Upstream competition and buyer mergers

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Abstract:
This paper analyses buyer mergers in the presence of upstream competition to supply imperfect substitutes. A likely consequence of imperfect substitutes is that buyers, following disagreement with some of their suppliers, can renegotiate with other suppliers. There are thus two different channels through which large buyers can obtain more favourable terms from their suppliers. On the one hand, as stated in the literature on buyer power, large buyers receive a discount if the suppliers' marginal costs are increasing. On the other hand, buyer power is related to increasing the outside options of the buyer. The present study provides a fuller picture of the circumstances under which large buyers are more likely to obtain a discount. In such a framework, size discounts arise even if suppliers' marginal costs are decreasing. Moreover, some examples are given here to illustrate a number of industry scenarios. The idea is to derive situations in which buyer mergers would not occur unless the buyer industry exceeds a certain concentration at the outset. In this way, it is possible to characterize a lower threshold for the degree of buyer concentration.

Key words:
Buyer power, buyer merger, retailing, upstream competition.

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1. Introduction

In many industries, suppliers are confronted with increasingly powerful buyers. For instance, a small number of large retailers now dominate the grocery retail market in several member states of the European Union. European antitrust authorities have been more and more concerned about the potential adverse consequences of the exercise of buyer power on suppliers' economic viability and welfare implications (See recent antitrust cases such as Kesko/Tuko, and Carrefour/Promodes).[1] There has also been rising concern about buyer power in the United States. Although market concentration in retailing is generally lower, there has been a recent increase of interest in understanding negotiations in other industries. Some good examples of such interest are provided by the empirical studies of Ellison and Snyder (2002) for the pharmaceutical and hospital-services markets and Chipty and Snyder (1999) for the media-industries.

The present study proposes a model that can be used to explain why large buyers may obtain lower prices in negotiation with suppliers. The approach adopted here departs from the "bargaining interface" model with a monopoly supplier and instead considers competing suppliers.[2] Buyers negotiate with two suppliers of imperfect substitutes. The available supply contracts are sufficiently rich so that firms can fully disentangle the issue of maximizing joint profits from the way of sharing these profits.[3] Importantly, when faced with two suppliers of imperfect substitutes, the buyer's bargaining position - following a disagreement with a supplier - depends crucially on how well the renegotiation can be handled with the other supplier. Therefore, we can distinguish two sources (or channels) of buyer power. The first channel is discussed by Chipty and Snyder (1999) and Raskovich (2003). The merging of buyers would account for a larger fraction of the supplier's total sales and would thus be negotiated less well at the margin. If suppliers have increasing marginal production costs, the incremental surplus increases more steeply than in proportion with buyer size, explaining why large buyers pay a lower price per unit. The second channel is of more interest here, since it captures the indirect effects of a buyer merger via competition between suppliers. It is related to increasing the buyer's outside option. In the case of a breakdown in bargaining between the buyer and a supplier, an out-of-equilibrium renegotiation may exhibit an increasing return to scale. In particular, the merging buyers' outside option may increase more than in proportion to merger size if suppliers then have concave costs.

The results of the present study reflect these two contrasting channels of buyer power. For instance, size discounts can occur even if the suppliers' marginal costs are decreasing. This may be the case if the effect related to the second source of buyer power is larger than the effect related to the first. To summarize, this paper gives a fuller picture of the circumstances under which large buyers are more likely to obtain a discount. Some examples are given to illustrate scenarios in industry.

This paper discusses the situation where buyers negotiate with a monopoly supplier, citing the studies of Chipty and Snyder (1999) and Raskovich (2003). If the aggregate surplus function across all negotiations is concave in quantity, the incremental surplus increases more than in

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[1]Kesko/Tuko, DGIV, case M.784 and Carrefour/Promodes, DGIV, case M.1684.
[2]The term"bargaining interface", is drawn from Inderst and Shaffer (2006b).
[3]Firms negotiate over what economists have called a "quantity-forcing" contract, which sets the jointly optimal quantity together with a fixed total purchasing price; the fixed total purchasing price is adjusted downwards to reflect the change in the buyer's bargaining power.

proportion with buyer size, explaining why large buyers pay a lower price per unit.[4]
Size discounts also emerge when there is an improvement in the large buyers' outside options. If a buyer is large enough, the threat of backward integration and producing the good itself is credible even with large start-up costs. This argument is formalized in Katz (1987), Sheffman and Spiller (1992) and Inderst and Wey (2005). Lower price per unit also emerges as a factor that can reduce the supplier's outside options. According to Inderst and Wey (2006), when bargaining breaks down with a large buyer, the supplier finds it difficult to unload this large quantity onto the remaining buyers since this involves "marching down" the declining marginal surplus functions for these buyers.
Continuing our review of the literature, if we instead consider competing suppliers, mergers would appear to create more powerful buyers. Snyder (1996 and 1998) proposes that collusion is difficult to sustain in the presence of a large buyer because such buyers are more likely to tempt an individual supplier into deviating from the collusive strategy. To illustrate this effect, we note that a supplier can win a large order by deviating in this way. To prevent undercutting at equilibrium, suppliers collude on a lower price for large buyers. Following a merger or a buyer alliance, as studied, respectively, by Inderst and Shaffer (2006) and Dana (2006), buyers may announce that they will no longer stock the goods of all previous suppliers, thus increasing the intensity of competition among suppliers.
More recently, Smith and Thanassoulis (2006) and Inderst (2006) considered the situation where a number of upstream firms compete to supply a homogeneous product to a number of downstream firms. As in this present study, the sales agents of each supplier negotiate independently with different buyers. In the absence of a deal, these agents will form rational expectations about the position of the upstream firms on the surplus function curves. Following Inderst, but in contrast to Smith and Thanassoulis, firms bargain over flexible tariffs.[5] However, there are different ways of modelling the break up of negotiations. Inderst considers a strategic model of alternating offers in which there is a possibility of adjusting all other supplies or purchases during a temporary delay in a given agreement. In contrast to Inderst, we consider the Nash bargaining solution for modelling the break up of negotiations. In this approach, following a disagreement with a one of the suppliers, the buyer and the other supplier are bound by their contract and out-of-equilibrium renegotiations will take place from this *status quo* position. Note that the buyer is then placed in a weaker position as suppliers are imperfect substitutes and there is only one supplier remaining to turn to in the event of a disagreement. Finally, there is another key difference with these other studies: suppliers are here assumed to be imperfect substitutes. Such a framework provides a better description of the supplier-supermarket bargaining interface: buyers stock a range of goods and suppliers are imperfect substitutes.[6]
Lastly, the present study contributes to the extensive literature on the incentives to merge in

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[4]See DeGraba (2005) and, Chae and Heidhues (2004) for studies in which total surplus function is also concave. The total surplus function is effectively concave, even if the supplier's cost function is linear, because the supplier is assumed to be risk averse. More generally, see Horn and Wolinsky (1988) and Stole and Zwiebel (1996), as well as Inderst and Shaffer (2006b) for an interesting review.
[5]The present author assumes that contracting takes place over non-linear pricing. The opposite assumption, given in Smith and Thanassoulis, is that contracts are based on linear pricing. However, recent econometric studies (Bonnet et al., 2004, and Berto Villas-Boas, 2004) suggest that non-linear contracting is pervasive.
[6]Only a few recent papers focus on this point. However, see Avenel and Caprice (2006) for an analysis of the choice of retailers' product line in the presence of market power at the manufacturing stage.

the context of industry scenarios. For instance, Perry and Porter (1985) propose different industry scenarios involving mergers by the entire industry or by only the first or second firms. We also discuss situations in which mergers would not occur unless the industry was sufficiently concentrated at the outset. In the model with vertical linkages presented here, there is a lower threshold to the degree of buyer concentration. Beneath this threshold, merging firms are worse off than in the pre-merger situation. In some examples with the suppliers having convex cost functions, it can be shown that the lower threshold of buyer concentration increases as upstream rivalry increases. Concave cost functions have the opposite result, with the threshold dropping as upstream rivalry rises.

