Buyer power from joint listing decision*

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Abstract

We show that collective bargaining can enhance downstream firms' buying power vis-à-vis their suppliers. We consider a model of vertically related markets, in which an upstream leader faces a competitive fringe of less efficient suppliers and negotiates with several firms that compete in a downstream market. We allow downstream firms to join forces in negotiating with suppliers, by creating a buyer group which selects suppliers on behalf of its members: If the group rejects the upstream leader's offer, then its members turn to the fringe suppliers. Transforming individual listing decisions into a joint listing decision makes delisting less harmful for a group member; this, in turn enhances the group members' bargaining position at the expense of the upstream leader. We also show that this additional buyer power can have an ambiguous impact on the upstream leader's incentives to invest.

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1 Introduction

During the last decades, retailers have increasingly sought to join forces so as to enhance their buyer power vis-à-vis suppliers. In Europe, the grocery industry has seen the emergence of large chains of independent supermarkets, such as *EDEKA* in Germany,[1] or *Leclerc*, *Intermarché* and *Système U* in France.[2] These chains have often formed buying alliances. For instance, in 1999 *Système U* created with *Leclerc* a buying alliance called Lucie, before joining in 2006 a European alliance (*European Market Distribution*) with another French retail competitor, *Casino*.[3] Similarly, in Finland the two leading chains of supermarkets, *Kesko* and *Tuko*, attempted to merge in 1996.[4] In the US, independent retail grocers, including the *Independent Grocers Alliance (IGA)* have long used buyer groups to negotiate with suppliers.[5] Other industries have undergone some consolidation as well. In France, for instance, the pharmaceutical retailing industry has seen the emergence of several buyer groups (*Astera*, *Giphar*, and *Giropharm*).[6] In the US, *Ace Hardware*, a cooperative of independent retail hardware stores, has now around 4,000 member stores. In Spain, the four tobacco processors joined forces in their negotiations with raw tobacco producers.[7]

In all these cases, downstream firms have relied on collective bargaining in order to gain buying power. Two commonly recognized benefits of such collective bargaining are the associated economies of scale and the ability to make a joint listing decision (or more precisely, a joint delisting decision, as stressed below). Economies of scale arise for example from common operational costs.[8] The ability to make a joint (de)listing decision arises when a group of individual downstream firms can commit to a decision that

[1] *EDEKA* accounted for around 20-25% of sales in German grocery and daily goods retail markets in 2007. See Bundeskartellamt (2008), B2-333-07, *EDEKA Zentrale AG & Co. KG / Tengelmann Warenhandelsgesellschaft KG.*

[2] *Leclerc*, *Intermarché* and *Système U* accounted respectively for 17%, 14% and 9% of sales in French grocery and daily goods retail markets in 2009 (TNS Worldpanel).

[3] *Casino* represented 10% of sales in French grocery and daily goods retail markets in 2009 (TNS Worldpanel).

[4] *Kesko* is a chain of independent stores, whereas *Tusko* has both integrated and independent stores. The concentration was blocked by the European Commission (Case IV/M.784).

[5] *IGA* is the world's largest voluntary supermarket chain with more than 5,000 member stores.

[6] *Astera*, *Giphar*, and *Giropharm* represent around 20% of the pharmaceutical retailing industry in France.

[7] See COMP/C.38.238/B.2, *Raw Tobacco Spain*, 20 October 2004, mentioned in RBB Economics (2007).

[8] See for instance RBB Economics (2007) at pp. 37-42.

binds all of its members. In France for instance, *Leclerc*, a chain of independent, large hypermarkets, negotiates listing fees with suppliers for their inclusion in the catalogue from which its members can select which products to carry. The threat of delisting has been viewed by the profession as an important lever in the negotiations between buyer groups and their suppliers, and delisting has actually occured over the years. *Leclerc* made for instance quite an impression in 2008 when it publicly announced that it was removing six well-known products from the shelves of its (independent) supermarkets.[9] The following year, *Leclerc* delisted *Nutella*, the famous hazelnut spread, whereas the popular *Danette* desert cream disappeared from *Intermarché* stores;[10] and more recently, *Leclerc* barred the products of *Lactalis*, the leading French manufacturer of cheese, butter and other milk products.[11] Yet, the impact of such delisting decisions has not been formally studied; and while the cost savings stemming from scale economies generate obvious benefits, the impact of joint (de)listing decisions is less clear.

The objective of this paper is to explore how joint delisting decision can affect buyer groups' bargaining power, and whether larger buyer groups benefit more from such joint delisting decisions. We consider a model of vertically related markets with secret contracting à la Hart and Tirole (1990). Upstream, a market leader faces a competitive fringe of less efficient suppliers; downstream, firms compete and use the suppliers' input to produce a homogeneous good. We allow a number of downstream firms to join forces in negotiating with the upstream leader: They create a buyer group, which selects suppliers on behalf of its members. In our baseline model, we focus on a simple rule that enables each group member to veto the upstream leader, in which case all group members turn to the fringe suppliers; later on, we extend the analysis to situations where a member has more limited influence on other members' listing decisions. We show that joint listing decisions indeed enhance the bargaining position of the group members. Intuitively, transforming individual delisting decision into a joint boycott makes such a decision less harmful for a group member, as the other group members will also have to deal with the alternative, less efficient suppliers. This, in turn, enhances the bargaining

[9] See the article in Le Figaro, available at http://www.lefigaro.fr/conso/2008/01/31/05007-20080131ARTFIG00452-leclerc-retire-six-produitsde-ses-rayons.php.

[10] See *Tribune Grande Conso*, available at http://www.olivierdauvers.fr/wp-content/uploads/2010/05/TGC80.jpg.

[11] See the article from the professional review LSA, available at http://www.lsa-conso.fr/un-affrontement-commercial-couteux-pour-leclerc-et-lactalis,120449.

position of each group member, by raising the value of its outside option.[12] This better bargaining position need not necessarily lead to lower prices for consumers, however, which echoes concerns voiced by antitrust authorities; for example, the European Commission states in its Guidelines: "Cost savings or other efficiencies that only benefit the parties to the joint purchasing arrangement will not suffice. Cost savings need to be passed on to consumers."[13]

The literature has used various ways to generate size-related discounts. Katz (1987) and Sheffman and Spiller (1992) model buyer power as downstream firms' ability to integrate backwards by paying a fixed cost. Getting larger reduces the average cost of this alternative option and allows in this way downstream firms to obtain better prices from the supplier.[14] Size may not only increase the value of a downstream firm's alternatives but also reduce the suppliers' alternatives. If the supplier's cost is convex, then dealing with a larger downstream firm reduces the (average) avoidable cost that is at stake, which weakens the seller's bargaining position; the downstream firm thus benefits from its larger size (Chipty and Snyder (1999));[15] similarly, when the negotiation breaks down with a large buyer, re-allocating production to the other buyers may be less valuable (Inderst and Wey (2007)). Inderst and Shaffer (2007) and Dana (2012) relate instead buyer power to the possibility, for a large buyer, to reduce the number of suppliers which it deals with.

These approaches focus on "pure" buyer power, in the sense that group members only interact on the buying side.[16] Dobson and Waterson (1997) and von Ungern-Sternberg (1996) consider instead "full mergers," in which the downstream firms not only join forces as buyers, but also eliminate competition between them as sellers. By contrast, we focus in this paper on the bargaining power that buyer groups confer to firms that are and remain competitors in the same downstream market. In practice downstream competition between group members varies accross buyer groups and industries. For

[12]As pointed out by one referee, the joint purchase decision can thus be seen as preventing the supplier from engaging in a "divide and conquer" strategy with downstream firms.

[13]Guidelines on the applicability of Article 101 of the Treaty on the Functionning of the European Union to horizontal co-operation agreements (2011/C 11/01), paragraph 219.

[14]See Inderst and Valletti (2011) and Inderst and Wey (2011) for recent contributions that build on this insight.

[15]See Smith and Thanassoulis (2012) and Bedre and Caprice (2011) for recent contributions along this line.

[16]That is, while group members may be competing in their respective downstream markets, they are not competing against each other in the same markets.

instance, in 2008 the French Competition Authority found that the "*Leclerc* group has two or more shops in around a quarter of the 208 customer catchment areas" under consideration.[17] In Germany, the Bundeskartellamt made a similar analysis for EDEKA in several customer catchment areas.[18] In all these situations, several group members thus often compete in the same downstream market.[19] By contrast, in the case of associations such as Group Purchasing Organizations (GPOs) for hospitals in the US, we would expect most group members to be active in different geographic markets.[20] In that case, our analysis would only apply to those members that do operate in the same local market. Likewise, for *IGA*, the US supermarket chain, the analysis would apply only where several outlets are present in the same city.

We also study the implications of our analysis for upstream investment incentives. As in Inderst and Wey (2011), downstream competition tends to induce suppliers to over-invest in productivity, by reducing downstream firms' outside options and thus allowing suppliers to obtain a bigger share of the industry profit. As in their paper, we also find that buyer groups can exacerbate this over-investment incentive; however, when a buyer group already involves a large proportion of the downstream firms, increasing its size further tends to eliminate the above mechanism (indeed, if all downstream firms join the buyer group, their outside option is no longer affected by the supplier's own productivity), which reduces investment incentives. This is in line with the concern, frequently expressed in policy circles, that suppliers respond to the exercise of buyer power "by under-investing in innovation and production" (FTC 2001, p.57).

The rest of the paper is organized as follows. We first present our framework (section 2), before showing how joint listing decisions benefit group members when they also

[17] See French Competition Authority (2010), Opinion 10-A-26, page 22.

The Authority moreover noted that the Herfindahl-Hirschmann Index median calculated in the customer catchment areas went from 2,800, when calculated at the store level, to 3,500 at the retail chain level, that is, when aggregating the stores from a same retail chain in a given customer catchment area.

[18] See Bundeskartellamt (2008), B2-333-07, *EDEKA Zentrale AG & Co. KG / Tengelmann Warenhandelsgesellschaft KG*, pages 60 and following, in which some customer catchment areas are studied in detail.

[19] Dobson et al. (Dobson Consulting, 1999) provide data on the five firm concentration ratio for European countries in food retail distribution sector. They show that at national level the average across member states increases by 10% points to over 60% when it is ajusted for buyer groups (page 78). If group members are, in some cases, in the same local market, as related before (see examples of Leclerc in France or EDEKA in Germany), local concentration is also higher, when it is ajusted for buyer groups.

[20] See the report of Federal Trade Commission (2004) on Health Care.

compete against each other in the same downstream markets (section 3). Section 4 discusses the robustness of our insights and also considers alternative governance rules, including public contracting (within the group) and less centralized listing decisions. We then build on the baseline analysis to study the impact of buyer groups on suppliers' investment (section 5). Section 6 concludes.

