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ORIGINAL ARTICLE

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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.

Keywords Regulation · Vertically related industries · Co-ownership

JEL Classification L22 · L51

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1 Introduction

The paper proposes a regulatory mechanism for vertically related industries characterized by a workably competitive downstream sector, 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 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 1950) 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

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

directly to set firms' strategic variables, or impose constraints on their choices (actions associated with conduct regulation).

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 (1993); Baron and Myerson (1982), and Sappington (1983) for the Bayesian regulation literature. These papers explicitly model the informational asymmetry between the regulator and the regulated firm).

Demsetz (1968) is a pioneering example of this type of structural regulation. He argues that average cost pricing can be achieved by auctioning the monopoly franchise rights, 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; (ii) 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 that 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 1888) 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.

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,

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

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).

The literature on essential facilities, vertical integration and access pricing is extensive. The paper most similar to ours in terms of spirit and methodology is Fjell et al. (2010). Their analysis deals with the case of a vertically integrated incumbent competing with a single downstream entrant to whom it sells access. They compare two access pricing regimes: (i) "exogenous" access pricing in which the firms are charged a constant access price which is set, in equilibrium, to exactly cover the access related expenses of the incumbent; and (ii) "endogenous" access pricing in which the firms explicitly recognize that the access price they face is a decreasing function of total output. Their principal result is that the endogenous access pricing rule is superior whenever the incumbent's upstream and downstream divisions are not fully integrated.

A particularly suitable application for the BC mechanism lies in vertically connected network industries in which the network manifests 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 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 commonly 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: Sect. 2 illustrates the economic environment and the characteristics of the BC arrangement; Sect. 3 analyzes the model; Sect. 4 shows the performance of the BC in a repeated game framework, where collusive behaviors may emerge. Finally, Sect. 5 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

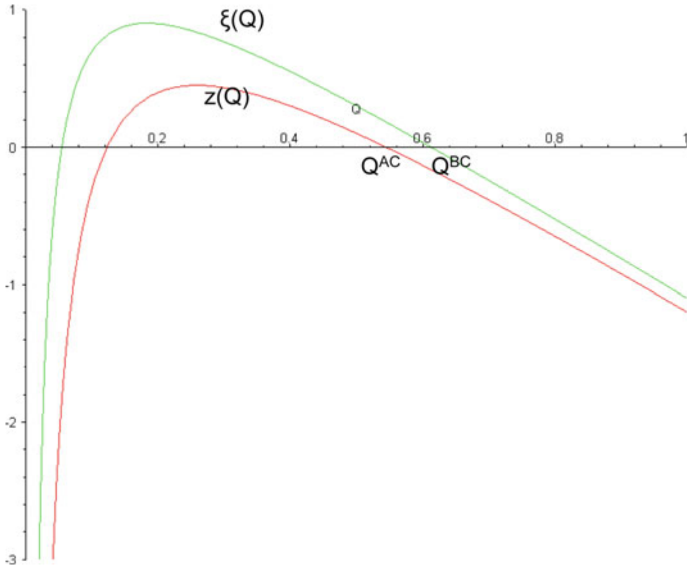

Fig. 1 Representation of equilibrium in the AC and in the BC games

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 total 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 zero 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. 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

4 For notational simplicity, we assume that the downstream firms are identical. However, our main result (Proposition 3) generalizes to the case of downstream firms having different (constant) marginal costs.

does not allow price discrimination by the upstream firm among downstream firms.[5] Sabotage is an alternative form of discrimination against some of the downstream firms, that issabotage,[6] and is a severe problem when the upstream entity is vertically integrated with one (or some of the) downstream firm(s). In the co-ownership scheme, the upstream entity can be regarded as being vertically integrated with all of the downstream companies; this gives each downstream firm some control on the upstream activity, thereby reducing the potential for sabotage.

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

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

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

[5] For the main results of the paper to apply (i.e., Proposition 3), 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.

[6] 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 (see, for example, Beard et al. 2001).

[7] The assumptions of the game are not stated in terms of supermodularity, as in the Cournot-type games we analyze, the players' decisions are strategic substitutes; therefore, supermodularity does not apply directly. We therefore decided to use the traditional Cournot model; Vives (1999) contains an accessible collection of results on Cournot models.

