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Buyer power and quality improvements[☆]

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Abstract

This paper analyses the sources of buyer power and the effect of buyer power on sellers' investment in quality improvements. In our model, retailers make take-it-or-leave-it offers to a producer and each of them in equilibrium obtains its marginal contribution to total profits (gross of sunk costs). In turn, the individual marginal contribution depends on the rivalry between retailers in the bargaining process. Rivalry increases when retailers are less differentiated and when decreasing returns to scale in production are larger. The allocation of total surplus affects the incentives of the producer to invest in product quality, an instance of the hold-up problem. An increase in buyer power not only makes the supplier and consumers worse off, but it may even harm retailers that obtain a larger share of a smaller surplus.

Keywords: Buyer power; Non-cooperative bargaining; Hold-up

1. Introduction

In the last decades, the retailing sector – in particular grocery retailing – has experienced a movement towards increased concentration. Broadly speaking, large retail chains and multinational retail companies (such as Wal-Mart, Carrefour, the Metro group) now play a dominant role, even though the phenomenon is not uniform across countries.[1] At the EU level, retailer concentration is further strengthened by purchasing alliances (operating nationally or cross-border such as Euro Buying or Buying International Group). Buyer power is also on the rise in other industries, such as automobile,[2] health care and cable television (in the US).[3]

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1 For example, in the UK, supermarkets accounted for 20% of grocery sales in 1960, but 89% in 2002, with the top five stores controlling 67% of all sales. France exhibits similar features. In other countries, such as Italy and the US, small independent retailers still retain a strong position in the market, although their position has eroded over time. Moreover, in the US, the supermarket industry is experiencing an unprecedented merger wave. For an overview of recent changes in the retail sector see Dobson and Waterson (1999), Dobson (2005) and OECD (1999).

2 The increased bargaining power of automakers when negotiating with parts suppliers is documented, among others, by Peters (2000).

3 In cable television, the concern of excessive buyer power of MSOs (multiple system operators) is one of the reasons why the Federal Trade Commission (FTC) has enforced legal restrictions on their size. See Raskovich (2003) and Chae and Heidhues (2004). In the healthcare sector,

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These trends have triggered investigations by anti-trust agencies and policy institutions around the world on the effects of increasing buyer power.[4] One concern that is often expressed is that, by squeezing the suppliers' profit margins, excessive buyer power may weaken their incentives to invest and innovate, thereby indirectly harming consumers and overall welfare. For instance, according to the FTC report, "even if consumers receive some benefits in the short run when retailers use their bargaining leverage to negotiate a lower price, they could be adversely affected by the exercise of buyer power in the longer run, if the suppliers respond by under-investing in innovation or production" (FTC, 2001, p. 57).

In this paper we formalize this argument by studying the impact of buyer power on a supplier's incentive to improve quality. We show that an increase in buyer power may be welfare detrimental by leading to quality deterioration. We also show that retailers themselves may be harmed by an increase in their power. Furthermore, we explore how buyer power depends on fundamentals about demand and technology through their impact on retailers' rivalry in the negotiation with the upstream producer.

We obtain these results is a model that assumes a monopolistic producer and two independent retailers. First, the supplier chooses to improve the *non-contractible* quality of its product through a *sunk* investment. The most natural interpretation of these assumptions is that the producer engages in R&D activities in order to achieve quality upgrading. This type of investment typically involves several uncontractible dimensions and is sunk when negotiation with retailers takes place. Higher quality makes final consumers more willing to pay for the good, thereby increasing total industry profits (gross of sunk costs).

After the quality decision, supply conditions are determined in bilateral negotiations. While most of the literature on buyer power employs specific cooperative solution concepts, we explicitly specify a non-cooperative bargaining protocol. This allows us to precisely identify how fundamentals (preferences and technology) affect buyer power. We consider the simplest bargaining setting in which buyer power and its sources can be analyzed. In particular, we assume that retailers make (simultaneous) take-it-or-leave-it offers to the producer, with no restrictions on the type of contracts that can be offered.

The solution of the negotiation game – given the quality choice – provides the following insights. Firstly, in equilibrium, total industry gross profits are maximized. This is obtained, without any restriction on contractual forms, as an outcome of the negotiation process. Secondly, total industry profits are distributed so that each retailer receives its marginal contribution, i.e. the additional surplus created when one more retailer is supplied. In turn, retailers' marginal contributions are determined by demand and supply conditions.

Let us consider first the demand channel. If retailers are perceived as perfectly substitutable by final consumers (because there is neither geographical differentiation nor differentiation in the provision of sale services), the maximum industry profit can be achieved by supplying one retailer only. Hence, the marginal contribution of each retailer is zero, and the supplier appropriates the entire surplus from the negotiation, even though retailers make take-it-or-leave-it offers. Differently stated, this case exhibits the strongest rivalry among retailers in the negotiation with the supplier. As retailers' differentiation increases, their marginal contribution increases as well (and rivalry weakens). Thus, the share of total profits they absorb in the negotiation increases.

This result provides a new insight on the effect of private labels, i.e. products sold under a retailer's own brand. It is well recognized that the offer of private labels makes a retailer a stronger bargainer when negotiating with a major supplier (national brand producer) by reducing the cost of delisting the national brand. We identify a different channel through which private labels affect this negotiation. A specific feature of private labels is that each retailer has exclusive right over the own brand product. As a result, the introduction of private labels contributes to differentiate rival retail chains, thereby increasing their marginal contribution and improving their bargaining position with respect to the national brands' manufacturers.

The second source of rivalry comes from the supply channel, through the convexity of the producer's cost function. With an increasing marginal cost curve the two retailers compete for the productive resources of the supplier. If a retailer increases its sales, it causes an increase in the marginal cost incurred to supply the other retailer, and therefore reduces the marginal profits created by the latter. A steeper marginal cost curve enhances this "congestion" effect.

buyers (drugstores, hospitals and HMOs) aggregate into large procurement alliances in order to reduce prescription drug costs. See Ellison and Snyder (2002) and DeGraba (2005).

[4] The growing concern about buyer power is documented in the *Symposium on Buyer Power and Antitrust, Antitrust Law Journal* (2005). See also Dobson and Waterson (1999), Rey (2000) and the reports by OECD (1999), FTC (2001), EC (1999).

This analysis contributes to the vast literature which studies the *sources* of buyer power.[5] Namely, we emphasize that buyer power is determined by the extent to which a buyer is essential to the creation of total surplus, which in turn depends not only on buyers' *size* but also on demand and supply conditions. In particular, the demand channel has been scarcely explored so far.[6] The importance of (strictly) convex production costs has been already emphasized in other papers, including Chipty and Snyder (1999) and Inderst and Wey (2003, 2006). However, these papers study the interaction between increasing marginal costs and buyer size,[7, 8] whereas we focus on the impact of changes in the convexity of the cost function on the power of symmetric buyers.

We then move backwards and analyze the quality choice made by the producer. An increase in buyer power, by reducing the share of total profits that the supplier extracts from the negotiation, weakens the producer's incentive to engage in quality improvement, an instance of the hold-up problem. Hence, it makes both the producer and final consumers worse off. Furthermore, we identify conditions under which an increase in buyer power turns out to harm also the retailers, because the "smaller-cake effect" dominates the "larger-slice" one.

This result relates to the recent literature which examines the effect of buyer power on the suppliers' incentives to invest and innovate and confirms that the *nature of the activity* undertaken by the upstream firm as well as the source of buyer power are crucial in order to assess the impact on investment incentives. We show that, when R&D activities are important in order to achieve quality improvements, buyer power may lead to quality deterioration, thereby harming welfare. Inderst and Shaffer (2007) and Chen (2006) show that buyer power may be welfare detrimental also when it leads to a distortion in the variety of products offered to consumers. Specifically, in Inderst and Shaffer (2007) manufacturers anticipate that a consolidated retailer (i.e. a single retailer controlling several outlets) will stock only one product at all outlets, and choose an inefficient *type* of variety in order to fit "average" preferences. In Chen (2006), a more powerful retailer induces a monopolist manufacturer to reduce the *number* of varieties offered to consumers, thereby exacerbating the distortion in product diversity caused by upstream monopoly.