This paper is organized as follows. Section 2 presents the model, while Section 3 sets the conditions that lead to the creation of buyer power. Some illustrative examples are given in Section 4. Section 4 also contains a discussion of some results. Section 5 concludes.

2. The model

2.1. Industry setting

Let us consider a goods market in which two suppliers A and B sell their products to an intermediary industry. Assume that suppliers' production technologies are described by twice continuously differentiable cost functions $C_A\left(x^A\right)$ and $C_B\left(x^B\right)$, with $C_k\left(0\right)=0$, $k=A,B$. Inputs are used by $N \geq 2$ downstream firms. The N downstream firms are identical and serve N identical independent markets. Let $R\left(x^A,x^B\right)$ denote revenues generated at each outlet by purchasing quantities x^A and x^B.

Importantly, some downstream firms (or outlets) may belong to the same owner. Assuming symmetry, the market for inputs is fully described by a set of buyers $i=1,...,I$ and the corresponding number of firms r_i controlled by each buyer i.

We assume symmetry in the intermediary industry to facilitate the presentation of results. Since it is restricted to independent downstream markets, the model is more relevant for cross-border mergers. Nevertheless, this restriction is commonly applied in many studies on downstream mergers and allows us to deal exclusively with interactions at the upstream level.

The industry setting is described as follows.

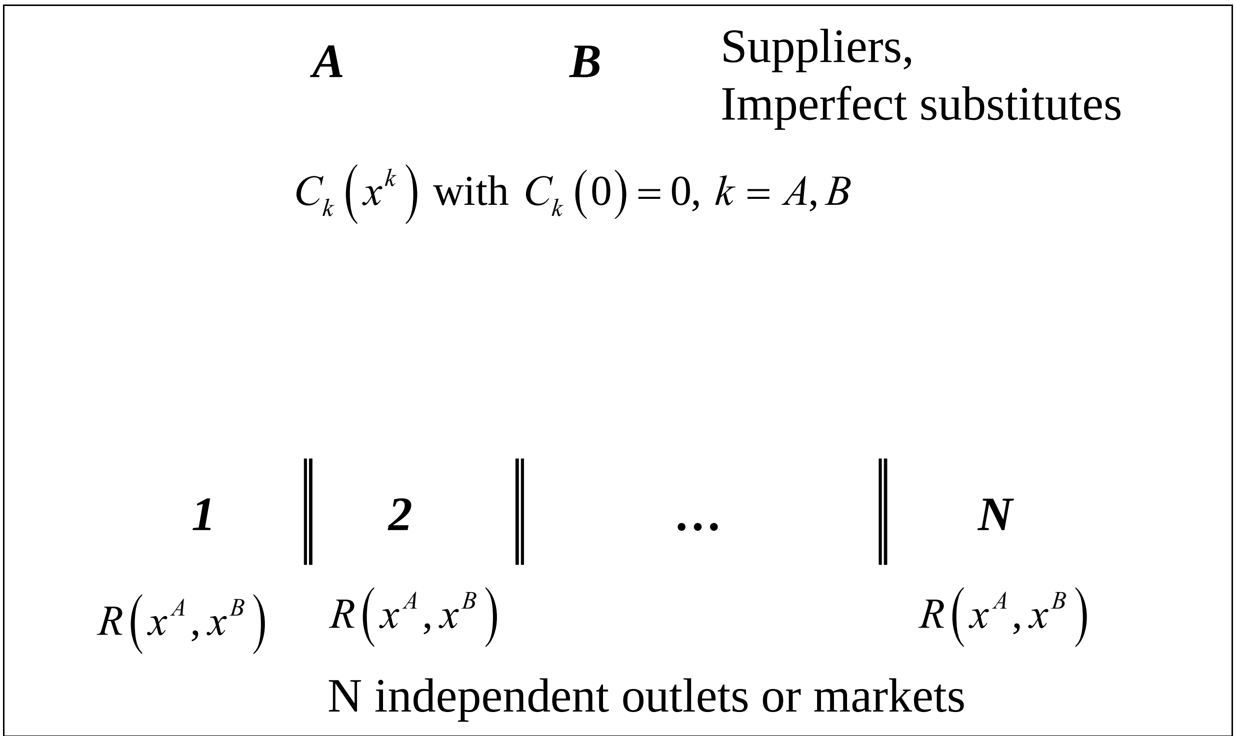

Figure 1: Industry setting

2.2. Negotiations

Supply contracts are determined in bilateral negotiations. Each buyer negotiates separately with each of the suppliers. In this study, bilateral contracts are allowed to be sufficiently complex to rule out problems of double marginalization. The contract of supplier k with buyer i, who purchases inputs for the r_i firms (or markets) that it controls, specifies a transfer $t_i^k\left(x^k\right)$ as a function of the supplied quantity x^k for $k=A,B.$ As there is no uncertainty in the model, at equilibrium, each buyer will receive deterministic quantities of supply. These quantities are denoted here by $\bar{x}_i^k$, while the respective transfer is $\bar{t}_i^k=t_i^k\left(\bar{x}_i^k\right)$ for $k=A,B.$ For simplicity, we assume that buyer i incurs no distribution costs other than payments for $\bar{x}_i^A$ and $\bar{x}_i^B$. Then, buyer i's profit can be expressed as:

$$r_i R\left(\frac{\bar{x}_i^A}{r_i},\frac{\bar{x}_i^B}{r_i}\right)-\bar{t}_i^A-\bar{t}_i^B. \tag{1}$$

While supplier k's profit is:

$$\bar{t}_i^k+\sum_{j\neq i}\bar{t}_j^k-C_k\left(\overline{X}^k\right), \text{ with } \overline{X}^k=\bar{x}_i^k+\sum_{j\neq i}\bar{x}_j^k, k=A,B. \tag{2}$$

To model simultaneous negotiations between each supplier and the different buyers, let us imagine that, as usual, each supplier employs I agents (or "account managers"). Each agent of k negotiates simultaneously without communication over the transfer $t_i^k\left(x^k\right)$, forming rational expectations about the outcomes of all the other negotiations. Furthermore, we assume here that both suppliers have the same exogenous bargaining power $1-\alpha$, with $\alpha\in\left(0,1\right)$. At equilibrium, the transfer $\bar{t}_i^k$ will be chosen such that the respective supplier k

receives the fraction $(1-\alpha)$ of its incremental surplus, which is generated by an agreement with i.

It is possible to imagine a very simple model of negotiations in which bilateral supplies are chosen to maximize total industry profits at equilibrium, i.e. if all negotiations are successful. Off equilibrium, from the point of view of the buyer, if bargaining breaks down between this buyer and a given supplier, the contract remains binding on the buyer and the other supplier. Thus, any out-of-equilibrium renegotiation between the buyer and the other supplier will start from this *status quo* basis.

