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ABSTRACT

Buyer Power and Quality Improvements*

This paper analyses the sources of buyer power and its effect on sellers' investment in quality improvements. In our model retailers make take-it-or-leave-it offers to a producer and each of them obtains its marginal contribution to total profits (gross of sunk costs). In turn, this 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. A repeated game argument shows that efficient quality improvements can be supported as an equilibrium outcome if the producer and retailers are involved in a long-term relationship.

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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 on the rise also in other industries, such as automobile,² healthcare and cable television (in the US).³

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 excessive buyer power may deteriorate suppliers' incentive by squeezing their profit margins and thus indirectly harm 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.

Our model 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. Higher quality makes final consumers more willing to pay for the good, thereby increasing total industry profits (gross of sunk costs). Af-

¹For example, in the UK supermarkets accounted for 20% of grocery sales in 1960, but 89% in 2002, with the top-5 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).

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

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

⁴The 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).

ter 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, absent 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 contribution is 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.

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.

We then analyze the quality choice made by the producer. 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.

Finally, we show that repeated interaction may induce the producer to choose the efficient quality level even in the presence of powerful buyers.

Related literature This paper relates to the growing literature on buyer power. This literature has addressed three main issues: (i) why larger buyers obtain better deals from sellers; (ii) whether wholesale discounts obtained by large buyers are passed on to final consumers; (iii) what are the implications of buyer power for suppliers' incentives.

The literature exploring the sources of buyer power is very heterogeneous.^{5,6} In a number of papers, size discounts arise because large buyers are better bargainers than small ones. This occurs for various reasons. Larger buyers can distribute the costs to generate alternative supply options over a larger number of units. This makes their threat to integrate backwards credible and improves their bargaining position with the supplier (Katz, 1987; Inderst and Wey, 2005b). In Inderst and Shaffer (forthcoming) a consolidated retailer may commit to stock only one variety at all outlets, thereby intensifying competition among potential suppliers. In other papers, including Chipty and Snyder (1999) and Inderst and Wey (2003, 2005a), the effect of buyer size on bargaining is more subtle. 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 aggregate surplus across all negotiations is *concave* in quantity, it follows that the incremental surplus from the negotiation involving the large buyer is higher *per-unit* than the incremental surplus from the transaction involving the small one. This higher per-unit incremental surplus translates into a lower per-unit price for the large buyers. The aggregate surplus function is concave, for instance, if the supplier has (strictly) convex production costs.

⁵Heterogeneity arises because there exists no single canonical formalization of the exchange between upstream and downstream firms. In particular, models differ for the assumptions on the class of contracts that firms can offer and on the bargaining procedure.

⁶See Snyder (2005) for a recent survey. For empirical and experimental evidence documenting the existence of buyer-size effects, see Scherer and Ross (1990, pp. 533-35), the summary in Ellison and Snyder (2002) and Normann, Ruffle and Snyder (2005).

We contribute to this literature emphasizing that buyer power is determined by the extent to which a buyer is essential to the creation of total surplus. In turn, this depends on buyers' size but also on demand and supply conditions. In particular, the demand channel has been scarcely explored so far.

In another strand of the literature, size discounts emerge because larger buyers destabilize collusion. For instance, a larger buyer, by accumulating a backlog of unfilled orders, may mimic a demand boom and force *sellers* to collude on lower prices (Snyder, 1996). Instead, in Tyagi (2001) it is the supplier which has incentives to offer lower prices to larger buyers in order to amplify cost asymmetries among downstream firms and undermine collusion in the *final market*.

Finally, buyer power may originate from risk aversion, as shown by Chae and Heidhues (2004) and DeGraba (2005).

The literature which studies the welfare effects of buyer power is less abundant. Most of the papers address the question of whether lower wholesale prices secured by powerful buyers imply lower final-good prices or higher welfare and show that this is not necessarily the case.⁷ For instance, Von Ungern-Sternberg (1996) and Dobson and Waterson (1997) show that price discounts obtained by *more concentrated* buyers translate into lower final-good prices only if downstream firms compete fiercely in the final market (e.g. because product differentiation is low) and thus double marginalization is not severe.⁸ In these papers the upstream market structure is given. Instead Fumagalli and Motta (2006) considers the possibility of upstream entry and shows that there is no welfare gain from buyers' concentration when downstream competition is strong enough. The reason being that intense downstream competition removes miscoordination failures among buyers and allows them to be supplied by a more efficient new entrant. Finally, Chen (2003) shows that an *exogenous* increase in the relative bargaining power of a dominant retailer benefits consumers because it triggers a decrease in the wholesale price charged by the supplier to the *fringe competitors*, thereby leading to lower final prices. In spite of this, total welfare may decrease because more production is allocated to the less efficient fringe competitors.

