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# On the optimality of the full cost pricing

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## Abstract

Most companies prefer to use absorption costing rule rather than marginal cost pricing. This article is aimed at defining the absorption costing rule as deriving from a principal-agent formulation of two tier organizations : (i) the upstream unit fixes the production capacity and uses it as a cost driver to compute the average cost (ii) the downstream unit operates on the market and chooses the output level on the basis of the average cost. Absorption costing results in two policies to be used according to the magnitude of the fixed cost. When the fixed cost is low, the capacity is fully used and a full cost pricing policy holds; when the fixed cost is high, a partial cost pricing policy holds since only a part of the fixed cost is passed on. The absorption costing rule competes with three pricing rules related to this two-tier structure and various payoffs functions associated to the decision levels: the separation, the transfer pricing and the integration. These rules are analyzed in the Cournot oligopoly case and comparisons in terms of profits are made. *Except in the monopoly case, there exists a wide range of values of the fixed cost, for which the full cost pricing dominates all the other rules.* In addition, there exists a specific value of the fixed cost for which the full cost pricing duplicates the monopoly and then leads to the first best solution of the Cournot oligopoly.

JEL Classification : D4, L22, M41.

Keywords : full cost pricing, imperfect competition.

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Figure 1 : the monopoly case

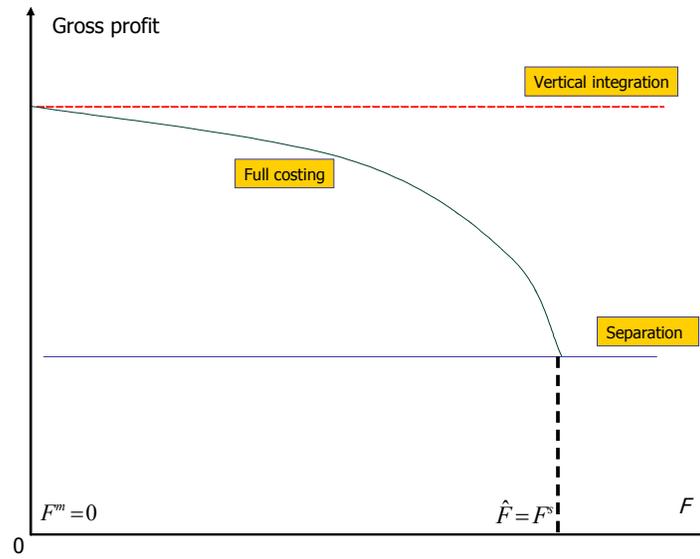


Figure 2 : the duopoly case

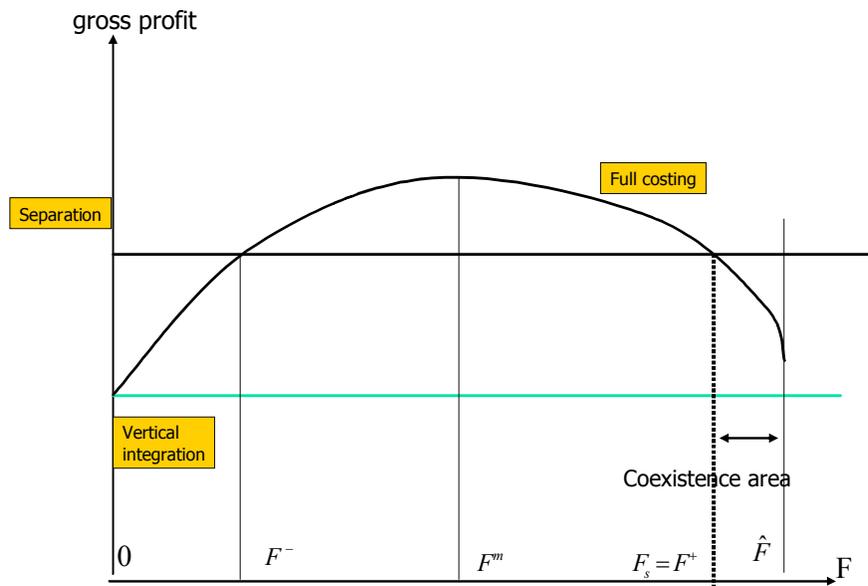
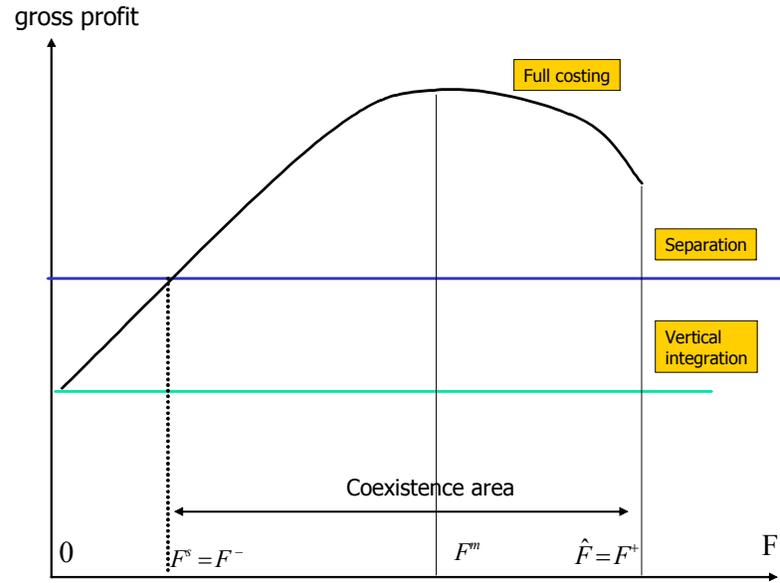


Figure 3 : the oligopoly case



On the optimality of the full cost pricing

April 28, 2008

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### Abstract

This article is aimed at defining the full cost pricing as a leader-follower game in two tier organizations: (i) the upstream unit fixes the production capacity and uses it as a cost driver to compute the average cost (ii) the downstream unit operates on the market and chooses the output level on the basis of the average cost. In the Cournot oligopoly case, the full cost pricing is compared with other pricing rules. There exists a wide range of values of the fixed cost, for which the full cost pricing dominates any other pricing rules, in terms of gross profit.

