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Bottleneck co-ownership

Abstract

This paper proposes a regulatory mechanism for vertically related industries in which the upstream "bottleneck" segment faces significant returns to scale while other (downstream) segments may be more competitive. In the proposed mechanism, the ownership of the upstream firm is allocated to downstream firms in proportion to their shares of input purchases. This mechanism, while preserving downstream competition, partially internalizes the benefits of exploiting economies of scale resulting from an increase in downstream output. We show that this mechanism is more efficient than a disintegrated market structure in which the upstream natural monopoly bottleneck sets a price equal to average cost.

JEL classifications: L22, L51

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1. Introduction

The paper proposes a regulatory mechanism for vertically related industries characterized by a fair degree of downstream competition, but by limited scope for competition in at least one of the upstream production stages.

For expositional simplicity, we assume for the rest of the paper that the vertical industry is composed of only two sectors, an upstream "bottleneck" sector characterized by increasing returns to scale, and a workably competitive downstream sector. Results can be easily extended to a more general case.

We exploit the vertical configuration to design a regulatory system for the industry in which downstream firms are required to form a production joint venture to co-own the bottleneck. In this bottleneck co-ownership (BC) agreement, the ownership of the input provider is shared among the downstream firms, and the ownership share of each downstream firm equals its share of purchases in the input market. This mechanism possesses a number of desirable properties.

(1) A single firm operates in the upstream sector, thereby efficiently exploiting upstream economies of scale.

(2) The nature of ownership of the upstream firm extends the downstream competition to the upstream sector. Thus, the BC ownership structure provides an alternative form of vertical relation, beyond the traditional distinction between vertically integrated and vertically disintegrated market structures.[1]

(3) The BC mechanism partially internalizes the cost externality due to upstream economies of scale by encouraging each downstream firm to "move down" the upstream average cost curve. Indeed, with scale economies any increase in output generates a reduction of average cost. Under vertical disintegration and linear input pricing, the input price is set *before* (and independently of) the input quantity decision. The actual output decision does not affect the per-unit input price, so that downstream firms do not appropriate the benefit from increasing output.[2] Under the BC mechanism, the input pricing and the input/output quantity decisions are made *simultaneously* (hence, the downstream firms' output decisions affect the upstream price) (4) The ownership link mitigates the problem of double marginalization (see Spengler (1952)) that comes up in the presence of vertically disintegrated imperfectly competitive stages of production.

(5) The informational requirement imposed on the regulator is limited. Following the definition in Vickers (1995), the BC mechanism is a form of structural regulation (as opposed to conduct regulation). Under structural regulation, the policy maker mandates a market structure (in this case, the nature of ownership) within which firms are free to set their strategic variables. The policy maker does *not* intervene directly to set firms' strategic variables, or impose constraints on their choices (actions associated with conduct regulation).

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[1] Such distinction, and the identification of the optimal vertical structure, have been the object of extensive research for both the unregulated and the regulated sectors. See, for example, Gilbert and Riordan (1995), Lee and Hamilton (1999), and Kühn and Vives (1999).

[2] An increase in output in fact generates a decrease in cost for the upstream firm (hence an increase in upstream profit). However, since the upstream price is set prior to the input/output purchase decision, the upstream benefit cannot be transferred to the downstream firms.

When compared to conduct regulation, structural regulation is less demanding, in terms of its informational requirement. Notwithstanding that, the schemes proposed by a large part of the literature, namely price and profit regulation, are forms of conduct regulation. Their successful implementation is, in general, subject to sufficient knowledge of the demand and/or of the cost functions by the regulators (see, for example, Loeb and Magat (1979) for the non-Bayesian regulation literature, and Laffont and Tirole (1990), Baron and Myerson (1982), and Sappington (1983) for the Bayesian regulator literature. These papers explicitly model the informational asymmetry between the regulator and the regulated firm).

The best known example of this type of structural regulation is due to Demsetz (1968), who argues that average cost pricing can be achieved by auctioning the monopoly franchise rights, and allocating the right to manage the monopoly to the firm offering to sell the product at the lowest price. As is well known, the outcome of such an "ideal" Demsetz auction upstream is equivalent to the standard "second best" result of upstream average cost pricing - the most efficient uniform pricing outcome if transfers from other sectors of the economy are ruled out (see Spulber, 1989). This "upstream average cost pricing" (AC) mechanism has two parts (i) inputs are delivered to downstream firms at average cost; (2) downstream firms compete à la Cournot. To preview our main result, we show that the total surplus resulting from the BC mechanism proposed here exceeds that resulting from application of the AC mechanism.