Only recently, some papers have begun to examine the impact of buyer power

⁷Note that, in order to study this issue, these papers rule out the possibility to offer efficient vertical contracts, i.e. contracts that allow to maximize aggregate profits. Indeed, if efficient contracts were feasible, increased concentration in the downstream market would have no impact on final prices because total industry profits would always be maximized, irrespective of the structure of the downstream market.

⁸In these papers, a merger between two buyers corresponds to one firm vanishing from the market. The remaining firms continue being symmetric so that they evaluate the impact of an increase in downstream concentration, not the impact of the formation of a larger buyer.

on the suppliers' incentives to invest and innovate.⁹ Inderst and Shaffer (forthcoming) and Chen (2006) confirm the aforementioned concerns and show that buyer power may decrease welfare through a distortion in the variety of products offered to consumers. Specifically, in Inderst and Shaffer (forthcoming) manufacturers anticipate that a consolidated retailer 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. We show that buyer power may lead also to quality deterioration.

By contrast, Inderst and Wey (2003, 2005a, 2005b) and Vieira-Montez (2004) challenge the view that the formation of larger buyers will invariably stifle investment by upstream firms. Indeed, downstream mergers 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 (2005b), in the presence of a large buyer - which differently from 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 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 and 2005a) suggest a different mechanism. When negotiating with fewer but larger buyers, the supplier can roll over more of "inframarginal" but less of "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.

This paper relates to the literature on the hold-up problem, dating 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, 1989 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.

The plan of the paper is the following. Section 2 presents the basic model and

⁹Differently from the previous ones, these models allow for sufficiently complex vertical contracts so that aggregate profits are always maximized. The structure of the downstream market affects only the distribution of surplus between upstream and downstream firms. This allows to isolate the effect of increased concentration in the downstream market on suppliers' incentives from the effect on final prices and quantities, and to focus only on the former.

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. Finally, Section 5 studies the case where the producer and retailers interact repeatedly.

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).

The timing of agents' decisions is the following:

- At time t_0 the producer chooses the quality level X of its product. Quality is not contractible. Quality chosen at time t_0 has commitment value.
- At time t_1 retailers make simultaneous take-it-or-leave-it offers to the producer. The proposed contracts leave the producer the right to choose the quantity to be delivered to retailers and sold in final markets.
- At time t_2 production and deliveries takes place and the good is distributed in the final market.

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 $C(Q)$ such that $C(0) = 0$. 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 $R(q', q'', X) := R_1(q', q'', X) = R_2(q'', q', X)$.

An assumption of our analysis is that the retailers let the producer choose the quantities (q_1, q_2) that will be sold on the downstream market and determine

such quantities indirectly through their contractual offers.¹⁰ An alternative interpretation is that the quantity delivered to a retailer is a capacity constraint in downstream competition and R_1, R_2 are downstream equilibrium revenue functions. If the downstream firms compete *à la* Cournot (under capacity constraints) the results do not change. We conjecture that our results would also hold under downstream price competition.

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 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.

A relevant benchmark in the analysis of negotiation is whether the firms adopt efficient contracts, i.e. contracts that allow 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 nonlinear contracts whereby the payment to the supplier by one retailer depends on the quantity sold to *both* retailers (and re-sold by them on the downstream market).¹¹ In particular, we also allow retailers to offer *exclusive contracts* where the supplier commits not to sell the product to the rival retailer (an exclusive contract is a contract that inflicts a sufficiently high penalty to the producer if it sells a positive quantity to the rival retailer). Exclusive contracts play an important role in deriving the essential uniqueness of the equilibrium outcome in the negotiation stage (see the proof of Proposition 1). For concreteness, although we allow any nonlinear contract, we often focus our attention on equilibrium con-

¹⁰They can also offer forcing contracts.

¹¹See Villas-Boas (2005) and Bonnet et al. (2005) for empirical evidence documenting that manufacturers and retailers use non linear pricing contracts.

tracts where retailer i pays back to the producer the revenue $R_i(q_1, q_2)$ collected and the supplier pays to retailer i a fixed amount (slotting allowance) S_i .