By contrast, Inderst and Wey (2003, 2005, 2006) and Vieira-Montez (2004) show that there exist situations where the formation of larger buyers may strengthen suppliers' incentives to invest in capacity or to adopt technologies with lower marginal costs, thereby raising consumer surplus and total welfare. For instance, in Inderst and Wey (2005), in the presence of a large buyer – who in contrast to small ones can credibly threaten to integrate backwards – the supplier benefits more from a reduction in marginal costs. Such a reduction makes the supplied firms more efficient so that, in the case of backward integration, the large buyer will face tougher competitors. This reduces the large buyer's outside option and allows the supplier to extract more surplus when negotiating with it. Inderst and Wey (2003, 2006) suggest a different mechanism. When negotiating with fewer but larger buyers, the supplier can roll over more of the "inframarginal" but less of the "marginal" costs. Hence, the presence of a large buyer makes the supplier more willing to choose a technology with lower incremental costs at high quantities.

Since the hold-up problem is at the core of our model, this paper relates also to the literature on this issue, which dates back to Klein et al. (1978) and Williamson (1979). This literature typically studies whether vertical integration (involving investing parties) alleviates the problem (see for instance, Grossman and Hart, 1986 and Hart and Moore, 1990). Instead our model studies the impact of fundamentals (preferences and technology) on the severity of the hold-up problem through their effect on rivalry among retailers in the negotiation with the producer.

Finally, we will discuss at the end of Section 2 some of the literature related to the outcome of the negotiation stage.

The plan of the paper is the following. Section 2 presents the basic model and the negotiation stage. Section 3 studies the quality choice of the producer and how this choice is affected by rivalry between downstream firms. Section 4 discusses the robustness of the basic model and some extensions. Section 5 concludes.

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[5] See Inderst and Mazzarotto (2006) and Inderst and Shaffer (2007) for extensive (policy oriented) surveys.

[6] For analytical convenience most of the papers assume that buyers operate in independent downstream markets.

[7] To see the point, consider a supplier which bargains separately and simultaneously with a small and a large buyer. Each buyer views itself as marginal, conjecturing that the other has completed its negotiation with the supplier efficiently. Hence, the incremental surplus over which the supplier and a buyer negotiate is computed assuming that the producer already supplies the other buyer. Since negotiation with the small buyer involves a smaller quantity, the incremental surplus associated to the large buyer is computed considering a smaller quantity as a starting point. If marginal costs are increasing, it follows that the transaction involving the large buyer generates a higher *per-unit* incremental surplus with respect to the transaction involving the small buyer. This higher per-unit incremental surplus translates into a lower per-unit price for the large buyer.

[8] However, Inderst (2006) shows that being a large buyer does not necessarily lead to a discount when there exist *multiple* suppliers with convex costs.

2. Basic model

We assume a monopolistic upstream supplier, or "producer" (denoted as P). To fix ideas we suppose that in the downstream market the product is distributed to final consumers, and there are two independent retail outlets, or "downstream firms" (denoted as D_1 and D_2).

Most authors analyzing vertical relationships with multiple retailers find it convenient to assume that orders are placed by retailers at the last stage of the game according to the outcome of downstream competition. We find it instead more convenient to assume that the producer and retailers agree on specific deliveries before downstream competition takes place. But it can be shown that the main results of this paper also hold under the previous assumption.[9] Therefore, we consider the following timing:

- At time t_0 the producer chooses the quality level X of its product incurring a sunk cost. Quality is not contractible.
- At time t_1 retailers make simultaneous take-it-or-leave-it offers to the producer. The producer decides whether to accept both, only one, or none of the offers. Its payoff (gross of the sunk cost) amounts to zero, if it does not accept any offer.
- At time t_2 production and deliveries take place.
- At time t_3 firms compete in the downstream market and the good is distributed to consumers.

For simplicity we assume that retailing does not involve additional costs. This is equivalent to assuming (more realistically) that retailers face a constant marginal cost (constant returns to scale). Revenues of retailer D_i are given by a function $R_i(q_1, q_2, X)$, which is assumed to be continuous, strictly concave in q_i, weakly decreasing in q_j and null for $q_i = 0$. All these assumptions are satisfied by the structural specification considered later on.

The production technology is summarized by a (weakly) convex cost function $C : \left[0, \overline{Q}\right] \to \mathbb{R}_+$ such that $C(0) = 0$. $\overline{Q}$ can be interpreted as a capacity constraint for the producer, and will be assumed to be "large".[10] This cost does not include sunk costs incurred to attain quality X. For notational simplicity we will omit X whenever this causes no confusion. Also, without substantial loss of generality, we assume that retailers' revenue functions are symmetric, and we write $R(q', q'', X) := R_1(q', q'', X) = R_2(q'', q', X)$ (hence, the second argument in R is the competitor's quantity).

We simplify our analysis of equilibria by not modeling explicitly the last stage of the game, that is downstream competition. Specifically, we do not distinguish between quantities delivered to retailers and quantities sold to consumers. This is without loss of generality. Whatever the form of downstream competition (price setting, quantity setting), the delivered quantities set constraints on sales. It can be shown that in equilibrium such constraints are binding and the equilibrium payoffs are the same as we obtain in the simplified analysis below.[11]

This simplification implies that we can solve the model proceeding backwards from time t_1.

2.1. Negotiation stage

To compute the (efficient) subgame perfect equilibrium outcome we first examine the subgame starting at date t_1. At date t_2 (in a subgame perfect equilibrium) the producer simply maximizes its payoff as determined by the accepted contracts; all the interesting action takes place at date t_1. We therefore refer to the subgame starting at date t_1 simply as the "negotiation stage".

In most of the literature, bargaining between the supplier and the retailer(s) is solved by adopting a specific cooperative solution concept. Instead, we explicitly specify a non-cooperative bargaining protocol. The assumption that retailers make take-it-or-leave-it offers does not imply that they can always appropriate the entire surplus associated to the negotiation. Therefore, this assumption allows us to study situations where the retailer's bargaining power changes as a function of the fundamentals, such as technology and the degree of substitutability between retailers.

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[9] For example we could use the setting and results of Rey et al. (2006) who derive the same coalition-proof (i.e. undominated) equilibrium payoffs as our paper.

[10] Large means that in equilibrium $\overline{Q}$ will not represent a binding constraint. More specifically we assume that $\overline{Q}$ is larger than the socially optimal production at the socially optimal quality level.

[11] We take for granted that the downstream competition stage always has an equilibrium, at least in mixed strategies.

A relevant benchmark in the analysis of negotiation is whether the firms in equilibrium adopt efficient contracts, i.e. contracts that allow them to maximize industry profits. We emphasize that the selection of efficient contracts is a *result* of our analysis, not an assumption, since firms are free to propose any kind of contract. In general, we allow for non-linear contracts, whereby the payment to the supplier by one retailer depends on the quantity sold to *both* retailers (and resold by them on the downstream market).[12] Technically, a contract in our model is an upper-semicontinuous[13] function $t_i : [0, \overline{Q}]^2 \to \mathbb{R}$, where $t_i(q_1, q_2)$ is the net transfer from D_i to P if P delivers q_1 to D_1 and q_2 to D_2. Among other contractual forms, this formulation allows retailers to offer *forcing contracts* where D_i requires P to deliver a specific *pair* of quantities to the retailers; it also allows retailers to offer *exclusive contracts*, where the supplier commits not to sell the product to the rival retailer. Exclusive contracts play an important role in deriving the bounds on equilibrium payoffs in the negotiation stage (see the proof of Proposition 1).[14]

Our negotiation stage is similar to a "menu auction" in the sense of Bernheim and Whinston (1986), with P playing the role of the "auctioneer" and D_1 and D_2 playing the role of the "bidders".[15] We postpone the discussion of this point until after the main result of this subsection.

We let $\widetilde{\Pi}$ denote the profit (gross of sunk costs) of a vertically integrated monopolist, and let $\overline{\Pi}$ denote the profit of an integrated firm which operates only one retailing outlet[16]:

$$\widetilde{\Pi} = \max_{q_1, q_2 \geq 0} \left[R(q_1, q_2) + R(q_2, q_1) - C(q_1 + q_2) \right], \tag{1}$$

$$\overline{\Pi} = \max_{q_1 \geq 0, q_2 = 0} \left[R(q_1, q_2) + R(q_2, q_1) - C(q_1 + q_2) \right] = \max_{q \geq 0} \left[R(q, 0) - C(q) \right]. \tag{2}$$

We assume that (1) and (2) have unique solutions. By symmetry, the solution of (1) must have $q_1 = q_2$.