Clearly, another natural benchmark consists in the industry second best, i.e., in the integrated industry average cost pricing, which would emerge in an "ideal" Demsetz auction for the vertically integrated sector. However, in this paper, we do not analyze the integrated industry average cost pricing benchmark, as we start from the consideration that liberalization of the potentially competitive sectors in vertically related markets is something per se desirable for a set of reasons which we do not explicitly model (see, for instance, Armstrong and Sappington, 2006, for an extensive discussion).

Co-ownership arrangements, such as joint ventures, have been analyzed quite extensively in the management and in the economics literature. Most of the work has focused on horizontal arrangements (see, for example, Bresnahan and Salop, 1986).[3]

The management literature (see, for example, Kogut, 1988) explains the emergence of joint ventures with three alternative reasons: transaction costs, organizational learning, and strategic behavior (in particular, consisting in entry deterrence and hedging against uncertainty). This literature models the emergence of endogenous profit-maximizing arrangements. Under a set of parameter values, the BC arrangements here proposed might as well emerge spontaneously in the context of a vertical industry, and could therefore be classified as ventures established for strategic reasons.

To our knowledge, the only paper that explicitly models vertical joint ventures is Park and Ahn (1999). Their environment is similar to that of our paper, with an upstream monopoly owned by the downstream competitors (thereby mitigating the double marginalization problem). However, in Park and Ahn, the upstream ownership shares are exogenously allocated. Hence, their mechanism, differently than ours, does not feature the desirable property of internalization of the cost externality due to upstream economies of scale (which crucially depends on the endogenous allocation of the upstream ownership shares).

A particularly suitable application for the BC mechanism lies in vertically connected network industries in which the network displays significant economies of scale, while the downstream retail sector is reasonably competitive. In the liberalized network markets, the BC mechanism could be regarded as a

[3] See also Boffa and Kiesling (2008) for an analysis of competitive joint ventures with an application to the electricity distribution sector.

welfare enhancing solution halfway between the two currently observed organizational modes: full vertical integration and disintegration

Input co-ownership agreements, especially in the form of joint ventures for the management of a particular asset, exist and are often employed in the real world. Spontaneous joint venture arrangements are observed, among other sectors, in pharmaceutical research and development, computer memory chip production, and oil pipelines: All of these sectors display significant economies of scale, which could potentially be exploiting the profitable internalization of scale economies induced by the BC through the proportion between upstream ownership shares and share of input purchases.

In the regulated sectors, forms of co-ownership (or competitive joint ventures) exist, for example, in the management of the electricity distribution companies in New Zealand. However, the ownership shares are fixed ex ante, and unrelated to the share of input purchases.

The present paper focuses on pricing issues, neglecting the (albeit important) issue of investment incentives and scope for product differentiation if the BC mechanism had to be implemented.

The rest of the paper is organized as follows: Section 2 illustrates the economic environment and the characteristics of the BC arrangement; Section 3 analyzes the model; Section 4 presents a linear example; Section 5 shows the performance of the BC in a repeated game framework, where collusive behaviors may emerge. Finally, Section 6 concludes.

2. The economic environment

2.1. The industry structure

Consider a vertical structure where the upstream sector exhibits increasing returns to scale, while the downstream stage is workably competitive. Both productive stages are essential for producing the final good. There are N firms that operate downstream. The downward sloping inverse demand curve for the homogeneous final product is given by $P(Q)$.

For simplicity, assume the upstream firm is a single-product firm that produces exclusively for the downstream sector at a cost $C(Q)$. Each downstream firm employs a fixed proportions technology where one unit of upstream input, combined with a given amount of additional inputs obtained at a constant marginal cost c_d, assumed to be null in what follows, produces one unit of output.[4] A one-to-one technology captures well the essence of the technological features in many network industries, where one unit of input flowing in the network (and bought by the downstream firm) is transferred to the end-users. Let p_U denote the input price charged to the downstream sector.

2.2. Ownership rules in the BC mechanism

The structural regulation imposed by the regulator involves each of the downstream firms owning a share of the upstream firm proportional to its share of upstream purchases.[5] The fact that the same parties compete downstream, while cooperating in the upstream firm, may generate incentives that could lead to inefficient discrimination among downstream firms. In order to avoid these potential inefficiencies, the regulator does not allow the upstream firm to price

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[4] For notational simplicity, we assume that the downstream firms are identical. However, our results would be unchanged if we allowed the downstream firms to have different (constant) marginal costs.

[5] Under homogeneity of downstream firms, the shares of input purchases are also equal to the equilibrium shares in the final product market, so that upstream ownership follows downstream market share. However, the mechanism would display analogous properties allowing for heterogenous (albeit constant) downstream marginal costs. In such case, the identity between upstream ownership shares and downstream market shares would not be preserved.

discriminate among downstream firms.[6] Alternative inefficient pricing policies, such as sabotage[7], should be avoided by specifying an appropriate institutional design of the decision-making procedure within the upstream bottleneck co-ownership.

