that cooperatives must have *comparative advantages* in some dimensions that can dominate or at least outweigh their disadvantages in others. One of the possible advantages is that primary producers avoid wrong production and investment levels due to *holdup* issues. Staatz (1984), among others, has argued that the risk of postharvest holdups against farmers is a primary reason for cooperatives' active presence in the marketing of short-lived agricultural products such as fruits, vegetables and milk.

In this paper, the risk of holdups is also important. It is, however, not holdups against primary producers but rather against a downstream monopsonist buyer that we focus on. We show that the volume control problem may serve as a commitment device that reduces the holdup against the downstream buyer and hereby makes it more attractive for the buyer to make specific investments. In effect, a downstream firm having a choice between a cooperatively owned and an investor-owned supplier may prefer the former.

Albaek and Schultz (1998) points to a related commitment benefit of the volume control problem. It happens when the cooperative sells in an oligopolistic market. In a Cournot market, there is an advantage to committing to a high production level since production levels are strategic substitutes. If a firm can push its reaction function outwards, e.g., by employing a manager whose salary depends on sales rather than profits, then this firm may gain since the other firms in the industry react by decreasing production (see, e.g., the papers by Vickers (1985) and Fershtman and Judd (1987)). Albaek and Schultz (1998) show that a similar mechanism is at play in an oligopolistic market where a cooperative faces ordinary profit-maximizing firms.

In summary, this paper suggests another advantage of the cooperative ownership related to the quantity control problem and downstream holdups. We show that the quantity control problem may actually benefit the members because it affects the way the company will negotiate with a downstream monopsonist buyer. The focus of the article is therefore on the interaction between ownership and management of business, on the one hand, and downstream market behavior, on the other.

In our model, the downstream firm is subject to a holdup problem because it must make a specific investment that is sunk and cannot be recovered. The subsequent bargaining with the upstream firm over price and quantity thus takes place over the quasi-rent (i.e., the specific investment cost is not considered) and the downstream firm consequently underinvests in the specific investment. The holdup problem emerges not just because of underspending on the specific investment, but also because the optimal response to that underspending is reduced output (which supports the underinvestment).

Because of the nature of the cooperative sharing rule, the primary producers overproduce. As a result, the cooperative processor is unable to credibly commit to the reduced output that would be optimal given that the specific investment has been sunk. In contrast, an investor-owned processor is able to credibly commit to this reduced output. Recognizing this lack of credible commitment when facing a cooperative, the downstream firm is able to spend more on the specific investment, which is beneficial to both it and the primary producers.

3. Model

We investigate a vertical relationship where $n \geq 2$ primary producers (e.g., farmers) deliver their production $q_i, i = 1, \ldots, n$ to a processing and marketing company U(pstream). U sells its products to company D(ownstream), which in turn sells the final product to consumers. The cost to the primary producer i when producing q_i is

$$c(q_i) = cq_i$$

and we assume that the processing and marketing cost in U is 0. U sells the quantity Q

$$Q \leq \sum_{i=1}^{n} q_i$$

at unit price p to D. D sells on a market with demand function

$$P(Q, I)$$

where I is a specific investment by D, e.g. in the promotion of these products from U. The sale does not entail any additional costs. We assume that U and D determine

$$(p, Q)$$

through a Nash negotiation ex post, i.e. after the initial investment has been determined.

Any excess production from the primary producers

$$Q_B = \sum_{i=1}^{n} q_i - Q$$

is sold by U in a less attractive, competitive goods market B(ulk) at price

$$p_B < c$$

Note that for simplicity, we assume a 1-to-1 relation between what is produced in the primary link and what is sold in the final markets.

The full timeline is illustrated in Figure 1 below.

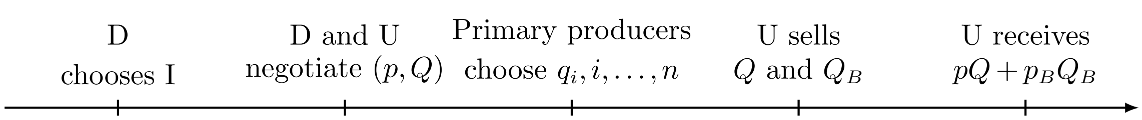

Figure 1 Timeline

Note that we assume (p, Q) to be determined by Nash bargaining ex post, i.e. after the initial investment. Hence, bargaining is taking place over the quasi rents and it is the lack of consideration of the investment cost in the bargain that is the source of the holdup problem, which a cooperative mitigates as we show in the paper.

In our model, D and U negotiate on the amount sold to D, Q, and the associated price per unit, p , before the individual producers choose their quantities, $q_1, \ldots, q_n$. This corresponds to a case where D and U makes a long term contract and is clearly a case to consider. It should be noted however that the parties in some contexts may also have the option to make short term contracts - and even renegotiate a long term contract. This could correspond to the case where Q and p are determined after the individual producers have made their quantity choice. Both ordering of the (Q, p) and $(q_1, ..q_n)$ decisions are therefore possible. In the paper, we focus on the ordering suggested by the timeline and we leave a full analysis of the alternative ordering to future research. Note also that a meat processing company, for example, may work with long term contracts with special retailer groups for more processed products while more bulk like products are sold on a competitive market with a fixed price p_B. In our model, we therefore have two markets, one allowing the sales of the negotiated Q at the price of p and the bulk market where $\sum_i q_i - Q$ is sold at the lower price p_B. In reality, the bulk price will seldom be known with full certainty when the farmers have to make their production decisions. The bulk price may therefore best be thought of as an expected price.