Remark 1. Under the stated assumptions $2\overline{\Pi} - \widetilde{\Pi} \geq 0$.

Proof. Let $(\widetilde{q}, \widetilde{q})$ be the symmetric solution to problem (1). Then

$$\begin{aligned} \widetilde{\Pi} &= 2R(\widetilde{q}, \widetilde{q}) - C(2\widetilde{q}) \leq 2R(\widetilde{q}, \widetilde{q}) - 2C(\widetilde{q}) \\ &\leq 2\left[\max_{q \geq 0} R(q, \widetilde{q}) - C(q)\right] \leq 2\left[\max_{q \geq 0} R(q, 0) - C(q)\right] = 2\overline{\Pi}, \end{aligned}$$

where the first inequality follows from the convexity of $C(\cdot)$ and $C(0) = 0$, and the last inequality follows from the assumption that $R(\cdot, \cdot)$ is weakly decreasing in its second argument. ■

Following Bernheim and Whinston (1986), we say that an equilibrium is *coalition-proof* if there is no other equilibrium where both retailers obtain a strictly higher profit. The following proposition says that there is a continuum of equilibrium payoff allocations, but in every coalition-proof equilibrium each downstream firm D_i gets its marginal contribution to industry surplus, that is, the difference between maximum industry surplus $\widetilde{\Pi}$ and the maximum surplus $\overline{\Pi}$ obtainable without D_i; the producer P obtains the rest of the maximum industry surplus.

Proposition 1. *In the negotiation stage,* (a) *the maximum equilibrium payoff of each retailer is* $\Pi_{D_i} = \widetilde{\Pi} - \overline{\Pi}$, *the minimum equilibrium payoff of the producer (gross of sunk costs) is* $\Pi_P = 2\overline{\Pi} - \widetilde{\Pi}$, *and the maximum equilibrium*

12 See Villas-Boas (2005) and Bonnet et al. (2005) for empirical evidence documenting that manufacturers and retailers use non-linear pricing contracts.

13 Upper-semicontinuity guarantees that, whatever the set of accepted contracts, the producer's problem admits a maximum. This is used to show the existence of a subgame perfect equilibrium.

14 It may be argued that considering a large set of contracts facilitates the analysis in that it allows for many possible deviations. But for our results it is sufficient to assume that the set of feasible contracts contains some minimal class of functions, such as all forcing contracts, or all sell-out contracts with a contingent fee that depends on whether the other retailer is served.

15 Bernheim and Whinston assume that the set of possible choices of the "auctioneer" (P in our case) is finite, whereas in our case it is a continuum. Furthermore, the option of not accepting an offer is not explicitly modeled in their framework. The following version of the negotiation stage can be seen as a special case of their framework: (i) (q_1, q_2) is chosen from a finite grid $G \subset \mathbb{R}^2_+$ containing $(0, 0)$, (ii) P does not have the option of explicitly rejecting offers, but each contract offer $t_i(q_i, q_j)$ has to satisfy the constraint $t_i(0, q_j) = 0$, so that choosing $q_i = 0$ is equivalent to rejecting i's offer. If G is sufficiently fine, such a model is essentially equivalent to ours.

16 By symmetry, it does not matter which retailing outlet is active. Also recall that these quantities depend on X, the given quality of the product.

payoff is $\Pi_P = \overline{\Pi}$*;* (b) *for each* $\Pi_P \in [2\overline{\Pi} - \widetilde{\Pi}, \overline{\Pi}]$ *there is an "efficient" equilibrium where the producer obtains* Π_P *and each retailer obtains* $\frac{1}{2}(\widetilde{\Pi} - \Pi_P)$*;* (c) *there is a unique coalition-proof equilibrium allocation where each retailer obtains the marginal contribution* $\widetilde{\Pi} - \overline{\Pi}$ *and the producer obtains* $2\overline{\Pi} - \widetilde{\Pi}$*.*

Proof. A strategy profile in the subgame is given by a pair of contract offers (t_1, t_2) (with $t_i : \mathbb{R}^2_+ \to \mathbb{R}$) and a strategy of the producer that specifies which contracts should be accepted and, for each set of accepted contracts, a pair of quantities (q_1, q_2), where $q_i = 0$ if t_i is rejected. A strategy of the producer is *sequentially rational* if (a) for each set of accepted contracts (q_1, q_2) maximizes P's profit, and (b) P accepts or reject contracts so as to obtain the highest maximum profit.

Upper-semicontinuity of the contract offers (t_1, t_2) implies that for any set of accepted contracts P has a sequentially rational continuation. To see this, first note that the sum of upper-semicontinuous functions is upper-semicontinuous. Therefore P's payoff is upper-semicontinuous in (q_1, q_2), which must be chosen in the compact set $\{(q_1, q_2) \in \mathbb{R}^2_+ : q_1 + q_2 \leq \overline{Q}\}$. Since every upper-semicontinuous function with compact domain has a maximum, P has a best reply to (t_1, t_2). From now on *we will only consider sequentially rational strategies of* P and focus on the retailers' incentives. We let $(\widetilde{q}, \widetilde{q})$ denote the solution of problem (1) and $\overline{q}$ denote the solution of problem (2). Thus $(\widetilde{q}, \widetilde{q})$ yields total gross profits $\widetilde{\Pi}$, and $\overline{q}$ yields $\overline{\Pi}$.

(a) We first show that $\Pi_{D_i} \leq \widetilde{\Pi} - \overline{\Pi}$ in equilibrium. Consider a strategy profile that yields payoffs Π_P, Π_{D_j} and $\Pi_{D_i} > \widetilde{\Pi} - \overline{\Pi}$. The latter inequality implies that P accepts D_i's offer. Note that, by sequential rationality, Π_P is at least as high as the maximum payoff P can achieve by accepting *only* D_i's offer. Since $\Pi_P + \Pi_{D_j} + \Pi_{D_i} \leq \widetilde{\Pi}$ and $\Pi_{D_i} > \widetilde{\Pi} - \overline{\Pi}$, it follows that $\Pi_P + \Pi_{D_j} < \overline{\Pi}$. Therefore D_j can offer an exclusive contract of the form $t'_j(q_j, 0) = \begin{cases} R(\overline{q}, 0) - S & \text{if } q_j = \overline{q}, \\ -k & \text{otherwise} \end{cases}$ where $k \geq \overline{\Pi}$ and $\Pi_{D_j} < S < \overline{\Pi} - \Pi_P$. The contract (if accepted) yields payoffs $\Pi'_P = \overline{\Pi} - S > \Pi_P$ and $\Pi'_{D_j} = S > \Pi_{D_j}$. Faced with such an offer, P accepts at most one contract. If only i's contract is accepted, the payoff is at most Π_P. Therefore P would accept D_j's exclusive contract t'_j, which implies that D_j has a profitable deviation.

Next we show that P cannot get less than $2\overline{\Pi} - \widetilde{\Pi}$ in equilibrium. If we could take for granted that the equilibrium is efficient, this result would follow directly from what we have just shown. But we show that this bound holds for all the subgame perfect equilibria, including the inefficient ones.[17] Consider a strategy profile inducing payoffs Π_{D_i}, Π_{D_j}, and $\Pi_P < 2\overline{\Pi} - \widetilde{\Pi}$. Let (wlog) $\Pi_{D_i} \leq \Pi_{D_j}$. Then $\Pi_{D_i} \leq (\widetilde{\Pi} - \Pi_P)/2$. Suppose that D_i offers instead an exclusive contract of the form $t'_i(q_i, 0) = \begin{cases} R(\overline{q}, 0) - S & \text{if } q_i = \overline{q}, \\ -k & \text{otherwise} \end{cases}$ where $k \geq \overline{\Pi}$ and $S = \overline{\Pi} - \Pi_P - \varepsilon$. This contract (if accepted) implements the payoffs $\Pi_P + \varepsilon$ for P and $\overline{\Pi} - \Pi_P - \varepsilon$ for D_i. By assumption ε can be chosen so that $0 < \varepsilon < \left[\left(2\overline{\Pi} - \widetilde{\Pi}\right) - \Pi_P\right]/2$. Then P accepts t'_i (otherwise it gets at most Π_P) and it can be checked that $\overline{\Pi} - \Pi_P - \varepsilon > (\widetilde{\Pi} - \Pi_P)/2$; thus D_i has a profitable deviation.