3. Analysis of the model

We first characterize the equilibrium output under the AC mechanism: i.e., under upstream average cost pricing, followed by downstream oligopolistic competition. Given the input price p_U, the input demand by the downstream industry is determined by the Cournot Nash equilibrium of the firms' rivalry in the final product market. Therefore, we begin with:

Assumption 1: (i) There exists a Cournot-Nash equilibrium for all positive p_U. (ii) The equilibrium is unique when p_U is sufficiently low so that firms produce positive outputs in equilibrium. (iii) This unique equilibrium is "well-behaved" in the sense that the equilibrium industry quantity of input (and output) is decreasing in p_U.

Parts (i) and (ii) require only minor regularity conditions on the market inverse demand function. Although part (iii) involves a substantive regularity

[6] For the main results of the paper to apply (i.e., for the *BC* rule to be welfare enhancing with respect to the *AC* arrangement), it is sufficient to assume that all the firms involved in the co-ownership observe the cost function, and the court in charge for the enforcement of the rules observe the transfer price, p_U, ensuring that it is non-discriminatory across the downstream firms.

[7] In the context of a vertical structure, sabotage is usually defined as an action taken by the upstream entity (assumed to have some degree of market power) aimed at increasing the cost of one or more of the downstream competitors, without raising upstream revenue. While sabotage is a source of productive inefficiencies, it may prove profit-maximizing when the upstream firm is vertically integrated with one of the downstream competitors, and the access price is regulated. In such cases, the integrated company extracts profits by increasing its downstream division's market share, as a result of the extra costs imposed to its competitors. The *BC* mechanism, which prohibits explicit market discrimination, is a potential candidate for sabotaging activities.

condition, it is quite plausible. It merely requires that the derived inverse demand function for the upstream input be downward sloping.[8]

In equilibrium, each individual downstream firm chooses its quantity q_i by solving the following maximization problem:

$$\max_{q_i} \pi_i(q_i, Q_{-i}) = q_i P(q_i + Q_{-i}) - p_U q_i; \qquad Q_{-i} \equiv \sum_{j \neq i} q_j = Q - q_i$$

For each firm, the First Order Necessary Condition for an interior optimum is given by:

(1) $$\frac{\partial \pi_i}{\partial q_i} = q_i P'(Q) + P(Q) - p_U = 0$$

Summing equation (1) over all N firms yields:

(2) $$x(Q; p_U, N) \equiv QP'(Q) + N[P(Q) - (p_U)] = 0$$

Equation (2) characterizes equilibrium (upstream and downstream) industry output as an implicit function of the input price and the number of firms.

Next, we give content to Assumption 1(iii) by performing comparative statics analysis on equation (2). By the Implicit Function Theorem:

(3) $$\frac{\partial Q^{AC}}{\partial p_U} = -\frac{x_{p_U}}{x_Q} = \frac{N}{Q^{AC} P''(Q^{AC}) + (N+1) P'(Q^{AC})}$$

Thus a necessary and sufficient condition for Assumption 1(iii) to be satisfied is $x_Q(Q^{AC}) < 0$.

Recall that the AC mechanism is one of upstream average cost pricing. This requires us to characterize the *lowest* intersection between the derived inverse demand curve $P^U(Q) \equiv Q^{AC^{-1}}(Q)$ and the decreasing average cost curve $AC(Q)$ of the upstream enterprise. Therefore, we need

[8] See Vives (1999), Chapter 4, for a discussion of the existence, uniqueness, and comparative statics properties of Cournot models.

Assumption 2: Define $Q^{AC} = \max_Q \{Q \mid P^U(Q) \geq AC(Q)\}$. We assume that this solution exits, is unique and strictly positive.

We are now in a position to complete the characterization of Q^{AC}, the output resulting from the AC mechanism. Substituting the price equals average cost condition $p_U = AC(Q^{AC})$ into equation (2) yields the equilibrium condition

(4) $$z(Q^{AC}, N) \equiv Q^{AC} P'(Q^{AC}) + N[P(Q^{AC}) - AC(Q^{AC})] = 0$$

We cannot guarantee that there is a unique solution to this equation, as it will be satisfied by any intersection of $AC(Q)$ and the derived demand curve for the input. However, if there are multiple intersections, the AC mechanism (and the idealized Demsetz auction) will select the one with the greatest Q. Clearly, it must be the case that the demand curve cuts the average cost curve from above at Q^{AC}. That is, it is required that:

$$\frac{\partial P^U(Q^{AC})}{\partial Q} = \frac{1}{\frac{\partial Q^{AC}}{\partial p_U}} = \frac{Q^{AC} P''(Q^{AC}) + (N+1)P'(Q^{AC})}{N} \leq AC'(Q^{AC})$$

Or equivalently

(5) $$Q^{AC} P''(Q^{AC}) + (N+1)P'(Q^{AC}) - NAC'(Q^{AC}) = z_Q(Q^{AC}, N) \leq 0$$ Thus, we have established the following result:

Proposition 1: Given Assumptions 1 and 2, the outcome of the AC mechanism, Q^{AC}, is such that $z(Q^{AC}) = 0$ and $z_Q(Q^{AC}) \leq 0$.