Since we assume that the ex post optimization is based on Nash bargaining, the inefficiencies we identify below are not the result of the classical double marginalization problem that occurs when two or more firms at different vertical levels in a supply chain each apply mark-ups to their prices. It may be worthwhile to analyze our problem under a no bargaining, classical double marginalization assumption as well. We leave this to another paper but conjecture that the cooperative form will have attractive properties in such settings as well because it is less attractive to reduce output and increase prices when the primary producers cannot directly be controlled.

There are of course several other natural extensions of our framework. Let us just mention one. In reality, upstream firms often support downstream sales through various marketing campaigns. This corresponds to a setting where also U makes an investment. Investment decisions in cooperatives raises a series of questions about voting rules and the sharing of investment costs among the members of the cooperative. Still as demonstrated in Albaek and Schultz (1997), it is likely that the result may be efficient cooperative investments. Presumably, therefore, it is likely that the introduction of U investments would make for more efficiency. Specific investments on both sides of a vertical relationship typically limits the holdup treat as it would hurt both parties. Since it is the limitation of the holdup treat that gives the cooperative form an advantage in our model, we can also conjecture that the comparative advantage of the cooperative form will decline in such an extended framework, where both U and D make investments

4. Integrated solutions

As a benchmark, let us assume first an entirely integrated and centrally controlled system where the primary producers, the upstream firm U and the downstream firm D are fully integrated. The total cost in the case is

$$\sum_{i=1}^{n} c(q_i) + I = \sum_{i=1}^{n} cq_i + I = cQ + I$$

and the integrated entity therefore choses I and Q to solve

$$\max_{\{I,Q\}} P(Q,I)Q - cQ - I$$

Note that we have here taken advantage of the fact that $p_B < c$; i.e., it never pays in a fully coordinated entity to produce for the B market.

We assume that the demand function $P(Q,I)$ is sufficiently regular to ensure the existence of a unique solution to the integrated problem[1]. The first-order conditions (FOCs) for an optimal solution to the integrated solution are

$$P(Q,I) + \frac{\partial P(Q,I)}{\partial Q} Q = c$$

and

$$\frac{\partial P(Q,I)}{\partial I} Q = 1$$

That is, marginal revenue must equal marginal cost in regard to both Q and I.

5. Investor-owned U

We now assume that U is investor-owned. In particular, U is not bound by the primary producers' right to supply and the sharing of net earnings in proportion to the primary deliveries, as in the case of a cooperative. Instead, U is a monopsony buyer with full bargaining power towards the primary producers.

We also assume that monopoly seller U and monopsonist buyer D cannot make long-term contracts. That is, they cannot negotiate the investment, the price and quantity ex ante, i.e. before the investment is undertaken. To characterize the outcome in this case, we must solve the model backwards.

5.1. Ex post optimization

With full control over the primary producers, the negotiation with them and subsequent production will be efficient. As the bulk commodity market B is not attractive, $c > p_B$, only the quantity Q that can be sold to D will be produced. Since there is no asymmetric information, we can assume that the monopoly seller U and the monopsonist buyer B bargain to create the largest possible surplus. This means that the production quantity is determined by

$$\max_Q P(Q,I)Q - cQ$$

i.e., U and D maximize the integrated profit for any given value of the specific investments I.

Therefore, the first order condition (FOC) for an optimum is

$$P(Q,I) + \frac{\partial P(Q,I)}{\partial Q} Q = c$$

[1] To ensure this, we might, for example, assume that

$$\frac{\partial P(Q,I)}{\partial Q} < 0, \frac{\partial P(Q,I)}{\partial I} > 0, \frac{\partial^2 P(Q,I)}{\partial Q^2} < 0, \frac{\partial^2 P(Q,I)}{\partial I^2} < 0 \text{ and } \frac{\partial^2 P(Q,I)}{\partial Q \partial I} = 0$$

We see that this corresponds to the condition of an optimal Q in the integrated solution. This does not mean, however, that the same amount is necessarily produced, since the specific investment I may differ.

5.2. Ex ante investment

Assuming symmetric Nash bargaining, the profits excluding I are split equally between the two parties. It follows that the downstream firm initially choses I to solve

$$\max_I \frac{1}{2}[P(Q,I)Q - cQ] - I$$

This follows from the fact that U gets half the profit (excluding I) but bears the full cost of the investment.

The FOC in this case is therefore

$$\frac{1}{2}\frac{\partial P(Q,I)}{\partial I}Q = 1$$

To show this, and similarly for the other ex ante cases below, one can either rely on the envelope theorem or simply use total differentiation and a simplification of the FOC for I using the FOC from the ex post problem of choosing (p,Q)[2].