Now consider a strategy profile such that $\Pi_P > \overline{\Pi}$. By definition of $\overline{\Pi}$, this implies that P finds it optimal to accept both offers $t_1$and t_2. Then each retailer D_i has a profitable deviation $t'_i \equiv t_i - \varepsilon$, where $0 < \varepsilon < \Pi_P - \overline{\Pi}$. To see this, note that if P accepts t'_i and t_j its payoff is $\Pi_P - \varepsilon > \overline{\Pi}$, and if P rejects t'_i its payoff is at most $\overline{\Pi}$.

(b) Fix $\Pi_P \in [2\overline{\Pi} - \widetilde{\Pi}, \overline{\Pi}]$ and consider the following strategy profile:

$$t_1(q_1, q_2) = \begin{cases} R(\widetilde{q}, \widetilde{q}) - \dfrac{1}{2}(\widetilde{\Pi} - \Pi_P), & \text{if } q_1 = \widetilde{q}, q_2 = \widetilde{q} \\ R(\overline{q}_1, 0) - (\overline{\Pi} - \Pi_P) & \text{if } q_1 = \overline{q}_1, q_2 = 0, \\ -k, & \text{otherwise,} \end{cases}$$

where $k \geq \widetilde{\Pi}$; t_2 is symmetric to t_1, P accepts both contracts, and P is sequentially rational in the choice of (q_1, q_2) for every set of accepted contracts. It can be checked that this is an equilibrium. Indeed, P is indifferent between accepting both contracts or only one: in both cases the payoff is $\Pi_P \geq 2\overline{\Pi} - \widetilde{\Pi} \geq 0$. In the candidate equilibrium each retailer gets $\frac{1}{2}(\widetilde{\Pi} - \Pi_P) \geq 0$ and we claim that it cannot obtain more by deviating to an alternative contract t'_i. To see this, note that P would accept t'_i only if it gets at least Π_P, which is the payoff of accepting only t_j. If P accepts

[17] For instance, an inefficient equilibrium is the one where each retailer offers an exclusive contract that gives $\overline{\Pi}$ to P and P just picks one of them: each of these offers is unbeatable.

only t_i' then D_i gets at most $\overline{\Pi} - \Pi_P$. Since $\Pi_P \geq 2\overline{\Pi} - \widetilde{\Pi}$, it follows that $\overline{\Pi} - \Pi_P \leq \frac{1}{2}(\widetilde{\Pi} - \Pi_P)$. If P accepts both t_i' and t_j, but does not choose $(q_1 = \widetilde{q}, q_2 = \widetilde{q})$ nor $(q_j = \overline{q}, q_i = 0)$, then P has to pay a high penalty. Thus the pair (t_i', t_j) is accepted only if (1) the result is the same as in the candidate equilibrium, or (2) $(q_j = \overline{q}, q_i = 0)$ and $\Pi_P' \geq \Pi_P$, which implies $\Pi_{D_i}' \leq \overline{\Pi} - \Pi_P' \leq \overline{\Pi} - \Pi_P \leq \frac{1}{2}(\widetilde{\Pi} - \Pi_P)$, or (3) P is compensated by i for the very high penalty k paid to j. In each case D_i is not better off than in the candidate equilibrium.

(c) Let $\Pi_P = 2\overline{\Pi} - \widetilde{\Pi}$ in the above equilibrium. Each retailer gets $\frac{1}{2}[\widetilde{\Pi} - (2\overline{\Pi} - \widetilde{\Pi})] = \widetilde{\Pi} - \overline{\Pi}$. By (a), there is no other equilibrium where both retailers get a strictly higher payoff. Therefore this equilibrium is coalition-proof, and every other coalition-proof equilibrium is payoff-equivalent to this one. ■

Discussion. In a setting with two retailers, downstream competition generates externalities: the quantity sold by one retailer in the final market affects its own revenues but also the revenues of the rival retailer. Hence, even though there exists an upstream monopolist, it is not obvious that the contracting parties attain the industry monopoly profits.

Specifically, when retailers have the initiative and make offers to the producer, restrictions on the set of feasible contracts can give rise to contracting externalities which may limit the joint profits that the agents are able to achieve in equilibrium.[18] For instance, Rey et al. (2006) shows that if retailers are restricted to adopt two-part tariffs, the industry monopoly profits cannot be sustained. Essentially, two-part tariffs are too simple to allow retailers to coordinate fully their decisions and leave scope for opportunistic behavior at the expense of the rival retailer. Imagine that retailers offer two-part tariffs where wholesale prices are large enough to sustain monopoly prices in the final market. Such a situation cannot be an equilibrium: each retailer would have incentive to deviate and offer a contract with a lower wholesale price. This would increase the joint profits of a vertical pair (deviant retailer–producer), thereby making the deviation profitable at the expense of the rival retailer whose sales and profits in the downstream market would decrease.[19]

Hence, more complex arrangements are required to internalize all the contracting externalities. For a model where orders are placed at the downstream competition stage, Rey et al. (2006) shows that industry monopoly profits can be attained through contingent three-part tariffs, which combine an up-front payment (made by the producer to the retailer) with two-part tariffs where the fee is paid (by the retailer) only when a positive quantity is ordered. Further, contractual terms must be contingent on whether the producer accepts both contracts or only one. Fees contingent on actual trade avoid opportunistic behavior: if a retailer undercuts the rival's wholesale price, the opponent "opts out" and decides not to sell in the downstream market, which makes the deviation unprofitable. However, to sustain the monopoly outcome fees must extract the entire retailers' downstream profits. Hence, in order to let the retailers obtain a share of the monopoly profits, up-front payments made by the producer are required. Finally, contingency on the set of accepted contracts also plays a crucial role, because it helps in limiting the scope for profitable deviations from a situation where the producer supplies both retailers to exclusivity. Indeed, Marx and Shaffer (2005) do not allow for contingency on the set of accepted contracts, and show that the equilibrium exhibits exclusive trade with one retailer, thereby failing to maximize industry profits.

Also our model considers contracts that are contingent on exclusivity. Moreover, we allow the producer, rather than the retailers, to choose quantities and we allow the contractual terms offered by one retailer to be contingent on the quantity delivered to the other retailer. This suffices to internalize all the externalities and to sustain the industry monopoly profits.

In the proof above, the equilibrium payoffs are implemented by forcing contracts. The same payoffs can be implemented with more flexible contracts. For example, the marginal contribution payoffs of part (3) can be implemented by contracts that let P choose quantities and give it appropriate incentives by making it the residual claimant of the retailer's revenues. Such a strategy profile is an example of "truthful equilibrium" in the sense of Bernheim and Whinston (1986), who work in a more abstract framework. Bernheim and Whinston show that all

[18] When the producer has the initiative and makes take-it-or-leave-it offers to the retailers, it is the fact that contract offers are *private* that gives rise to contracting externalities, which in turn may prevent the monopolist from sustaining the vertically integrated outcome. See Rey and Tirole (2006) for an overview of the literature on this issue.

[19] In contrast, Bernheim and Whinston (1998) considers a setting where two producers offer supply contracts to a single retailer. If so, two-part tariffs (with a variable component that covers the manufacturer's production costs) suffices to achieve the industry monopoly profits. If one producer offers such a contract, the joint profits of the retailer and of the rival producer coincide with total profits (up to a fixed fee). Thus, the choice that maximizes the joint profits of a vertical pair also maximizes the total profits. In their setting, contracting externalities arise for other reasons, for instance because there exist third parties not present at the contracting stage.

truthful equilibria are efficient and coalition-proof, and that coalition-proof equilibrium payoffs can be implemented by truthful equilibria. A similar result holds for the negotiation stage of our model. The specific structure of our "menu auction" allows us to obtain uniqueness of coalition-proof equilibrium payoffs.[20] The equilibrium payoffs of part (2) of the proof are efficient and can be implemented with "locally truthful" contracts (Grossman and Helpman, 1994).[21] In these equilibria the producer cannot fully appropriate the gross surplus $\widetilde{\Pi}$ and therefore in the quality choice stage they typically give rise to a form of the hold-up problem, although not as severe as with the marginal-contribution equilibrium payoff selected by the coalition-proofness criterion. From now on we apply the coalition-proofness criterion.