We now characterize the equilibrium output under the BC mechanism.

Each firm's profits are given by:

(6) $$\pi_i^{BC} = q_i P(Q) - p_U q_i + \left(\frac{p_U q_i}{\sum_j p_U q_j} \right) (p_U Q - C(Q)) = q_i [P(Q) - AC(Q)]$$

By inspecting the profit function, one can observe that the transfer price (as long as it is non-discriminatory across all the firms) is irrelevant in the final outcome. The single (relevant) task for the *BC* manager is cost-minimization, something in the interest of each of the shareholders of the *BC*. Leaving aside issues of sabotage, this eliminates a potentially important source of conflicts of interest within the co-ownership. In such an arrangement, individual shareholders have little incentives to try to capture the firm operator, whose control is therefore relatively simple.[9]

In equilibrium, the First Order Necessary Condition for an interior optimum for each firm is given by:

(7) $$\frac{\partial \pi_i^{BC}}{\partial q_i} = q_i[P'(Q) - AC'(Q)] + P(Q) - AC(Q) = 0$$

By aggregation, one obtains a condition characterizing any interior Nash equilibrium outcome ($Q^{BC} > 0$) resulting from the application of the BC mechanism:

(8) $$\xi(Q^{BC};N) \equiv Q^{BC}P'(Q^{BC}) + N[P(Q^{BC}) - AC(Q^{BC})] - Q^{BC}AC'(Q^{BC}) = 0$$

Since the BC mechanism involves the Nash equilibrium of a game, we need to guarantee that said equilibrium is well-defined. This is accomplished through:

Assumption 3: (i) There exists a unique Nash equilibrium for the BC game resulting in a strictly positive industry output. (ii) The equilibrium is "well-behaved" in the sense that equilibrium industry output is a strictly increasing function of the number of firms.

The game underlying the BC mechanism is not the standard Cournot oligopoly model. However, it does share an important special structure with the

[9] This is especially true in industries where the product quality has only minor variations, such as, for example, electricity transmission and distribution, as well as gas or water transportation. Of course, this does not preclude the need for an appropriate governance structure of the *BC*, disciplining the interactions among the shareholders and between them and its operator.

Cournot model: the Best Replies of each player depend only upon the *aggregate* choices of its rivals, Q_{-i}. In the present context, the assumption that the demand curve is steeper than the average cost curve is sufficient (but not necessary) for uniqueness.[10]

Assumption 3(ii) is clearly more restrictive, but seems to be a minimum requirement for a well-behaved equilibrium system. Its import can be characterized by using equation (8) to perform comparative statics analysis on Q^{BC} with respect to N: (9)

$$\frac{\partial Q^{BC}}{\partial N} = -\frac{\xi_N(Q^{BC},N)}{\xi_Q(Q^{BC},N)} = -\frac{P(Q^{BC}) - AC(Q^{BC})}{Q^{BC}[P''(Q^{BC}) - AC''(Q^{BC})] + (N+1)[P'(Q^{BC}) - AC'(Q^{BC})]} > 0$$

The numerator of equation (9) is equal to the unit profits that would be earned by a hypothetical vertically integrated monopolist if the monopolist produced Q^{BC}. This term must clearly be positive at any quantity at which total industry profits are positive. Thus, in order for Assumption 3(ii) to be satisfied, the denominator, ξ_Q, must be negative.[11] We have thus established the following result:

Proposition 2: Given Assumption 3, the outcome, $Q^{BC} > 0$, of the BC mechanism satisfies the following conditions: $\xi(Q^{BC},N) = 0$ and $\xi_Q(Q^{BC},N) < 0$.

Proposition 1 and Proposition 2 have provided the necessary characterizations of the market outcomes under the AC mechanism and BC mechanism. In order to be able to establish our main result, however, we also need to ensure that there are no $Q > Q^{BC}$ satisfying equation 8 (that amounts to

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[10] See Vives (1999), pages 42-44, for a discussion of existence and uniqueness results for this class of games.