The FOC shows that downstream firm D underinvests as a direct consequence of the holdup problem. Since half of the investment gains are captured by U in the ex post negotiations, D has less incentive to invest.

6. Cooperatively owned U

Let us now assume that the upstream processing and marketing firm U is cooperatively owned by the primary producers.

In this case, it is not necessarily the case that $\sum_{i=1}^{n} q_i = Q$. The autonomous primary producers, the members and owners of U, can choose to overproduce. In fact, they have incentives to do so since they are paid the average net earnings per unit of product. The average earnings are determined by the earnings in both markets. Although bulk production is actually loss-making because the primary producers' marginal costs are greater than the price here, $c > p_B$, the individual producer benefits from marginal production going to the bulk market since it is paid the average price

[2] From the ex post optimization, we have the optimal production level Q as a function of I, $Q(I)$. The investment problem for the downstream buyer D is therefore to choose I to solve

$$\max_I \frac{1}{2}[P(Q(I),I)Q(I) - cQ(I)] - I$$

After reorganizing the terms, total differentiation gives

$$\frac{1}{2}\frac{\partial P(Q,I)}{\partial I}Q + \frac{1}{2}[\frac{\partial P(Q,I)}{\partial Q} + P(Q,I) - c]Q\frac{\partial Q}{\partial I} = 1$$

The squared parenthesis is zero by the ex post optimization problem.

$$\bar{p} = \frac{[pQ + p_B(\sum_{j=1}^{n} q_j - Q)]}{\sum_{j=1}^{n} q_j}$$

To find the resulting equilibrium outcome, we must again solve the problems backwards.

6.1. Ex post optimization

Primary producer i chooses production level q_i to solve its profit maximization problem

$$\max_{q_i} \ \bar{p}q_i - cq_i = \max_{q_i} \ [pQ + p_B(\sum_{j=1}^{n} q_j - Q)]\frac{q_i}{\sum_{j=1}^{n} q_j} - cq_i$$

since its share of the U net revenue is equal to its share of total production. The corresponding FOC for an optimal production level reduces to

$$(p - p_B)Q\frac{\sum_{j=1}^{n} q_j - q_i}{(\sum_{j=1}^{n} q_j)^2} + p_B = c$$

Assuming a symmetric solution, $\forall i : q_i = q$, we can rewrite this as

$$(p - p_B)Q\frac{(n-1)q}{n^2q^2} + p_B = c$$

i.e., as

$$q = \frac{(n-1)}{n^2}\frac{(p - p_B)}{(c - p_B)}Q$$

We see how production increases towards infinity as the bulk price approaches the marginal cost. The fact that it goes to infinity is a consequence of constant marginal costs, but that it is growing reflects that the primary producer overproduces in an attempt to obtain a larger share of earnings. Each producer only takes into account how increased production reduces the price it receives, not how the price fall affects the other members. The individual members effectively act like the players in a Cournot oligopoly, cf. also Ireland and Law (1983) and Bogetoft and Olesen (2007)

The resulting profit π_i to producer i is

$$\pi_i(p, Q) = (pQ + p_B(nq - Q))\frac{1}{n} - cq$$

Inserting the optimal q, we obtain

$$\pi_i(p, Q) = (pQ + p_B(\frac{(n-1)}{n}\frac{(p - p_B)}{(c - p_B)}Q - Q))\frac{1}{n} - c\frac{(n-1)}{n^2}\frac{(p - p_B)}{(c - p_B)}Q$$

which reduces to

$$\pi_i(p, Q) = \frac{(p - p_B)}{n^2}Q$$

It may seem surprising that the profit to an individual producer does not directly depend on its marginal cost. The reason is, however, that the primary producers compete to obtain a large share of the extra gains $(p-p_B)Q$ from selling to downstream firm D instead of the bulk market. Primary producers use their production levels to obtain a larger share. Therefore, the marginal cost affects the production level, but the production level and thereby the marginal cost also determine the share of the earnings an individual producer can obtain. In effect, the role of the marginal cost cancels out.

Consider now the negotiation between upstream firm U and downstream firm D. Again, we assume that it is a Nash negotiation and the two parties are equally strong.

In the negotiations, U seeks to maximize the joint profit of its members,

$$\sum_{i=1}^{n} \pi_i(p,Q) = n\frac{(p-p_B)}{n^2}Q$$

D, on the other hand, seeks to maximize its profit, disregarding the costs I, which are sunk. That is, D will seek to maximize $(P(Q,I)-p)Q$. The objective function in the negotiation problem is the product of the two surpluses, and the negotiation problem can be formulated as

$$\begin{aligned} &\max_{Q,p} \; [(P(Q,I)-p)Q][n\tfrac{p-p_B}{n^2}Q] \\ &s.t. \quad p \geq c \\ &\qquad \tfrac{n-1}{n}\tfrac{p-p_B}{c-p_B}Q \geq Q \end{aligned}$$

The first condition says that agreeing with D on price p must be at least as good as the outside option of not producing at all. The second condition says that the members of U must produce enough to honor the agreed-upon production level Q.