2 A simple framework

We consider two vertically related markets. In the upstream market a leader, U, faces a constant marginal cost of production c, whereas a competitive fringe, $\hat{U}$, supplies at cost $\hat{c} > c$. In the downstream market n competitors, $D_1, ..., D_n$, transform the input into a homogenous final good, on a one-to-one basis and at no additional cost. We assume that the inverse demand for the final good, denoted by $p = P(Q)$, satisfies the following regularity conditions:

Assumption 1: $P(0) > c$ and, for any $Q \geq 0$,

$$P'(Q) < 0 \text{ and } P'(Q) + P''(Q)\,Q < 0.$$

These standard conditions first state that the industry is viable and demand is strictly decreasing; the last one ensures that downstream equilibria are well-behaved. In particular, it implies that the profit function

$$\pi(q_i; Q_{-i}, c) \equiv [P(Q_{-i} + q_i) - c]\,q_i$$

is strictly concave, and that a symmetric Cournot oligopoly, in which all firms face the same cost c, has a unique, symmetric and stable equilibrium,[21] in which each firm sells $q^C(c)$, solution to $q^C = R^C\left((n-1)\,q^C; c\right)$, where

$$R^C(Q_{-i}; c) \equiv \arg\max_{q_i \geq 0} \pi(q_i; Q_{-i}, c)$$

denotes the standard Cournot best response to rivals' aggregate quantity Q_{-i}. Dropping

[21] See Lemma 2 (with $s = n$) for a formal proof.

the argument c unless explicitly needed, we will denote by $Q^C \equiv nq^C$, $p^C \equiv P\left(Q^C\right)$, and $\Pi^C \equiv \left(p^C - c\right) Q^C$ the associated aggregate output, price and profit; the per-firm profit is then:

$$\pi^C \equiv \left(p^C - c\right) q^C.$$

We will assume that wholesale contracts are secret,[22] and thus consider the following competition game:

- Stage 1: (a) U secretly offers each D_i a tariff $T_i(.)$; (b) Each D_i secretly accepts or rejects U's offer.
- Stage 2: Each D_i secretly orders a quantity $\hat{q}_i$ from the fringe and, if it has accepted $T_i(.)$, a quantity q_i from U; the downstream firms then transform the intermediate product into final good, observe the total output Q and sell their own output at price $P(Q)$.

As is well-known,[23] secret contracting creates a risk of opportunism: As D_i's rivals do not observe neither U's offer nor D_i's acceptance decision, in their bilateral negotiation U and D_i have an incentive to free-ride on downstream rivals' margins; this, in turn, prevents U from fully exerting its market power. The extent to which this is the case depends on how downstream firms interpret unexpected offers; for the sake of exposition, we will focus here on *passive conjectures* and thus assume that downstream firms stick to their equilibrium beliefs.[24] A downstream firm D_i, anticipating an aggregate equilibrium output Q_{-i} from its rivals, is then willing to pay $P(Q_{-i} + q_i) q_i - \max_q \pi(q; Q_{-i}, \hat{c})$ for

[22] If wholesale contracts were public, they would have potential strategic effects. See, Bonanno and Vickers (1988), Rey and Stiglitz (1988,1995) and Shaffer (1991) for examples, in which they could be used to dampen downstream competition.

Besides its plausibility, secret contracting allows us to ignore these potential strategic effects and focus instead purely on bargaining power.

[23] See the seminal paper from Hart and Tirole (1990), as well as O'Brien and Shaffer (1992) and McAfee and Schwartz (1994). Rey and Tirole (2007) provides an overview of this literature.

[24] When downstream firms compete in quantities in a Cournot fashion, as here, passive beliefs correspond to the wary beliefs introduced by McAfee and Schwartz (1994).

This assumption captures the above mentioned risk of opportunism, and makes the analysis particularly tractable. See Rey and Tirole (2007) for a detailed discussion.

any quantity q_i, which leads the more efficient supplier, U, to supply $q_i = R^C(Q_{-i}; c)$.[25] It follows that the resulting equilibrium yields the Cournot outcome:

Proposition 1 *Under passive conjectures, the above competition game has a unique subgame perfect equilibrium outcome, in which:*

(i) Each D_i sells the competitive quantity q^C, which it buys from U.

(ii) Each D_i earns the profit it could obtain by turning instead to the competitive fringe:

$$\hat{\pi} \equiv \max_{q \geq 0} \pi\left(q; (n-1)\, q^C, \hat{c}\right).$$

Proof. See Hart and Tirole (1990). ■

3 Buyer group

In order to join forces in their negotiations with U, downstream firms can form a buyer group. In practice the nature of buyer groups, and thus their governance, varies across industries and countries. This can affect in particular the extent to which negotiations are centralized, as well as the amount of information on contract terms that is shared within the group. For instance, when two leading retail chains such as *Système U* and *Casino* in France join forces within a common buyer group, each group member can be expected to retain some discretion in its negotiations with suppliers. In these situations, the buyer group negotiates general purchasing terms and conditions, whereas its members bilaterally negotiate additional specific, customized terms. By contrast, in the case of associations such as *IGA* in the US, which regroups a large number of mostly small and medium-sized stores, we may expect these stores to take on board the deals negotiated on their behalf by the association; contract terms are then likely to be more uniform and shared among group members.

[25] U finds it profitable to supply each D_i, as it can charge

$$\begin{aligned}
& P\left(Q_{-i} + R^C(Q_{-i}; c)\right) R^C(Q_{-i}; c) - \max_q \pi(q; Q_{-i}, \hat{c}) \\
= \; & cR^C(Q_{-i}; c) + \max_q \pi(q; Q_{-i}, c) - \max_q \pi(q; Q_{-i}, \hat{c}) \\
> \; & cR^C(Q_{-i}; c).
\end{aligned}$$

For the sake of exposition, and in order to focus on bargaining effects, we will assume here that downstream firms keep negotiating bilaterally, and secretly, with their suppliers, and only join forces in their listing decisions. That is, contract offers remain secret, even within the group, but each group member can now veto U's offers to the group; for simplicity, we will assume that in such an event all group members must turn to the less efficient fringe suppliers for all their needs. This fits well with the first type of situations mentioned above, where group members negotiate specific terms and conditions directly with the supplier. In the next section, we discuss the additional strategic effects that arise when contract offers are observed within the group (or when group members simply stick to the terms negotiated by the group), and also consider less drastic veto decisions.

Thus, suppose that $s \leq n$ downstream firms form a buyer group G, which modifies the first stage of the competition game as follows:

- Stage 1a: As before; in particular, each group member only observes the offer it receives, not the offers made to the other members.

- Stage 1b: Each group member recommends whether to accept or reject U's offers to the group G; these offers are all accepted if members unanimously recommend doing so, and all rejected otherwise. The other downstream firms decide individually whether to accept the offer they received. Acceptance decisions are again private information: Members of the buyer group know whether U's offers have been accepted by the group, but do not observe non-members' decisions, and these firms only observe their own decisions.

Members' outside options are thus the outcome of the following oligopoly game, in which s group members face a cost $\hat{c}$ and compete in quantities among themselves, anticipating that outsiders put on the market a given total quantity Q_o:

Lemma 2 *Suppose that the s members of the buyer group, facing the same cost $\hat{c}$ and anticipating an output level Q_o from firms outside the group, compete in quantities among themselves; then:*

(i) This competition yields a unique, stable equilibrium, in which each group member sells $q^s = q^s(Q_o, \hat{c})$, satisfying

$$q^s \equiv R^C\left(Q_o + (s-1)\, q^s; \hat{c}\right). \tag{1}$$

(ii) Furthermore, letting $\pi^s(Q_o, \hat{c}) \equiv (P(Q_o + sq^s(Q_o, \hat{c})) - \hat{c})\, q^s(Q_o, \hat{c})$ *denote the associated profit for each member, we have:*

- $q^s(Q_o, \hat{c}) > 0$ *(and thus* $\pi^s(Q_o, \hat{c}) > 0$*) if and only if* $P(Q_o) > \hat{c}$*.*
- *Whenever* $q^s(Q_o, \hat{c}) > 0$*,*

$$\frac{\partial q^s}{\partial Q_o}, \frac{\partial q^s}{\partial \hat{c}} < 0 \text{ and } \frac{\partial \pi^s}{\partial Q_o}, \frac{\partial \pi^s}{\partial \hat{c}} < 0.$$

Proof. See Appendix A. ■

Obviously, there always exists trivial equilibria in which at least two members reject the offer, and thus U does not supply group members: As no member is pivotal in that case, they are all indifferent about their recommendation. However, there also exists an equilibrium in which U, being more efficient, keeps supplying all firms. Furthermore, in any such equilibrium, U enters again into *bilaterally efficient* contracts, which leads it to supply the competitive quantity q^C to all firms; the introduction of a buyer group thus does not affect the equilibrium price and outputs. It however alters the bargaining power of the group members: By vetoing U's offers, they can now secure $\pi^s(Q_o, \hat{c}) = \pi^s\left((n-s)\, q^C, \hat{c}\right)$. This leads to:

Proposition 3 *There exists an equilibrium in which* U *supplies all firms. Furthermore, under passive conjectures, in any such equilibrium:*

(i) All firms sell the competitive quantity q^C*.*

(ii) Each non-member earns $\hat{\pi}^1 = \hat{\pi}$*, whereas each group member earns*

$$\hat{\pi}^s \equiv \pi^s\left((n-s)\, q^C, \hat{c}\right).$$

Proof. See Appendix B. ■

Thus, in equilibrium, U ends up supplying the Cournot quantity to all firms, whether they belong to the buyer group or not. Forming a buyer group however affects the division of profits. While non-member firms still earn $\hat{\pi}$, group members earn instead $\hat{\pi}^s > \hat{\pi}$. Vetoing U's offers enhances group members' outside options: A member which rejects U's offer must again rely on less efficient suppliers, but this situation is not as bad as before, as now the vetoing firm is not the only one in this position. As a result, group members benefit from enhanced bargaining power, and the more so, the bigger the group G:

Proposition 4 *$\hat{\pi} = \hat{\pi}^1 \leq \hat{\pi}^2 \leq ... \leq \hat{\pi}^n < \pi^C$; furthermore, for $s > 1$, $\hat{\pi}^s > \hat{\pi}^{s-1}$ whenever $\hat{\pi}^s > 0$ (i.e., whenever $P\left((n-s)\,q^C\right) > \hat{c}$).*

Proof. See Appendix C. ■

As mentioned above, the key intuition here is that, by joining forces in their negotiation with the leading supplier, group members enhance their outside option: Turning to less efficient suppliers remains costly, but it becomes less painful when the other members have to do the same. Conversely, alternative decision rules, which do not necessarily grant veto power to a group member, are less effective in enhancing that members' bargaining power, as they do not guarantee that members will be "in good company" if they reject U's offers.[26]

4 Discussion and extensions

In this section, we first stress that our insights do not depend on the nature of downstream competition (subsection 4.1), before discussing our modelling framework and considering alternative features of buyer groups (subsection 4.2), as well as situations where group members have more limited influence on each others' listing decisions (subsection 4.3). We then draw the implications of the above analysis for the formation of buyer groups and discuss the robustness of our insights by considering several additional extensions (subsection 4.4).