JEL Classification : D4, L22, M41.

Keywords : full cost pricing, imperfect competition, strategic effects

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## 1 Introduction

Economic theory argues that the firm must use a pricing on the basis of marginal (or variable) cost, so that the fixed costs are not taken into account. In words, the consumer has not to bear the fixed cost which has to be deduced a posteriori from the firm's profit.

It is known that the firms are reluctant to accept this type of reasoning; Usually they prefer to fix the prices on a full or absorption cost basis. The surveys by Govindarajan and Anthony (1983) and Shim and Sudit (1995) on American manufacturing companies indicate that more than 60% of them use full-cost pricing. Such a divergence between the business practices and the theoretical recommendations is well known since the seminal article by Hall and Hitch (1939) (for a survey of the main contributions to this debate, see Lukas, 1999, cf. also Mongin, 1997).

Clearly the marginal cost pricing is historically related to integrated structures managed on a command and control basis to achieve productivity goals. This apparatus may be inappropriate in today's business world of *the Modern Firm* (Roberts, 2004) where the organizations, in search of flexibility, operate under delegation mechanisms and/or contracts between independent actors located overseas. Integration is no longer the dominant form of organization. In this context, the key role of the cost-based pricing rules has to be analyzed in terms of the incentives they produced within decentralized organizations operating in interaction with autonomous partners or rivals.

However absorption costing is always considered as a rule of thumb with poor conceptual background. The average cost of a product is usually based on a *budgeted* or *expected* quantity of output used to compute the average cost which may differ from the *actual* quantity sold once a cost based pricing rule is applied. The relationship between the budgeted and the actual quantity remains a black hole of the theoretical literature so that a formal definition of the absorption costing is missing. Our paper is aimed at clarifying this point.

We propose here a leader-follower formulation of the absorption costing rule: as we know, the marginal cost pricing derives from the profit maximization principle of the firm considered as an unique decision maker. Transposing this argument, the absorption costing will be defined here as the result of interrelated maximization problems involving subunits of the firm.

Hence the firm under consideration is a two-tier organization in a deterministic environment where the upstream unit is in charge of providing a capacity of service or product to a downstream unit which runs the production capacity and sells on the market. In this context, it is quite natural to use the production capacity as the budgeted quantity. This is a reasonable point of view since in many industries, production capacity generates the

greatest part of the fixed costs and is under the control of a specific subunit of the organization located at an upper level of the organization.

This two-tier structure resorts to various organizations analyzed in IO literature, e.g.: supply chain systems (e.g. Corbett and Karmarkar, 2001), divisional firms with production departments (or headquarters) as upstream and marketing departments (or profit centers) as downstream units (Zhao, 2000), network systems with providers of facilities as upstream and users as downstream units (Laffont et al., 1998a and 1998b).

In this context, the absorption costing rule is embedded in a specific organization structure: the upstream unit fixes the production capacity and passes a part of the fixed cost on the downstream unit by charging him with a variable cost equal to the average cost of capacity. Clearly, the absorption costing competes with the pricing rules related to two typical vertical relations<sup>1</sup>:

(i) *The vertical integration*, where the upstream and the downstream units are merged. This leads the firm to use the standard marginal cost pricing rule. (ii) *The separation* where the upstream unit charges a wholesale price to the downstream unit and the downstream unit seeks to maximize his specific profit. This induces the standard double mark-up effect (cf. Spengler, 1950).

As defined above, the absorption costing is closely related to the separation rule: *the specific ingredient of the absorption costing is the capacity constraint which plays the role of a vertical restraint*. Accordingly the impact of the absorption costing in terms of profits, prices and quantities is likely to resort to standard arguments drawn from the vertical restraint literature (cf. Rey and Tirole, 1986). Furthermore, the separation is a natural benchmark of absorption costing, more legitimate than the marginal cost pricing (embedded here in the vertical integration) with regard to the current organization forms in business where the vertical integration is not necessarily allowed for the sake of flexibility or exogenous managerial considerations.

The paper is aimed at developing a comparative analysis of these vertical relations in the symmetric Cournot oligopoly case. Our main finding is the following: except in the monopoly case, there exists a specific value of the fixed cost for which the full cost pricing rule duplicates the monopoly and then leads to the maximal gross profit of the industry. Consequently, for a wide range of values of the fixed cost, the absorption costing rule dominates all the other rules.