For instance, from the point of view of a buyer i who fails to agree a deal with supplier A (out of equilibrium), we can express the new bargaining set-up between buyer i and supplier B, with respect to t_i^B, x_i^B, in terms of a set of payoff pairs:

$$\left(r_i R\left(0, \frac{x_i^B}{r_i}\right) - t_i^B,\ t_i^B + \sum_{j \neq i} \bar{t}_j^B - C_B\left(x_i^B + \sum_{j \neq i} \bar{x}_j^B\right)\right) \tag{3}$$

with the disagreement point defined as:

$$\left(r_i R\left(0, \frac{\bar{x}_i^B}{r_i}\right) - \bar{t}_i^B,\ \bar{t}_i^B + \sum_{j \neq i} \bar{t}_j^B - C_B\left(\overline{X}^B\right)\right). \tag{4}$$

Importantly, we assume that the outcomes are determined in all other negotiations.[7]

Off equilibrium, the negotiation process yields the following solution:

$$\left(\tilde{x}_i^B, \tilde{t}_i^B\right) = \arg x_i^B, t_i^B \max \left[r_i R\left(0, \frac{x_i^B}{r_i}\right) - t_i^B - \left(r_i R\left(0, \frac{\bar{x}_i^B}{r_i}\right) - \bar{t}_i^B\right)\right]^{\alpha} . \left[t_i^B - C_B\left(x_i^B + \sum_{j \neq i} \bar{x}_j^B\right) - \left(\bar{t}_i^B - C_B\left(\overline{X}^B\right)\right)\right]^{(1-\alpha)}. \tag{5}$$

Off equilibrium, as a result of Nash bargaining, buyer i obtains α of the increment to total surplus generated by renegotiation with supplier B. The increment to total surplus, i.e.,

$$r_i\left[R\left(0, \tfrac{\tilde{x}_i^B}{r_i}\right) - R\left(0, \tfrac{\bar{x}_i^B}{r_i}\right)\right] - \left[C_B\left(\tilde{x}_i^B + \sum_{j \neq i} \bar{x}_j^B\right) - C_B\left(\overline{X}^B\right)\right] \tag{6}$$

is the sum of two terms, namely, the increment to downstream surplus, $r_i\left[R\left(0, \tfrac{\tilde{x}_i^B}{r_i}\right) - R\left(0, \tfrac{\bar{x}_i^B}{r_i}\right)\right]$ and the increment to upstream surplus, $-\left[C_B\left(\tilde{x}_i^B + \sum_{j \neq i} \bar{x}_j^B\right) - C_B\left(\overline{X}^B\right)\right]$.

The adopted bargaining solution combines both non-cooperative and cooperative concepts to obtain clear-cut results. Firstly, we assume that the equilibrium solution is characterized by efficient allocation, i.e., negotiations maximize total industry profits at equilibrium if all negotiations are successful.[8] Such a specification is made for sake of convenience. It allows us to rule out any downstream or upstream efficiency, using the terminology of Chipty and

[7]The equilibrium is fully specified, and we may assume both buyer i and B's agent believe that negotiations with buyers $j \neq i$ reach an outcome regardless of the renegotiation carried out by themselves (out of equilibrium) . In the study of McAfee and Schwartz (1994), such beliefs are termed "passive".

[8]In the terminology of bilateral markets, we can thus assume "quantity forcing contracts". See, for example, Inderst and Wey (2003).

Snyder (1999), when examining the effects of buyer merger.[9] At equilibrium, quantities would not show any variation following a merger.
Secondly, we consider that renegotiating will change when one supplier fails to come to an agreement (out of equilibrium). Economies of scale may arise from renegotiating, depending on the shape of the increment-to-total-surplus function generated by renegotiation after disagreement with a given supplier.
The bargaining solution adopted here is discussed in section 4, using the example of a bargaining game in which the Nash bargaining solution applies both at and off equilibrium.

2.3. Equilibrium

The terms $X_N^{A,*}$ and $X_N^{B,*}$ are used to denote the quantities that maximize total industry profits:

$$X_N^{A,*}, X_N^{B,*} = \arg X_N^A, X_N^B \max N.R\left(\frac{X_N^A}{N}, \frac{X_N^B}{N}\right) - C_A\left(X_N^A\right) - C_B\left(X_N^B\right). \tag{7}$$

By symmetry, total industry profits are maximized by supplying $\frac{X_N^{A,*}}{N}$ and $\frac{X_N^{B,*}}{N}$ to each of the N firms. In addition, we assume $X_N^{A,*} > 0$ and $X_N^{B,*} > 0$. This assumption may imply restrictions to ensure the model is specified.[10] Total industry profits are given by:

$$\Pi_N^* = N.R\left(\frac{X_N^{A,*}}{N}, \frac{X_N^{B,*}}{N}\right) - C_A\left(X_N^{A,*}\right) - C_B\left(X_N^{B,*}\right). \tag{8}$$

Moreover, let us consider the subset $I' \subseteq I$, where $\Pi^{k,*}_{N-\sum_{i\in I'}}$ denotes the total industry profits in the case of no agreement between k and the subset I'. For instance, taking I' defined by buyer i, we obtain the following equation:

$$\Pi^{k,*}_{N-r_i} = \left(N - r_i\right).R\left(\frac{X_N^{A,*}}{N}, \frac{X_N^{B,*}}{N}\right) + r_i.R\left(0, \frac{X_N^{l,*}}{N}\right) - C_k\left(\left(N - r_i\right)\frac{X_N^{k,*}}{N}\right) - C_l\left(X_N^{l,*}\right). \tag{9}$$

With the chosen bargaining solution, if there is no agreement between supplier k and buyer i, off-equilibrium renegotiation is allowed between supplier l and buyer i. $\Pi^{k,\sim}_{N-r_i}$ denotes the total industry profits if there is no agreement between k and buyer i, allowing renegotiation between supplier l and buyer i. In this case, the total industry profits can be written as:

$$\begin{aligned} \Pi^{k,\sim}_{N-r_i} = {} & \left(N - r_i\right).R\left(\frac{X_N^{A,*}}{N}, \frac{X_N^{B,*}}{N}\right) + r_i.R\left(0, \frac{\tilde{x}_i^{l}}{r_i}\right) \\ & - C_k\left(\left(N - r_i\right)\frac{X_N^{k,*}}{N}\right) - C_l\left(\left(N - r_i\right)\frac{X_N^{k,*}}{N} + \tilde{x}_i^{l}\right) \end{aligned} \tag{10}$$

where $\tilde{x}_i^{l}$ is defined in Equation (5).
Note that, since efficient allocation is required at equilibrium, equilibrium quantities are

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[9]The present approach differs from that of Chipty and Snyder's, since these authors consider the Nash bargaining solution at equilibrium.
[10]In the section 4 for illustrative examples, conditions on parameters are given such that the model can be specified.

independent of buyer merger. As a consequence, only transfer will depend on buyer merger.

Proposition 1.
Supplier k, facing a buyer i controlling r_i, obtains a fraction $(1-\alpha)$ of the respective incremental contribution to total industry profits, which equals $(1-\alpha)\left[\Pi_N^* - \Pi_{N-r_i}^{k,*} - \alpha\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right)\right]$.
Transfer is given by:

$$t_i^{k,*} = \frac{r_i}{N}\left[\Pi_N^* - \Pi_0^{k,*} + C_k\left(X_N^{k,*}\right)\right] - \alpha\left(\Pi_N^* - \Pi_{N-r_i}^{k,*}\right) - (1-\alpha)\alpha\left[\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right]. \quad (11)$$

Then, the revenue of supplier k can be written as follows:

$$\Pi_N^* - \Pi_0^{k,*} - \alpha\left[\sum_{i\in I}\left(\Pi_N^* - \Pi_{N-r_i}^{k,*}\right) + (1-\alpha)\sum_{i\in I}\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right)\right] \quad (12)$$

and buyer i's total profits are:

$$\frac{r_i}{N}\left[\Pi_0^{B,*} + \Pi_0^{A,*} - \Pi_N^*\right] + \alpha\left[\sum_{k=A,B}\left(\Pi_N^* - \Pi_{N-r_i}^{k,*}\right) + (1-\alpha)\sum_{k=A,B}\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right)\right]. \quad (13)$$

Proof. See Appendix.

Note that, for $\alpha = 0$, where suppliers have all the bargaining power, supplier k simply obtains an incremental contribution to the total industry surplus. From the point of view of buyer i, renegotiation with the other supplier - following a disagreement with k - generates zero profit since $\alpha = 0$. k's total profits are then given by:

$$\Pi_N^* - \Pi_0^{k,*}. \quad (14)$$

and i's total profits are given by:

$$\frac{r_i}{N}\left[\Pi_0^{B,*} + \Pi_0^{A,*} - \Pi_N^*\right]. \quad (15)$$

It is noteworthy that buyer i's profits are non-zero, since there is competition among suppliers.
At the other extreme, when $\alpha = 1$, each buyer can extract their full contribution. According to the assumptions, the suppliers' profits in (12) are non-negative. Thus, restrictions may emerge that are needed to make sure the model is specified. The following illustrative examples provide conditions that ensure suppliers' profits are non-negative.