4.1 On the role of downstream competition

We developed our analysis in a context of Cournot downstream competition, where output decisions are strategic substitutes; similar insights however apply to other types of downstream competition, such as Bertrand competition with differentiated products,

[26]For example, if U's offers are accepted by the group as long as $p < s$ members recommend acceptance, then there exists equilibria in which U leaves only $\hat{\pi}$ to each and every firm, within as well as without the group (indeed, if $p+1$ members recommend acceptance, no member is pivotal, and thus belonging to the buyer group makes no difference).

where consumer prices are strategic complements:[27] As shown by O'Brien and Shaffer (1992), secret contracting leads again the upstream supplier to offer non-linear tariffs with cost-based marginal wholesale prices, so that final prices and quantities are again "competitive" (that is, the equilibrium outcome is similar to that of an n-firm oligopoly in which all firms face the unit cost c). As above, forming a group does not affect the behavior of outsiders, but still enhances the bargaining position of insiders. Hence, the nature of downstream competition does not play a key role when contracts remain secret among group members (more on this below).

4.2 On the role of buyer groups

The above framework aims at capturing how buyers groups can enhance their members' bargaining positions in their negotiations with suppliers. The particular modelling choice – namely, focusing on joint listing decisions, keeping tariff negotiations bilateral and secret – is in line with some of the examples mentioned above, such as the creation of a common buyer group by the French retail chains *Système U* and *Casino*. It also fits well with the case of *Leclerc*, the French chain of independent, large hypermarkets: On the one hand, as noted in the introduction, the chain has been famous for delisting at times well-known products; on the other hand, each member retains the ability to negotiate special deals on a bilateral basis.[28] Note in particular that, while we limited the group to make only listing decisions, the analysis applies as well when the group negotiates centrally general terms and conditions, or when bilateral contract offers are circulated within the group, as long as contract terms can be adjusted through secret bilateral negotiations between U and each group member.[29]

In other cases, the buyer group may centrally negotiate purchasing terms and conditions, which then readily apply to all members. Such a buyer group still brings the

[27]See Vives (1999) for a characterization of the conditions under which firms' decisions are strategic complements or substitutes, for both Bertrand and Cournot competition.

[28]In oral hearings, national brand manufacturers have complained that they must grant discounts to get listed by the group (so-called listing fees), and then negotiate additional discounts with each Leclerc hypermarket, beyond those already offered to the buyer group.

[29]Public contracts can have commitment power if renegotiations are constrained, e.g. by agency problems such as adverse selection between the contracting parties. However, as pointed out by Caillaud *et al.* (1995), this is made possible when the parties wish to pre-commit themselves to be more aggressive than they would otherwise. As here U and the group members wish instead to attenuate the competition among themselves, public contracts have no bite if secret renegotiations are feasible.

bargaining benefits emphasized above, by enhancing the outside options of its members. But in addition, by making contract terms more uniform among group members, which thus become aware of the terms available to the other members, such a buyer group can eliminate the opportunism problem among its members; it then has an incentive to act as a "cartel" and negotiate a contract that *de facto* eliminates competition among group members[30] – typically making them less aggressive in the downstream market. Contrary to the case where negotiations remain secret within the group, such buyer groups have the same effect as a merger; they thus have an impact on the equilibrium outcome, and hurt consumers.[31] They moreover trigger a strategic effect, as outsiders adjust their behaviour in response to group members being less aggressive. This strategic effect however depends on the nature of downstream competition: If downstream decisions are strategic complements, as is often the case with Bertrand competition, forming a buyer group tends to make outsiders "softer", thus reinforcing the incentives to join a group; by contrast, when downstream decisions are strategic substitutes, as is often the case with Cournot competition, this strategic effect is negative.[32]

4.3 More limited influence on listing decisions

So far, we have assumed that any member can veto the supplier, with the result that all group members turn to the competitive fringe; such veto power could for instance be embedded in the governance charter of the buying group, or result from an implicit understanding – e.g., through reputation and relational contracting – among group members. In some cases, however, the opposition of one group member may have a more limited impact on the relationship between the supplier and the other group members. We now show that our insights carry over as long as a member has significant influence

[30] A simple two-part tariff would suffice to achieve this; the wholesale price can be adjusted so as to induce the appropriate outcome in the downstream market, and the fixed fee – which can be negative, if needed, as in the case of slotting allowances – can then be used to share the profits as desired.

[31] For studies of buyer groups that focus on this feature of buyer groups, see Foros and Kind (2008) and Doyle and Han (2014).

[32] This, in turn, may deter a firm from joining the group. For example, for a linear demand $P(Q) = 1 - Q$ and $c = 0$, we know that forming a buyer group of two firms is not profitable when $\hat{c} = 0$ (see Salant *et al.*, 1983: Mergers are not profitable unless they include almost all firms). Setting-up a two-firm group is however profitable when $\hat{c} = P\left((n-1)\,q^C\right) = 2/(n+1)$: The outside options of the two firms become positive, which is not the case when they negotiate separately. By continuity, this remains the case when $\hat{c}$ is large enough. In this range, forming a two-firm buyer group is profitable, only because of the bargaining effect highlighted above. We thank Mike Riordan for this point.

over the other members.[33]

To see this, let us return to our baseline model with secret contracting, but suppose now that the rejection by one member induces the other members to drop the supplier for a share ϕ of their needs.[34] This parameter can be interpreted as a proxy for the influence that an individual member has on the purchasing decisions of the group. For instance, as leading manufacturers often supply many products, a member may be able to convince others to drop some of the manufacturers' products but not all of them (e.g., not the manufacturers' flagship products).

Members' outside options are thus now the outcome of oligopolistic competition, in which a member that rejects the supplier's offer faces a cost $\hat{c} \equiv c + \Delta$, whereas the other members face a cost $c + \phi\Delta$, $\phi \in (0,1)$ (outsiders still sell an aggregate quantity $Q_o = (n-s)\, q^C$). This oligopolistic competition yields a unique, stable equilibrium, in which the rejecting member's output, $\underline{q}^s$, again satisfies

$$\underline{q}^s \equiv R^C \left(Q_o + (s-1)\, q^s; c + \Delta\right),$$

whereas each other member's output, q^s, now satisfies:

$$q^s \equiv R^C \left(Q_o + (s-2)\, q^s + \underline{q}^s; c + \phi\Delta\right).$$

Letting $\underline{q}^s(\phi)$ and $q^s(\phi)$ denote the resulting outputs, and

$$\hat{\underline{\pi}}^s(\phi) \equiv \left[P\left(Q_o + (s-1)\, q^s(\phi) + \underline{q}^s(\phi)\right) - (c+\Delta)\right] \underline{q}^s(\phi)$$

and

$$\hat{\pi}^s(\phi) \equiv \left[P\left(Q_o + (s-1)\, q^s(\phi) + \underline{q}^s(\phi)\right) - (c+\phi\Delta)\right] q^s(\phi)$$

respectively denote the resulting profits for the rejecting member and the others, we have $\underline{q}^s(\phi) \leq q^s(\phi)$ (and thus $\hat{\underline{\pi}}^s(\phi) \leq \hat{\pi}^s(\phi)$), because $c + \Delta \geq c + \phi\Delta$, and $\underline{q}^s(\phi) > 0$ (and thus $\hat{\underline{\pi}}^s(\phi) > 0$) whenever $P\left(Q_o + (s-1)\, q^s(\phi)\right) > c + \Delta$.

In equilibrium, U ends up supplying again the Cournot quantity to all firms, whether they belong to the buyer group or not; however, the division of profits differs from the

[33] We thank the editor, Martin Cripps, for suggesting this extension.

[34] For simplicity, we assume symmetry in the members' influence within the purchasing group. The analysis readily extends to the case where some group members have more influence than others.

benchmark case ($\phi = 1$): The other members still react to the rejection of the supplier but now face a lower cost than the rejecting member. Hence, if non-member firms still earn $\hat{\pi}$, group members now earn $\underline{\hat{\pi}}^s(\phi)$, their outside option in case of refusal. The formation of a buyer group of size s remains profitable as long as $\underline{\hat{\pi}}^s(\phi) > \hat{\pi}^1 = \hat{\pi}$. When $\phi = 0$, the formation of a buyer group is not profitable, as other group members increase their quantities in reaction to the output reduction of the rejecting member: $q^s(0) > q^C$, as output decisions are strategic substitutes; group members' outside options are then lower than outsiders' ones. Setting-up a group is however profitable when $q^s(\phi) < q^C$, as group members' outside options are then higher. We know that this is indeed the case for $\phi = 1$ and, by continuity, this remains the case when ϕ is large enough. For example, for a linear demand $P(Q) = 1 - Q$ and $c = 0$, forming a group is profitable (i.e., $q^s(\phi) < q^C$) whenever $\phi > 1/2$.[35]

Finally, note that forming and/or joining a purchasing group is always profitable, for any ϕ, when downstream decisions are strategic complements; indeed, when one member turns to the competitive fringe, the other members then react by becoming less aggressive (e.g., by raising their prices), which benefits the first member – even if the others stick to the supplier (i.e., even if $\phi = 0$).

4.4 Other extensions

Group formation. The analysis of the previous section emphasizes that there is strength in numbers: Relying on less efficient suppliers becomes less and less costly when other firms have to do so as well. It follows that joining a group not only benefits the additional member, but also benefits the existing group members. Hence, in the absence of any restriction on the size of the group, we would expect all downstream firms to join the buyer group, thereby maximizing their resulting bargaining benefits.

The analysis is slightly more involved if, in addition to generating these bargaining benefits, the group also eliminates opportunism among its members, by making contracts public within the group and allowing it to act as a cartel. Joining the group then makes a firm less aggressive – against the other members, and also against the rivals. If downstream competition involves strategic complements, then the additional strategic effects further contribute to encourage firms to join the group. If instead downstream

[35] We have $q^C = \frac{1}{n+1}$ and $q^s(\phi) = \frac{1-(n-s)q^C+\Delta(1-2\phi)}{s+1}$, leading to $q^C - q^s(\phi) = \left(\phi - \frac{1}{2}\right)\frac{2\Delta}{s+1}$.

competition involves strategic substitutes, then group members become weaker competitors, whereas outsiders become tougher competitors. In the same way that a merger benefits outsiders more than it benefit insiders, and may even make them worse-off, a firm may prefer remaining outside the group rather than joining it. Yet, forming a large enough group would still enhance its members' outside option, compared with what they would obtain in the absence of any group (in particular, forming an encompassing group that includes all downstream firms remains always profitable).

Multiple buyer groups. Also, while for the sake of presentation we focused on a single buyer group, the analysis applies as well when several (separate) groups are formed: The members of a group of size s then all earn $\hat{\pi}^s$. Yet, in the absence of any restriction on group size, we would still expect the firms to form a single, encompassing buyer group. Indeed, prospective members benefit more from joining a larger group ($s' > s$ implies $\hat{\pi}^{s'+1} - \hat{\pi} > \hat{\pi}^{s+1} - \hat{\pi}$), and any existing group member benefits as well from switching to a larger group ($s' \geq s$ implies $\hat{\pi}^{s'+1} > \hat{\pi}^s$).