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

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

Summing Eq. 1 over all N firms yields:

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

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 Eq. 2. By the Implicit Function Theorem:

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

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

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

Assumption 2 Define $Q^{AC} = \max_Q\{Q|P^U(Q) \geq AC(Q)\}$. 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 $p_U = AC\left(Q^{AC}\right)$ into Eq. 2 yields the equilibrium condition

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

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:

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

Or equivalently

$$Q^{AC}P''(Q^{AC}) + (N+1)P'\left(Q^{AC}\right) - NAC'(Q^{AC}) = z_Q(Q^{AC}, N) \leq 0 \quad (5)$$

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 $z_Q(Q^{AC}) \quad \leq 0$.*

We now characterize the equilibrium output under the BC mechanism.
Each firm's profits are given by:

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

By inspecting the profit function, we note 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.[8]

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

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

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

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

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

8 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.

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 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.[9]

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

$$\begin{aligned}\frac{\partial Q^{BC}}{\partial N} &= -\frac{\xi_N(Q^{BC}, N)}{\xi_Q(Q^{BC}, N)} \\ &= -\frac{P\left(Q^{BC}\right) - AC\left(Q^{BC}\right)}{Q^{BC}[P''\left(Q^{BC}\right) - AC''(Q^{BC})] + (N+1)[P'(Q^{BC}) - AC'(Q^{BC})]} > 0\end{aligned} \tag{9}$$

The numerator of Eq. 9 is equal to the unit profit (margin) 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.[10] 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* $\xi_Q(Q^{BC}, N) < 0$.

Propositions 1 and 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:

Assumption 4 Equation 8 has no roots for $Q > Q^{BC}$.[11]

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 Eq. 4 from Eq. 8 yields

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

9 See Vives (1999), pp. 42–44, for a discussion of existence and uniqueness results for this class of games.

10 The positivity of the numerator and Eq. 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, $P''(Q) < AC'''(Q)$, would suffice for the weak negativity of ξ_Q.

11 Sufficient conditions for Assumption 4 to hold are that, for $Q \geq Q^{BC}$: (i) $P''(Q) < AC''(Q)$ and (ii) $P'(Q) < AC'(Q)$.

Thus, $\xi(Q)$ lies everywhere above $z(Q)$. By Proposition 1, $z(Q)$ cuts the Q axis from above at Q^{AC}. From Eq. 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, $Q^{BC} > Q^{AC}$. □

Our result is illustrated in Fig. 1:[12]

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:

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

Assumption 5 ensures concavity of (11).

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

$$P(Q^*) = C'(Q^*). \tag{12}$$

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

$$P(Q^*) < AC(Q^*) \tag{13}$$

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} both lie 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, $TS\left(Q^{BC}\right) > TS(Q^{AC})$. □

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. By contrast, 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

[12] The graph is drawn using: $N = 2$, $C(Q) = F = 0.1$, $P(Q) = 1 - Q$.

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. Also, observe that, as intuitively plausible, the second-best result at the industry level, i.e., vertically integrated average cost pricing, yields a higher output than the BC mechanism (In such a mechanism, however, we would miss all the benefits, not modeled here, emerging from the liberalization of the downstream sector). 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.

4 Collusive behavior

This section analyzes the collusive potential of the bottleneck co-ownership as compared to the AC mechanism. Determining which of the two mechanisms is more conducive to collusion is relevant for qualifying the welfare analysis. The sources of collusion in the two games differ both because of the different structure of the two games under perfect information, and because the two games may generate different levels of interaction among firms, thereby leading to possibly different informational structures across them.

The section elaborates on the collusive potential of the AC and BC games under perfect information, and discusses the possible effects of the different level of interactions among firms in the two games at the end of the section.

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 an infinitely repeated game characterized by Cournot reversion strategies. Under both regimes, the individual rationality constraint for the sustainability of collusion prescribes:

$$\frac{\pi_j^{\text{coll}}}{1-\delta} \geq \pi_j^{\text{dev}} + \frac{\delta \pi_j^{\text{cour}}}{1-\delta} \tag{14}$$

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 (14), we observe 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. Considering a linear example, with $P(Q) = 1 - Q$, $N = 2$, $C(Q) = F$, there exists a critical value of the fixed cost $\left(F = \frac{2}{3}\sqrt{3} - 1 = 0.1547\right)$ above which 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 profit from deviation 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, in our example, $0.125 < F \leq 0.25$,[13] 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 example, when F is relatively high), BC is welfare-superior to AC even in a repeated game setting. The analysis on collusion has been carried out under the assumption of perfect information (including perfect monitoring of upstream cost and rivals' output); however, we recognize that, if we abandoned it, we could envision situations in which the BC arrangement, by expanding the scope for interaction among firms, may facilitate the formation of cartels, as well as their success, thanks to a better information on the rivals' cost structures, leading to an easier monitoring of the possible deviations. While this notion cannot be straightforwardly analyzed within a formal model, it should certainly be regarded as a crucial empirical issue.