The second inequality reduces to

$$p \geq \frac{nc-p_B}{n-1}$$

Since $c > p_B$, we also have

$$\frac{nc-p_B}{n-1} > c$$

The first inequality in the bargaining problem is therefore redundant, and the bargaining problem reduces to

$$\begin{aligned} &\max_{Q,p} \; \tfrac{1}{n}(p-p_B)(P(Q,I)-p)Q^2 \\ &s.t. \quad p \geq \tfrac{nc-p_B}{n-1} \end{aligned}$$

We can distinguish two types of solutions to this problem. One type is an *inner solution* where the constraint is not binding, i.e. where $p > \frac{nc-p_B}{n-1}$. The other type is a *constrained solution* where the constraint is binding, $p = \frac{nc-p_B}{n-1}$. In an inner solution, the negotiations between U and D leads to a price p that automatically makes it sufficiently attractive for the members of U to produce at least the agreed upon quantity Q. In a constrained solution, the settlement price p needs to be increased in order for the members to produce Q. The inner solutions correspond to situations where marginal costs are relatively low compared to the demand for the final product. The constrained solutions correspond to less lucrative settings.

In an *inner solution*, where we can ignore the side constraint, the FOCs with respect to Q and p can be reduced to

$$2(P(Q,I)-p)+\frac{\partial P(Q,I)}{\partial Q}Q=0$$

$$p=\frac{1}{2}(P(Q,I)+p_B)$$

If we insert the last FOC into the first, we obtain

$$P(Q,I)+\frac{\partial P(Q,I)}{\partial Q}Q=p_B$$

Compared to the integrated case and the case of an investor-owned U, we see that the solution involves higher production. In fact, there is overproduction for the given investment I. The marginal revenue on the left-hand side is set equal to the bulk price p_B and not to the real marginal cost c. The intuition is that the extra production for the D market can be taken from the bulk market at an alternative cost of p_B that is lower than the marginal production cost c. Let Q^* be the solution to this problem.

In the case of a *constrained solution*, i.e., a solution with the binding side-constraint, the first-order condition with respect to Q is the same since Q is not part of the constraint.

The constrained solution therefore fulfills

$$2(P(Q,I)-p)+\frac{\partial P(Q,I)}{\partial Q}Q=0$$

$$p=\frac{nc-p_B}{n-1}$$

Inserting the last condition in the former, we obtain

$$P(Q,I)+\frac{1}{2}\frac{\partial P(Q,I)}{\partial Q}Q=\frac{nc-p_B}{n-1}$$

Let Q^{**} be the solution to this problem.

It may seem surprising that downstream buyer D pays a price per unit of

$$p=\frac{nc-p_B}{n-1}$$

Consider, for example, the case where the bulk market is basically absent, $p_B=0$. In that case, we have

$$p=\frac{nc}{n-1}$$

Therefore, the buyer pays more than the primary producer's fixed marginal cost c. Intuitively, one may therefore think that the primary producers would expand their production indefinitely.

This is not the case, however. The marginal revenue going to the individual producer is less. In fact, it is precisely c. The reason is that the total revenue to the cooperative is fixed. Therefore, the only effect of producing more comes from the fact that the individual producer can extract a larger share of the cooperative's fixed revenue. Therefore, the individual producer contemplating an increase in production does not obtain marginal revenue of $\frac{nc}{n-1}$ but of c. To see this formally, let us imagine that the downstream buyer pays $\tilde{p}$. Now, producer i's profit is

$$\tilde{p}Q\frac{q_i}{\sum_{j=1}^n q_j} - cq_i$$

The FOC for an optimal q_i is therefore

$$\tilde{p}Q\frac{\sum_{j=1}^n q_j - q_i}{(\sum_{j=1}^n q_j)^2} - c = 0$$

In equilibrium, all primary producers produce q, and the first-order condition reduces to

$$\tilde{p}Q\frac{(n-1)q}{(nq)^2} - c = 0$$

or

$$\tilde{p} = \frac{nc}{n-1}\frac{nq}{Q}$$

The downstream buyer only wants a production of Q and therefore has no interest in a payment that leads to overproduction, $nq > Q$. The downstream buyer can therefore use a payment of $\tilde{p} = \frac{nc}{n-1}$.

The traditional quantity control problem for cooperatives suggests that cooperatives tend to overproduce since each individual member looks at the increase in total revenue and its share of the revenue. When demand is downwards sloping, this leads to overproduction since the individual member does not internalize the price decline that its increased production imposes on others. In the constrained case we study here, the incentives to increase production are weaker. Total revenue does not increase when production increases, and only the share of the revenue is affected. This leads to much weaker incentives and forces the downstream buyer to pay more than would be required could D contract directly with the individual producer.

6.2. Ex ante investment

Downstream firm D seeks to choose investment I to maximize its profit. Consider first the case of an inner solution. When we insert ex post production and price levels into D's profit function, we obtain that D's ex ante profit is

$$\Pi_D^* = (P(Q,I) - p)Q - I = \frac{1}{2}(P(Q^\star, I) - p_B)Q^* - I$$

Using total differentiation and simplifying using the ex post FOCs, we obtain that the FOC for optimal investment I is

$$\frac{1}{2}\frac{\partial P(Q^*,I)}{\partial I}Q^* = 1$$

Since D only obtains half of the gains from producing for its market rather than the bulk market, D underinvests for the given production level Q^*. On the other hand, production level Q^* is higher than it is in the case with an investor-owned upstream firm U, and the resulting investment level may therefore also be more efficient in the case of a cooperatively owned U.