Product differentiation. We focused for simplicity on a homogenous final good, but the analysis applies as well when downstream competitors are differentiated. In this case, closer competitors benefit more from joining forces in their negotiations with the leading supplier. As the introduction of a buyer group does not affect the equilibrium outputs, the key intuition still refers to group members' outside option: If turning to less efficient suppliers remains costly, it is less painful when the other members, which have to do the same, are the ones offering the closest substitutes. To illustrate this point, suppose for instance that the downstream market consists of a differentiated four-firm Cournot oligopoly, where D_1 and D_2 produce the same product (good A), whereas D_3 and D_4 produce an imperfect substitute (good B). We thus have:

$$p_1 = p_2 = \hat{P}\left(Q_A, Q_B\right) \text{ and } p_3 = p_4 = \hat{P}\left(Q_B, Q_A\right),$$

where $Q_A = q_1 + q_2$ and $Q_B = q_3 + q_4$. For the sake of exposition, assume further that the inverse demand $\hat{P}$ is linear and given by:

$$\hat{P}\left(Q_A, Q_B\right) = 1 - Q_A - \sigma Q_B,$$

where $0 \leq \sigma < 1$. Suppose moreover that c and $\hat{c}$ satisfy $c = 0$ and $\hat{\pi} = \hat{\pi}^1\left(\hat{c}, 0\right) > 0$, which amounts to $\hat{c} < \frac{2}{3+2\sigma}$. With or without a group, all firms sell the competitive quantity $q^C = \frac{1}{3+2\sigma}$. In the absence of any buyer group, each D_i moreover earns the competitive profit $\hat{\pi} = \left(\frac{1}{3+2\sigma} - \frac{\hat{c}}{2}\right)^2$. If D_1 and D_3 (producing imperfect substitutes) join forces in their negotiations with U, then these two firms each secure $\hat{\pi}^{13} \equiv \left(\frac{1}{3+2\sigma} - \frac{\hat{c}}{2+\sigma}\right)^2 \geq \hat{\pi}$.[36] If instead it is D_1 and D_2 (producing perfect substitutes) that join forces, then these firms obtain an even larger profit, $\hat{\pi}^{12} \equiv \left(\frac{1}{3+2\sigma} - \frac{\hat{c}}{3}\right)^2 > \hat{\pi}^{13}$. Thus, for any $\sigma < 1$, it is more profitable for D_1 and D_2 to join forces rather than for D_1 and D_3 (see Appendix D).

5 Upstream investment incentives

An often-voiced concern raised by buyer power relates to its impact on suppliers' incentives to invest and innovate. To explore this issue, we now introduce investment decisions in our baseline framework. More precisely, we add here an additional stage (stage 0) at the beginning of the competition game, in which the dominant supplier, U, can invest F in order to reduce its marginal cost c, from some initial level $\overline{c} > 0$ to a lower level $\underline{c} \in [0, \overline{c}[$. In this extended framework, we study the impact of the size of the buyer group (established before the beginning of the game) on U's equilibrium investment decision. Introducing explicitly U's cost c as an argument in the above-defined functions, we will denote by $q^C(c)$ and $\pi^C(c)$ the individual quantity and profit in a Cournot equilibrium based on cost c, by $\Pi^C(c)$ the corresponding industry profit, and by $\hat{\pi}^s(\hat{c}, c) = \pi^s\left((n-s)\, q^C(c), \hat{c}\right)$ the outside option (and equilibrium profit) of a member of a buyer group of size s. Note that, by construction, $q^n(0, \hat{c}) = q^C(\hat{c})$ and $\hat{\pi}^n(\hat{c}, c) = \pi^C(\hat{c})$; thus, Lemma 2 implies $q^C(c), \pi^C(c) > 0$ if and only $c < P(0)$, in which case $dq^C/dc, d\pi^C/dc < 0$.

Obviously, it is socially or privately interesting to invest only when this allows U to be the most effective supplier (i.e., $\underline{c} < \hat{c}, P(0)$). The incentives to invest however also depend on whether the competitive fringe, too, is an effective supplier ($\hat{c} \gtrless P(0)$), as well as on whether U is initially more efficient than the fringe ($\overline{c} \gtrless \hat{c}$). More precisely, in equilibrium U supplies the downstream firms whenever it is more efficient than the

[36] For $\sigma = 0$, D_1 and D_3 do not benefit from joining forces $\left(\hat{\pi}^{13} = \hat{\pi}\right)$, as they do not compete in the same market.

fringe, that is, whenever its cost c is lower than $\hat{c}$; we will therefore let

$$\Pi_I(c) \equiv \Pi^C(\min\{c, \hat{c}\})$$

denote the industry profit, as a function of U's cost c, and

$$\Delta_I = \Pi_I(\underline{c}) - \Pi_I(\overline{c})$$

denote the investment benefit for the industry. Similarly, as a member of a buyer group of size s obtains a profit equal to $\hat{\pi}^s(\hat{c}, \min\{c, \hat{c}\})$ when U's cost is c, U's profit can then be written as

$$\Pi_U^s(c) \equiv \Pi_I(c) - s\hat{\pi}^s(\hat{c}, \min\{c, \hat{c}\}) - (n-s)\hat{\pi}^1(\hat{c}, \min\{c, \hat{c}\}),$$

and its incentive to invest is driven by a private benefit equal to

$$\Delta_U^s = \Pi_U^s(\underline{c}) - \Pi_U^s(\overline{c}).$$

When $\hat{c} < \underline{c}$, investing does not allow U to become a viable supplier, and thus is neither privately nor socially desirable. Conversely, when the competitive fringe does not offer a viable option (i.e., when $\hat{c} \geq P\left((n-s)q^C(\overline{c})\right)$), downstream firms obtain zero profit whether there is a buyer group or not; this leads U to fully internalize the impact of its investment on the industry profit and thus aligns its incentives with that of the industry (that is, $\Delta_U^s = \Delta_I$). The same applies when downstream firms form an encompassing group (i.e., $s = n$), as they then earn a profit equal to $\Pi^C(\hat{c})$, regardless of U's cost; therefore, U fully internalizes again the impact of its on the industry profit, and $\Delta_U^n = \Delta_I$.

In all other cases (that is, when $s < n$ and $\underline{c} < \hat{c} < P\left((n-s)q^C(\overline{c})\right)$), by investing U increases its profit not only by lowering its cost, but also possibly by limiting the value of downstream firms' outside option, if they were to turn to the fringe suppliers; indeed, we then have:

$$\begin{aligned} \Delta_U^s - \Delta_I &= s\left[\hat{\pi}^s(\hat{c}, \min\{\overline{c}, \hat{c}\}) - \hat{\pi}^s(\hat{c}, \underline{c})\right] \\ &\quad + (n-s)\left[\hat{\pi}^1(\hat{c}, \min\{\overline{c}, \hat{c}\}) - \hat{\pi}^1(\hat{c}, \underline{c})\right], \end{aligned} \tag{2}$$

where the terms in brackets are non-negative (and the first one is positive), as $\hat{\pi}^k(\hat{c}, c)$ weakly increases with c (and strictly so for $k = s$) from $\underline{c}$ to $\min\{\overline{c}, \hat{c}\}$. As a result, U has excessive incentives to invest, compared with what would maximize industry profits (that is, $\Delta_U^s > \Delta_I$):

Proposition 5 $\Delta_U^s \geq \Delta_I$ *for any* $\overline{c} > \underline{c} \geq 0$*, any* $\hat{c} \geq 0$ *and any* $s \in \{1, ..., n\}$*; more precisely:*

(i) $\Delta_U^s = \Delta_I$ *if* $\hat{c} < \underline{c}$, $\hat{c} \geq P\left((n-s)\, q^C(\overline{c})\right)$*, or* $s = n$*.*

(ii) $\Delta_U^s > \Delta_I$ *if instead* $s < n$ *and* $\underline{c} < \hat{c} < P\left((n-s)\, q^C(\overline{c})\right)$*.*

Proof. See Appendix E. ■

Reducing downstream firms' rents thus gives U an additional motive for investing in cost reduction, which tends to increase its incentives to invest, beyond what would maximize industry profitability. We now show that, while creating or expanding a buyer group increases downstream firms' profit at the expense of U, the impact on U's incentives to invest is however ambiguous. For example, when $\hat{c} \geq P\left(q^C(\overline{c})\right)$, the formation of a buyer group either has no effect (as long as $s < n$, because then $\hat{\pi}^s(\hat{c}, \overline{c}) = \hat{\pi}^s(\hat{c}, \underline{c}) = 0$), or reduces U's rent by $\Pi^C(\hat{c})$, regardless of U's cost (if $s = n$). Thus, while the creation or the expansion of a buyer group can reduce U's rent (if $s = n$), it never affects U's investment incentives in that case ($\Delta_U^s = \Delta_I$ for any $s \leq n$). When instead $\hat{c} < P\left(q^C(\overline{c})\right)$, setting-up a large enough group (i.e., s close enough to n) allows downstream firms to obtain a positive profit, and expanding it further moreover tends to make downstream firms' outside option less sensitive to U's cost, at it reduces the number of downstream firms that rely on U in this alternative scenario, which tends to eliminate the scope for overinvestment; thus, for s large enough, we expect Δ_U^s to decrease as s further increases, and eventually converge towards Δ_I. When instead the buyer group is initially small, expanding its size strengthens downstream firms' weak bargaining position, and may well do so more effectively when U is itself not too strong; this, in turn, may reinforce U's incentives to invest in cost reduction; for example, if $\hat{\pi}^s(\hat{c}, \overline{c}) > \hat{\pi}^s(\hat{c}, \underline{c}) = 0$, then U clearly has an extra incentive to invest when a buyer group of size s has formed, so as to prevent downstream firms from gaining any bargaining power, and thus $\Delta_U^s > \Delta_I$. The following Proposition reflects this intuition:

Proposition 6 *For any* $\overline{c} > \underline{c} \geq 0$ *and any* $s < n$*: (1)* $\Delta_U^{s+1} = \Delta_U^s$ *if* $\hat{c} \leq \underline{c}$ *or* $\hat{c} \geq P\left(q^C\left(\overline{c}\right)\right)$*; (2) if instead* $\underline{c} < \hat{c} < P\left(q^C\left(\overline{c}\right)\right)$*:*

(i) $\Delta_U^{s+1} < \Delta_U^s$ *for* s *large enough.*

(ii) However, if $\hat{c} \geq P\left(\left(n-1\right) q^C\left(\overline{c}\right)\right)$*, then* $\Delta_U^{s+1} \geq \Delta_U^s$ *for* s *not too large, with at least one strict inequality in that range.*

Proof. See Appendix F.1. ■

Setting-up of expanding a buyer group may thus *foster* U's incentives to invest if the group is not too large, and tends instead to counterbalance the overinvestment bias, and reduce investment incentives, when the group is large. To illustrate this proposition, suppose for example that the costs $\hat{c}, \overline{c}, \underline{c}$ satisfy $\hat{c} > \overline{c} > \underline{c}$, $\pi^C\left(\hat{c}\right) > 0$, and $\hat{\pi}^1\left(\hat{c}, \overline{c}\right) = \hat{\pi}^1\left(\hat{c}, \underline{c}\right) = 0$. There then exists $\bar{s}$ and $\underline{s} \geq \bar{s}$ such that $\hat{\pi}^s\left(\hat{c}, \overline{c}\right) > 0$ (resp., $\hat{\pi}^s\left(\hat{c}, \underline{c}\right) > 0$) if and only if $s \geq \bar{s}$ (resp., $s \geq \underline{s}$). We then have (Figure 1 provides an illustration for $n = 10$, $P\left(Q\right) = 1 - q$, $\hat{c} = 0.7$, $\overline{c} = 0.45$, and $\underline{c} = 0$; see Appendix F.2 for a detailed analysis of this case):

- In the range $s < \bar{s}$, $\hat{\pi}^s\left(\hat{c}, \overline{c}\right) = \hat{\pi}^s\left(\hat{c}, \underline{c}\right) = 0$, and thus $\Delta_U^s = \Delta_I$.