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".¹² We postpone the discussion of this point until after the main result of this subsection.

We let $\tilde{\Pi}$ denote the profit (gross of sunk costs) of a vertically integrated monopolist, and let $\bar{\Pi}$ denote the profit of an integrated firm who operates only one retailing outlet:¹³

$$\tilde{\Pi} = \max_{q_1, q_2 \geq 0} [R(q_1, q_2) + R(q_2, q_1) - C(q_1 + q_2)], \quad (1)$$

$$\bar{\Pi} = \max_{q_1 \geq 0, q_2 = 0} [R(q_1, q_2) + R(q_2, q_1) - C(q_1 + q_2)] = \max_{q \geq 0} [R(q, 0) - C(q)]. \quad (2)$$

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 $2\bar{\Pi} - \tilde{\Pi} \geq 0$.

Proof. Let q^* be the solution to problem (1). Then

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

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

¹²Bernheim 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 model is essentially equivalent to ours.

¹³By symmetry, it does not matter which retailing outlet is active. Also recall that these quantities depend on X , the given quality of the product.

profit. The following proposition says that there is a continuum of equilibrium pay-off 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 $\tilde{\Pi}$ and the maximum surplus $\bar{\Pi}$ obtainable without D_i ; the producer P obtains the rest of the maximum industry surplus.

Proposition 1 *In the negotiation stage, (1) the maximum equilibrium payoff of each retailer is $\Pi_{D_i} = \tilde{\Pi} - \bar{\Pi}$, the minimum equilibrium payoff of the producer (gross of sunk costs) is $\Pi_P = 2\bar{\Pi} - \tilde{\Pi}$, and the maximum equilibrium payoff is $\Pi_P = \bar{\Pi}$; (2) for each $\Pi_P \in [2\bar{\Pi} - \tilde{\Pi}, \bar{\Pi}]$ there is an “efficient” equilibrium where the producer obtains Π_P and each retailer obtains $\frac{1}{2}(\tilde{\Pi} - \Pi_P)$; (3) there is a unique coalition-proof equilibrium allocation where each retailer obtains the marginal contribution $\tilde{\Pi} - \bar{\Pi}$ and the producer obtains $2\bar{\Pi} - \tilde{\Pi}$.*

Proof. A strategy profile in the subgame is given by a pair of contract offers (t_1, t_2) (with $t_i : \mathbf{R}_+^2 \rightarrow \mathbf{R}$) 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. We will only consider sequentially strategies of P and focus on the retailers' incentives.

(1) We first show that $\Pi_{D_i} \leq \tilde{\Pi} - \bar{\Pi}$ in equilibrium. Consider a strategy profile that yields payoffs Π_P, Π_{D_j} and $\Pi_{D_i} > \tilde{\Pi} - \bar{\Pi}$. The latter inequality implies that P accepts D_i 's offer. 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 $\Pi_P + \Pi_{D_j} + \Pi_{D_i} \leq \tilde{\Pi}$, it follows that $\Pi_P + \Pi_{D_j} < \bar{\Pi}$. Therefore D_j can offer an exclusive contract of the form $t'_j(q_j, 0) = R(q_j, 0) - S$ where $\Pi_{D_j} < S < \bar{\Pi} - \Pi_P$. The contract (if accepted) yields payoffs $\Pi'_P = \bar{\Pi} - S > \Pi_P$ 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 $2\bar{\Pi} - \tilde{\Pi}$ in equilibrium. Consider a strategy profile inducing payoffs Π_{D_i}, Π_{D_j} , and $\Pi_P < 2\bar{\Pi} - \tilde{\Pi}$. Let (wlog) $\Pi_{D_i} \leq \Pi_{D_j}$. Then $\Pi_{D_i} \leq (\tilde{\Pi} - \Pi_P)/2$. Suppose that D_i offers instead an exclusive contract of the form $t'_i(q_i, 0) = R(q_i, 0) - S$, where $S = \bar{\Pi} - \Pi_P - \varepsilon$. This contract (if accepted) implements the payoffs $\Pi_P + \varepsilon$ for P and $\bar{\Pi} - \Pi_P - \varepsilon$ for D_i . By assumption ε can be chosen so that $0 < \varepsilon < \left[\left(2\bar{\Pi} - \tilde{\Pi} \right) - \Pi_P \right] / 2$. Then P

accepts t'_i (otherwise he gets at most Π_P) and it can be checked that $\bar{\Pi} - \Pi_P - \varepsilon > (\tilde{\Pi} - \Pi_P)/2$; thus D_i has a profitable deviation.