[11] The positivity of the numerator and equation (7), the FONC for the firm optimization problem, establishes that, at equilibrium, the second term in denominator is negative: i.e., the demand curve must (locally) be steeper than the average cost curve. Therefore, the additional regularity condition that, at the equilibrium output, $P'' < AC''$ would suffice for the weak negativity of ξ_Q.

ensuring that there are no minima or saddle points for $Q > Q^{BC}$).[12] This guarantees that there is no other intersection between ξ and the Q axis besides Q^{BC}. To that end, we impose the extra regularity condition that $\xi_Q(Q^{BC},N) < 0$ for all the output level above the (unique) equilibrium of the BC game. This is accomplished through:

Assumption 4: For $Q \geq Q^{BC}$: i) $P''(Q) < AC''(Q)$ and ii) $P'(Q) < AC'(Q)$

Observe that the restrictions imposed by Assumption 4 have to hold only for "large" levels of output (i.e., output above the equilibrium). This substantially reduces the severity associated to such restrictions.

Therefore, we are now in a position to establish our main result:

Proposition 3: Given Assumptions 1-4, the BC mechanism results in a greater industry output than the AC mechanism: i.e., $Q^{BC} > Q^{AC}$.

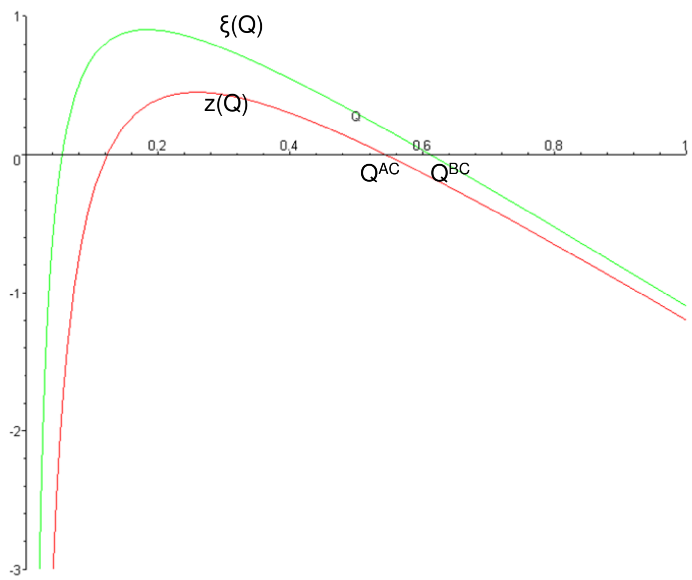
Proof: We begin by establishing a relationship between the equations characterizing market outcomes under the two mechanisms. Subtracting equation (4) from equation (8) yields

(10) $\xi(Q,N) - z(Q,N) = -QAC'(Q) > 0$

Thus, $\xi(Q)$ lies everywhere above $z(Q)$. By Proposition 1, $z(Q)$ cuts the Q axis from above at Q^{AC}. From equation (10), $\xi(Q^{AC}) > 0$. By Assumptions 3(i) and 4, ξ intersects the Q axis only once in the relevant direction, at Q^{BC}. By Proposition 2, ξ is decreasing in Q. Therefore, $Q^{BC} > Q^{AC}$. Q.E.D.

Our result is illustrated by the following graph:[13]

[12] The fact that another maximum does not exist is guaranteed by Assumption 3(i) on the existence of a single equilibrium for the BC mechanism.
[13] The graph is drawn using the same data as the example that will follow in Section 3: $N=2$, $C(Q)=F=0.1$, $P(Q) = 1 - Q$



We now show that total surplus under the BC mechanism exceeds total surplus under the AC mechanism. To do this, we use Assumption 5 - a standard regularity condition that guarantees total surplus to have a maximum.

Assumption 5: The demand function is steeper than the upstream marginal cost function, when the latter is decreasing, that is: $P'(Q) < C''(Q)$

Proposition 4: Given Assumptions 1-5, aggregate total surplus in the upstream and the downstream markets is higher under the BC arrangement than under AC.

Proof:

Aggregate total surplus in the upstream and the downstream markets is defined as:

(11) $TS(Q) = \int_0^Q P(s)ds - Q - C(Q)$

Assumption 5 ensures concavity of (11).

The total surplus maximizing output $Q*$ satisfies the first order necessary conditions for maximization:

(12) $P(Q*) = C'(Q*)$.

Observe that, since $AC'(Q) < 0$:

(13) $P(Q*) < AC(Q*)$

Equation (13) shows that the total industry profit at the total surplus maximizing output level is negative. This implies that Q^{BC} and Q^{AC} lie both below $Q*$. Further, the concavity of (11) ensures that total surplus is increasing for $Q \leq Q*$.

Finally, Proposition 3 shows that $Q^{BC} > Q^{AC}$. Hence, $TS(Q^{BC}) > TS(Q^{AC})$.

Q.E.D.