3. Bargaining effects

Using Proposition 1, we may ask what conditions allow a larger buyer to obtain a more favourable deal. The average profit by outlet of buyer i is given by the following equation: $\phi_i = R\left(\frac{X_N^{A,*}}{N}, \frac{X_N^{B,*}}{N}\right) - \frac{t_i^{A,*}}{r_i} - \frac{t_i^{B,*}}{r_i}$.

Hence, it appears that a buyer merger is profitable whenever ϕ_i strictly increases with the number of controlled firms, i.e.,

$$\frac{\partial \phi_i}{\partial r_i} = \frac{1}{r_i}\left[\sum_{k=A,B}\left(\frac{t_i^{k,*}}{r_i} - \frac{\partial t_i^{k,*}}{\partial r_i}\right)\right] > 0, \quad (16)$$

since $X_N^{A,*}$ and $X_N^{B,*}$ are unchanged.[11] Note that, due to efficient contracting, the conditions for a profitable buyer merger and size discounts are identical.
It is possible to modify equation (16) to distinguish the different motives for buyer merger. Only bargaining motives are relevant here, since any downstream or upstream efficiency has been ruled out. In particular, we define $(k = A, B; k \neq l = A, B)$

$$BPD_k = -\alpha\left[\frac{\Pi_N^* - \Pi_{N-r_i}^{k,*}}{r_i} - \frac{\partial\left[\Pi_N^* - \Pi_{N-r_i}^{k,*}\right]}{\partial r_i}\right], \tag{17}$$

$$BPI_k = -\alpha(1-\alpha)\left[\frac{\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}}{r_i} - \frac{\partial\left[\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right]}{\partial r_i}\right]. \tag{18}$$

In brief, the terms BPD_k and BPI_k express the effects of the merger on the merging buyers' **bargaining position** with respect to supplier k. We need to distinguish direct from indirect effects. The well-known term BPD_k indicates the direct effect of buyer merger on supplier k. Assuming $C_k\left(x^k\right)$ is convex, marginal buyers contribute less to industry surplus than inframarginal buyers. The sign of the term BPD_k is positive if $C_k\left(x^k\right)$ is convex. Merging buyers would pay lower prices to supplier k, in accordance with the received wisdom in the theoretical literature (Chipty and Snyder, 1999). The term BPI_k is new and captures the indirect effect of a buyer merger on supplier k via out-of-equilibrium renegotiation with supplier l $(l \neq k = 1, 2)$ following a disagreement. Formally, it depends on the surplus that is at stake between l and the buyer:

$$\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*} \tag{19}$$

i.e., the additional revenue derived from selling $r_i\left(\frac{\tilde{x}_i^l}{r_i} - \frac{X_N^{l,*}}{N}\right)$ more units minus the additional costs incurred by producing these units.
In terms of relevant effects, condition (16) becomes

$$\left(BPD_A + BPI_A\right) + \left(BPD_B + BPI_B\right) > 0. \tag{20}$$

Condition (20) is quite intuitive. Merging buyers have a greater incentive to merge if the merger leads to increasing the bargaining effects. According to the literature, assuming $C_k\left(x^k\right)$ is convex, the payment that the supplier receives from merging buyers would be lower in the case of a merger. In the present model, the sign of the term BPD_k, expressing the direct effect, is actually positive. However, the payment that the supplier receives from merging buyers would only be lower in the case of a merger, assuming $C_k\left(x^k\right)$ is convex, if the sign of the sum $BPD_k + BPI_k$ is positive. We can see that the sign of the indirect bargaining effect BPI_k depends solely on the curvature of $C_l\left(x^l\right)$.

Proposition 2.

(i) If $C_k''\left(x^k\right) > 0$ *for* $x^k > 0$*, then* $BPD_k > 0$*. If* $C_k''\left(x^k\right) < 0$ *for* $x^k > 0$*, then* $BPD_k < 0$.

(ii) If $C_l''\left(x^l\right) > 0$ *for* $x^l > 0$*, then* $BPI_k < 0$*. If* $C_l''\left(x^l\right) < 0$ *for* $x^l > 0$*, then* $BPI_k > 0$.

Proof. See Appendix.

[11] In the model, equilibrium quantities are not affected by a buyer merger.

Some insight into Proposition 2 is provided by Fig. 2. For simplicity, this figure illustrates the case of a merger between two buyers of one outlet. For instance, let us consider the bargaining position of the merging buyers with respect to supplier A. The model predicts that i) the sign of the term BPD_A is positive if $C_A''\left(x^A\right) > 0$ and ii) the sign of the term BPI_A is negative if $C_B''\left(x^B\right) > 0$. If buyers 1 and 2 do not merge, the negotiated tariffs $t_1^{A,*}$ and $t_2^{A,*}$ depend on their marginal contribution to supplier A's gross surplus, which is related to the marginal cost to suppliers A and B (labelled M in Fig. 2). If the buyers merge, the negotiated tariff $t_{1+2}^{A,*}$ depends on buyer 1's marginal contribution to supplier A's gross surplus, which is related to the relative marginal cost M for suppliers A and B, plus the inframarginal contribution of buyer 2 to the gross surplus of supplier A. This latter is related to the relative inframarginal marginal costs for suppliers A and B (labelled IM in Fig. 2). If $C_A\left(x^A\right)$ is convex, as in the upper panel of Fig. 2, the inframarginal cost for equilibrium quantities is lower than the marginal cost, so the inframarginal buyer contributes more to the industry surplus than the marginal buyer in a buyer merger. We obtain $BPD_A > 0$.[12] If $C_B\left(x^B\right)$ is convex, as in the lower panel of Fig. 2, a disagreement with supplier A leads to an increase in the quantity purchased from supplier B by merging firms in an out-of–equilibrium situation. For merging buyers in this situation, the inframarginal cost related to supplier B is higher than the marginal cost, so the inframarginal buyer contributes less to the industry surplus than the marginal buyer. Since the outside option of the merging buyers decreases in the merger, we obtain $BPI_A < 0$.

[12]See also Chipty and Snyder (1999).