Now consider a strategy profile such that $\Pi_P > \bar{\Pi}$, which 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 $0 < \varepsilon < \Pi_P - \bar{\Pi}$. To see this, note that if P accepts t'_i and t_j its payoff is $\Pi_P - \varepsilon > \bar{\Pi}$, and if P rejects t'_i its payoff is at most $\bar{\Pi}$.

(2) Consider the following strategy profile:

$$t_1(q_1, q_2) = \begin{cases} R_1(q_1, q_2) - \frac{1}{2}(\tilde{\Pi} - \Pi_P), & \text{if } q_2 > 0, \\ R_1(q_1, 0) - (\bar{\Pi} - \Pi_P) & \text{if } q_2 = 0, \end{cases} \quad (3)$$

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. P is indifferent between accepting both contracts or only one: in both cases the payoff is $\Pi_P \geq 2\bar{\Pi} - \tilde{\Pi} \geq 0$. In the candidate equilibrium each retailer gets $\frac{1}{2}(\tilde{\Pi} - \Pi_P) \geq 0$ and 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 only t'_i then D_i gets at most $\bar{\Pi} - \Pi_P$. Since $\Pi_P \geq 2\bar{\Pi} - \tilde{\Pi}$, $\bar{\Pi} - \Pi_P \leq \frac{1}{2}(\tilde{\Pi} - \Pi_P)$. If P accepts both t'_i and t_j then D_i gets at most $\tilde{\Pi} - \Pi_P - \frac{1}{2}(\tilde{\Pi} - \Pi_P) = \frac{1}{2}(\tilde{\Pi} - \Pi_P)$.

(3) Let $\Pi_P = 2\bar{\Pi} - \tilde{\Pi}$ in the above equilibrium. Each retailer gets $\frac{1}{2}[\tilde{\Pi} - (2\bar{\Pi} - \tilde{\Pi})] = \tilde{\Pi} - \bar{\Pi}$. By (1), 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. ■

The contracts considered in the second part of the proof (eq. (3)) feature a fixed component (slotting allowance) that is contingent on whether the producer also serves the other retailer. Rey *et al* (2006) also consider payment schedules contingent on exclusivity, although they assume that retailers, rather than the producer, choose quantities. They show that allowing for "conditional three-part tariffs" (i.e. an upfront slotting allowance, paid when the contract is signed, and a variable component paid when a positive quantity is ordered) it is possible to attain in equilibrium the industry monopoly profit. Instead, in Marx and Shaffer (2005) three-part tariffs are not contingent on the set of contracts accepted by the producer. They show that without contingency, in equilibrium the manufacturer trades with one retailer only, and thus industry profits are not maximized. The reason why contingent offers are essential is that they help limiting the scope for profitable deviations from a situation where the producer supplies both retailers

to exclusivity, thereby making such situation more stable.

The equilibrium strategy profile put forward in part (3) of the proof above 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 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.¹⁴ The equilibria of part (2) of the proof are efficient and "locally truthful" (Grossman and Helpman, 1994). In these equilibria the producer cannot fully appropriate the gross surplus $\tilde{\Pi}$ 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.

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

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:

$$I(X - X_0) = (X - X_0)^\beta \quad (4)$$

¹⁴Bergeman 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.

with $\beta > 2$,¹⁵ where X is the chosen quality. Variable costs of production are quadratic:

$$C(q) = \frac{q^2}{2k}. \quad (5)$$

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:

$$U(q_1, q_2, y) = X(q_1 + q_2) - \frac{1}{(1 + \sigma)} \left[q_1^2 + q_2^2 + \frac{\sigma}{2} (q_1 + q_2)^2 \right] + y \quad (6)$$

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.¹⁶ 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:

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

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 $\sigma \rightarrow \infty$, 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:

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

¹⁵We also considered the case $1 < \beta \leq 2$; most of the qualitative results hold, but the analysis becomes more complex.

¹⁶This utility function is due to Shubik and Levitan (1980). Demand functions derived from it display some desirable properties (see following discussion).

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 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 $\sigma = 0$, rivalry is nil, while the case $\sigma \rightarrow \infty$ corresponds to maximum rivalry of the two retailers.