Lastly, our analysis can be related to a different approach to two-stage strategic interaction that derives results about the second (negotiation) stage by looking at the core of the associated coalitional-form game (see Brandenburger and Stuart Jr. (in press). Stuart (in press) evaluates different distributions of buyers' demand (keeping total demand fixed) from the seller's perspective, and finds that the seller always prefers demand to be fragmented and evenly distributed across buyers. Although he looks at the whole core, the driving force for his results is how the seller's minimum payoff in the core is related to the exogenous variables (such as the distribution of demand). This payoff is given by the difference between the total surplus and the summation of the buyers' marginal contribution, which is the coalition-proof equilibrium payoff we identify. This suggests that the qualitative conclusions of our analysis are quite robust with respect to the exact way we model competition between buyers.

Next we consider a structural specification of the revenue and cost functions, and solve the model backwards.

3. Downstream firms's rivalry and quality choice

In this section we analyze quality choice in various market settings that are characterized by different levels of rivalry of the downstream firms when bargaining with the producer. The main features of the model are the impact of quality on demand and costs and the channels through which rivalry in the bargaining stage depends on market and technology fundamentals. More specifically, in our setting quality improvements entail sunk costs and enhance consumers' willingness to pay, while the degree of rivalry between retailers in the bargaining stage depends on final demand substitutability and the steepness of the marginal costs of production.

We describe the model starting from the supply of the product and then moving to the demand for the good distributed by the two retailers.

Producer P supplies a single good, whose baseline quality is X_0. Quality improvements above the baseline level entail sunk costs according to the following expression:

$$I(X - X_0) = (X - X_0)^{\beta} \tag{3}$$

with $\beta > 2$,[22] where X is the chosen quality. The variable costs of production are quadratic:

$$C(q) = \frac{q^2}{2k} \tag{4}$$

where k is a parameter inversely related to decreasing returns to scale. The lower k, the steeper the marginal costs: we shall show later on that this implies a more intense rivalry of the retailers in the bargaining stage, when they compete for the productive resources of the supplier.

Moving to the demand side, the preferences of a representative consumer are described by the following utility function:

$$U(q_1, q_2, y) = X(q_1 + q_2) - \frac{1}{(1+\sigma)}\left[q_1^2 + q_2^2 + \frac{\sigma}{2}(q_1 + q_2)^2\right] + y \tag{5}$$

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[20] Bergemann and Välimäki (2003) show that, in the context of a common agency game, if there is a unique truthful equilibrium outcome it coincides with the marginal contribution equilibrium.

[21] See the working paper Battigalli et al. (2006).

[22] We also considered the case $1 < \beta \leq 2$; most of the qualitative results hold, but the analysis becomes more complex.

where q_1 and q_2 are the quantities of the good sold by the two retailers and y is the expenditure in the outside good.[23] It is evident from the expression above that the higher the quality X, the higher the utility from consumption of the good. Moreover, the sales of the good realized by the two retailers (q_1 and q_2) are (horizontally) differentiated, for instance due to different locations of the outlets. From this utility function we can derive the inverse demand functions:

$$p_i = X - \frac{1}{1+\sigma}\left(2q_i + \sigma\left(q_1 + q_2\right)\right)$$

with $i = 1, 2$ and $\sigma \in [0, \infty]$. This latter parameter describes the degree of substitutability of the two retailers. If $\sigma = 0$, they operate in independent markets, i.e. there is no substitution between the two sales. Conversely, if $\sigma \to \infty$, the final consumers view the two goods as perfectly homogeneous. A convenient property of this demand system is that, for given prices and quality, aggregate demand and consumers' surplus do not vary with the degree of substitutability σ. To show this, the demand functions are

$$q_i = \frac{1}{2}\left[X - p_i(1+\sigma) + \frac{\sigma}{2}(p_1 + p_2)\right]$$

for $i = 1, 2$. Aggregate demand, therefore, is equal to

$$q_1 + q_2 = X - \frac{1}{2}(p_1 + p_2)$$

and is independent of σ. In other words, for given prices and quality the dimension of the final market (and the consumers' and total surplus) does not depend on the differentiation of the two retailers. The parameter σ, therefore, can be interpreted as a pure measure of the rivalry between the two retailers in the bargaining process with the supplier: when we shall apply Proposition 1(c) to this model, it will turn out that σ influences only the allocation of surplus between the producer and the retailers, but not total surplus. If $\sigma = 0$, the rivalry is nil, while the case $\sigma \to \infty$ corresponds to maximum rivalry of the two retailers.

In order to apply Proposition 1(c) we now turn to computing total gross profits $\widetilde{\Pi}$ when both retailers are active, and gross profits $\overline{\Pi}$ when only one retailer serves the final market. $\widetilde{\Pi}$ is obtained by solving the following program:

$$\max_{q_1, q_2}\left\{\left[X - \frac{1}{1+\sigma}\left(2q_1 + \sigma(q_1 + q_2)\right)\right]q_1 + \left[X - \frac{1}{1+\sigma}\left(2q_2 + \sigma(q_1 + q_2)\right)\right]q_2 - \frac{(q_1 + q_2)^2}{2k}\right\}.$$

The FOC's:

$$\frac{\partial \Pi}{\partial q_i} = X - \frac{1}{1+\sigma}(2q_i + \sigma(q_i + q_j)) - \frac{2+\sigma}{1+\sigma}q_i - \frac{\sigma}{1+\sigma}q_j - \frac{q_i + q_j}{k} = 0$$

for $i, j = 1, 2, i \neq j$, yield

$$\widetilde{q}_1 = \widetilde{q}_2 = \frac{kX}{2(1+2k)} \tag{6}$$
$$\Pi(\widetilde{q}_1, \widetilde{q}_2) = X^2\frac{k}{2(1+2k)} \equiv \widetilde{\Pi}.$$

Note that $\widetilde{\Pi}$ is increasing in X and in k (and does not depend on σ).

The gross profit when only one retailer is active, $\overline{\Pi}$, is obtained from

$$\max_{qi}\left\{\left(X - \frac{1}{1+\sigma}(2q_i + \sigma q_i)\right)q_i - \frac{(q_i)^2}{2k}\right\}.$$

The FOC is given by

$$-\frac{1}{k(\sigma+1)}\left(q_i + 4kq_i + \sigma q_i - Xk - Xk\sigma + 2k\sigma q_i\right) = 0.$$

[23] This utility function is due to Shubik and Levitan (1980). Demand functions derived from it display some desirable properties (see following discussion).

Hence,

$$\overline{q} = \frac{Xk(1+\sigma)}{4k+\sigma+2k\sigma+1}$$

and

$$\Pi(\overline{q}, 0) = \frac{1}{2}\frac{X^2k\,(\sigma+1)}{4k+\sigma+2k\sigma+1} \equiv \overline{\Pi}.$$

According to Proposition 1(c), the producer's profit (gross of the cost of the investment in quality) is given by

$$\begin{aligned}\Pi_P &= 2\overline{\Pi} - \widetilde{\Pi} = 2\left(\frac{1}{2}\frac{X^2k\,(\sigma+1)}{4k+\sigma+2k\sigma+1}\right) - X^2\frac{k}{4k+2} \\ &= \frac{1}{2}X^2k\frac{\sigma+2k\sigma+1}{(2k+1)\,(4k+\sigma+2k\sigma+1)} \\ &= \widetilde{\Pi}\cdot\alpha_P \end{aligned} \tag{7}$$

where

$$\alpha_P = \frac{\sigma+2k\sigma+1}{4k+\sigma+2k\sigma+1}$$

is the producer's share of total profits $\widetilde{\Pi}$. The retailer's profits are

$$\begin{aligned}\Pi_{D_i} &= \widetilde{\Pi} - \overline{\Pi} = X^2\frac{k}{2(1+2k)} - \frac{1}{2}\frac{X^2k\,(\sigma+1)}{4k+\sigma+2k\sigma+1} \\ &= \widetilde{\Pi}\cdot(1-\alpha_P)/2. \end{aligned} \tag{8}$$

The producer's share of total profit is increasing in σ and decreasing in k:

$$\begin{aligned}\frac{\partial\alpha_P}{\partial\sigma} &= \frac{4k(1+2k)}{(4k+\sigma+2k\sigma+1)^2} > 0 \\ \frac{\partial\alpha_P}{\partial k} &= \frac{-4(\sigma+1)}{(4k+\sigma+2k\sigma+1)^2} < 0.\end{aligned}$$

This result allows us to understand how demand substitutability and the steepness of the marginal cost curve influence the bargaining outcome. Recall that each retailer will obtain in equilibrium, as the outcome of the bargaining process, the incremental profits that are generated by moving from one to two retailers, i.e. its contribution to the creation of the overall profits. Marginal contributions, in turn, depend on both the demand substitutability parameter σ and the decreasing returns parameter k.