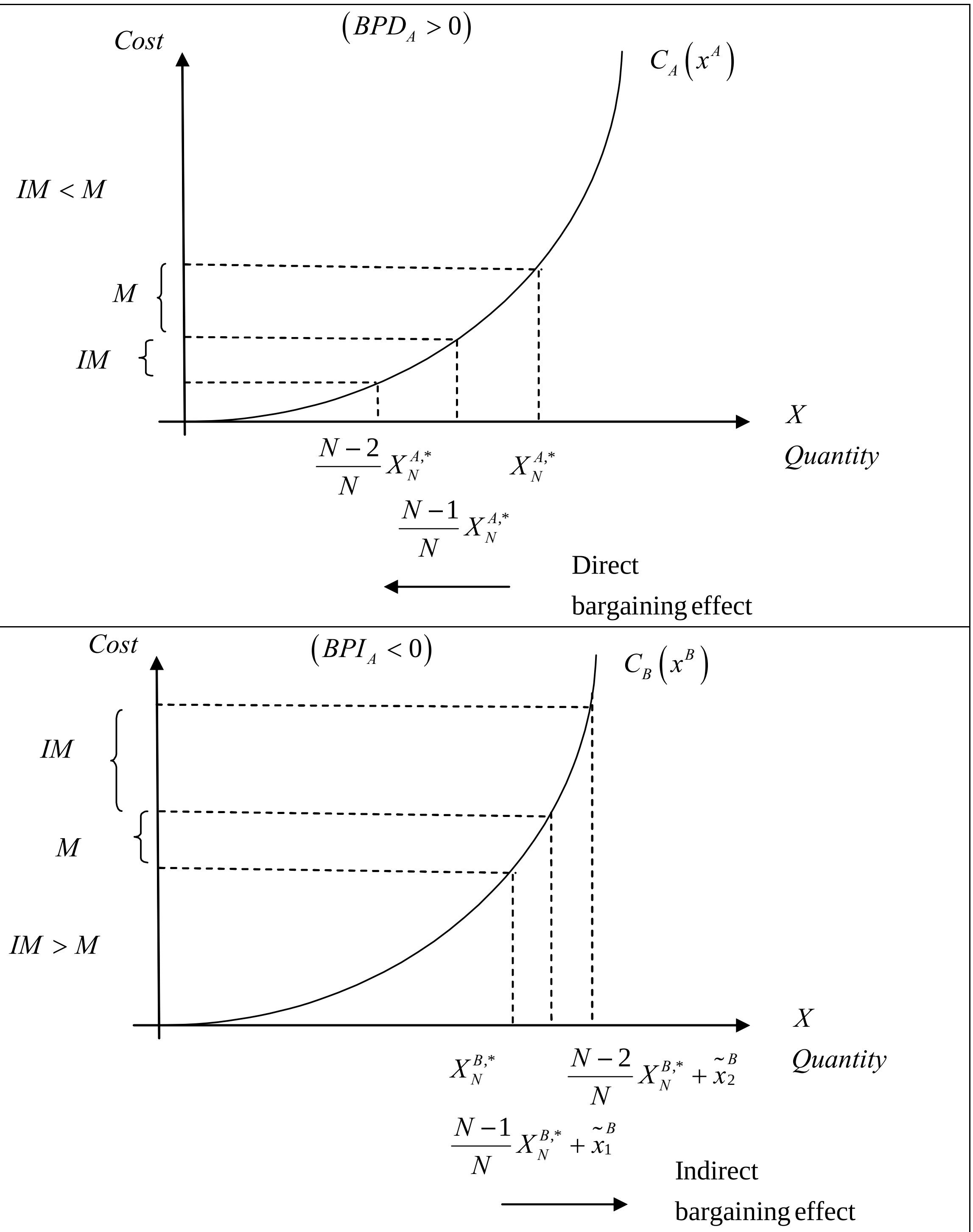

Figure 2: Bargaining effects with respect to supplier A

Assuming symmetry between suppliers A and B, and $C_A(x) = C_B(x) = C(x)$ for $x > 0$, we can derive an exhaustive list of cases in which buyer mergers would be profitable. Depending on the curvature of the suppliers' cost functions, a profitable buyer merger will fall into one of two possible categories. The list can be inferred from the following corollary.

Corollary 3.

(i) If $C''(x) > 0$ *for* $x > 0$*, buyer merger is profitable only when* $BPD_k > |BPI_k|$.

(ii) If $C''(x) < 0$ for $x > 0$, buyer merger is profitable only when $|BPD_k| < BPI_k$.

This analysis provides some useful empirical insights. It is possible to observe large buyers paying lower prices to sellers because of bargaining effects, irrespective of whether the suppliers' cost functions are convex. In the absence of any classical downstream efficiency effects, buyer merger may be profitable.
Chipty and Snyder's study (1999) of the cable-television industry showed that the gross surplus function for a representative program service supplier was convex, i.e., the production cost function was concave. Within their framework, this implies that a merger should worsen rather than enhance the buyers' bargaining position. This framework does not take upstream competition into account. The model presented here provides a new insight, indicating that buyer mergers may be profitable in terms of bargaining effects even if the production cost function is concave. The key factor is upstream competition. Such size discounts emerge when the production cost function is concave, provided the indirect bargaining effect is larger than the direct bargaining effect. In other words, within the framework of the present model, upstream competition can restore the profitability of buyer merger in terms of bargaining position even if production cost functions are concave.
In addition, the present results are consistent with some empirical evidence. Ellison and Snyder (2002) and Sorensen (2003) studied circumstances under which buyer-size discounts emerge. They observed size discounts in pharmaceutical and hospital-services markets, but only if the suppliers were competing and not in a monopoly setting. Upstream competition seems to operate as a key factor.

4. Illustrative examples

4.1. Industry scenarios

The present model provides a number of industry scenarios. Previous models did not address the question of whether a lower threshold could be characterized for the degree of downstream concentration in certain kinds of industry. The idea here is to derive situations in which downstream mergers would not occur unless the downstream industry was sufficiently concentrated to begin with. We consider two linear-demand examples irrespective of whether suppliers' cost functions are convex.
The inverse demand functions for two products A and B facing an outlet can be written as:

$$P_A\left(x^A, x^B\right) = 1 - x^A - \gamma x^B \quad \text{and} \quad P_B\left(x^B, x^A\right) = 1 - x^B - \gamma x^A \tag{21}$$

where $\gamma \in (0,1)$ is a measure of the degree of rivalry, corresponding to the consumer perception of similarity between goods A and B. When $\gamma = 0$, the goods are viewed as independent, but as γ approaches unity, they become closer substitutes. At the limit $\gamma = 1$, the goods are considered perfect substitutes. In the first example, the suppliers' production technology can be described by convex cost functions such as:

$$C_k\left(x^k\right) = \beta_1 x^k + \frac{\beta_2}{3}\left(x^k\right)^3, \text{in which } \beta_1 = 0.1, \beta_2 = 0.03\left(k = A, B\right). \tag{22}$$

The second example involves suppliers that can be described in terms of concave cost functions such as:

$$C_k\left(x^k\right) = \beta_1 x^k + \frac{\beta_2}{3}\left(x^k\right)^3, \text{in which } \beta_1 = 0.1, \beta_2 = -0.03\left(k = A, B\right). \tag{23}$$

Corollary 3 implies that profitable buyer mergers will only arise if the direct bargaining effect is stronger than the offsetting indirect bargaining effect in the case of convex suppliers' cost functions. Concave suppliers' cost functions have the opposite result. In both examples, we can derive explicit conditions controlling the competitiveness of the upstream market and the degree of downstream concentration. These conditions then determine to what extent merging downstream firms are better off than in the pre-merger situation.

Proposition 4.
In the first example, with convex cost functions as given by Equation (22), the downstream concentration has a lower threshold value that rises as upstream rivalry increases.
Proposition 5.
In the second example, with concave cost functions as given by Equation (23), the downstream concentration has a lower threshold value that falls as upstream rivalry increases.

The above propositions show that, depending on the description used for suppliers' production technologies, an increase in upstream rivalry may either reduce or increase the set of parameters that determine whether merging buyers are better off than in the pre-merger situation. In the first example, covered by Proposition 4, an increase in upstream competitiveness γ decreases the set of parameters controlling the profitability of a given merger. As a result, the lower threshold of downstream concentration rises as upstream rivalry increases. In the second example, covered by Proposition 5, an increase in upstream rivalry γ has the opposite effect. This is because there is an offset between direct bargaining effects and indirect bargaining effects, which corresponds to an increase in upstream competitiveness. In the first example, any increase in upstream competitiveness impairs the level of merging buyers' outside options, increasing the importance of the negative indirect bargaining effect. This effect counterbalances the positive direct bargaining effect of merging as upstream rivalry rises. In the second example, the outside options of the merging buyers become wider along with the increase in upstream competitiveness, thus increasing the importance of the positive indirect bargaining effect. This offsets the negative direct bargaining effect due to merging as upstream rivalry rises.