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

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

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:

$$\begin{aligned} \tilde{q}_1 &= \tilde{q}_2 = \frac{kX}{2(1+2k)} \\ \Pi(\tilde{q}_1, \tilde{q}_2) &= X^2 \frac{k}{2(1+2k)} \equiv \tilde{\Pi} \end{aligned} \tag{7}$$

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

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

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

The FOC is given by:

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

Hence,

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

and

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

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

$$\begin{aligned} \Pi_P &= 2\bar{\Pi} - \tilde{\Pi} = 2 \left(\frac{1}{2} \frac{X^2 k (\sigma + 1)}{4k + \sigma + 2k\sigma + 1} \right) - X^2 \frac{k}{4k + 2} \\ &= \frac{1}{2} X^2 k \frac{\sigma + 2k\sigma + 1}{(2k + 1)(4k + \sigma + 2k\sigma + 1)} \\ &= \tilde{\Pi} \cdot \alpha_P \end{aligned} \quad (8)$$

where

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

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

$$\begin{aligned} \Pi_{D_i} &= \tilde{\Pi} - \bar{\Pi} = X^2 \frac{k}{2(1 + 2k)} - \frac{1}{2} \frac{X^2 k (\sigma + 1)}{4k + \sigma + 2k\sigma + 1} \\ &= \tilde{\Pi} \cdot (1 - \alpha_P) / 2 \end{aligned} \quad (9)$$

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 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 ($\sigma \rightarrow \infty$), 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 ($k \rightarrow \infty$) the supply side rivalry channel vanishes.

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

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

The FOC is given by:

$$\begin{aligned} \frac{\partial \Pi_P}{\partial X} &= \alpha_P \frac{\partial \tilde{\Pi}(X)}{\partial X} - \beta(X - X_0)^{\beta-1} = 0 \\ &= X \frac{k}{(2k+1)} \frac{\sigma + 2k\sigma + 1}{(4k + \sigma + 2k\sigma + 1)} - \beta(X - X_0)^{\beta-1} = 0 \end{aligned} \quad (10)$$

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 $\tilde{\Pi}(X) - (X - X_0)^\beta$: this result reminds the well know 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 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 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 total (gross) profits $\tilde{\Pi}$ become larger. Since the producer

gross profits are $\alpha_P \tilde{\Pi}$, 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 $\tilde{\Pi}$; finally, the producer is better off, although its bargaining position deteriorates, due to the strong increase in total gross profits $\tilde{\Pi}$.

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 occur.

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, Fumagalli and Polo (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.¹⁷ 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 the quality chosen by at least one of the producers increases.

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 now 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 neighbourhood 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.

5 Long-Term Relationship between Producer and Retailers

So far we did not analyze the possibility to mitigate the hold-up problem by means of self-enforcing agreements. In this section we analyze a model of repeated interaction between a producer and two retailers preceded by an ex ante quality choice. We adapt and apply a rather general result about the multiplicity of equilibria in

¹⁷We 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.

repeated agency games¹⁸ to show that under mild assumptions repeated interaction can provide appropriate incentives for ex ante non-contractible investments and that this is consistent with a wide range of distributions of the surplus.

But first we 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 $\bar{\Pi}(X)$, less than the maximum gross surplus $\tilde{\Pi}(X)$. This implies that it may be impossible to provide the producer with credible and effective incentives inducing the efficient quality choice. In particular, the efficient quality choice of the static model, $X^* = \arg \max_{X_0 \geq 0} \tilde{\Pi}(X) - I(X - X_0)$, is not implementable in subgame perfect equilibrium if $\bar{\Pi}(X^*) - I(X^* - X_0) < 0$, because in this case P is better off choosing X_0 rather than X^* , as X_0 guarantees a non-negative net profit.^{19,20}

We consider a dynamic game where first a producer P makes a non contractible quality choice $X \geq X_0$, incurring a sunk cost $I(X - X_0)$, and then it plays repeatedly the sequential game described in Section 2 with retailers D_1 and D_2 . The game has infinite horizon and discount factor δ which comprises a fixed conditional probability of termination of the relationship. Thus, letting $\Pi_i(t, X)$ denote the flow payoff of player i at time t given X , the (expected) present discounted values for P and D_i are, respectively,

$$\sum_{t=1}^{\infty} \delta^t \Pi_P(t, X) - I(X - X_0),$$

$$\sum_{t=1}^{\infty} \delta^t \Pi_{D_i}(t, X).$$

We assume that (i) $\tilde{\Pi}(\cdot)$ and $I(\cdot)$ are increasing and continuous, (ii) $I(0) = 0$,

¹⁸The techniques are borrowed from Battigalli and Maggi (2004) who in turn adapt arguments from Abreu (1988).