What distinguishes the monopoly and the oligopoly cases is the strategic effects involved in the quantity setting competition of two-tier firms. The mechanism explaining the dominance of the full cost pricing rule is of similar nature as those described in the delegation game literature (e.g. Fershtman

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<sup>1</sup>We do not consider here two-part tariff pricing rules, assuming for instance that resale opportunities cannot be prevented at the downstream level.

and Judd, 1987, Barcena-Ruiz and Espinosa, 1999) where various managerial compensation schemes for the downstream managers (including the rival's profit as in Vroom, 2006) may lead to less aggressive behaviors and accordingly better profits.

The rest of the paper is organized as follows. The next section provides a short review of the related literature. Section (3) is devoted to the leader-follower formulation of the absorption costing rule and its interpretation in terms of vertical restraint. The equilibrium conditions are analyzed in section 4. We prove that, under absorption costing, two different policies are likely to be alternatively used by the firm: (i) *The full-cost pricing policy*, where the capacity is equal to the output; this policy is used for low values of the fixed cost. (ii) *the partial cost pricing policy* where the capacity is strictly higher than the output; only a part of the fixed cost is passed on the downstream unit; it coincides to the separation rule. For intermediate values of the fixed cost, the absorption costing leads to a coexistence of a full-cost and a partial cost pricing equilibrium. Section (5) is devoted to a systematic profit comparison of the various pricing rules and the proof of the main result. Concluding remarks are given in section (6).

## 2 Related literature

The recent literature has advocated the strategic content of the absorption costing practices: What actually matters is the type of cost reporting and internal accounting practices used by the organization and its impact on the performance of the firms according to the strategic interactions at work in the competitive environment: Alles and Datar (1998) use a two-tier structure of the firm; they develop a model where two oligopolistic decentralized firms strategically select their cost-based transfer prices between production and marketing departments. They show how a cost-based transfer price can be used as a competitive weapon through a cross subsidization of some products. Other contributions in this vein include Narayanan (2000) and Hughes and Kao (1998).

Our contribution is in the line of Göx (2000) who analyses the use of the transfer pricing rule (i.e. with the upstream unit maximizing the whole profit) as a strategic device in divizionalized firms operating on a price setting differentiated duopoly. This author shows that the adoption of an absorption costing rule is perceived by any firm as signalling that the opponent uses transfer prices above marginal cost and then is a source of higher profits for both duopolists; Göx introduces the absorption costing without stressing the fact that its existence conditions are not satisfied for high values of the fixed cost. In addition the separation case is not considered by this author although it should not be dominated by the transfer pricing in a price setting duopoly.

Our contribution deals with Cournot oligopoly competition which allows us to analyze the sensitivity of the results with respect to the industry concentration (measured by the number of oligopolists). The separation case deserves a particular attention as it coincides with the absorption costing rule for high values of the fixed cost. The separation is compared with the integration as in Greenhut and Ohta (1979), Lin, (1988), Bonanno and Vickers, (1988) and similar results are found.

### 3 Absorption costing in a leader-follower game

This paper deals with Cournot competition between firms selling an homogeneous final product. But, of course, the definition of absorption costing we are going to introduce now holds for any market conditions in terms of competition structure and substitutability of the products.

#### 3.1 Market and organizational structure

Let us consider an industry of  $n$  identical firms involved in a Cournot competition on the quantities  $q_i$ ,  $i = 1, \dots, n$  sold on a final market, with an unit production cost equal to zero, as commonly postulated in IO literature, for simplicity. Each firm faces an identical fixed cost  $F$ . The market demand is determined by the inverse demand function  $p(q)$ , with  $q = \sum_{i=1}^n q_i$  and  $p' < 0$ . Let us assume that the gross profit function of the industry  $P(q) = p(q)q$  is concave, namely :

$$2p' + p''q \leq 0, \quad (1)$$

so that the monopoly quantity  $q^m$ , solution of  $p + p'q = 0$ , is unique. Let  $q^c$  be the global quantity of the symmetric Cournot equilibrium, solution of  $p + p'q/n = 0$ . Condition (1) implies the inequality  $2p'(q) + p''(q)q_i, \forall q_i \leq q \leq 0$ , which guarantees the concavity of the gross profit  $pq_i$  of firm  $i$  and then the existence and the unicity of the Cournot equilibrium. Firm  $i$  is said to be profitable if it gets a positive net profit, namely :

$$pq_i - F \geq 0. \quad (2)$$

Any firm  $i$  is a two-tier firm where the upstream unit is in charge of providing a capacity of service or product  $y_i$  to the downstream unit which sells a quantity  $q_i$  at the market price  $p$  while competing with the downstream units of the rivals. In this context, the fixed cost  $F$  covers the infrastructure expenditures and the overhead associated with the delivery of capacity  $y_i$ . For the sake of simplicity, we assume that the unit cost of capacity is negligible. This assumption is quite realistic in network systems, where the great part of the capacity costs are fixed (for instance transporting networks like

railways, computer networks etc...). Hence the production capacity essentially plays the role of a budgeted quantity level with no specific variable cost incurred. This assumption - which could be relaxed in further investigations - yields more tractable results and easier comparisons.