- In the range $\bar{s} \leq s < \underline{s}$, $\hat{\pi}^s\left(\hat{c}, \underline{c}\right) = 0$ but $\hat{\pi}^s\left(\hat{c}, \overline{c}\right)$ is positive and increases with s; as a result, U has more incentives to invest than what would maximize industry profits ($\Delta_U^s > \Delta_I$), and the more so, the larger the buyer group: Δ_U^s increases as s increases.

- Finally, in the range $s > \underline{s}$, $\hat{\pi}^s\left(\hat{c}, \overline{c}\right)$ and $\hat{\pi}^s\left(\hat{c}, \underline{c}\right)$ are both positive and increasing in s. While $\hat{\pi}^s\left(\hat{c}, \underline{c}\right)$ remains smaller than $\hat{\pi}^s\left(\hat{c}, \overline{c}\right)$ as s increases, it first increases more slowly, and then more quickly than $\hat{\pi}^s\left(\hat{c}, \overline{c}\right)$ (and the two coincide with $\pi^C\left(\hat{c}\right)$ for $s = n$); as a result, Δ_U^s first increases and then decreases as s increases (and finally coincides again with Δ_I for $s = n$).

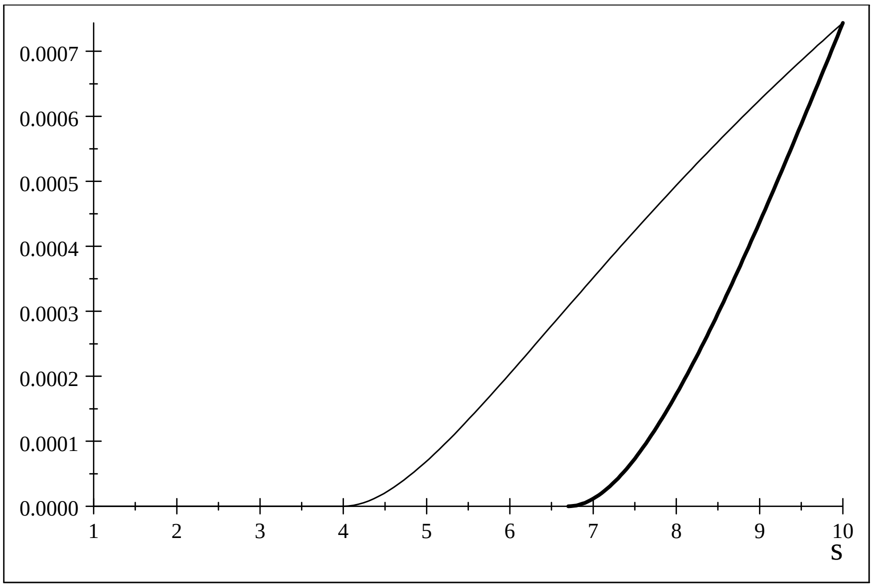

Figure 1a: Retailers' profits ($\hat{\pi}^s(\hat{c}, \underline{c})$ – in bold – and $\hat{\pi}^s(\hat{c}, \bar{c})$)

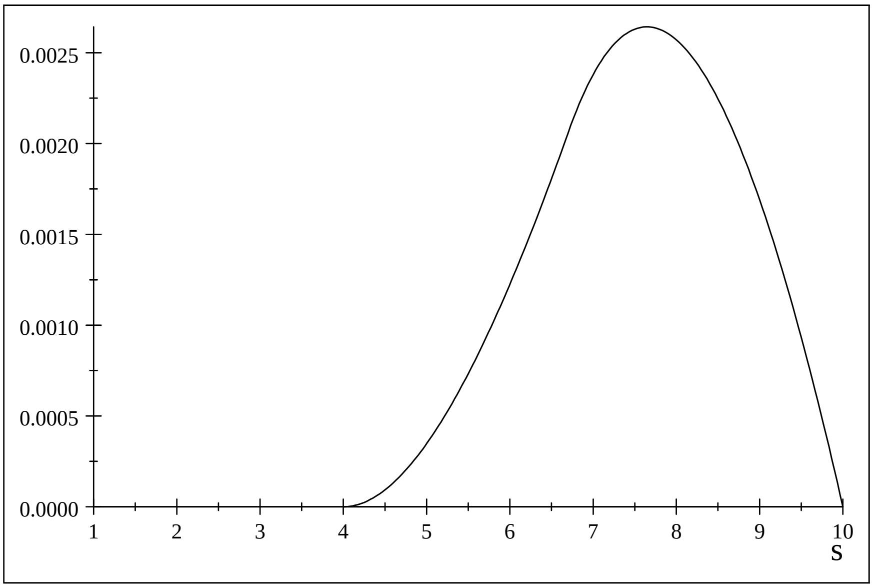

Figure 1b: Investment incentives (Δ_U^s)

Implications for group formation. The above analysis shows that forming a group affects U's investment incentives, as well as the value of group members' outside option. More precisely: (i) keeping constant the investment level, downstream firms are always willing to join as large a group as possible, as this enhances their bargaining position, and thus their equilibrium profit; and (ii) keeping constant the size of the group, the value of this outside option decreases as U's invests more. As increasing the size of the group eventually decreases U's investment incentives – back to the level (Δ_I) that would prevail absent a buyer group –, it follows that, in order to maximize the value of their equilibrium profit, downstream firms still have an incentive to join as large a group as possible: This minimizes U's investment incentives (as $\Delta_I \leq \Delta_U^s$ for any size s), and moreover maximizes their bargaining position, given this investment level.

6 Conclusion

While the literature on buyer power has mainly studied the impact of downstream firms' mergers, in this paper we focus instead on the bargaining power that *buyer groups* confer to firms that are and remain competitors in the same downstream market. We show that, by joining forces in their procurement negotiations, downstream firms can enhance their bargaining position at the expense of their suppliers. They can do so by creating a buyer group that selects suppliers on behalf of its members, in which each group member can veto an offer, in which case all group members must turn to alternative suppliers. Transforming individual listing decisions into a joint listing decision makes delisting less harmful, which in turn improves group members' bargaining position compared to outsiders.

We show further that, while giving each member veto power on other members' listing decisions maximizes the bargaining effect of the buyer group, the insights carry over to less drastic veto power.[37]

Moreover, while for the sake of presentation we consider a situation where all firms compete in the same downstream market, the analysis applies as well to "hybrid" buyer groups, where some members are on separate markets while others compete in the same market. It is however the presence of competition among group members that enhances their bargaining position. Thus, prospective members benefit more from joining a group in which the number of direct competitors is the largest.[38]

[37]Formally, when downstream decisions are strategic substitutes, as is the case in the example with Cournot competition we provide, a group remains profitable as long as each member can influence the other members' listing decisions for a significant share of their needs. When instead downstream decisions are strategic complements, as is often the case with Bertrand competition, the incentives of forming a buyer group are always positive.

[38]In the same vein, closer competitors gain more from joining forces in their negotiations with sup-

We also show that the group's additional buyer power can have an ambiguous impact on a supplier's incentives to invest: Enlarging a buyer group may foster its incentives to invest if the group is not too large, and tends instead to counterbalance overinvestment biases, and reduce investment incentives, when the group is already quite large.

Finally, in our baseline model secret contracting implies that contracts are bilaterally efficient; hence, the enhanced bargaining position conferred by buyer groups does not affect final prices and output levels, and has no impact either on outsiders. When instead contracts are public within the group, e.g., when purchasing terms are centrally negotiated, the bargaining effects just highlighted are still present, but additional, strategic effects kick in as well. Forming a group remains profitable if downstream competition involves strategic complements or else when the group is large enough. In addition, buyer groups then have an impact on the equilibrium outcome: Consumers face higher prices and outsiders benefit from the formation of a buyer group. This echoes a concern often voiced by antitrust authorities, as the cost savings resulting from joint purchasing arrangements are not necessarily passed on to consumers, and consumer prices may well increase.

Which of the "public" or "secret" contracting paradigms is more relevant (in terms of plausible assumptions and/or of predicted outcomes) is likely to varry across industries or countries. Our analysis provides a framework which can be used to test empirically these alternative paradigms.

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Appendix

A Proof of Lemma 2

The following Lemma will be useful:

Lemma 7 *Under Assumption 1, for any $k \in \mathbb{N}^*$ and any Q and q satisfying $Q \geq q \geq 0$, $kP'(Q) + P''(Q)\,q < 0$.*

Proof. Because $P'(Q) < 0$, the expression $kP'(Q) + P''(Q)\,q$ is negative whenever $P''(Q) \leq 0$; if instead $P''(Q) > 0$, then Assumption 1, together with $P'(Q) < 0$ and $q \leq Q$, yields

$$kP'(Q) + P''(Q)\,q \leq P'(Q) + P''(Q)\,Q < 0.$$

■

Assumption 1 ensures that each group member's profit is strictly concave in its own quantity: letting q_i denote the member's output, $Q_{-i} = Q_o + \sum_{j\in S\setminus\{i\}}$ its rivals' aggregate output and $Q = Q_{-i} + q_i$ the total output, we have

$$\frac{\partial^2 \pi\left(q_i; Q_{-i}, \hat{c}\right)}{\partial q_i^2} = 2P'(Q) + P''(Q)\,q_i < 0,$$

where the inequality stems from Lemma 7. Furthermore, the first-order derivative of the member's profit is:

$$\left.\frac{\partial \pi\left(q_i; Q_{-i}, \hat{c}\right)}{\partial q_i}\right|_{q_i=0} = P(Q) - \hat{c}.$$

Therefore, if $P(Q) \leq \hat{c}$, then all group members choose $q_i = 0$, in which case $Q = Q_o$ and thus $P(Q_o) \leq \hat{c}$; conversely, if $P(Q_o) \leq \hat{c}$, so that $P(Q) < \hat{c}$ for any $Q > Q_o$, each member necessarily chooses $q_i = 0$, which satisfies (1).