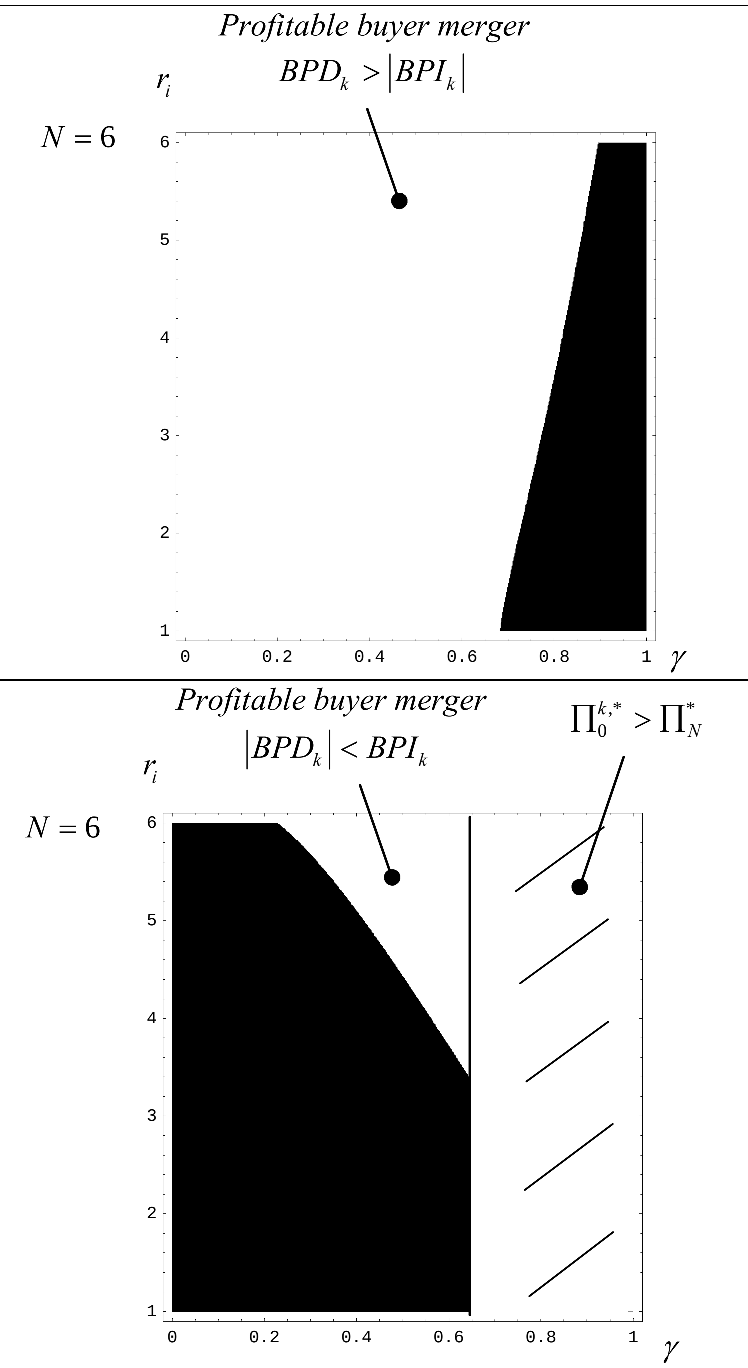

Figure 3: Profitable buyer merger

According to Propositions 4 and 5, we obtain the results illustrated in Fig. 3 (Proposition 4 with convex cost functions in the upper panel and Proposition 5 with concave cost functions in the lower panel). In this example, we set $\alpha = 0.5$, $N = 6$.[13]

4.2. Discussion

In the following, we discuss the adopted bargaining solution in some detail, using an

[13]Note the restriction applied in the lower panel is to ensure that the model is specified. The model is well defined for $\Pi_N^* > \Pi_0^{k,*}$.

illustrative example. In the general analysis, we choose bilateral supplies to maximize total industry profits at equilibrium, i.e., if all negotiations are successful. This specification is made for sake of convenience, allowing us to derive some clear-cut results. An alternative approach would be to assume that the bargaining game is a result of Nash bargaining **both** at equilibrium and off equilibrium.

At equilibrium, the bargaining process between buyer i and supplier k, with respect to x_i^k, t_i^k, can now be described by a set of payoff pairs:

$$\left(r_i R\left(\frac{x_i^k}{r_i}, \frac{\overline{x}_i^l}{r_i} \right) - t_i^k - \overline{t}_i^l, t_i^k + \sum_{j \neq i} \overline{t}_j^k - C_k\left(x_i^k + \sum_{j \neq i} \overline{x}_j^k \right) \right) \tag{24}$$

and the disagreement point:

$$\left(r_i R\left(0, \frac{\tilde{x}_i^l}{r_i} \right) - \tilde{t}_i^B, \sum_{j \neq i} \overline{t}_j^k - C_k\left(\sum_{j \neq i} \overline{x}_j^k \right) \right). \tag{25}$$

The outcomes in all other negotiations are given.[14]

The new solution arising from the negotiation process is thus given by:

$$\begin{aligned} \left(\overline{x}_i^k, \overline{t}_i^k \right) = \arg x_i^k, t_i^k \max &\left[r_i R\left(\frac{x_i^k}{r_i}, \frac{\overline{x}_i^l}{r_i} \right) - t_i^k - \overline{t}_i^l - \left(r_i R\left(0, \frac{\tilde{x}_i^l}{r_i} \right) - \tilde{t}_i^B \right) \right]^{\alpha} \\ &\cdot \left[t_i^k + \sum_{j \neq i} \overline{t}_j^k - C_k\left(x_i^k + \sum_{j \neq i} \overline{x}_j^k \right) - \left(\sum_{j \neq i} \overline{t}_j^k - C_k\left(\sum_{j \neq i} \overline{x}_j^k \right) \right) \right]^{(1-\alpha)}. \end{aligned} \tag{26}$$

Let us assume suppliers have zero production costs for low total capacity $\overline{\overline{X}}^k$, such that:

$$X_N^{k,*} = \arg X_N^k \max N.R\left(\frac{X_N^k}{N}, \frac{X_N^{l,*}}{N} \right) < \overline{\overline{X}}^k, k \neq l = A, B. \tag{27}$$

Furthermore, producing a quantity exceeding this total capacity $\overline{\overline{X}}^k$ implies a fixed cost to invest in new production capacity. We denote this cost as $F_k = F$. Suppliers still have zero marginal cost of production when it is in excess of this total capacity $\overline{\overline{X}}^k$.

Consequently, in an off-equilibrium situation, if negotiations between supplier k and buyer i break down, total capacity $\overline{\overline{X}}^l$ may be binding in the renegotiation between l and i. In such a case, buyer i obtains the fraction α of the net surplus generated by the renegotiation with supplier l, which is $\alpha\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*} \right)$ where:

[14]Let us assume beliefs are "passive" according to the terminology of McAfee and Schwartz (1994), the equilibrium is fully specified.

$$\Pi^{k,\sim}_{N-r_i} = \left(N-r_i\right) R\left(\frac{X^{k,*}_N}{N}, \frac{X^{l,*}_N}{N}\right) + Max\left\{ Max_{x^l_i}\ r_i R\left(0, \frac{x^l_i}{r_i}\right) - F, r_i R\left(0, \frac{\overline{\overline{X}}^l - \left(N-r_i\right)\frac{X^{l,*}_N}{N}}{r_i}\right)\right\}. \tag{28}$$

In such an example, it is straightforward to show that total industry profits are maximized at equilibrium.[15] In the general model, we need to assume that total industry profits are maximized at equilibrium, even though this may appear to be an extreme assumption. Nevertheless, with an alternative approach using Nash bargaining both at and off equilibrium, the result of the bargaining game in this example is such that industry profits are maximized. All the results obtained for such an example continue to be valid if we focus on this alternative bargaining.

To supplement the results for this example, this study sets explicit conditions on the competitiveness of the upstream market and the degree of downstream concentration. These conditions determine whether merging downstream firms are better off than in the pre-merger situation, as discussed in the previous section. As given in Equation (21), we define the inverse demand functions for products A and B facing an outlet, i.e. $\overline{\overline{X}}^k = X^{k,*}_N + 1$, $F = 0.02$, $\alpha = 0.5$ and $N = 10$.