### 3.2 Absorption costing and vertical restraint

According to the two-tier structure of the firms, the absorption costing rule can be defined in a leader-follower game setting. Let us formulate it for any downstream market conditions:

**Definition 2 (Absorption costing)** *The upstream unit of firm  $i$  fixes the production capacity and uses it by charging the downstream unit with a cost per unit of output  $F/y_i$ , so as to maximize  $U_i = Fq_i/y_i$ . The downstream unit uses  $F/y_i$  as a unit cost parameter in maximizing his profit  $R_i = (p - F/y_i)q_i$ , under the prevailing final market conditions.*

Any firm  $i$  has to satisfy a capacity constraint  $q_i \leq y_i$ , meaning that no rationing of output is allowed. A priori any firm may indifferently impose its capacity constraint either to the upstream or the downstream unit. It is a matter of choice within the organization. For simplicity we assume that the capacity constraint  $q_i \leq y_i$  is imposed to the upstream unit  $i$  so that the market equilibrium conditions prevailing at the downstream level are not affected by the capacity constraints of the competing firms<sup>2</sup>. In this context, the upstream unit program of firm  $i$  can be written as the optimization problem (3),

$$\begin{cases} \max_{y_i, q_i} U_i \\ s.t \text{ downstream equilibrium conditions} \\ y_i - q_i \geq 0. \end{cases} \quad (3)$$

Using the change of variable  $w_i = F/y_i$ , program (3) can be rewritten as the program (4).

$$\begin{cases} \max_{q_i, w_i} w_i q_i \\ s.t \text{ downstream equilibrium conditions} \\ w_i \leq F/q_i. \end{cases} \quad (4)$$

When the constraint  $w_i \leq F/q_i$  is not binding, the absorption costing coincides with the separation rule prevailing in a distribution channel, where

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<sup>2</sup>This assumption might be crucial in a price setting oligopoly : A contrario, if the capacity constraint were assumed to be imposed at the downstream level, this would make the quantities of the downstream units bounded from above by the capacities previously decided : this creates a situation à la Kreps and Scheinkman (1983) where capacity or output constraints faced at the downstream level may transform price into quantity competition as the reaction opportunities of the rivals are restricted. Of course, this does not apply in the Cournot competition case considered here.

the upstream and the downstream units are respectively assimilated to a supplier charging a wholesale price  $w_i$  and a retailer maximizing his profit  $R_i = (p - w_i)q_i$ . This guarantees the existence of the absorption costing concept for any value of the fixed cost. In addition the capacity constraint can be seen as an upstream vertical restraint, something like a *wholesale maintenance price*, expressing that the upstream unit cannot recover more than the fixed cost of the firm; i.e.  $U_i \leq F$ .

## 4 Equilibrium conditions

Let us derive together the Cournot equilibrium conditions of the absorption costing and the separation rules. The upstream units simultaneously fix the  $y_i$  or  $w_i$  at stage 1; at stage 2, the downstream units are involved in a Cournot competition on the quantities  $q_i$ . Two types of information structures may be considered here (cf. Göx, 2000) :

- *The non observable game* in which, at the beginning of stage 2, the downstream unit of any firm  $i$  does not observe the decisions taken at stage 1 by his rivals.
- *The observable game* in which, at the beginning of stage 2, the downstream unit of any firm  $i$  observes the decisions taken at stage 1 by his rivals .

As we will see later, both games yield here qualitatively similar results. For simplicity, we will only consider the non observable case. Under the absorption costing rule, the first order condition of the downstream unit  $i$  maximization is:

$$\left(p(q_{-i} + q_i) - \frac{F}{y_i}\right) + p'(q_{-i} + q_i)q_i = 0, \quad (5)$$

where  $q_{-i} = \sum_{j \neq i} q_j$ . Accordingly, the upstream unit maximization program of the absorption costing is:

$$\begin{cases} \max_{q_i, y_i} Fq_i/y_i \\ q_i \leq y_i, \\ \left(p(q_{-i} + q_i) - \frac{F}{y_i}\right) + p'(q_{-i} + q_i)q_i = 0, \end{cases} \quad (6)$$

the solution of which defines the reaction function  $y_i(q_{-i})$ ,  $q_i(q_{-i})$ , respectively of the production capacity and output of firm  $i$ . Since the firms are identical, we restrict the analysis to symmetric solutions. Let us denote  $\{q_i^*(F), y_i^*(F)\}$ ,  $i = 1, \dots, n$ . The equilibrium output and capacity of any firm for a given value of the fixed cost  $F$ . Let us introduce now the additional concavity condition :

$$4p'(q) + 5p''(q)q_i + p'''(q)(q_i)^2 \leq 0, \forall q_i \leq q, \quad (7)$$

ensuring that the associated separation program (4) without the constraint  $w_i \leq F/q_i$ , has an unique solution.

We are looking for an equilibrium solution of the absorption costing game satisfying the following condition expressing that the standard Cournot solution is recovered when the fixed cost is negligible.

**Condition 3 (consistency)** *The absorption cost pricing is close to the marginal cost oligopoly pricing when the fixed cost is close to zero:*

$$\lim_{F \rightarrow 0} q_i^*(F) = \lim_{F \rightarrow 0} y_i^*(F) = q^c.$$

The equilibrium conditions are determined by the relative position of the fixed cost with respect to two specific values,  $\hat{F}$  and  $F^s$  :

**Proposition 4** *Let  $\hat{F} = \max_q (p(q)q/n + p'(q)(q/n)^2) / n$ . There exists  $F^s \leq \hat{F}$ , such that, for any firm  $i$ :*

- For  $F \leq F^s$ , all the firms use a **full-cost pricing policy**; the unique equilibrium is such that:

- Output function  $q_i^*(F) = q^*(F)/n$  is differentiable and strictly decreasing, on  $[0, \hat{F}]$ , with  $q^*(F)$  the unique solution of:

$$p - nF/q + p'q/n = 0, \quad (8)$$

*satisfying the consistency condition.*

- No excess capacity occurs i.e.  $y_i^*(F) = q^*(F)/n$ , and the fixed cost is fully passed on.