When instead $P(Q) > \hat{c}$, each group member must choose a positive quantity $q_i > 0$, thus satisfying the first-order condition

$$P(Q) + P'(Q)\,q_i = \hat{c}.$$

If follows that $q_i = q^s$ (i.e., all members must choose the same quantity),[39] where $q^s > 0$ thus satisfies (1) or, equivalently, the first-order condition

$$P\left(sq^s + Q_o\right) + P'\left(sq^s + Q_o\right)q^s = \hat{c}. \tag{3}$$

Let $Q^s \equiv sq^s + Q_o$ denote the aggregate equilibrium output. Differentiating (3) with respect to $\hat{c}$, Q_o and q^s yields:

$$\begin{aligned}
\frac{\partial q^s}{\partial \hat{c}} &= \frac{1}{(s+1)\,P'\left(Q^s\right) + P''\left(Q^s\right)sq^s} < 0, \\
\frac{\partial q^s}{\partial Q_o} &= -\frac{P'\left(Q^s\right) + P''\left(Q^s\right)q^s}{(s+1)\,P'\left(Q^s\right) + P''\left(Q^s\right)sq^s} < 0,
\end{aligned}$$

where the inequalities follow from Lemma 7.

We now turn to π^s. Using $\pi^s = \max_{q_i} \pi\left(q_i; Q_o + (s-1)\,q^s, \hat{c}\right)$ and the envelope theorem, we have:

$$\begin{aligned}
\frac{\partial \pi^s}{\partial \hat{c}} &= \left.\frac{\partial \pi\left(q_i; Q_{-i}, \hat{c}\right)}{\partial Q_{-i}}\right|_{q_i=q^s, Q=Q^s} (s-1)\,\frac{\partial q^s}{\partial \hat{c}} + \left.\frac{\partial \pi\left(q_i; Q_{-i}, \hat{c}\right)}{\partial \hat{c}}\right|_{q_i=q^s, Q=Q^s} \\
&= P'\left(Q^s\right)q^s\,(s-1)\,\frac{\partial q^s}{\partial \hat{c}} - q^s \\
&= \left[\frac{(s-1)\,P'\left(Q^s\right)}{(s+1)\,P'\left(Q^s\right) + P''\left(Q^s\right)sq^s} - 1\right]q^s \\
&= -\frac{2P'\left(Q^s\right) + P''\left(Q^s\right)sq^s}{(s+1)\,P'\left(Q^s\right) + P''\left(Q^s\right)sq^s}q^s < 0,
\end{aligned}$$

[39] This is a common feature of aggregative games, where one player's objective depends on others' decisions only through an aggregator (here, total output) of all individual decisions. See Anderson, Erkal and Piccinin (2011) for a recent treatment of such games.

where the inequality follows again from Lemma 7. The envelope theorem yields similarly:

$$\begin{aligned}
\frac{\partial \pi^s}{\partial Q_o} &= \left.\frac{\partial \pi\left(q_i;Q_{-i},\hat{c}\right)}{\partial Q_{-i}}\right|_{q_i=q^s,Q=Q^s}\left(1+(s-1)\frac{\partial q^s}{\partial Q_o}\right) \\
&= P'\left(Q^s\right)q^s\left(1+(s-1)\frac{\partial q^s}{\partial Q_o}\right) \\
&= P'\left(Q^s\right)q^s\frac{2P'\left(Q^s\right)+P''\left(Q^s\right)q^s}{(s+1)P'\left(Q^s\right)+P''\left(Q^s\right)sq^s}<0,
\end{aligned}$$

where the inequality follows again from $P'(Q)<0$ and Lemma 7.

B Proof of Proposition 3

Consider a candidate equilibrium in which: (i) U supplies all firms, which implies that all group members recommend accepting U's offers, and (ii) $q_i \neq R^C\left(Q_{-i};c\right)$ for some downstream firm D_i, where Q_{-i} denotes the aggregate equilibrium output of D_i's rivals. D_i's equilibrium profit, of the form $\pi_i = P\left(Q_{-i}+q_i+\hat{q}_i\right)\left(q_i+\hat{q}_i\right)-T_i-\hat{c}\hat{q}_i$, must satisfy $\pi_i \geq \hat{\pi}_i$, where $\hat{\pi}_i$ represents the profit that D_i can obtain with its relevant outside option: $\hat{\pi}_i = \pi^1\left(Q_{-i},\hat{c}\right)$ if D_i does not belong to the buyer group G, whereas $\hat{\pi}_i = \pi^s\left(Q_o,\hat{c}\right)$ otherwise, where Q_o denotes the aggregate equilibrium output of firms outside G. Moreover, the constraint $\pi_i \geq \hat{\pi}_i$ must be binding; otherwise, U could deviate and slightly increase the payment T_i: under passive conjectures, D_i would still accept (or, if belonging to G, would still recommend acceptance, leading G to accept U's offers), and the deviation would thus increase U's profit. Therefore, we must have $\pi_i = \hat{\pi}_i$.

Suppose now that U deviates and offers D_i to supply $\tilde{q}_i = R^C\left(Q_{-i};c\right)$ for some total price $\tilde{T}_i$. Under passive conjectures, D_i anticipates its rivals to stick to their equilibrium outputs, and (other) group members to keep recommending acceptance of U's offers to the group. It follows that, if D_i accepts the offer, the impact of this deviation on the joint profits of U and D_i is given by:

$$\begin{aligned}
& \left\{\left[\tilde{T}_i - c\tilde{q}_i\right] + \max_{q\geq 0}\left[P\left(Q_{-i}+\tilde{q}_i\right)\left(\tilde{q}_i+q\right)-\tilde{T}_i-\hat{c}q\right]\right\} \\
& -\left\{\left[T_i - cq_i\right]+\left[P\left(Q_{-i}+q_i+\hat{q}_i\right)\left(q_i+\hat{q}_i\right)-T_i-\hat{c}\hat{q}_i\right]\right\} \\
\geq & \left\{\left[\tilde{T}_i - c\tilde{q}_i\right]+\left[P\left(Q_{-i}+\tilde{q}_i\right)\tilde{q}_i-\tilde{T}_i\right]\right\}-\left\{\left[T_i-cq_i\right]+\left[P\left(Q_{-i}+q_i+\hat{q}_i\right)\left(q_i+\hat{q}_i\right)-T_i-\hat{c}\hat{q}_i\right]\right\} \\
= & \left(P\left(Q_{-i}+\tilde{q}_i\right)-c\right)\tilde{q}_i-\left\{\left(P\left(Q_{-i}+q_i+\hat{q}_i\right)-c\right)\left(q_i+\hat{q}_i\right)-\left(\hat{c}-c\right)\hat{q}_i\right\}.
\end{aligned}$$

The last expression is positive, as $\left(P\left(Q_{-i}+\tilde{q}_i\right)-c\right)\tilde{q}_i = \max_{\tilde{q}\geq 0}\left(P\left(Q_{-i}+\tilde{q}\right)-c\right)\tilde{q}$ and:

- If $\hat{q}_i = 0$, then $q_i+\hat{q}_i = q_i \neq R^C\left(Q_{-i};c\right)$ implies

$$\left(P\left(Q_{-i}+q_i+\hat{q}_i\right)-c\right)\left(q_i+\hat{q}_i\right) < \max_{\tilde{q}\geq 0}\left(P\left(Q_{-i}+\tilde{q}\right)-c\right)\tilde{q}.$$

- If $\hat{q}_i > 0$, then:

$$\begin{aligned}
\left(P\left(Q_{-i}+q_i+\hat{q}_i\right)-c\right)\left(q_i+\hat{q}_i\right)-\left(\hat{c}-c\right)\hat{q}_i &< \left(P\left(Q_{-i}+q_i+\hat{q}_i\right)-c\right)\left(q_i+\hat{q}_i\right) \\
&\leq \max_{\tilde{q}\geq 0}\left(P\left(Q_{-i}+\tilde{q}\right)-c\right)\tilde{q}.
\end{aligned}$$

  Therefore, in both cases the deviating offer increases the joint profit of U and D_i if it is accepted; there thus exists a price $\tilde{T}_i$ that is mutually profitable, i.e., that gives D_i more than $\pi_i = \hat{\pi}_i$ (so that U's offer is indeed accepted, either individually or by the group) and yet increases U's profit.

Therefore, any equilibrium in which U supplies all firms, and firms have passive conjectures, must be such that $q_i = R^C\left(Q_{-i};c\right)$ for $i = 1,...,n$; this, in turn, implies $q_i = q^C$. It follows that, in any such equilibrium:

- If D_i does not belong to G, it can secure $\hat{\pi}_i = \hat{\pi}$ by rejecting U's offer.
- If instead D_i belongs to G, it can secure $\hat{\pi}_i = \hat{\pi}^s$ by recommending the rejection of U's offers to the group.

Conversely, suppose that U offers to supply q^c to each D_i, for a total payment equal to $P\left(nq^C\right)q^C - \hat{\pi}_i$, where $\hat{\pi}_i$ is defined as above. By construction, a deviating offer that is acceptable by D_i cannot increase the joint bilateral profit of U and D_i; as D_i can secure $\hat{\pi}_i$ by rejecting U's offer (or recommending its rejection), such deviation cannot be profitable for U. Obviously, deviating and not supplying a non-member firm D_i is also unprofitable, as it would reduce U's profit by

$$\left(P\left(nq^C\right)-c\right)q^C-\hat{\pi}=\pi^1\left((n-1)\,q^C;c\right)-\pi^1\left((n-1)\,q^C;\hat{c}\right)\geq 0.$$

Finally, deviating offers that are rejected by the buyer group G cannot be profitable either, as it would reduce U's profit by

$$s\left[\left(P\left(nq^C\right)-c\right)q^C-\hat{\pi}^s\right]=s\left[\pi^s\left((n-s)\,q^C;c\right)-\pi^s\left((n-s)\,q^C;\hat{c}\right)\right]\geq 0.$$

C Proof of Proposition 4

By construction, $\hat{\pi}=\pi^1\left((n-s)\,q^C;\hat{c}\right)=\hat{\pi}^1$, $\hat{\pi}^n=\pi^n\left(0;\hat{c}\right)$ and $\pi^C=\pi^n\left(0;c\right)$; furthermore, the latter is positive from Assumption 1 and Lemma 2, which in turn implies $\pi^C=\pi^n\left(0;c\right)>\hat{\pi}^n=\pi^n\left(0;\hat{c}\right)$.

Let $\hat{q}^s\equiv q^s\left((n-s)\,q^C;\hat{c}\right)$ denote each group member's continuation equilibrium output if the group were to reject U's offers. From Assumption 1 and Lemma 2, $q^C=q^s\left((n-s)\,q^C;c\right)>0$ and:

$$q^C=q^s\left((n-s)\,q^C;c\right)>\hat{q}^s=q^s\left((n-s)\,q^C;\hat{c}\right).$$

By construction, for $s>1$, we have $\hat{\pi}^{s-1}=\pi^{s-1}\left((n-s+1)\,q^C;\hat{c}\right)$ and:

$$\hat{\pi}^s=\pi^{s-1}\left((n-s)\,q^C+\hat{q}^s;\hat{c}\right).$$

The conclusion then follows from Lemma 2, which implies that the profit function $\pi^s\left(Q_o,\hat{c}\right)$ decreases as the outsiders' output Q_o increases, and does strictly so as long as it remains positive, which is the case if and only if $P\left(Q_o\right)>\hat{c}$.