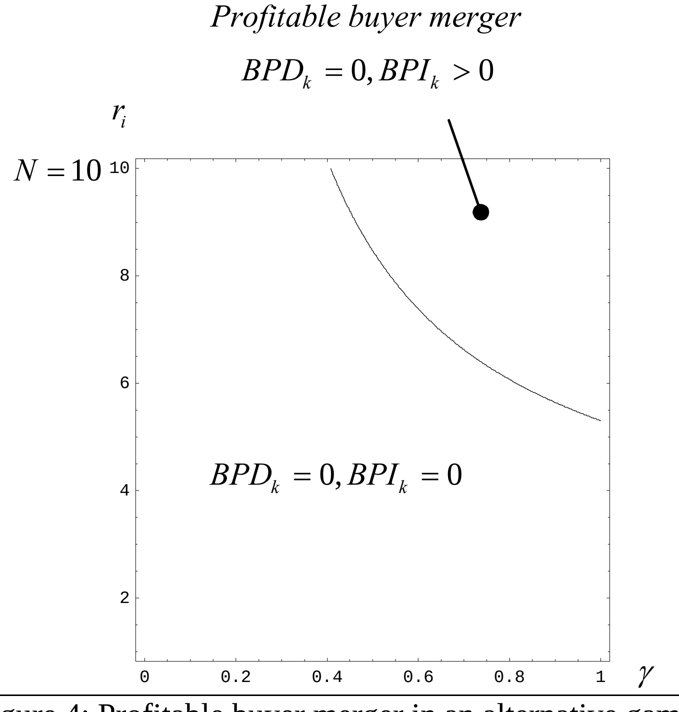

Figure 4: Profitable buyer merger in an alternative game

[15]Intuitively, industry profits are maximized at equilibrium with the newly adopted bargaining approach since suppliers have zero marginal cost of production for a given total capacity $\overline{\overline{X}}^k$ exceeding $X^{k,*}_N$. Supplementary information can be obtained from the author on request.

5. Conclusion

This paper analyses buyer mergers in the presence of upstream competition to supply imperfect substitutes. We can distinguish two sources of buyer power. The first source is discussed in the literature on buyer power, including studies by Chipty and Snyder (1999) and Raskovich (2003). If suppliers have increasing marginal production costs, incremental surplus increases more than proportionally with buyer size, explaining why large buyers pay a lower price per unit. This corresponds to a direct effect. The second source is of more interest here, since it captures the effect of buyer merger via competition between suppliers. It involves increasing the buyer's outside options, and corresponds to an indirect effect. In the event of a breakdown in bargaining between a buyer and one supplier, out-of-equilibrium renegotiation will exhibit increasing return to scale if suppliers have concave costs. From this, we can infer that size discounts will occur even if suppliers' marginal costs are decreasing. Such a case arises if the direct effect related to the first source of buyer power is lower than the indirect effect related to the second source.

In addition, the modelling results presented here are consistent with some empirical studies since a buyer merger can be profitable in terms of bargaining effects even if the production cost function is concave. As shown by Ellison and Snyder (2002) and Sorensen (2003), upstream competition seems to operate as a key factor in the emergence of buyer-size discounts. In their empirical studies of pharmaceutical and hospital-services markets, these authors (*op. cit.*) observed size discounts only in the case of competing suppliers, but not in monopoly situations.

The present study defines situations in which a buyer merger would not occur unless the buyer industry were sufficiently concentrated to begin with. The characterization of a lower threshold to the degree of buyer concentration is directly relevant to the guidelines and practice laid down by antitrust authorities. We show that a lenient approach to small buyer mergers would create situations that might motivate bargaining in some new buyer merger, in cases where the buyer industry was sufficiently concentrated at the outset. Thus, even small buyer mergers should attract the concern of antitrust authorities.

Because of the assumption of efficient contracting, equilibrium quantities remain unchanged in a buyer merger. This study does not deal with welfare and consumer surplus.[16] An alternative approach would be to consider the Nash bargaining solution both at and off equilibrium, as in the specific example studied here, but applied to the general case. The formal analysis of such an approach will be addressed in further research.

Finally, this model framework can be used to analyse the potential adverse long-term consequences of buyer power on suppliers' economic viability and their incentives to invest and innovate.[17]

[16] See Dobson and Waterson (1997) and von Ungern-Sternberg (1996) for a discussion of these issues.

[17] See Inderst and Wey (2003, 2006) and Inderst and Shaffer (2006) for such applications.

6. Appendix

Proof. Proposition 1

The equilibrium payoff of supplier k is denoted by U_k^* for $k = A, B$ and that of buyer i by V_i^* for $i \in I$. If there is no agreement between k and buyer i, supplier k receives a payoff of $U_k^*(i)$. Since we allow for renegotiation between supplier l and buyer i, if there is no agreement between k and buyer i, buyer i's profits are equal to $V_i^{\sim}(k)$. If there is no renegotiation, we denote buyer i's profits by $V_i^*(k)$.

According to the assumption, the vector of supplies to all buyers with whom an agreement was reached is chosen to maximize industry profits. We now consider negotiations between supplier k and buyer i. In the case of a disagreement, supplier k receives the following payoff:

$$U_k^*(i) = \sum_{j \in I \setminus \{i\}} t_j^k \left(r_j \frac{X_N^{k,*}}{N} \right) - C_k \left((N - r_i) \frac{X_N^{k,*}}{N} \right) \tag{29}$$

Ignoring the renegotiation between buyer i and supplier l, buyer i receives a payoff of:

$$V_i^*(k) = r_i R\left(0, \frac{X_N^{l,*}}{N} \right) - t_i^l \left(r_i \frac{X_N^{l,*}}{N} \right). \tag{30}$$

Let us bear in mind that, out of equilibrium, buyer i obtains the fraction α of the net surplus generated by the renegotiation with supplier l, which corresponds to $\alpha\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*} \right)$ where:

$$\begin{aligned} \Pi_{N-r_i}^{k,\sim} \quad &= Max_{x_i^l} \, (N - r_i) R\left(\tfrac{X_N^{A,*}}{N}, \tfrac{X_N^{B,*}}{N} \right) + r_i R\left(0, \tfrac{x_i^l}{r_i} \right) \\ &\quad - C_k \left((N - r_i) \tfrac{X_N^{k,*}}{N} \right) - C_l \left(x_i^l + (N - r_i) \tfrac{X_N^{l,*}}{N} \right). \end{aligned} \tag{31}$$

In the case of a disagreement with k, the payoff received by buyer i can be written as:

$$V_i^{\sim}(k) = V_i^*(k) + \alpha\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*} \right). \tag{32}$$

Note that the total surplus in the negotiations with i is equal to:

$$\sum_{j \in I \setminus \{i\}} t_j^k \left(r_j \tfrac{X_N^{k,*}}{N} \right) - C_k \left(X_N^{k,*} \right) + r_i R\left(\tfrac{X_N^{A,*}}{N}, \tfrac{X_N^{B,*}}{N} \right) - t_i^l \left(r_i \tfrac{X_N^{l,*}}{N} \right). \tag{33}$$

By subtracting the outside option $U_k^*(i)$ of supplier k in (29) and the outside option of buyer i in (32) from the total surplus in the negotiations with i in (33), we obtain the net surplus

$$\begin{aligned} &r_i \left[R\left(\tfrac{X_N^{A,*}}{N}, \tfrac{X_N^{B,*}}{N} \right) - R\left(0, \tfrac{X_N^{l,*}}{N} \right) \right] \\ &\quad - \left[C_k \left(X_N^{k,*} \right) - C_k \left((N - r_i) \tfrac{X_N^{k,*}}{N} \right) \right] - \alpha\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*} \right). \end{aligned} \tag{34}$$

Substituting to obtain Π_N^* and $\Pi_{N-r_i}^{k,*}$, the net surplus can be written as:

$$\Pi_N^* - \Pi_{N-r_i}^{k,*} - \alpha\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right). \tag{35}$$

Supplier k obtains the fraction $(1-\alpha)$ of the net surplus, while buyer i obtains the fraction α of the net surplus. Thus, we obtain the following expression for the transfer:

$$\begin{aligned} t_i^{k,*} &= (1-\alpha)\left[\Pi_N^* - \Pi_{N-r_i}^{k,*} - \alpha\left(\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right)\right] \\ &\quad - \left[C_k\left((N-r_i)\tfrac{X_N^{k,*}}{N}\right) - C_k\left(X_N^{k,*}\right)\right]. \end{aligned} \tag{36}$$

Substituting to obtain $\Pi_0^{k,*}$, we can transform (36) into:

$$t_i^{k,*} = \frac{r_i}{N}\left[\Pi_N^* - \Pi_0^{k,*} + C_k\left(X_N^{k,*}\right)\right] - \alpha\left(\Pi_N^* - \Pi_{N-r_i}^{k,*}\right) - (1-\alpha)\alpha\left[\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right]. \tag{37}$$

Substituting $t_i^{k,*}$ from (37) into U_k^*, as well as the equilibrium payoffs V_i^* of supplier k and buyer i, we finally obtain the results given in (12) and (13).