- For  $F > \hat{F}$ : all the firms use a **partial cost pricing policy**; the unique equilibrium is such that:

- The output function  $q_i^*(.)$ , is constant and equal to the separation output  $q_i^s = q^s/n$  with  $q^s$  solution of:

$$p + p''q^2/n^2 + 3p'q/n = 0. \quad (9)$$

- Excess capacity occurs, i.e.  $q^s/n < y_i^*(F)$  and the fixed cost is partially passed on.

- The production capacity  $y_i^*(.)$  is a linear and increasing function.

- For  $F^s < F \leq \hat{F}$ , all the firms use either a full or a partial cost pricing policy; the two types of equilibria coexist.

**Proof.** see Appendix. ■

Let us interpret the threshold values  $\hat{F}$  and  $F^s$  :

The value  $\hat{F}$ , defined as  $\max_q [p(q)q/n + p'(q)(q/n)^2]$  has a clear meaning in the symmetric case<sup>3</sup> : it is the payoff ( $w_i q_i$  in the formulation (4)) any upstream unit would gain through a monopoly collusion at the upstream level.

The value  $F^s$  is equal to  $(p(q^s)q^s/n + p'(q^s)(q^s/n)^2)$ , namely the payoff of any upstream unit  $i$  under the separation rule. When the fixed cost is lower than  $F^s$ , the partial cost pricing is not feasible, since the upstream units are not allowed to gain more than the fixed cost, by construction. Hence :

- When the fixed cost is low ( $F \leq F^s$ ), the firms hold the full-cost pricing policy and the fixed cost is fully passed on the downstream units through an average cost computed on the basis of the quantity really sold under Cournot competition. This case coincides with the absorption costing notion used by Göx (2000) in a price setting duopoly context.
- When the fixed cost is high ( $\hat{F} < F$ ), the firms use the separation rule where only a part of the fixed cost is passed on the downstream units.
- When the fixed cost takes intermediate values ( $F^s \leq F \leq \hat{F}$ ), the two previous types of equilibria coexist. Such a coexistence is inherent to the oligopoly competition, since, in the monopoly case,  $F^s = \hat{F}$ .

In the linear case, for  $p(q) = 1 - q$ , the threshold values of the fixed cost are  $\hat{F} = \frac{1}{4(n+1)}$  and  $F^s = \frac{2}{(n+3)^2} \leq \hat{F}$ . The full-cost industry output

and the market price are given by  $q^*(F) = q = \frac{n \left(1 + \sqrt{(1 - 4F(n+1))}\right)}{2(n+1)}$

and  $p^*(F) = \frac{(n+2) - n\sqrt{(1 - 4F(n+1))}}{2(n+1)}$ . When  $F$  varies from 0 to

$\hat{F}$ ,  $q^*$  decreases from  $n/(n+1)$  to  $n/2(n+1)$  and the price increases from  $1/(n+1)$  to  $(n+2)/2(n+1)$ . In the separation/partial cost pricing case, we have  $q^s = \frac{n}{(n+3)}$ ,  $y_i^s = \frac{1}{2}F(n+3)$ ,  $p^s = \frac{3}{n+3}$ .

#### 4.1 Profitability

Let us examine the profitability of the firms under the various pricing rules:

(i) For  $F \leq \hat{F}$ , the absorption costing coincides with the full cost pricing rule, which is profitable since, by relation (8),  $pq/n - F = -p'/n^2 \geq 0$ ; the

<sup>3</sup>This expression has been suggested by a referee.

separation rule is not everywhere profitable, for instance, in the linear, case, only for  $n \leq 6$ .

(ii) For  $F > \hat{F}$ , the absorption costing coincides with the separation.

Altogether, the profitability conditions of the absorption costing cannot be more restrictive than those of the separation and the integration rule, since the latter is dominated by the separation in oligopoly (cf. below section.(5)).Accordingly, when the firms' number increases, the absorption costing rule is the last rule for which the firms are still profitable.

## 4.2 Robustness and stability

Clearly, under the assumptions made on the demand function, equation (8) has two solutions for  $F \leq \hat{F}$  (and no solution at all for  $F > \hat{F}$ ) ; the consistency condition amounts to selecting the solution  $q^*(F)$  which coincides with the integration case when the fixed cost is equal to zero ; This guaranties the robustness of the equilibrium solution in a neighborhood of  $F = 0$ . As it is economically relevant, the quantity decrease when the fixed cost, up to the value  $\hat{q} = q^*(\hat{F})$ .

In terms of stability,  $q^*(F)$  can be considered as a long run equilibrium state of the adjustment process  $(q_t)$  defined by the recursive equation  $q_{t+1} = F/(p(q_t) + p'(q_t)q_t/n)$ , where each firm computes in period  $t + 1$  its average cost on the basis of the quantity sold in period  $t$  (cf Hanson (1992) for a similar analysis when the cost-plus rate is supposed to be constant). Since  $q^*(F) \geq \hat{q}$ , it can easily be proved that this long run equilibrium state is stable<sup>4</sup>

## 4.3 Observability

Let us sketch the observable case : the downstream unit of each firm observes the production capacity levels of *all* the firms. At stage 1 the upstream unit of firm  $i$  takes into account the absorption costing policy used by her rivals so that she has to solve the following optimization program:

$$\begin{cases} \max_{q_j, y_i} Fq_i/y_i \\ q_i \leq y_i, \\ (p(q_{-j} + q_j) - \frac{F}{y_j}) + p'(q_{-j} + q_j)q_j = 0, \\ j = 1, \dots, n \end{cases} \quad (10)$$