D Illustration for imperfect substitutes

We study here the differentiated four-firm Cournot oligopoly introduced in section **??**, in which D_1 and D_2 produce good A whereas D_3 and D_4 produce good B.

In the absence of any buyer group, each D_i ($i = 1, 2, 3, 4$) sells the competitive quantity q^C, which solves

$$\max_q \hat{P}\left(q^C + q, 2q^C\right) q = \left(1 - \left(q^C + q\right) - 2\sigma q^C\right) q.$$

As this profit is concave, q^C is thus characterized by the first-order condition:[40]

$$0 = 1 - \left(q^C + q\right) - 2\sigma q^C - q\Big|_{q=q^C} = 1 - (3 + 2\sigma) q^C,$$

i.e.,

$$q^C = \frac{1}{3 + 2\sigma}.$$

Furthermore, each D_i earns the profit it could obtain by turning to the competitive fringe:

$$\hat{\pi} = \left(\hat{P}\left(q^C + \hat{q}, 2q^C\right) - \hat{c}\right)\hat{q} \equiv \max_q \left(\hat{P}\left(q^C + q, 2q^C\right) - \hat{c}\right) q,$$

where

$$\begin{aligned}
\left(\hat{P}\left(q^C + q, 2q^C\right) - \hat{c}\right) q &= \left(1 - (1 + 2\sigma) q^C - q - \hat{c}\right)\hat{q} \\
&= \left(1 - \frac{1 + 2\sigma}{3 + 2\sigma} - q - \hat{c}\right)\hat{q} \\
&= \left(\frac{2}{3 + 2\sigma} - q - \hat{c}\right) q.
\end{aligned}$$

The profit $\hat{\pi}$ is positive when $\hat{c} < \frac{2}{3+2\sigma}$, in which case $\hat{q}$ is determined by the first-order condition:

$$\frac{2}{3 + 2\sigma} - \hat{c} - 2\hat{q} = 0,$$

i.e.,

$$\hat{q} = \frac{1}{3 + 2\sigma} - \frac{\hat{c}}{2},$$

[40] In what follows, $\hat{P}_1$ denotes the partial derivative of $\hat{P}$ with respect to its first argument.

leading to

$$\hat{\pi} = \left(\frac{1}{3+2\sigma} - \frac{\hat{c}}{2}\right)^2.$$

Suppose now that D_1 and D_2 form a buyer group. Equilibrium quantities remain the same, and outsiders still earn $\hat{\pi}$, but the group members now each secure:

$$\hat{\pi}^{12} = \left(\hat{P}\left(2\hat{q}^{12}, 2q^C\right) - \hat{c}\right)\hat{q}^{12} \equiv \max_q \left(\hat{P}\left(\hat{q}^{12} + q, 2q^C\right) - \hat{c}\right) q,$$

where

$$\begin{aligned}
\left(\hat{P}\left(\hat{q}^{12} + q, 2q^C\right) - \hat{c}\right) q &= \left(1 - \left(\hat{q}^{12} + q\right) - 2\sigma q^C - \hat{c}\right)\hat{q} \\
&= \left(1 - \left(\hat{q}^{12} + q\right) - \frac{2\sigma}{3+2\sigma} - \hat{c}\right)\hat{q} \\
&= \left(\frac{3}{3+2\sigma} - \left(\hat{q}^{12} + q\right) - \hat{c}\right) q.
\end{aligned}$$

The first-order condition yields, for $q = \hat{q}^{12}$:

$$\frac{3}{3+2\sigma} - \hat{c} - 3\hat{q}^{12} = 0,$$

i.e.,

$$\hat{q}^{12} = \frac{1}{3+2\sigma} - \frac{\hat{c}}{3},$$

leading to

$$\hat{\pi}^{12} = \left(\frac{1}{3+2\sigma} - \frac{\hat{c}}{3}\right)^2.$$

If instead D_1 and D_3 form a buyer group, they each gain:

$$\hat{\pi}^{13} = \left(\hat{P}\left(q^C + \hat{q}^{13}, q^C + \hat{q}^{13}\right) - \hat{c}\right)\hat{q}^{13} \equiv \max_q \left(\hat{P}\left(q^C + q, q^C + \hat{q}^{13}\right) - \hat{c}\right) q,$$

where

$$\begin{aligned}
\left(\hat{P}\left(q^C+q, q^C+\hat{q}^{13}\right)-\hat{c}\right) q &= \left(1-\left(q^C+q\right)-\sigma\left(q^C+\hat{q}^{13}\right)-\hat{c}\right) \hat{q} \\
&= \left(1-\frac{1+\sigma}{3+2\sigma}-q-\sigma\hat{q}^{13}-\hat{c}\right) \hat{q} \\
&= \left(\frac{2+\sigma}{3+2\sigma}-q-\sigma\hat{q}^{13}-\hat{c}\right) q.
\end{aligned}$$

The first-order condition yields, for $q=\hat{q}^{13}$:

$$\frac{2+\sigma}{3+2\sigma}-(2+\sigma)\,\hat{q}^{13}-\hat{c}=0,$$

i.e.,

$$\hat{q}^{13}=\frac{1}{3+2\sigma}-\frac{\hat{c}}{2+\sigma},$$

leading to

$$\hat{\pi}^{13}=\left(\frac{1}{3+2\sigma}-\frac{\hat{c}}{2+\sigma}\right)^2.$$

It is straightforward to check that $\hat{\pi}^{12}>\hat{\pi}^{13}>\hat{\pi}$.

E Proof of Proposition 5

The following Lemma will be useful:

Lemma 8 *For any $k\in\{1,...n-1\}$, and any $\hat{c},c\geq 0$:*

$$\frac{\partial\hat{\pi}^k}{\partial c}\left(\hat{c},c\right)\geq 0, \tag{4}$$

with a strict inequality whenever $c<P(0)$ (i.e., $q^C(c)>0$) and $\hat{c}<P\left((n-k)\,q^C(c)\right)$.

Proof. We have:

$$\frac{\partial\hat{\pi}^k}{\partial c}\left(\hat{c},c\right)=\left.\frac{\partial\pi^k}{\partial Q_o}\left(Q_o,\hat{c}\right)\right|_{Q_o=(n-k)q^C(c)}(n-k)\,\frac{dq^C}{dc}(c)\,.$$

The conclusion then follows from Lemma 2, which ensures that $\frac{\partial \pi^k}{\partial Q_o}(Q_o, \hat{c})\Big|_{Q_o=(n-k)q^C(c)} \geq 0$, with a strict inequality whenever $\hat{c} < P\left((n-k)\, q^C(c)\right)$, and (when applied to the case $Q_o = 0$ and $s = n$) $\frac{dq^C}{dc} \leq 0$, with a strict inequality whenever $c < P(0)$. ■

We now consider in turn the various cases discussed in the text:

- When $\hat{c} < \underline{c}$, investing does not allow U to become a viable supplier, and thus is neither privately nor socially desirable: $\Delta_U^s = \Delta_I = 0$.

- When $\hat{c} \geq P\left((n-s)\, q^C(\overline{c})\right)$, the competitive fringe does not offer a viable option: $\hat{\pi}^s(\hat{c}, c) = 0$, and thus $\Pi_U^s(c) = \Pi_I(c)$, for both $c = \min\{\underline{c}, \hat{c}\}$ and $c = \min\{\overline{c}, \hat{c}\}$; therefore, U fully internalize the impact of its investment on the industry profit: $\Delta_U^s = \Delta_I$.

- When $s = n$, downstream firms earn a profit equal to $\hat{\pi}^n(\hat{c}, c) = \Pi^C(\hat{c})$, regardless of U's cost c; this leads again U to internalize fully the impact of its on the industry profit: $\Delta_U^s = \Delta_I$.

Consider now the case where $s < n$ and $\underline{c} < \hat{c} < P\left((n-s)\, q^C(\overline{c})\right)$. As $\min\{\underline{c}, \hat{c}\} = \underline{c}$, $\Delta_U^s - \Delta_I$ is given by (2), and in addition $\min\{\underline{c}, \hat{c}\} = \underline{c} < \min\{\overline{c}, \hat{c}\}$. Lemma 8 then implies that the terms in brackets, $\hat{\pi}^s(\hat{c}, \min\{\overline{c}, \hat{c}\}) - \hat{\pi}^s(\hat{c}, \underline{c})$ and $\hat{\pi}^1(\hat{c}, \min\{\overline{c}, \hat{c}\}) - \hat{\pi}^1(\hat{c}, \underline{c})$, are both non-negative. The first term is moreover positive, because $\frac{\partial \hat{\pi}^s}{\partial c}(\hat{c}, c)\Big|_{c=\min\{\overline{c}, \hat{c}\}} > 0$:

- If $\hat{c} \leq \overline{c}$, $\hat{\pi}^s(\hat{c}, \min\{\overline{c}, \hat{c}\}) = \hat{\pi}^s(\hat{c}, \hat{c}) = \pi^C(\hat{c})$, and $\hat{c} < P\left((n-s)\, q^C(\overline{c})\right) (\leq P(0))$ implies $\hat{c} < P(0)$, which in turn implies $\pi^C(\hat{c}) > 0$ and thus $\hat{c} < \left(P\left(nq^C(\hat{c})\right) <\right) P\left((n-s)\, q^C(\hat{c})\right)$; therefore, from Lemma 8, $\frac{\partial \hat{\pi}^s}{\partial c}(\hat{c}, c)\Big|_{c=\hat{c}} > 0$.

- If $\hat{c} > \overline{c}$, $\hat{\pi}^s(\hat{c}, \min\{\overline{c}, \hat{c}\}) = \hat{\pi}^s(\hat{c}, \overline{c})$; $\hat{c} < P\left((n-s)\, q^C(\overline{c})\right)$ then implies $\overline{c} < \left(\hat{c} < P\left((n-s)\, q^C(\overline{c})\right) <\right) P(0)$, and thus from Lemma 8, $\frac{\partial \hat{\pi}^s}{\partial c}(\hat{c}, c)\Big|_{c=\overline{c}} > 0$.

The conclusion follows.

F Upstream investment incentives

F.1 Proof of Proposition 6

Consider first the case $\hat{c} \geq P\left(q^C(\overline{c})\right) \left(\geq P\left(q^C(\underline{c})\right)\right)$.