In the constrained solution, the optimal production level was Q^{**}, and the profit of D is

$$\Pi_D^{**} = (P(Q,I)-p)Q - I = (P(Q^{**},I) - \frac{nc-p_B}{n-1})Q^{**} - I$$

Optimizing with respect to I, once again using total differentiation and simplifying using the ex post FOC, we obtain the following FOC for an optimal investment level

$$\frac{1}{2}\frac{\partial P(Q,I)}{\partial Q}\frac{\partial Q^{**}}{\partial I}Q^{**} + \frac{\partial P(Q^{**},I)}{\partial I}Q^{**} = 1$$

This case is slightly more complicated since the price paid to the cooperative is fixed, and therefore the ex post prices do not change. We see that there are two effects of investing. One is the direct effect of the investment on the final good price and hereby on D's revenue, $\frac{\partial P(Q^{**},I)}{\partial I}Q^{**}$. Investing leads to a higher final goods price. There is, however, also a (negative) indirect effect on the final goods price. Since the optimal production level also increases, this tends to lower the final good price, $\frac{1}{2}\frac{\partial P(Q,I)}{\partial Q}\frac{\partial Q^{**}}{\partial I}Q^{**}$.

Therefore, even in the constrained case where downstream firm D does not share the price gains directly with the cooperative, the downstream firm obtains less than the full margin and therefore underinvests.

7. Comparisons

Let us first note that a cooperatively owned U leads to an inner solution when

$$\frac{1}{2}(P(Q,I)+p_B) \geq \frac{nc-p_B}{n-1}$$

The left-hand side is the average of the prices U gets from selling to the final goods market via D, $P(Q,I)$, and to the bulk market, p_B. The right-hand side is (a little) larger than c since $c > p_B$

$$p* = \frac{nc-p_B}{n-1} = \frac{nc-c}{n-1} + \frac{c-p_B}{n-1} = c + \frac{c-p_B}{n-1}$$

We therefore see that in situations with a relatively high price in the final goods market in relation to marginal costs, we obtain an internal solution. In other words, when the final goods market is relatively *lucrative* (or marginal costs are low) so that this inequality is met, the indirect Cournot competition between the primary producers means that they overproduce and thus ensure that U can live up to its supply obligations towards D. If, on the other hand, the primary goods market is *less lucrative* (or marginal costs are high), we obtain the constrained solution with a cooperatively owned U.

The FOCs in our different settings are summarized in Table 1.

	FOC for Q	FOC for I	Profit of D
Integrated	$P(Q,I)+\frac{\partial P(Q,I)}{\partial Q}Q=c$	$\frac{\partial P(Q,I)}{\partial I}Q=1$	
Investor-owned U	$P(Q,I)+\frac{\partial P(Q,I)}{\partial Q}Q=c$	$\frac{1}{2}\frac{\partial P(Q,I)}{\partial I}Q=1$	$\frac{1}{2}(P(Q,I)-c)Q-I$
Coop-owned U inner	$P(Q,I)+\frac{\partial P(Q,I)}{\partial Q}Q=p_B$	$\frac{1}{2}\frac{\partial P(Q,I)}{\partial I}Q=1$	$\frac{1}{2}(P(Q,I)-p_B)Q-I$
Coop-owned U constr.	$P(Q,I)+\frac{1}{2}\frac{\partial P(Q,I)}{\partial Q}Q=p*$	$\frac{1}{2}\frac{\partial P(Q,I)}{\partial Q}\frac{\partial Q}{\partial I}Q+\frac{\partial P(Q,I)}{\partial I}Q=1$	$(P(Q,I)-p*)Q-I$

Table 1 Characteristics of the optimal solutions in different settings.

Consider first the production conditions. Since $p_B < c$ and p^* is only sightly above c for reasonable values of n, we see that as long as c is not too large the FOCs for Q leads to higher production levels under cooperative-ownership compared to investor-owned ownership of U.

It follows also that the investment level under cooperative ownership will be higher as long as c is not too large. The investment level under cooperative ownership will therefore tend to be closer to the integrated case.

Both effects will make profits to the downstream buyer D larger under cooperative-ownership of U compared to the investor-owned U for values of c that are not too large. D will therefore in many settings prefer negotiating and trading with a cooperative compared to investor-owned U.

Let us close by considering a more specific example where we assume that

$$P(Q,I)=2+\sqrt{I}-Q$$

In this case, the investment I induces a parallel upwards shift in the demand function. Via a series of trivial yet tedious manipulations of the FOCs and side constraints above, we obtain the solutions shown in Table 2.