The intuition behind this result is straightforward. Under BC firms (partially) internalize the benefit of upstream economies of scale in the profit function (since each firm's reaction function incorporates the impact of its own output decision on the upstream average cost). Therefore they end up producing a higher output, and obtaining a lower equilibrium profit when compared to the AC situation. On the contrary, under the AC mechanism, the input/output quantity decision is taken after the input price decision. As a consequence, the actual quantity decision has no effect on the upstream input price. The fixed input price is a double-edged sword for the firm. On the one hand, firms exploit it as a commitment device to achieve a high price (this effect prevails when the AC mechanism yields a higher output than the integrated monopoly structure); on the other hand, firms may be harmed by it (when the AC mechanism yields a lower output than the integrated monopoly structure), as they are unable to commit to a higher input demand (which would increase their profit, through the reduction of average cost). Indeed, once the auction is run and the price is fixed, downstream firms have an incentive to restrict their demand regardless of the upstream price.[14] Also, observe that, as intuitively plausible, the second-best result at the industry level, i.e., industry-wise average cost pricing, yields a higher output than the BC mechanism.

As a result of the higher output, total surplus in the BC mechanism exceeds that of the AC mechanism. The standard intuition that, in association with lower output, the larger producers' surplus is offset by the smaller consumers' surplus, applies in the present case as well.[15]

4. An illustrative example

Consider the vertically related industry structure discussed in Section 2.

Also assume the following:

i) a linear demand function of the form: $P(Q) = 1 - Q$;

ii) an upstream cost function of the form $C = F$ (zero upstream marginal costs);

iii) $N = 2$, i.e., two firms operate in the downstream market.

We now compare the outcome under the BC mechanism to that resulting from the AC mechanism. Under the AC mechanism, each downstream firm's demand as a function of the upstream transfer price is:

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[14] Notice that the BC results could be replicated by any mechanisms in which the unit price of the upstream input is allowed to change with the input quantity. However, allowing for input prices contingent on input quantity within a Demsetz auction framework is very complicated. Furthermore, differently than the BC mechanism, it requires knowledge of the shape of the upstream cost function by the regulator. An alternative solution might consist in setting the input price after the input demand has been revealed (in practice, running the Demsetz auction after the output decisions).

[15] Observe that, in general, total output would be higher in a system characterized by industry-wide average cost pricing, which represents the second best. In such a mechanism, however, we would miss all the benefits, not modeled here, emerging from the liberalization of the downstream sector.

$q_i = \frac{1-p_U}{3}$, with $p_U \leq 1$. If we impose a symmetric outcome, the overall input demand is: $Q = \frac{2(1-p_U)}{3}$. Upstream average cost pricing, as resulting from an "ideal" Demsetz auction, entails:

(14) $\left(\frac{2(1-p_U)}{3}\right)p_U = F$

From (14), we derive the equation defining the set of break-even prices:

$$p_U = \frac{-1 \pm \sqrt{1-6F}}{-2}$$

The equilibrium price in the "ideal" Demsetz auction is the lowest in the set of break-even prices. Hence:

(15) $p_U = \frac{1-\sqrt{1-6F}}{2}$

From (15), the aggregate output follows:

(16) $Q^{AC} = \frac{2(1-p_U)}{3} = \frac{1+\sqrt{1-6F}}{3}$

(16) has a positive solution as long as there exists $p_U \geq 0$, or for $F \leq \frac{1}{6}$.

As the cost function for each downstream firm includes only the constant marginal cost p_U, and no fixed costs, the existence of a positive solution to (16) is a necessary and sufficient condition for the existence of an equilibrium involving positive profit.

We now turn to the analysis of the BC agreement. Under it, the equilibrium output for each downstream firm is: $q_i = \frac{1 \pm \sqrt{1-3F}}{6}$

On aggregate, [16]

(17) $Q^{BC} = \frac{1+\sqrt{1-3F}}{3}$

(17) has a positive solution if $F < \frac{1}{3}$.

As the cost function of any downstream firms in the BC game includes a proportion of the upstream fixed cost, the existence of a positive solution to (4) does not guarantee that profits at Q^{BC} are positive. Indeed, for there to exist an equilibrium involving weakly positive profit in the BC game, one needs the extra condition that $Q^{BC} * P^{BC} - F \geq 0$, which has a solution for $F \leq \frac{1}{4}$.

The example shows two crucial properties of the performance of the BC mechanism against AC.

First, for all values of the fixed cost for which an equilibrium involving positive profit exists both under BC and under AC, (4) is larger than (3); hence, output under BC exceeds output under AC[17]. Indeed, under BC firms (partially) internalize the benefit of upstream economies of scale in the profit function (since each firm's reaction function incorporates the impact of its own output decision on the upstream average cost). Therefore, they end up producing a higher output, and obtaining a lower equilibrium profit when compared to the AC situation. On the contrary, under the AC mechanism, the input/output quantity decision is taken after the input price decision. As a consequence, the actual quantity decision has no effect on the upstream input price. Also, observe that, as intuitively plausible, the second-best result at the industry level, i.e., industry-wise average cost pricing, yields a higher output than the BC mechanism. Indeed, under industry-wise average cost pricing, $p = \frac{F}{Q}$, and $Q = \frac{1+\sqrt{1-4F}}{2}$.