It can be proved that proposition (4) still applies : the only difference lies in the partial costing/separation case, with relation (9) determining the total

<sup>4</sup>The alternative solution of equation (8) is an increasing function  $q^-(F)$ , with  $q^-(0) = 0$ , and  $\lim_{F \rightarrow 0} F/q^-(F) = p(0)/n$ . In the linear case,  $q^-(F) = n(1 - \sqrt{(1 - 4F(n+1))})/2(n+1)$ . Since  $q^-(F) \leq \hat{q}$ , it corresponds to an unstable long run equilibrium of the adjustment process.

output replaced by :

$$q(-pn + pn^2 - p'q + 2p'nq)p'' + p'n(pn^2 + 2qp'n + qp') = 0 \quad (11)$$

This implies that the observable and non observable equilibria differ under the separation rule; but there is no difference when the full-cost pricing policy holds, since relation (8) is valid in both cases and then yields the same quantity and price. The profit analysis gives similar results.

## 5 Profit analysis

In this section, we are going to compare the profits made by the firms under the various rules under consideration. Since the absorption costing rule coincides with the separation for  $F \geq \hat{F}$ , we will restrict the analysis to values of the fixed cost lower than  $\hat{F}$ . Then the comparisons will be made between the integration, the full cost pricing and the separation rules.

In the monopoly case, it is well know that vertical integration is better than separation (double marginalization) and the full cost pricing (dominated by the marginal cost pricing). This raises the question to see what would happen in the oligopoly case where strategic effects matter.

### 5.1 Dominance relations

Since the firms are identical, the comparisons can be made in terms of global gross profit  $P$ .

**Proposition 5** *There exists  $n^s \geq 3$ , such that, for  $n \geq n^s$ , the separation dominates the integration.*

**Proof.** see appendix ■

In the monopoly case, the integration dominates the separation: this is the standard result about the double mark-up effect which dissipates the profit. This proposition is in line with the literature on vertical integration in price-setting oligopoly (e.g. Greenhut and Ohta, 1979, Lin, 1988, Bonanno and Vickers, 1988, Abiru *et al.*, 1998, Cavero *et al.* 1998 ): when the firms are price makers, downstream competition holds on prices which are bounded from below by the wholesale prices decided at the upstream levels so that the price cutting opportunities of the downstream units are restrained, specially when the products are weakly differentiated. This induces a *dampening of the competition effect* within the industry which boosts the equilibrium profits. Such a phenomenon, still works in our quantity-setting competition with homogeneous product, so that at the Cournot equilibrium, the profits are better off under vertical separation.

But the full cost pricing enables to do still better. The vertical restraint mechanism associated with the capacity constraints at the upstream level

induces a voluntary limitation of action at the downstream level, implying a "puppy-dog" behavior of all the firms. Then the full cost pricing gives the firms an additional tool for upgrading the profits. Hence the following theorems, which elucidate the circumstances under which this occurs. Both theorems represent the main results of this article. Let  $P^m$  be the standard monopoly profit of the industry.

**Theorem 6** *There exists a value  $F^m = (n-1)P^m/n^2 \in [0, \hat{F}]$  at which the full-cost pricing oligopoly duplicates the standard monopoly of the industry.*

**Proof.** see Appendix. ■

This theorem means that there exists a value of the fixed cost  $F^m$  for which the full cost pricing yields a gross individual profit equal to  $P^m/n$ . This result is quite intuitive if the fixed cost value is considered as a parameter which could formally be used as an instrument to achieve a specific objective of the industry, namely the maximization of the global gross profit, which then holds for  $F = F^m$ . The "optimal" value  $F^m$  can be written  $\alpha_n(P^m/n)$ , with  $\alpha_n = (1 - 1/n)$ . It is proportional to the gross monopoly profit per firm. The coefficient  $\alpha_n$  measures the competitiveness of the industry: it is equal to 0 in the monopoly case and tends to 1 when  $n \rightarrow \infty$ . It does not depend on the demand function. Of course, when  $n \rightarrow \infty$ , the fixed cost value  $F^m \rightarrow 0$ , since the gross profit per firm  $P^m/n \rightarrow 0$ . It is worth mentioning that  $F^m$  is maximum for  $n = 2$ .

**Theorem 7** *For  $n \geq 2$ , there exists an interval of fixed cost values  $[F^-, F^+] \subset [0, \hat{F}]$ , where the full-cost pricing rule dominates the separation.*

**Proof.** This is an immediate consequence of the theorem (6). For  $F = F^m$ , the full-cost pricing strictly dominates any pricing rule. By continuity of the profit function, the full cost pricing dominates the separation (and the integration) in a neighborhood  $[F^-, F^+]$  of  $F^m$ , except in the monopoly case where  $F^m = 0$ . ■

This theorem states that there exists a non empty set of values of the fixed cost for which all the competitors are better off in terms of gross profit if they all use the full cost pricing rule. Economically, the fixed cost level is related to the use of a technology which is here identical for all the firms. This result reveals that the adoption of the full cost pricing rule might be a way of restoring anticompetitive rents for specific combinations of technology ( $F$ ) and market structure ( $n$ ).