	Integrated	Investor-owned U	Coop-owned U Inner solution $p_B \geq A$	Coop-owned U Constrained solution $p_B < A$
Investment $\sqrt{I}$	$\frac{2-c}{3}$	$\frac{2-c}{7}$	$\frac{2-p_B}{7}$	$\frac{4-2p^*}{7}$
Production Q	$\frac{2(2-c)}{3}$	$\frac{4(2-c)}{7}$	$\frac{4(2-p_B)}{7}$	$\frac{6(2-p^*)}{7}$
Final price $P(Q,I)$	$\frac{4+c}{3}$	$\frac{8+3c}{7}$	$\frac{8+3p_B}{7}$	$\frac{6+4p^*}{7}$
Trading price p		$\frac{4+5c}{7}$	$\frac{4+5p_B}{7}$	$p^* = \frac{nc-p_B}{n-1}$
Profit of D		$\frac{(2-c)^2}{7}$	$\frac{(2-p_B)^2}{7}$	$\frac{2(2-p^*)^2}{7}$

Table 2 Solutions when $P(Q,I) = 2 + \sqrt{I} - Q$. **(**$A = \frac{7nc-4(n-1)}{5n+2}$**)**

To interpret the results, recall that $p_B < c < p*$. The formulas reflect how trading with a cooperatively owned U leads to investment levels that are more reminiscent of the integrated case than those in the case where D deals with an investor-owned U. We see specifically how the marginal cost c is replaced by the bulk price p_B in the case of an internal solution under cooperative ownership. In the case of a constrained cooperative solution, the investment $(\frac{2(2-p^*}{7})^2$ is almost four time higher than under investor ownership of U when p^* is only slightly higher than c.

An illustration of the profits to downstream firm D is given in Figure 2.

With the investor owned U, the profit to D, $\frac{(2-c)^2}{7}$, depends only on the marginal cost c to the primary producers. The D profit in this case is illustrated by the thick blue graphs.

When U is a cooperative, the D profit is illustrated by the thick red graphs. The details of the solutions depend on the number of primary members n, the price at the bulk market, p_B and the marginal costs c. For small value of c, the inner solution suffices to produce the desired output Q. For larger values of c, we get the constrained solution.

The vertical lines show the values of marginal costs c making the different organizational structures optimal for the downstream firm.

In the top panel, we assume only 2 primary producers, and we assume that the bulk market price p_B is 0. In this case, we see that from the point of view of downstream firm D, cooperatively owned processing and marketing firm U is preferable as long as marginal costs are no larger than approximately 0.45. If we increase the number of primary producers to $n = 10$, the cooperative solution is preferred by D for all marginal costs except for those above approximately 1.5. This is illustrated in the middle panel. Finally, we note that if we introduce a bulk market with a price of 0.3, marginal costs below 0.3 of course lead to infinite production. More importantly, the profit to the downstream firm declines in the case of an inner solution since the primary producers now have at least somewhat attractive alternatives. This is illustrated in the bottom panel.

The intuition of these outcomes is as follows. For small values of marginal costs c, the primary producers are willing to produce a large quantity. Their incentives to capture a large share of their joint profits lead to nontrivial production for the bulk market in the inner solution. In this case, the price firm D has to pay is relatively low. As the marginal costs increase, a higher internal price between U and D firms is necessary to ensure that enough is produced. The constrained solution makes the profit decline when the marginal cost increases. Lastly, when the marginal cost becomes sufficiently high, it may be better for firm D to be able to make a contract with an investor-owned U who has more control of the production level of the primary producers. An investor-owned upstream U has the advantage that it can make take-it-or-leave-it contracts with the primary producers.

8. Applications

The theory in this paper lends structure to several real-world phenomena, including the apparent success of marketing cooperatives in farming, the widespread use of mutual funds and the construction of aggregators in, for example, the energy sector.

8.1. Farming

An obvious application is to think of the coop members as farmers who jointly operate a processing and marketing cooperative. The cooperative can sell products to either a downstream firm or to a less lucrative bulk market. For example, you can think of U as a dairy group, D as a supermarket chain and B as the market for milk powder. As the specific investment, we might think, for example, of a sales promotion activity intended to boost consumers' perceived value of the upstream firm's products.

We have seen that the investment level under cooperative ownership is closer to the first-best integrated investment level than it is in the setting where the upstream firm is investor-owned. Likewise, we have seen that the profits to the downstream supermarkets are larger if the upstream firm is a cooperative rather than an investor-owned entity, if the marginal costs are not very high, or if the cooperative has only a few members. We see therefore that if the downstream firm initially has a choice between two alternative upstream suppliers, one being investor-owned and one being cooperatively owned, the firm would often prefer to trade with the cooperatively owned firm.