Code-sharing arrangements occurring between two or more otherwise competing airlines in commercial aviation share several similarities with the proposed BC mechanism, and may raise analogous concerns on the incentives to collude for firms involved in such agreements. Therefore, we will briefly review the empirical evidence available on this form of partnerships, in order to gain some insights on what might happen, in terms of collusive prospects, in the BC mechanism.

Under code-sharing, an airline agrees to sell access to some of its seats to a competitor on selected routes. When shared routes enjoy a special Antitrust immunity, the two airlines may cooperate in choosing prices for the route. Code-sharing arrangements allow companies to connect two destinations, through multiple segments, without having to expand their network, but by simply issuing tickets for code-shared segments operated by a rival company. This is expected to benefit consumers, who enjoy a wider range of destinations, as well as possibly lower prices on the shared routes as a result of the removal of incentives for double marginalization. However, as code-sharing arrangements only involve a subset of the routes offered by each airline, antitrust authorities have been concerned that they would facilitate collusion even on markets and routes in which carriers are instead supposed to compete. Motivated by this worry, a paper by Gayle (2008) estimated the collusive side effects of codeshare arrangements, looking in particular at the US experience with the Continental-Northwest-Delta agreement. He finds no evidence of code sharing arrangements bringing about more collusion on partners' overlapping routes. The insight we might gain from

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

Gayle's paper is that there is no evidence that cooperation in a subset of markets (in the forms of access to a competitor's infrastructure, and, in some cases, of cooperative price decisions), increases the collusive prospects in the other markets, in which the two companies are just competitors. Gayle's results, therefore, may be regarded as supporting the view that the BC mechanism does not necessarily increase the likelihood of collusive outcomes.[14]

5 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. Even when the vertically integrated company is subject to price and access regulation, it can still find ways (for instance, by sabotaging the competitors' operations) to gain an unfair advantage over its rivals in the most competitive sector, to the detriment of competition. This point has been clearly raised, in the context of the telecommunication sector, by Crew, Kleindorfer and Sumpter (2004), who argue in favor of divestiture of the United States Regional Bell Operating Companies. The authors advocated vertical disintegration (and ownership unbundling) between the, essentially monopolistic, upstream local wireline telecom network and the downstream potentially competitive local exchange carriers[15].

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, BC 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 better than full vertical disintegration (since it avoids the emergence of

[14] We thank a referee for suggesting us this analogy.

[15] The evolution of the telecom industry over the recent years, which saw a substantial expansion of the role of wireless providers (see, for instance, California Public Utilities Commission Communications Division—Policy Branch, Staff White Paper, (2008)), requires a reconsideration of the approach towards market power in the sector. Consumers, who traditionally used to regard wireless services as mostly complements and supplementary to the baseline wireline services, are now increasingly viewing wireless and wireline as substitutes. In this context, competitors to the wireline incumbent operators may choose the wireless option; furthermore, the deployment of technologies such as 3G, Wi-fi, and Wi-max has increased the competitiveness of last-mile telecommunication services (for instance, VoIP services can be delivered over wi-fi). The competitive benefits of unbundling, while still significant, are now less so than they were at the time of Crew et al. (2004) proposal. That said, the increasing concentration in the United States telephony, potentially further exacerbated by the proposed merger between AT&T and T-Mobile that is currently undergoing Antitrust scrutiny, gives major cause for concern.

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. Furthermore, 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.

Finally, the BC mechanism, given our setting, is clearly not a first-best mechanism. It is welfare-dominated by a number of alternative arrangements, including vertically integrated average-cost pricing (with respect to which our mechanism possesses some non-modeled advantages, such as the prevalence of competition whenever economically feasible), and an average-cost-regulated upstream two-part tariff.[16] However, an average-cost-regulated upstream two-part tariff imposes a relevant informational load on the regulator. In addition, while the result that BC increases output over AC generalizes to downstream firms with heterogeneous marginal costs, the efficiency result of the average-cost-regulated upstream two-part tariff does not.

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[16] We thank a referee for pointing this out.

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