Proof. Proposition 2

Using Equation (16), we find that ϕ_i strictly increases with the number of controlled firms r_i if

$$\sum_{k=A,B}\left(\frac{t_i^{k,*}}{r_i} - \frac{\partial t_i^{k,*}}{\partial r_i}\right). \tag{38}$$

Then, we rearrange $\frac{t_i^{k,*}}{r_i} - \frac{\partial t_i^{k,*}}{\partial r_i}$ into a form allowing us to distinguish the two effects. Substituting $t_i^{k,*}$ from (37) into $\frac{t_i^{k,*}}{r_i} - \frac{\partial t_i^{k,*}}{\partial r_i}$ gives:

$$-\alpha\left[\frac{\Pi_N^* - \Pi_{N-r_i}^{k,*}}{r_i} - \frac{\partial\left[\Pi_N^* - \Pi_{N-r_i}^{k,*}\right]}{\partial r_i}\right] - \alpha(1-\alpha)\left[\frac{\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}}{r_i} - \frac{\partial\left[\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right]}{\partial r_i}\right]. \tag{39}$$

BPD_k denotes the **direct** effect of the merger on the merging buyers' bargaining position with respect to supplier k:

$$BPD_k = -\alpha\left[\frac{\Pi_N^* - \Pi_{N-r_i}^{k,*}}{r_i} - \frac{\partial\left[\Pi_N^* - \Pi_{N-r_i}^{k,*}\right]}{\partial r_i}\right] \tag{40}$$

and BPI_k denotes the **indirect** effect of the merger:

$$BPI_k = -\alpha(1-\alpha)\left[\frac{\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}}{r_i} - \frac{\partial\left[\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right]}{\partial r_i}\right]. \tag{41}$$

Condition (38) becomes:

$$\left(BPD_A + BPI_A\right) + \left(BPD_B + BPI_B\right) > 0. \tag{42}$$

Consider the assertion (i) concerning the sign of BPD_k. By substituting Π_N^*, $\Pi_{N-r_i}^{k,*}$ and

$\frac{\partial \Pi_{N-r_i}^{k,*}}{\partial r_i}$ into BPD_k, we obtain:

$$BPD_k = \alpha \left[\frac{C_k\left(X_N^{k,*}\right) - C_k\left(\left(N-r_i\right)\frac{X_N^{k,*}}{N}\right)}{r_i} + \frac{\partial\left(\left(N-r_i\right)\frac{X_N^{k,*}}{N}\right)}{\partial r_i} C_k^{'}\left(\left(N-r_i\right)\frac{X_N^{k,*}}{N}\right)\right], \tag{43}$$

which is strictly negative if supplier k's costs are strictly concave.
For assertion (ii) concerning the sign of BPI_k, we can rewrite (41) by substituting $\Pi_{N-r_i}^{k,\sim}$, $\Pi_{N-r_i}^{k,*}$ and $\frac{\partial\left[\Pi_{N-r_i}^{k,\sim} - \Pi_{N-r_i}^{k,*}\right]}{\partial r_i}$. This provides us with:

$$\begin{aligned} BPI_k = \left(1-\alpha\right)\alpha \Bigg[& r_i \frac{\partial\left(\frac{\tilde{x}_i^l}{r_i}\right)}{\partial r_i} R^{'}\left(0, \frac{\tilde{x}_i^l}{r_i}\right) + \frac{C_l\left(\left(N-r_i\right)\frac{X_N^{l,*}}{N} + \tilde{x}_i^l\right) - C_l\left(X_N^{l,*}\right)}{r_i} \\ & - \frac{\partial\left(\left(N-r_i\right)\frac{X_N^{l,*}}{N} + \tilde{x}_i^l\right)}{\partial r_i} C_l^{'}\left(\left(N-r_i\right)\frac{X_N^{l,*}}{N} + \tilde{x}_i^l\right)\Bigg]. \end{aligned} \tag{44}$$

The sign of the term BPI_k results from the sum of two terms

$$r_i \frac{\partial\left(\frac{\tilde{x}_i^l}{r_i}\right)}{\partial r_i} R^{'}\left(0, \frac{\tilde{x}_i^l}{r_i}\right), \tag{45}$$

and

$$\frac{C_l\left(\left(N-r_i\right)\frac{X_N^{l,*}}{N} + \tilde{x}_i^l\right) - C_l\left(X_N^{l,*}\right)}{r_i} - \frac{\partial\left(\left(N-r_i\right)\frac{X_N^{l,*}}{N} + \tilde{x}_i^l\right)}{\partial r_i}. \tag{46}$$

$\tilde{x}_i^l$ satisfies $R^{'}\left(0, \frac{x_i^l}{r_i}\right) - C_l^{'}\left(x_i^l + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right) = 0$. By taking $z = \frac{x_i^l}{r_i}$, we note that this expression satisfies $R^{'}\left(0,z\right) - C_l^{'}\left(r_i z + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right) = 0$. By applying this condition to the implicit function theorem, we then obtain:

$$\frac{dz}{dr_i} = -\frac{-\frac{\partial\left[r_i z + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right]}{\partial r_i} C_l^{''}\left(r_i z + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right)}{R^{''}\left(0,z\right) - r_i C_l^{''}\left(r_i z + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right)}. \tag{47}$$

Using the second-order condition for $\tilde{x}_i^l$, we find that

$$\frac{1}{r_i} R^{''}\left(0, \frac{x_i^l}{r_i}\right) - C_l^{''}\left(x_i^l + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right) < 0. \tag{48}$$

Note that

$$\begin{aligned} & R^{''}\left(0,z\right) - r_i C_l^{''}\left(r_i z + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right) \\ & = r_i\left[\frac{1}{r_i} R^{''}\left(0, \frac{x_i^l}{r_i}\right) - C_l^{''}\left(x_i^l + \left(N-r_i\right)\frac{X_N^{l,*}}{N}\right)\right], \end{aligned} \tag{49}$$

$\frac{dz}{dr_i}$ is of the same sign as $-C_l^{''}\left(r_i z+\left(N-r_i\right)\frac{X_N^{l,*}}{N}\right)$, since the following term $\frac{\partial\left[r_i z+\left(N-r_i\right)\frac{X_N^{l,*}}{N}\right]}{\partial r_i}$ is positive. Thus, $\frac{\partial\left(\frac{\tilde{x}_i^l}{r_i}\right)}{\partial r_i}$ is strictly negative if supplier l's costs are strictly convex. Using the first-order condition for $\tilde{x}_i^l$, we obtain $R^{'}\left(0,\frac{x_i^l}{r_i}\right)>0$, since $C_l^{'}\left(x_i^l+\left(N-r_i\right)\frac{X_N^{l,*}}{N}\right)>0$. Using $R^{'}\left(0,\frac{x_i^l}{r_i}\right)>0$ and $\frac{\partial\left(\frac{\tilde{x}_i^l}{r_i}\right)}{\partial r_i}$, which are both strictly negative if supplier l's costs are strictly convex, yields (45), which is strictly negative if supplier l's costs are strictly convex.
Expression (46) is also strictly negative if supplier l's costs are strictly convex.
Therefore, summing (45) and (46), we finally validate the assertion (ii).

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