When the degree of differentiation between the two retailers decreases (i.e. σ increases), the incremental profits generated by each individual retailer fall, reducing the share of total profits that can be kept in equilibrium. In the limit, with perfectly homogeneous retailers ($\sigma \to \infty$), all the surplus is captured by the producer. Notice that the decreasing contribution of each retailer to total profits as demand substitutability increases does not depend on the fact that horizontal rivalry in the final market increases, leading to lower prices and profits: retailers, in fact, will adopt in any case efficient contracts, as proved in Proposition 1, that maintain the overall profits at the level of the vertically integrated solution. However, when retailers are more similar (higher σ), each one is less essential in the creation of total profits, and each one can be replaced with minor losses by the rival.

Moving to the supply side rivalry channel, with increasing marginal costs the two retailers compete for the productive resources of the supplier. The marginal cost to produce and sell in one market depends on the amount produced and sold in the other market. Hence, if a retailer increases its sales, it causes an increase in the marginal cost incurred to supply the other retailer, and therefore reduces the marginal profits created by the latter. Hence, an expansion in one retailer's sales reduces the other retailer's ability to extract surplus from the producer in the bargaining stage. An increase in k, making the marginal cost flatter, reduces this "congestion" effect in production and therefore reduces the producer's share of total profits. In the limit, with flat marginal costs ($k \longrightarrow \infty$) the supply side rivalry channel vanishes.

We can now consider the optimal choice of quality by the producer in the initial stage:

$$\max_X \left[\alpha_P \cdot \widetilde{\Pi}(X) - (X - X_0)^\beta\right].$$

The FOC is given by

$$\frac{\partial \Pi_P}{\partial X} = \alpha_P \frac{\partial \widetilde{\Pi}(X)}{\partial X} - \beta(X - X_0)^{\beta-1} = 0$$
$$= X \frac{k}{(2k+1)} \frac{\sigma + 2k\sigma + 1}{(4k + \sigma + 2k\sigma + 1)} - \beta(X - X_0)^{\beta-1} = 0. \quad (9)$$

A simple inspection of this maximization problem reveals that, since $\alpha_P < 1$, the supplier will choose a level of quality lower than the one that maximizes total profits $\widetilde{\Pi}(X) - (X - X_0)^\beta$: this result recalls the well known hold-up problem and the associated distortions in the level of investment. The reduction in quality is less severe the higher the share of total profits α_P obtained by the producer, i.e. the stronger is the rivalry of retailers in the bargaining process. Hence, the producer invests more in quality improvements as the degree of substitutability of retailers increases. This result and its implications are illustrated by the following proposition.

Proposition 2 (*Impact of Demand-side Rivalry*).

(1) *The equilibrium quality is increasing in the degree of substitutability of retailers* σ.
(2) *Consumers' surplus, producer's profits, total profits and total welfare are increasing in* σ.
(3) *When* k *is sufficiently large, retailers' profits are increasing in* σ *for low levels of* σ.

Proof. See Appendix A. ■

Recall that with efficient contracts the level of output is always at the (integrated) monopoly level, for any value of σ. Thus, the effect of σ on consumers does not originate from a reduction of final prices. Consumers are better off when retailers' substitutability increases because the hold-up problem becomes less severe and quality increases. Similarly, the aggregate profits of the vertical chain do not depend directly on σ. Still, they increase as the degree of substitutability increases through the indirect effect on quality. As for the producer, its profit is increasing in σ because it obtains an increasing share of aggregate (gross) profits. All this implies that total welfare increases in the degree of substitutability between retailers.

Instead, an increase in σ has two opposite effects on the retailers' profits. Aggregate (gross) profits increase but a lower share of these profits is appropriated by the retailers. It can be shown that when k is sufficiently large the retailers' profits increase in σ for low degree of substitutability. In this case not only demand-side rivalry but also supply-side rivalry is very low, since marginal costs of production are almost flat. Hence, the producer obtains a very limited share of total profits, thereby investing almost nothing in quality improvements. Since the cost of quality improvements increases very slowly close to the origin, a rise in substitutability triggers a steep increase in quality. The consequent increase of aggregate profits dominates the deterioration of the retailers' bargaining position.

Moving to the supply rivalry channel, we have to point out that, for given quality X, parameter k exerts two effects. First, parameter k is inversely related to retailers' "congestion" when they compete for the productive resources of the supplier; this represents a source of rivalry on the supply side, hence an increase in k reduces the share of total (gross) profits accruing to the producer, α_P. Second, parameter k also affects the total gross profits (and consumer surplus and total welfare as well), by affecting the slope of the marginal cost curve, entailing an efficiency effect: when k increases, the total (gross) profits $\widetilde{\Pi}$ become larger. Since the producer gross profits are $\alpha_P \widetilde{\Pi}$, an increase in parameter k generates conflicting effects on the quality choice. When the efficiency effect dominates, quality is increasing in k. This occurs when the demand rivalry channel is sufficiently important (σ high enough), or when demand rivalry is poor (σ low) and k is low. In the former case, the producer appropriates a relatively high share of total gross surplus (through the demand rivalry channel) even for large k; hence the negative impact of k on its bargaining power is relatively low. In the latter case, the strong bargaining position of the producer is sustained by the supply channel (k low). Moreover, with very steep marginal costs, total output is low, and flatter marginal costs, inducing an output expansion, generate a relevant increase in total gross profits. Hence, the efficiency effect comes out to be very strong. The positive effect of k on quality translates into a similar effect on consumers' surplus and producer's and retailers' profits. Consumers benefit from both the increase in quality and the reduction in prices induced by flatter marginal costs; retailers' profits increase through the improvement in their bargaining position and a higher total surplus $\widetilde{\Pi}$; finally, the producer is better off, although its bargaining position deteriorates, due to the strong increase in total gross profits $\widetilde{\Pi}$.

When the producer's bargaining position is weak (low σ and high k) this effect prevails over the efficiency effect, and an increase in k reduces quality and producer's profits. The effects on the other agents are mixed, because the reduced quality lowers surplus, but the flatter marginal costs increase it. Hence, non-monotonic effects arise.

This is summarized by Proposition 3.

Proposition 3 (*Impact of Supply-side Rivalry*).

(1) *When $\sigma \geq \sqrt{2}$, or $\sigma < \sqrt{2}$ and k is sufficiently low, the equilibrium quality, consumers' surplus, total profits, retailers' profits, producer profits and total welfare are increasing in k;*
(2) *When $\sigma < \sqrt{2}$ and k is sufficiently large the equilibrium quality and producer profits are decreasing in k.*

Proof. See Appendix A. ■

4. Discussion and extensions

We have proved that retailers' rivalry in the bargaining stage influences the producer incentives to invest in quality, when product improvements entail sunk costs. This instance of the hold-up problem comes out to be quite robust to different variations of the basic model, that are discussed at length in Battigalli et al. (2006). Here we briefly review these extensions.

When higher quality is achieved through more expensive inputs, thereby affecting variable rather than sunk costs, we still obtain that an increase in demand rivalry (higher σ) has a positive effect on quality, producer's and consumers' surplus.[24] Similarly to Proposition 2, point (3), retailers' profits initially increase and then decrease in σ.

We have also considered the case of upstream competition, assuming that two producers serve the two retailers. In this more complex setting, we have approximated an increase in (supply) rivalry by comparing a downstream monopoly market with the case of two retailers active in separate markets but served under diseconomies of scale by the producers. We prove that in this latter case at least one of the producers invests in quality improvement.

Finally, in Appendix B we consider the endogenous choice of k by the producer, adding process innovation to product quality improvements. The hold-up problem is then extended to the decision on the steepness of the marginal cost curve, since the whole cost of k is borne by the producer while the efficiency effect on total gross surplus is shared with the retailers. On top of this, the producer further reduces k to enhance its bargaining position with the retailers. Hence, we obtain sub-optimal investments in both X and k. It turns out that these two strategic variables are complements: in a neighborhood of the equilibrium, flatter marginal costs entail stronger incentives to raise quality and higher quality entails stronger incentives to improve productive efficiency. This implies that lower buyer power (higher σ), by alleviating distortions, is associated to more intense product and process innovation.