[17] It may be easily shown that this implies that total welfare is higher under BC than under AC.

This is larger than $Q^{BC} = \frac{1+\sqrt{1-3F}}{3}$ for all the values of the fixed cost for which an equilibrium in the BC game exists, except for the limit value $F = \frac{1}{4}$, where the two output level are equal.

Second, the threshold of fixed costs below which an equilibrium involving positive profit exists is higher under BC than it is under AC. That is, there exist values of the fixed costs (namely, $\frac{1}{6} \leq F \leq \frac{1}{4}$) such that a profitable equilibrium exists in the BC game, but not under AC. Indeed, under AC, because of its sequential structure, the downstream firms will make positive profit given the upstream price. When F is large enough to guarantee a sufficiently small industry profit, the downstream profit would exceed the overall industry profit, thereby determining an upstream loss. Under such circumstances, the upstream firm prefers not to produce. Under BC, on the other hand, whenever F is such that the industry is potentially profitable, an equilibrium exists[18].

Finally, observe that profit under AC $\left(\frac{1+\sqrt{1-6F}}{3}\right)\left(\frac{2-\sqrt{1-6F}}{3}\right)-F$ exceeds profit under BC, i.e.

$$\left(\frac{1+\sqrt{1-6F}}{3}\right)\left(\frac{2-\sqrt{1-6F}}{3}\right)-F > \left(\frac{1+\sqrt{1-3F}}{3}\right)\left(\frac{2-\sqrt{1-3F}}{3}\right)-F$$

when

(18) $F < \frac{2}{3}\sqrt{3}-1 = 0.1547$.

A possible intuition for this result is that, holding the number of firms fixed, when the economies of scale are very significant (in the specific example, when F is relatively high), then the AC mechanism yields an output level below

[18] This implies that a profitable equilibrium under BC exists whenever a profitable equilibrium under industry-wise average cost pricing exists.

that of an integrated monopoly. In such cases, an increase in output (as long as it is sufficiently small) increases profit.

5. Collusive behaviors

This paragraph analyzes the collusive potential of the bottleneck co-ownership as compared to the AC mechanism.

A natural concern with the BC arrangement here proposed is that it might prove more collusion-friendly. As BC expands the scope for interaction among firms – the argument goes - the collusive potential might increase as well, through a mechanism similar, among others, to that illustrated by Gilo, Moshe and Spiegel (2006) for the case of horizontal co-ownership arrangements.

By adopting the repeated game model classically used to study tacit collusion (see Friedman, 1971), we show that in fact which of the two mechanisms is more likely to lead to collusive outcomes depends on the parameters of the model.

Consider again all the assumptions in the example in Section 4, and an infinitely repeated game characterized by Cournot reversion strategies. Under both regimes, the individual rationality constraint for the sustainability of collusion prescribes:

$$\frac{\pi_j^{coll}}{1-\delta} \geq \pi_j^{dev} + \frac{\delta\pi_j^{cour}}{1-\delta} \tag{19}$$

For collusion to be feasible, the discounted monopoly profit must exceed the sum of the one-shot deviation profit and the continuation profit (where the continuation profit is the static game profit, that is Cournot).

By inspecting (19), one can observe at first that π_j^{coll} is unchanged across the two regimes. The industry profit under a collusive agreement corresponds in both cases to the profit accrued to a hypothetical vertically integrated monopolist. On the contrary, both profits of continuation π_j^{cour} and from deviation π_j^{dev} may vary. The role of the continuation profit is crucial. Equation (18) provides the critical value of the fixed cost ($F = \frac{2}{3}\sqrt{3} - 1 = 0.1547$) above which, in our example, co-ownership is more profitable than AC when static quantity competition is played.

The one-shot profit from deviation is higher under BC, due to the beneficial internalization of the reduction in average cost. Hence, the deviation profit contributes to making collusion less likely under BC, thereby lowering the critical fixed cost value above which BC decreases the likelihood of collusion.

As a result, when $0.125 < F \leq 0.25$,[19] BC is less collusive than AC, while for $F < 0.125$ the opposite is the case. Therefore, holding the number of firms fixed, when economies of scale are significant (in our case, when F is relatively high), BC is welfare-superior to AC even in a repeated game setting.