**Proposition 8** *There exists  $\hat{n} \geq 2$ , such that, for any  $F \in [0, \hat{F}]$ , the full-cost pricing dominates the integration if  $n \geq \hat{n}$ , it is dominated by it if not.*

**Proof.** see Appendix. ■

This proposition states that the dominance of the full cost pricing vis à vis the integration rule holds for any value of the fixed cost, except in the monopoly case.

## 5.2 Comments and interpretations

Let us analyze the impact of the fixed cost on the full cost pricing gross profit, as compared to those under the integration and the separation rules. Since the fixed cost determines the average cost borne by the downstream unit, two opposite effects are at work in oligopoly : (i) The double mark-up effect which deteriorates the profits and is leveraged by the average cost (ii) the dampening competition effect which is related to the role of the average cost level in restraining the reaction opportunities of the rivals and boosts the profits

(a) *In the monopoly case*, we have  $F^m = 0$ . The situation is represented on figure 1. Clearly, the integration dominates both the separation and the full cost pricing. This is the standard result expressing that the marginal cost pricing is better than any other rules. But the full-cost pricing policy dominates the separation rule. This confirms the role of vertical restraint played by the capacity constraint which mitigates the double mark-up effect between the upstream and the downstream unit and then restores a part of the profit which would have been gained under the integration rule. Even in the monopoly case, the full cost pricing may be a good alternative to the marginal cost pricing when the integration is not allowed for organizational reasons.

Figure1 : insert here

(b) *In the oligopoly*, the separation dominates the integration; it also dominates the full-cost pricing in two extreme cases: (i) when  $F$  is low, the dampening of competition effect is more effective under the separation rule which then dominates the full cost pricing (ii) when  $F$  is high, the double markup effect prevails and deteriorates the full-cost pricing gross profits, as compared to the separation. In the interval  $[F^-, F^+]$ , these effects neutralize each other and the full-cost pricing dominates both the separation and the integration.

It can easily be proved that the threshold value  $F^s$  is higher than  $F^m$  for  $n = 2$ , and lower for  $n \geq 3$ . Then, in the duopoly case,  $F^s$  is equal to  $F^+$ ; it is equal to  $F^-$  in the oligopoly case. In duopoly (depicted on figure 2), the dominance of the full cost pricing holds outside the coexistence area, where it is the unique equilibrium. In oligopoly (depicted on figure 3), this holds in the coexistence area, where the full cost pricing is one of the two possible absorption costing equilibria.

Figure 2 : insert here

Figure 3 : insert here

A meaningful property immediately results from theorem (6): the firms would benefit to use the full-cost pricing by charging the same level  $F^m$  of fixed cost which ensures the best possible gross individual profit  $P^m/n$ . Of course, this is not true in terms of net profit  $p q_i - F$ , which is always maximal for  $F = 0$ <sup>5</sup>. However, this opens an avenue for coordination within the oligopoly under the auspices, for instance, of an eventual common provider of the technology used in the industry. If the actual fixed cost of the technology is  $F$ , the provider could suggest the firms to consider only a part  $F^m$  as the basis to compute their average cost. If all the firms agree on this accounting rule, they get the best net profit they can achieve with the technology.

## 6 Conclusion

The optimality of the full-cost pricing indicated in the title of this paper turns out to have a threefold meaning: (i) The full-cost pricing derives from an optimization program based on a principal-agent formulation of the organization (section 3). (ii) In a Cournot competition setting, it may dominates all other pricing rules and (iii) for a specific value of the fixed cost, it duplicates the monopoly and then leads to a first best solution of the Cournot oligopoly (section 5). The key ingredient of our analysis is to consider the firm as a two tier organization involved in a principal-agent relationship. Such a decomposition have some relevancy with regard to the common business practices: in many industries, the firms have an upstream unit working as the control entity of downstream units, while using the production capacity as a relevant cost driver for the accounting management, and then a proxy measure of the budgeted output.

Extensions of this work have to consider the role of the production capacity in a more general way. When the variable capacity cost is non zero, full-cost pricing policy does not change and then all the dominance properties established here are valid. although the partial cost pricing no longer coincides with the separation structure. Relaxing the zero capacity cost assumption does not alters substantially our main findings. More importantly, a particular attention should be given to oligopoly models which explicitly introduce the production capacities (cf. Thépot, 1995, for Bertrand competition); the question is to see what is going on when the production capacity

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<sup>5</sup>It can be check that the derivative of  $p(q^*(F))q^*(F) - nF$  with respect to  $F$  is negative at  $F = 0$ , thanks to the concavity assumptions on the profit functions.

is borne by the downstream units as do Kreps and Scheinkman (1983) in a price setting oligopoly context. Exploring other forms of competition, market structures and product differentiation is on our research agenda; as it is well documented in the literature on vertical relations, these elements crucially determine the comparative results in terms of performance and stability. More generally, our approach turns out to be a rather simple way of incorporating increasing returns to scale elements in IO standard models, in the perspective of examining technology choice or strategic investment problems, for instance.