We have also investigated the possibility to solve (or mitigate) the hold-up problem by means of self-enforcing agreements.[25] In particular, we have analyzed a dynamic game where first a producer P makes a non-contractible quality choice, and then it plays repeatedly the sequential game described in Section 2 with retailers D_1 and D_2. The game has infinite horizon. We first show that, if the discount factor is high enough ($\delta > 1/2$), for every quality choice X there is a multiplicity of equilibria of the ensuing infinitely repeated game, which allows one to support *any* division of the (gross) surplus $\widetilde{\Pi}(X)$. Since the repeated game equilibrium (and the associated payoff distribution) can be selected as a function of X, it is then easy to show that it is possible to induce the efficient quality choice as a subgame perfect equilibrium outcome.[26]

[24] We assume that when quality is offered above the baseline level the producer incurs a (negligible) fixed cost. Otherwise the producer would be indifferent with respect to the quality of the good because it always recovers the higher variable costs associated to quality improvements.

[25] The formal proofs of the results mentioned in these discussion can be found in Battigalli et al. (2006).

[26] Note that, if one is willing to give up coalition-proofness in the "static" setting analyzed in the previous sections, the multiplicity result of Proposition 1(2) can be used to mitigate the hold-up problem by letting P's continuation equilibrium share of the gross surplus depend on the quality choice. However, by Proposition 1(1) the upper bound on P's gross surplus in subgame perfect equilibrium is $\overline{\Pi}(X)$, less than the maximum gross surplus $\widetilde{\Pi}(X)$. This implies that it may be impossible to provide the producer with credible and effective incentives inducing the efficient quality choice.

5. Concluding remarks

In this paper we endorse the concern that buyer power may stifle suppliers' incentives to invest by showing that an increase in buyer power leads to quality deterioration when R&D activities are crucial to obtain quality improvements. Thus an increase in buyer power harms consumers and total welfare, but may turn out to be detrimental also to retailers. Finally, we highlight the role of fundamentals about technology and preferences as sources of buyer power by exploring their impact on retailers' rivalry in the negotiation with the upstream supplier.

Contrary to most of the literature on this issue, we explicitly model a bargaining protocol in a non-cooperative setting. Retailers make simultaneous take-it-or-leave-it offers to the producer proposing a contract, with no *a priori* restrictions on its form. Coalition-proof equilibrium contracts always entail the implementation of the efficient outcome, i.e. the one that would arise in case of a consolidated vertical chain. Moreover, in equilibrium each retailer appropriates a fraction of total industry profits corresponding to its marginal contribution to total surplus.

It follows that demand and supply characteristics, by affecting retailers' marginal contributions, determine the profits left to the producer. On the demand side, retailers' substitutability is the key parameter. Each retailer contributes more to total profits the more differentiated it is with respect to the other, while in the case of perfectly homogeneity each one can replace the other and demand rivalry is most intense. In this case all the surplus goes to the producer.

The supply channel, instead, works through decreasing returns in production, that in a sense make the two retailers competing for a scarce input at the production stage. The steeper the marginal costs curve, the lower the marginal contribution of each retailer to the total surplus, because an expansion of a retailer increases the marginal cost for supplying the other, reducing industry profits. More intense supply rivalry, again, leads to a higher share of surplus left to the producer.

Once the features of negotiation on the formation and distribution of industry profits are highlighted, we consider the effects on the incentives of the producer to invest in quality improvement. Since in our setting quality is non-contractible, the interaction of retailers and producer is open to the hold-up problem. In fact, the incentive to initially invest in quality improvements depends on the fraction of total profits that in equilibrium is left to the producer.

We identify conditions under which an increase in rivalry, by boosting quality improvements and industry profits, benefits not only consumers and the producer, which gets a larger fraction of profits, but also the retailers, which receive a smaller slice of a much bigger cake.

These results are robust to different ways in which quality can be increased, through sunk investment in R&D or advertising as in our benchmark model, as well as through more valuable intermediate inputs that affect marginal costs. Further, they extend to the case where the producer decides not only on product quality but also on process innovation that makes the marginal cost curve flatter. Lower buyer power (more intense rivalry) alleviates the hold-up problem and leads to an improvement in both choices.

Appendix A. Omitted proofs

Proposition 2.

Proof. Let us denote as $X^*(\sigma, k)$ the equilibrium level of quality, function of the parameters σ and k; we use a similar notation for the other equilibrium values such as $CS^*(\sigma, k)$, $\widetilde{\Pi}^*(\sigma, k)$ etc. From (9) it is easy to show that

$$\frac{\partial X^*(\sigma,k)}{\partial \sigma} = \frac{\frac{\partial^2 \Pi_P}{\partial X \partial \sigma}}{-\frac{\partial^2 \Pi_P}{\partial^2 X}} = \frac{\frac{kX^*}{(2k+1)}\frac{\partial \alpha_P}{\partial \sigma}}{\beta(\beta-1)(X^*-X_0)^{\beta-2} - \frac{k}{(2k+1)}\frac{\sigma+2k\sigma+1}{(4k+\sigma+2k\sigma+1)}} > 0 \tag{10}$$

since $\frac{\partial^2 \Pi_P}{\partial^2 X} < 0$ in a neighborhood of the optimal level of quality and $\frac{\partial \alpha_P}{\partial \sigma} > 0$. By inspection of (9), $\lim_{\sigma\to 0, k\to\infty} X^*(\sigma) = X_0$: when $k \to \infty$ there exists no supply-side rivalry between retailers as marginal costs of production tend to be constant. When $\sigma \to 0$, there exists no demand-side rivalry either. Hence, the producer's share of total surplus is zero and it has no incentive to improve quality. Consequently, since $\beta > 2$, $\lim_{\sigma\to 0, k\to\infty} \frac{\partial X^*(\sigma,k)}{\partial \sigma} = +\infty$.

From (5), in equilibrium, the consumer surplus is given by

$$CS^*(\sigma, k) = U(\widetilde{q}, \widetilde{q}) - 2\widetilde{q}\, p(\widetilde{q}) = 2(\widetilde{q})^2 = \frac{k^2 X^{*2}}{2(2k+1)^2}.$$

It is easy to show that

$$\frac{\partial CS^*(\sigma,k)}{\partial\sigma}=\frac{k^2X^*}{(2k+1)^2}\frac{\partial X^*}{\partial\sigma}>0.$$

By (6), it follows immediately that in equilibrium

$$\frac{\partial\widetilde{\Pi}^*(\sigma,k)}{\partial\sigma}=\frac{kX^*}{2k+1}\frac{\partial X^*}{\partial\sigma}>0.$$

By the envelope theorem and $\frac{\partial\alpha_P}{\partial\sigma}>0$,

$$\frac{\partial\Pi_P^*(\sigma,k)}{\partial\sigma}=\widetilde{\Pi}\frac{\partial a_P}{\partial\sigma}>0.$$

Since the net producer profits, the gross profits of the vertical chain and consumers' surplus are increasing in σ, in equilibrium the total welfare is also increasing in σ. Finally, by (8),

$$\frac{\partial\Pi_{D_i}^*}{\partial\sigma}=\frac{1}{2}\left[(1-\alpha_P)\frac{\partial\widetilde{\Pi}}{\partial X}\frac{\partial X^*}{\partial\sigma}-\widetilde{\Pi}^*\frac{\partial a_P}{\partial\sigma}\right]\tag{11}$$

$$=\frac{1}{2}\left[(1-\alpha_P)\frac{kX^*}{2k+1}\frac{\frac{kX^*}{(2k+1)}\frac{\partial\alpha_P}{\partial\sigma}}{\beta(\beta-1)(X^*-X_0)^{\beta-2}-\frac{k}{(2k+1)}\alpha_P}-\widetilde{\Pi}^*\frac{\partial a_P}{\partial\sigma}\right]\tag{12}$$

$$=\frac{1}{2}\frac{\partial a_P}{\partial\sigma}\widetilde{\Pi}^*\left[\frac{2(1-\alpha_P)\frac{k}{2k+1}}{\beta(\beta-1)(X^*-X_0)^{\beta-2}-\frac{k}{(2k+1)}\alpha_P}-1\right].\tag{13}$$

From $\lim_{\sigma\to0,k\to\infty}\frac{\partial X^*(\sigma,k)}{\partial\sigma}=+\infty$ and $\lim_{\sigma\to0,k\to\infty}X^*(\sigma,k)=X_0$, $\lim_{\sigma\to0,k\to\infty}\alpha_P(\sigma,k)=0$, $\lim_{\sigma\to0,k\to\infty}\frac{\partial\alpha_P}{\partial\sigma}=\frac{1}{2}$ it follows that

$$\lim_{\sigma\to0,k\to\infty}\frac{\partial\Pi_{D_i}^*}{\partial\sigma}=+\infty.$$

Hence, retailers' profits are increasing in σ when rivalry is very weak (σ small and k large). Moreover, $\lim_{\sigma\to\infty}\Pi_{D_i}^*=0$, that is, when (demand) rivalry is very intense retailers' profits decrease and tend to vanish. Therefore, when k is large, retailers' profits are non-monotonic in σ. ■

Proposition 3.