While the analysis on collusion has been carried out under the assumption of perfect information (including perfect monitoring of upstream cost and rivals' output), a natural concern is related to an environment of imperfect information, where the co-ownership arrangement may facilitate knowledge of the upstream cost, and, as a result, allowing for a better monitoring technology. However, under BC, the upstream and the downstream decisions are simultaneous. A firm cannot punish a rival's defection until the subsequent period. However, by the next period, the firm would have been aware of the defection in an AC context as well, having observed the average cost as well as the rival's output. In this sense, BC does not hurt monitoring. If anything, it can in fact favor it: Under the assumption that a Demsetz auctioneer has rational expectations, and perfectly forecasts any deviations from the cartel, the non-defecting firm would recognize the deviation when the transfer price is announced, and would be able to punish the rival immediately, thereby discouraging the deviation itself. As a

[19] Notice that for F>0.25, there is no production, as even the integrated monopoly would incur a loss if he decided to produce

consequence, in a context of imperfect information, AC (rather than BC) would provide firms with more sophisticated monitoring devices, potentially able to enhance collusion.

6. Conclusions

The previous literature which has focused on static models of efficiency of vertical industries has shown that vertical integration may be beneficial because firms' decisions not being simultaneous brings about two kinds of problems:

i) double marginalization;

ii) a cost externality when returns on scale are not constant.

An important drawback of vertical integration is that in vertical structures characterized by different degrees of potential competition the least competitive sector may employ a variety of methods (including contractual arrangements) to extend its market power to the full production chain, thereby harming competition in the industry.

This paper describes an input co-ownership mechanism characterized by a form of vertical integration that fosters the competition (observed in the most competitive sector) across all the various vertically related sectors involved in production. In terms of social welfare, the mechanism tends to perform better than vertical integration (as it allows competition between a number of firms equal to the number of firms in the most competitive sector), and than full vertical disintegration (since it avoids the emergence of double marginalization). It also performs better than upstream average cost pricing followed by downstream competition, as in the BC, differently than in the AC, firms partially internalize the benefit (in terms of average cost reduction) associated with an upstream output increase. Finally, when economies of scale are significant, the BC arrangement increases firms' profit with respect to AC. In the context of a repeated game, this makes a deviation from a collusive agreement more attractive under BC, thereby comparatively reducing its collusive potential.

Bibliography

Armstrong, Mark and Vickers, John "Price Discrimination, Competition and Regulation", The Journal of Industrial Economics, 41, 1993, 335-359

Armstrong, Mark and Sappington, David "Regulation, Competition and Liberalization", Journal of Economic Literature, 44, 2006, 325-366

Baron, David and Myerson, Roger "Regulating a monopolist with unknown costs", Econometrica, 50, 1982, 911-930

Boffa, Federico and Lynne Kiesling "Network Regulation through Ownership Structure: an Application to the Electric Power Industry", 2008, mimeo

Bresnahan, Timothy and Salop, Steven "Quantifying the Competitive Effects of Production Joint Ventures", International Journal of Industrial Organization, 4, 1986, 155-175

Demsetz, Harold "Why regulate utilities", Journal of Law and Economics, 11, 1968, 55-65

Friedman, James "A Non-cooperative Equilibrium for Supergames", Review of Economic Studies, 28, 1971, 1-12

Gilo, David, Moshe, Yossi and Spiegel, Yossi "Partial cross ownership and tacit collusion", The Rand Journal of Economics, 37, 2006, 81-99

Gilbert, Richard and Riordan, Michael "Regulating complementary products: a comparative institutional analysis", The Rand Journal of Economics, 26, 1995, 243-256

Kogut, Bruce "Joint Ventures: Theoretical and Empirical Perspectives", Strategic Management Journal, 9, 1988, 319-332

Kuhn, Kai-Uwe and Vives, Xavier "Excess Entry, Vertical Integration, and Welfare", The Rand Journal of Economics, 30, 1999, 575-603

Lee, Sang Hyup and Hamilton, Jonathan "Using Market Structure to Regulate a Vertically Integrated Monopolist", Journal of Regulatory Economics, 15, 1999, 223-248

Loeb, Martin and Magat, Wesley "A Decentralized Method for Utility Regulation", Journal of Law and Economics, 22, 1979, 399-404

Park, Yong-Sam and Ahn, Byong-Hun "Joint Ownership and Interconnection Pricing in Network Industries", International Review of Economics and Finance, 8, 1999, 183-198

Sappington, David "Optimal Regulation of a Multiproduct Monopoly with Unknown Technological Capabilities", Bell Journal of Economics, 14, 1983, 453-463

Spengler, Joseph "Vertical Integration and Antitrust Policy", The Journal of Political Economy, 58, 1950, 347-352

Spulber, Daniel "Regulation and Markets", The MIT Press, Cambridge, 1989

Vickers, John "Competition and Regulation in Vertically Related Markets", Review of Economic Studies, 62, 1995, 1-17

Vives, Xavier "Oligopoly Pricing", The MIT Press, Cambridge, 1999

Vogelsang, Ingo and Finsinger, Jörg "A Regulatory Adjustment Process for Optimal Pricing by Multiproduct Monopoly Firm", Bell Journal of Economics, 10, 1979, 157-171.