- For any $s < n$, $\hat{\pi}^s(\hat{c}, \overline{c}) = \hat{\pi}^s(\hat{c}, \underline{c})\,(= 0)$; therefore:
  - If $q^C(\overline{c}) > 0$, then $P\left(q^C(\overline{c})\right) > \overline{c}$; $\hat{c} \geq P\left(q^C(\overline{c})\right)$ thus implies $\hat{c} > \overline{c} > \underline{c}$, and we have: $\hat{\pi}^s(\hat{c}, \min\{\overline{c}, \hat{c}\})\,(= \hat{\pi}^s(\hat{c}, \overline{c})) = \hat{\pi}^s(\hat{c}, \min\{\underline{c}, \hat{c}\})\,(= \hat{\pi}^s(\hat{c}, \underline{c})) = 0$, and thus $\Delta_U^s = \Delta_I$.
  - If $q^C(\overline{c}) = 0$, then $\hat{c} \geq P\left(q^C(\overline{c})\right) = P(0)$ implies that $\hat{c}$ is never a viable option (even when outsiders are also supplied at $\hat{c}$), and thus again $\hat{\pi}^s(\hat{c}, \min\{\overline{c}, \hat{c}\}) = \hat{\pi}^s(\hat{c}, \min\{\underline{c}, \hat{c}\}) = 0$, and $\Delta_U^s = \Delta_I$.
- For $s = n$, we also have $\hat{\pi}^n(\hat{c}, \min\{\overline{c}, \hat{c}\}) = \hat{\pi}^n(\hat{c}, \min\{\underline{c}, \hat{c}\})\,\left(= \pi^C(\hat{c})\right)$, and thus $\Delta_U^s = \Delta_I$.

Therefore, for any $s \in \{1, ..., n\}$, $\Delta_U^s = \Delta_I$; thus, $\Delta_U^{s+1} = \Delta_U^s$ for any $s < n$. Likewise, if $\hat{c} \leq \underline{c}$, then $\Delta_U^s = \Delta_I = 0$ for any $s \in \{1, ..., n\}$, and thus $\Delta_U^{s+1} = \Delta_U^s$ for any $s < n$.

We now assume $\underline{c} < \hat{c} < P\left(q^C(\overline{c})\right)$, and distinguish two cases.

Case 1: $\underline{c} < \hat{c} \leq \overline{c}$. In that case, investing allows U to become an effective supplier, and

$$\Delta_U^s = \Pi_U^s(\underline{c}) = \Pi_I(\underline{c}) - s\hat{\pi}^s(\hat{c}, \underline{c}) - (n - s)\,\hat{\pi}^1(\hat{c}, \underline{c})\,.$$

Therefore, for $s \in \{1, ..., n-1\}$:

$$\begin{aligned}
\Delta_U^{s+1} - \Delta_U^s &= \Pi_U^{s+1}(\underline{c}) - \Pi_U^s(\underline{c}) \\
&= -s\left[\hat{\pi}^{s+1}(\hat{c}, \underline{c}) - \hat{\pi}^s(\hat{c}, \underline{c})\right] - \left[\hat{\pi}^{s+1}(\hat{c}, \underline{c}) - \hat{\pi}^1(\hat{c}, \underline{c})\right] \\
&\leq 0,
\end{aligned}$$

where the inequality follows from the fact that downstream firms' outside option increases with s; this inequality is moreover strict whenever $\hat{c} < P\left((n - s - 1)\,q^C(\underline{c})\right)$, which is the case for s large enough (as $\hat{c}\left(< P\left(q^C(\overline{c})\right)\right) < P(0)$).

Case 2: $(\underline{c} <)\,\overline{c} < \hat{c} < P\left(q^C(\overline{c})\right)$. In that case, U is already an effective supplier when it faces a cost $\overline{c}$, and investing allows it to further increase its efficiency; we then have:

$$\Delta_U^s = \Delta_I + (n - s)\left[\hat{\pi}^1(\hat{c}, \overline{c}) - \hat{\pi}^1(\hat{c}, \underline{c})\right] + s\left[\hat{\pi}^s(\hat{c}, \overline{c}) - \hat{\pi}^s(\hat{c}, \underline{c})\right].$$

From Proposition 5, $\Delta_U^n = \Delta_I$ and $\Delta_U^s \geq \Delta_I$ for any $s < n$, with a strict inequality when $\hat{c} < P\left((n - s)\,q^C(\overline{c})\right)$. Therefore:

- As $\hat{c} < P\left(q^C\left(\overline{c}\right)\right)$, $\Delta_U^{n-1} > \Delta_U^n = \Delta_I$; therefore, there exists $\bar{s} \leq n$ such that $\Delta_U^{s-1} > \Delta_U^s$ for $s \in \{\bar{s}, .., n\}$.
- If in addition $\hat{c} \geq P\left((n-1)\, q^C\left(\overline{c}\right)\right)$, then $\Delta_U^s = \Delta_I$ for s small enough (namely, as long as $\hat{c} \geq P\left((n-s)\, q^C\left(\overline{c}\right)\right)$), whereas $\Delta_U^s > \Delta_I$ for s large enough (e.g., for $s = n-1$); therefore, there exists $\underline{s} \geq 1$ such that $\Delta_U^{s+1} \geq \Delta_U^s$, with at least one strict inequality, for $s \in \{1, ..., \underline{s}\}$.

F.2 Illustration: linear demand

Suppose that demand is linear: $P(Q) = 1 - Q$. We then have:

- $q^C(c)$ solves

$$\arg\max_q \left(P\left((n-1)q^C(c) + q\right) - c\right) q = \left(1 - (n-1)\, q^C(c) - q - c\right) q,$$

and is thus characterized by the first-order condition

$$0 = \left(1 - (n-1)\, q^C(c) - q - c\right) q\Big|_{q=q^C} = 1 - c - (n+1)\, q^C(c) = 0,$$

i.e.

$$q^C(c) = \frac{1-c}{n+1}.$$

- A member of a group of size s obtains

$$\hat{\pi}^s = \left(\hat{P}\left((n-s)\, q^C + (s-1)\, \hat{q}^s + \hat{q}^s\right) - \hat{c}\right) \hat{q}^s \equiv \max_q \left(\hat{P}\left((n-s)\, q^C + (s-1)\, \hat{q}^s + q\right) - \hat{c}\right) q,$$

where

$$\left(\hat{P}\left((n-s)\, q^C + (s-1)\, \hat{q}^s + q\right) - \hat{c}\right) q = \left(1 - (n-s)\, q^C - (s-1)\, \hat{q}^s - q - \hat{c}\right) \hat{q}.$$

The first-order condition yields, for $q = \hat{q}^s$:

$$0 = 1 - (n-s)\, q^C(c) - s\hat{q}^s - \hat{c} - \hat{q}^s = 1 - (n-s)\, q^C(c) - (s+1)\, \hat{q}^s - \hat{c},$$

or

$$(s+1)\hat{q}^s + (n-s)\frac{1-c}{n+1} = 1-\hat{c},$$

leading to:

$$\begin{aligned}
\hat{q}^s(\hat{c},c) &= \frac{(s+1)-(n+1)\hat{c}+(n-s)c}{(n+1)(s+1)}, \\
\hat{\pi}^s(\hat{c},c) &= \left(\frac{(s+1)-(n+1)\hat{c}+(n-s)c}{(n+1)(s+1)}\right)^2.
\end{aligned}$$

Therefore, $\hat{q}^s(\hat{c},c)$ and $\hat{\pi}^s(\hat{c},c)$ are positive if and only if

$$s > \hat{s}(c) = \frac{(n+1)\hat{c}-1-nc}{1-c}.$$

We then have $\bar{s} = \hat{s}(\overline{c})$ and $\underline{s} = \hat{s}(\underline{c})$.

In particular, for $n = 10$ and $\hat{c} = 0.7$, we have:

$$\hat{s} = \left[\frac{(10+1)\hat{c}-1-10c}{(1-c)}\right]_{\hat{c}=0.7} = \frac{10c-6.7}{c-1},$$

Thus, for $\overline{c} = 0.45$ and $\underline{c} = 0$: $\bar{s} = \left[\frac{10c-6.7}{c-1}\right]_{c=0.45} = 4$ and $\underline{s} = \left[\frac{10c-6.7}{c-1}\right]_{c=0} = 6.7$, and

$$\begin{aligned}
\hat{\pi}^s(\hat{c},\overline{c}) &= \left[\left(\frac{(s+1)-(n+1)\hat{c}+(n-s)\overline{c}}{(n+1)(s+1)}\right)^2\right]_{n=10,\hat{c}=0.7,\overline{c}=0.45} = \frac{1}{121}\frac{(0.55s-2.2)^2}{(s+1)^2}, \\
\hat{\pi}^s(\hat{c},\underline{c}) &= \left[\left(\frac{(s+1)-(n+1)\hat{c}+(n-s)\underline{c}}{(n+1)(s+1)}\right)^2\right]_{n=10,\hat{c}=0.7,\underline{c}=0} = \frac{1}{121}\frac{(s-6.7)^2}{(s+1)^2},
\end{aligned}$$

which was used to generate Figure 1.a.

Turning to investment incentives, we have

$$\Pi^C(c) = n\hat{\pi}^1(c,c) = \frac{10}{121}(1-c)^2,$$

and thus:

$$\Delta_I = \Pi^C(\underline{c}) - \Pi^C(\overline{c}) = \left[\frac{10}{121}(1-c)^2\right]_{c=0} - \left[\frac{10}{121}(1-c)^2\right]_{c=0.45} = 5.7645 \times 10^{-2}.$$

Using $\Delta_U^s = \Delta_I + s\left[\hat{\pi}^s\left(\hat{c},\overline{c}\right) - \hat{\pi}^s\left(\hat{c},\underline{c}\right)\right]$ leads to:

- For $s = 1, ..., 4$, $\hat{\pi}^s\left(\hat{c},\overline{c}\right) = \hat{\pi}^s\left(\hat{c},\underline{c}\right) = 0$ and thus $\Delta_U^s = \Delta_I$.

- For $s = 5, 6$, $\hat{\pi}^s\left(\hat{c},\overline{c}\right) > \hat{\pi}^s\left(\hat{c},\underline{c}\right) = 0$ and thus U's bias is positive:

$$\Delta_U^s - \Delta_I = s\hat{\pi}^s\left(\hat{c},\overline{c}\right) = s\frac{1}{121}\frac{\left(0.55s - 2.2\right)^2}{\left(s+1\right)^2} > 0,$$

  and increases with s.

- For $s = 7, ..., 9$, $\hat{\pi}^s\left(\hat{c},\overline{c}\right) > \hat{\pi}^s\left(\hat{c},\underline{c}\right) > 0$ and thus U's bias remains positive:

$$\Delta_U^s - \Delta_I = s\left[\hat{\pi}^s\left(\hat{c},\overline{c}\right) - \hat{\pi}^s\left(\hat{c},\underline{c}\right)\right] = s\left[\frac{1}{121}\frac{\left(0.55s - 2.2\right)^2}{\left(s+1\right)^2} - \frac{1}{121}\frac{\left(s - 6.7\right)^2}{\left(s+1\right)^2}\right] > 0,$$

  but decreases as s increases, as illustrated by Figure 1.b.

- Finally, for $s = 10$, $\hat{\pi}^s\left(\hat{c},\overline{c}\right) = \hat{\pi}^s\left(\hat{c},\underline{c}\right) > 0$, and thus again $\Delta_U^s = \Delta_I$.