Proof. From (9),

$$\frac{\partial X^*(\sigma,k)}{\partial k}=\frac{\frac{\partial^2\Pi_P}{\partial X\partial k}}{-\frac{\partial^2\Pi_P}{\partial^2X}}=\frac{X^*\frac{(4k^2(\sigma^2-2)+4k\sigma(\sigma+1)+(\sigma+1)^2)}{(2k+1)^2(4k+\sigma+2k\sigma+1)^2}}{\beta(\beta-1)(X^*-X_0)^{\beta-2}-\frac{k}{(2k+1)}\frac{\sigma+2k\sigma+1}{(4k+\sigma+2k\sigma+1)}}.$$

When $\sigma\geq\sqrt{2}$, the numerator is positive. When $\sigma<\sqrt{2}$, the numerator is negative for k large enough.

When $\frac{\partial X^*}{\partial k}>0$, it immediately follows that

$$\frac{\partial CS(\sigma,k)}{\partial k}=\frac{k^2X^*}{(2k+1)^2}\frac{\partial X^*(\sigma,k)}{\partial k}+\frac{X^{*2}k}{(2k+1)^3}>0$$

$$\frac{\partial\widetilde{\Pi}^*(\sigma,k)}{\partial k}=\frac{kX^*}{(2k+1)}\frac{\partial X^*(\sigma,k)}{\partial k}+\frac{X^{*2}}{2(2k+1)^2}>0$$

$$\frac{\partial\Pi_{D_i}^*(\sigma,k)}{\partial k}=\frac{1}{2}\left[(1-\alpha_P)\frac{\partial\widetilde{\Pi}(X)}{\partial X}\frac{\partial X^*}{\partial k}-\widetilde{\Pi}^*\frac{\partial\alpha_P}{\partial k}\right]>0.$$

In the latter case, recall that $\frac{\partial\alpha_P}{\partial k}<0$. Differently stated, when k increases not only do total profits increase, but also the share appropriated by retailers. Hence the latter's profits cannot but increase.

By the envelope theorem,

$$\begin{aligned}\frac{\partial \Pi_P^*}{\partial k} &= \frac{\partial \alpha_P}{\partial k}\widetilde{\Pi}^* + \alpha_P \frac{\partial \widetilde{\Pi}^*(\sigma,k)}{\partial k} \\ &= \frac{-4(\sigma+1)}{(4k+\sigma+2k\sigma+1)^2}\frac{X^{*2}k}{2(2k+1)} + \frac{\sigma+2k\sigma+1}{(4k+\sigma+2k\sigma+1)}\frac{X^{*2}}{2(2k+1)^2} \\ &= \frac{X^{*2}\left(4k^2(\sigma^2-2)+4k\sigma(\sigma+1)+(\sigma+1)^2\right)}{2\,(2k+1)^2\,(4k+\sigma+2k\sigma+1)^2}.\end{aligned}$$

Hence, $\frac{\partial \Pi_P^*(\sigma,k)}{\partial k} > 0$ iff $\frac{\partial X^*(\sigma,k)}{\partial k} > 0$.

Since, when quality in increasing in k, the net producer profits, total gross profits and consumers surplus are increasing in k, the total welfare is also increasing in k. ■

Appendix B. Endogenous choice of *k*

This appendix solves for the optimal level of product innovation ($X^*(\sigma)$) and process innovation ($k^*(\sigma)$). We assume that process innovation entails a unit sunk cost $r > 0$. Hence, the producer solves the following program:

$$\max_{X,k}\left[\alpha_P(k)\widetilde{\Pi}(X,k) - (X-X_0)^\beta - rk\right].$$

The FOCs are given by

$$\begin{aligned}\frac{\partial \Pi_P}{\partial X} &= \alpha_P \frac{\partial \widetilde{\Pi}(X,k)}{\partial X} - \beta(X-X_0)^{\beta-1} = 0 \\ &= X\frac{k}{(2k+1)}\frac{\sigma+2k\sigma+1}{(4k+\sigma+2k\sigma+1)} - \beta(X-X_0)^{\beta-1} = 0 \qquad (14)\end{aligned}$$

$$\begin{aligned}\frac{\partial \Pi_P}{\partial k} &= \alpha_P \frac{\partial \widetilde{\Pi}(X,k)}{\partial k} + \widetilde{\Pi}\frac{\partial \alpha_P}{\partial k} - r = 0 \\ &= \frac{X^2}{2}\frac{\left(4k^2(\sigma^2-2)+4k\sigma(\sigma+1)+(1+\sigma)^2\right)}{(2k+1)^2\,(4k+\sigma+2k\sigma+1)^2} - r = 0. \qquad (15)\end{aligned}$$

Inspection of (15) reveals that the producer chooses a lower level of k (compared to the one that maximizes total profits) not only because it does not appropriate entirely the benefit of an increase in k but also because by decreasing k it increases its share of total gross surplus (recall that $\partial\alpha_P/\partial k < 0$). From (14), one obtains the optimal level of quality for given k, denoted as $X(k)$. Similarly, from (15), one obtains the optimal level of process innovation for given X, denoted as $k(X)$. The solution of the program above is given by the intersection of the two functions. Note that

$$\begin{aligned}\frac{\mathrm{d}k(X)}{\mathrm{d}X} &= \frac{\frac{\partial^2 \Pi_P}{\partial k \partial X}}{-\frac{\partial^2 \Pi_P}{\partial^2 k}} \\ &= \frac{X\frac{4k^2(\sigma^2-2)+4k\sigma(\sigma+1)+(1+\sigma)^2}{(2k+1)^2(4k+\sigma+2k\sigma+1)^2}}{-\frac{\partial^2 \Pi_P}{\partial^2 k}}.\end{aligned}$$

Since $\frac{\partial^2 \Pi_P}{\partial^2 k} < 0$ in a neighborhood of the optimal level of k, and since Eq. (15) implies $4k^2(\sigma^2-2)+4k\sigma(\sigma+1)+(1+\sigma)^2 > 0$, it follows that $\frac{\mathrm{d}k(X)}{\mathrm{d}X} > 0$.

In turn, we have already proved that

$$\frac{\partial X(k)}{\partial k} = \frac{\frac{\partial^2 \Pi_P}{\partial X \partial k}}{-\frac{\partial^2 \Pi_P}{\partial^2 X}} = \frac{X\frac{\left(4k^2(\sigma^2-2)+4k\sigma(\sigma+1)+(\sigma+1)^2\right)}{(2k+1)^2(4k+\sigma+2k\sigma+1)^2}}{\beta(\beta-1)(X-X_0)^{\beta-2} - \frac{k}{(2k+1)}\frac{\sigma+2k\sigma+1}{(4k+\sigma+2k\sigma+1)}}$$

which is positive either if $\sigma \geq \sqrt{2}$ or $\sigma < \sqrt{2}$ and k sufficiently large. However, since the equilibrium level of k must be such that $4k^2(\sigma^2 - 2) + 4k\sigma(\sigma + 1) + (1 + \sigma)^2 > 0$, the intersection between the two functions must be in the increasing part of $X(k)$.

From (10) we already know that an increase in σ shifts $X(k)$ upward. From (15) it follows that an increase in σ also shifts $k(X)$ upward:

$$\frac{\partial k(X,\sigma)}{\partial \sigma} = \frac{\frac{\partial^2 \Pi_P}{\partial k \partial \sigma}}{-\frac{\partial^2 \Pi_P}{\partial^2 k}} = \frac{4kX^2 \frac{\sigma+1}{(4k+\sigma+2k\sigma+1)^3}}{-\frac{\partial^2 \Pi_P}{\partial^2 k}} > 0.$$

Hence, an increase in σ increases both the optimal levels of X and k. ■

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