This may help explain the apparent success of processing and marketing cooperatives in farming in many countries. Not only do such cooperatives reduce the hold-up risk against farmers, as it have

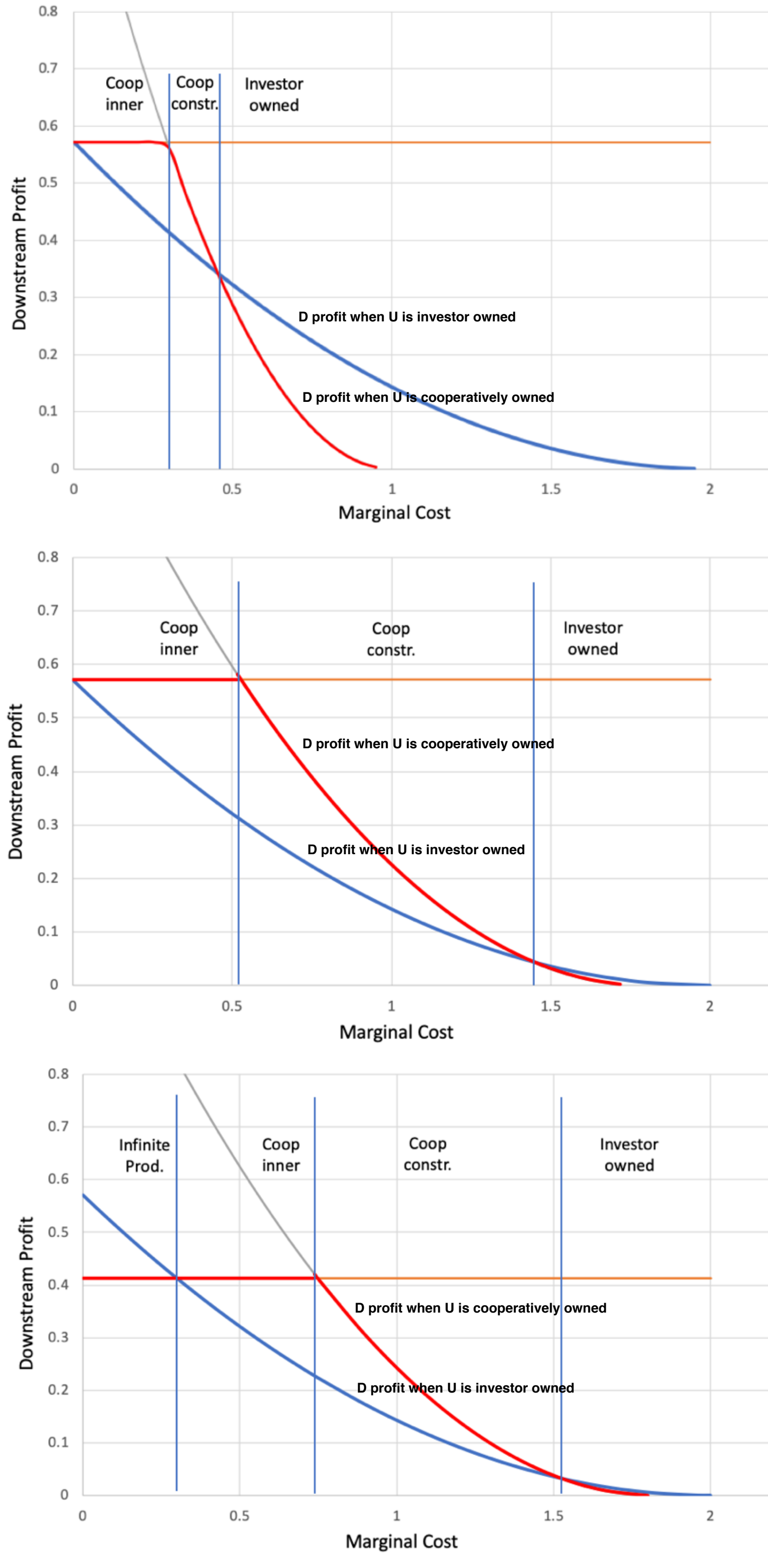

Figure 2 Profit of D as a function of marginal cost c **when**
$$P(Q, I) = 2 + \sqrt{I} - Q$$
Top: $n = 2, p_B = 0$. **Middle:** $n = 10, p_B = 0$. **Bottom:** $n = 10, p_B = 0.3$.

previously been emphasized in the literature. Cooperatives also reduce the hold-up risk against a downstream buyer, as shown in this paper.

8.2. Mutual Funds

Mutual funds are another arrangement that our framework can help elucidate. Mutual funds pool money from their members and use that money to buy other securities, usually stocks and bonds. The upstream firm in this case would be the board of directors, and the downstream firm would be the funds management firm. In our stylized model, the management firm can invest in T-bonds with a return p_B that is lower than the investors' costs of providing capital, c, and they can invest in a primary product, which we can think of as stocks, providing a return of $P(Q, I)$.

The earnings on the underlying securities are shared among the members in proportion to their individual investments. Mutual fund shares can typically be purchased or redeemed as needed at the fund's current net asset value (NAV) per share, which is typically settled at the end of each trading day. Hence, a marginal investment is not paid its marginal profit but the average profit of all investments of the mutual fund.

Mutual funds can be divided into closed-end and open-end funds. Closed-end funds have a set number of shares issued to subsequent members through an initial public offering. This is very similar to the idea of a new generation cooperative. A majority of mutual funds are open-end, however, much like a traditional cooperative. An open-end mutual fund does not have a set number of shares. Instead, the fund issues new shares to an investor based upon the current net asset value and redeem the shares when the investor decides to sell. Open-end funds always reflect the net asset value of the fund's underlying investments because shares are created and destroyed as necessary.