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**Proof of proposition (4).**

Let us rewrite the upstream maximization program (6) as follows:

$$\max q_i/y_i, \quad (12)$$

subject to

$$Fq_i/y_i = p(q_{-i} + q_i)q_i + p'(q_{-i} + q_i)q_i^2, \quad (13)$$

and

$$q_i \leq y_i.$$

$\Phi(q_i)$  denotes the right-hand side of equation (13). Under condition (7), function  $\Phi$  is concave with  $\Phi(0) = \Phi(R_i(q_{-i})) = 0$ , where  $R_i$  is the reaction function of firm  $i$  in the Cournot oligopoly model, given by the equation  $p(q_{-i} + q_i) + p'(q_{-i} + q_i)q_i = 0$ . Function  $\Phi$  is unimodal; let  $G(q_{-i})$  be its maximum value which is reached at  $q_i = r(q_{-i}) \in [0, R_i(q_{-i})]$ , defined by the first-order condition:

$$p(q_{-i} + q_i) + 3p'(q_{-i} + q_i)q_i + p''(q_{-i} + q_i)q_i^2 = 0. \quad (14)$$

Let  $Q(q_{-i}, F)$  be a solution of the equation :

$$F = p(q_{-i} + q_i)q_i + p'(q_{-i} + q_i)q_i^2,$$

which exists for  $F \leq G(q_{-i})$ . Clearly, a solution of the upstream unit maximization program is given by the formulas

$$\begin{aligned} y_i &= q_i = Q(q_{-i}, F), \text{ if } F \leq G(q_{-i}, F) \\ q_i &= r(q_{-i}), y_i = Fr(q_{-i})/G(q_{-i}), \text{ if } F > G(q_{-i}, F). \end{aligned}$$

These conditions yield two types of equilibria which are characterized as follows in the symmetric case: let  $\hat{F} = \max(p(q)q/n + p'(q)(q/n)^2)$  and  $\hat{q} = \arg \max(p(q)q/n + p'(q)(q/n)^2)$ .

(i) For  $F \leq \hat{F}$ , the full cost pricing equilibrium prevails, with a quantity  $q^*(F)$  solution of

$$\gamma(q, F) = (p(q) - \frac{nF}{q}) + p'(q)q/n = 0. \quad (15)$$

On  $[0, \hat{F}]$ , the equation (15) may have more than one solution. Then we have to select a solution satisfying the consistency condition, ensuring that, when the fixed cost tends to zero, the Cournot marginal pricing case is found again. This condition is :

$$\lim_{F \rightarrow 0} q^*(F) = q^c.$$

Such a solution exists and is unique : by definition, we have  $\gamma(q^c, 0) = 0$  and  $\frac{\partial \gamma}{\partial q}(q^c, 0) < 0$ . Using the implicit functions theorem, there exists a unique continuous function  $q^* : [0, \hat{F}] \rightarrow ]0, q^c]$ , such that  $q^*(0) = q^c$ ,  $\gamma(q^*(F), F) = 0$  and  $\frac{\partial \gamma}{\partial q}(q^*(F), F) < 0 \forall F \in [0, \hat{F}]$ . Furthermore,  $\frac{dq^*}{dF} = -\frac{\partial \gamma}{\partial F} / \frac{\partial \gamma}{\partial q} \leq 0$ , for  $F \in [0, \hat{F}]$  : the function  $q^*(\cdot)$  is decreasing and the equilibrium output quantity  $q^*(F)$  is lower than  $q^c$ .

(ii) For  $F \geq \hat{F}$ , excess capacity occurs. Relations 14 gives the separation case solution  $q^s$ , defined by:

$$p + p''q^2/n^2 + 3p'q/n = 0. \quad (16)$$

Relation  $(p - \frac{F}{y_i}) + p'q/n = 0$  yields the capacity level proportional to the fixed cost  $F$ ,  $y_i = F/(p(q^s) + p'(q^s)q^s/n)$ . Consequently, the capacity constraint is satisfied for any values of  $F$  such that  $y_i \geq q^s/n$ , namely  $\gamma(q^s, F) \leq 0$ , i.e. for  $F \geq F^s = p(q^s)q^s/n + p'(q^s)(q^s/n)^2$ , which is lower than  $\hat{F}$

Then, for values of the fixed cost in interval  $[F^s, \hat{F}]$ , there are two Nash symmetric equilibria. Such a multiplicity disappears for  $n = 1$ , where  $k \equiv 0$  and  $F^s = \hat{F}$ . Hence the result.

**Proof of proposition (5).**

Let  $\pi(q) = p + p'q/n$ . Thanks to relation (1), functions  $\pi$  and  $P'$  are decreasing ; we have  $\pi(q^s) = -q[2p' + p''q/n] \geq 0$ , i.e.  $q^s \leq q^c$ . Similarly, we have  $P'(q^s) = [(3-n)p - p''q^2/n]/3$ , which is positive for  $n = 1$  and negative if  $n$  is large enough. Then, there exists  $n^s \geq 3$ , such that, for  $n \geq n^s$ ,  $P'(q^s) \leq 0$ , namely  $q^s \geq q^m$ , and then  $P(q^s) \geq P(q^c)$ . Hence the result.

**Proof of theorem (6)**

It is easy to check that  $q^m$  is solution of (15), for  $F^m = (n-1)P^m/n^2$ . For this particular value of the fixed cost  $F^m \leq \hat{F}$ , the full-cost pricing oligopoly replicates the standard monopoly case.

**Proof of proposition (8)**

One has to prove that  $P(q^*(F)) \geq P^c$ , or equivalently,

$$nF - p'(q^*(F))(q^*(F))^2/n \geq -p'(q^c)(q^c)^2. \quad (17)$$

This inequality holds for  $F = 0$  (as an equality), and the left hand side is an increasing function of  $F$  if  $n$  is large enough. Hence relation (17) is valid.