We might assume that the mutual fund invests first in the must profitable underlying securities and later in less lucrative ones. Alternatively, we might assume that it becomes increasingly difficult for managers to find good investments when a larger amount comes under administration. Either way, open-end mutual funds potentially suffer from a volume management problem. By investing more, an individual investor extracts part of its surplus from the fact that its marginal investment is paid the average gains and not the lower marginal gains to the mutual fund.

Our model suggests that this drawback comes with an advantage when long-term contracts cannot be signed, i.e., when the members cannot commit to leaving the funds untouched for an extended period. In this case, there is an increased risk of underinvestment in research and development in the management firm. The cooperative sharing of the surplus and the tendency to overinvest alleviate this problem.

8.3. Aggregators

In many sectors, decentralized small scale activities have to be aggregated to be useful in other parts of the the sector. This happens for example in the energy sector as well as in the gig economy, in crowd sourcing contexts etc

A good example of this is the electricity sector. Decentralized and renewable energy production is often small scale and have to be aggregated to substitute for large scale generation to cover consumption and to help balancing of the energy networks. Likewise, demand management and flexibility involves a series of individual consumers that are paid to adjust demand or to hand over some of its planned consumption in terms of flexibility products. An important question is how to rely on such decentralized sources. The cooperative form is an interesting solution to this problem that is already used in several countries. In general, as explained by Capellán-Pérez et al. (2018), European renewable energy cooperatives started in the 1970s and 1980s with the promotion of community-owned wind energy projects but, as time went by, new technologies are being incorporated such as photovoltaics, as well as covering heating needs by the use of biomass boilers or solar thermal panels connected to district heating networks.

As shown in this paper, organizing aggregators as cooperatives may serve to avoid not only hold-ups against the small scale producers and consumers, but also against the buyers of such services, i.e. wholesale and retail sellers of energy.

The fact that members of a traditional cooperative behaves more or less like Cournot competitors make sourcing from a cooperative very cost efficient. Even disregarding the specific investment, it is interesting to look at a small example. Assume that a buyer has a fixed sourcing budget of A. Also, let us assume that the small scale sellers share the budget in proportion to their share of aggregate production

$$\text{Share } S_i = \frac{q_i}{\sum_{j=1}^{n} q_j}$$

Alternatively, one can - in line with the tournament literature, cf. eg. Lazear and Rosen (1981), - think of A as a grand prize and let the probability of winning be S_i. Either way, producer i will in this case solve the following problem

$$\max_{q_i} A \frac{q_i}{\sum_{j=1}^{n} q_j} - cq_i$$

The FOC for an optimal production level is therefore

$$A \frac{\sum_{j=1}^{n} q_j - q_i}{(\sum_{j=1}^{n} q_j)^2} - c = 0$$

In symmetric equilibrium, $q_j = q \; \forall j$, we obtain

$$A \frac{n-1}{n^2 q} - c = 0$$

or equivalently

$$q = \frac{A}{nc}\frac{n-1}{n}$$

If the buyer could contract directly with the primary producers, he could incentivize them to each produce $\frac{A}{nc}$. For large values of n, the fraction $\frac{n-1}{n}$ is almost equal to one, and therefore the production the buyer can source from the cooperative is almost the same. This shows the efficiency of buying from an upstream cooperative even when no specific investment is at stake.

9. Conclusions

We have shown that in a vertical relationship between an upstream supplier U and a downstream investor-owned buyer D, there may be certain advantages to U being cooperatively owned instead of investor-owned. These benefits stem from the volume management problem that a traditional cooperative faces because members have free delivery rights and net earnings are shared among members in proportion to their deliveries. The volume management problem affects the opportunities for D to be threatened with a holdup when it makes an ex ante investment. In the case of an investor-owned U, the holdup problem leads to investment and production levels that are further away from the first-best solution than is the case when U is cooperatively owned. In this way, the cooperative ownership of the processing and marketing organization not only serves to protect the up-stream providers against hold-up, it also protects the downstream buyers.

The results in this paper lends structure to several real-world phenomena. To illustrate this, we have discussed the apparent success of marketing cooperatives in farming, the widespread use of open-ended mutual funds and the construction of aggregators in, for example, the energy sector.

There are many obvious extensions of this work. It would for example be relevant to introduce asymmetric information about production costs c. In one such setting, Bogetoft (2005), we consider how to organize the processing and marketing of an agricultural product when farming costs are known only by the individual farmers. We show that when marginal costs are uncorrelated, the market for final goods is competitive, and the market for processing is noncompetitive, the socially optimal production levels are sustained by a cooperative and a cooperative only.

Another extension could be to make more specific case studies and to study settings where traditional cooperatives have been successful and where New Generation Cooperatives NGCs have failed, cf., e.g., Grashuis and Cook (2018) for a recent discussion. NGCs have been formed in part to cope with the volume control problem of traditional cooperatives, but as shown in this paper, this problem may actually benefit downstream investments and demand.

It would also be interesting to make a carefull analysis of some of the sectors of the modern economy, including the ever expanding gig-economy. It is very likely that some of the organizational solutions that has served generations of small family farms could be useful in such settings.

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