¹⁹Choosing X_0 the producer incurs no sunk costs and obtains a continuation equilibrium profit larger or equal to $2\bar{\Pi}(X_0) - \tilde{\Pi}(X_0) \geq 0$.

²⁰We note that, in the specific model analyzed in Section 3, X^* can be implemented for a wide range of parameters. But, as pointed out in the text, in general one cannot guarantee that the "participation constraint" of P is satisfied at X^* . For example, one can find nonconvex investment cost functions $I(\cdot)$ that make X^* non-implementable due to the violation of this constraint.

and (iii) the efficient quality choice exists and is unique:

$$X^* = \arg \max_{X \geq X_0} \frac{\delta}{1 - \delta} \tilde{\Pi}(X) - I(X - X_0).$$

We first show that, if the discount factor is high enough, for every quality choice X there is a multiplicity of equilibria of the ensuing infinitely repeated game, which allows to support any division of the surplus. 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 X^* as a subgame perfect equilibrium outcome.

Lemma 1 *If $\delta \geq \frac{1}{2}$, any division of the (gross) surplus $\tilde{\Pi}(X)$ can be supported by a subgame perfect equilibrium of the repeated sequential game that obtains after the quality choice stage.*

Proof. See Appendix A. ■

The intuition is as follows. Suppose the players want to implement an efficient allocation $(\Pi_P(X), \Pi_{D_1}(X), \Pi_{D_2}(X))$ in each period. This can be achieved by adapting to our sequential setting the "optimal-penal-code" approach of Abreu (1986): whenever a firm deviates from the equilibrium path, or from a punishment path, it triggers an equilibrium punishment phase where it receives its maxmin payoff (zero). Since the retailers have a first-mover advantage in the stage game, punishing retailers after a deviation may be difficult. We consider strategies that punish retailers by allocating all the surplus to the producer (even if only one of them has deviated). This entails rejection by P of any offer that does not allocate all the surplus $\tilde{\Pi}(X)$ to P . But with high discounting (δ small) P would also accept offers that give it a small share of the surplus. Suppose that the retailers' offers are such that P obtains $\tilde{\Pi}(X) - \varepsilon$.²¹ According to the equilibrium strategies P should reject, yielding zero profits (to all players) in the current period, but making P receive the whole surplus $\tilde{\Pi}(X)$ in all future periods. On the other hand, if P accepts it will be punished from the next period. Therefore P rejects only if $\frac{\delta}{1-\delta}\tilde{\Pi}(X) \geq \tilde{\Pi}(X) - \varepsilon$, where ε can be arbitrarily small. This explains the condition $\delta \geq \frac{1}{2}$.

We can now prove the main result of this section:

²¹For example, on the retailers' punishment path each retailer D_i is supposed to offer the contract $t_i(q_1, q_2) = R_i(q_1, q_2)$, but -say - D_1 may deviate and offer $t_1(q_1, q_2) = R_1(q_1, q_2) - \varepsilon$. The resulting distribution if P accepts (and then chooses (q_1, q_2) optimally) is $(\tilde{\Pi}(X) - \varepsilon, \varepsilon, 0)$.

Proposition 4 *If $\delta \geq \frac{1}{2}$, for all $\Pi_D \in \left[0, \tilde{\Pi}(X^*) - \frac{1-\delta}{\delta}I(X^* - X_0)\right)$ there exists a subgame perfect equilibrium of the whole game implementing the efficient quality choice X^* and such that retailers' aggregate instantaneous profit is Π_D .*

Proof. By Lemma 1, for each X and $\Pi_P \in [0, \tilde{\Pi}(X)]$ there is an equilibrium of the repeated game such that the gross instantaneous profit of P is Π_P and the aggregate instantaneous profit of retailers is $\Pi_D = \Pi_{D_1} + \Pi_{D_2} = (\tilde{\Pi}(X) - \Pi_P) \geq 0$. Therefore it is possible to implement in equilibrium the following instantaneous gross profit function for P :

$$\Pi_P(X) = \max\{0, \tilde{\Pi}(X) - \Pi_D\}.$$

Then, in period 0, P chooses quality to solve the problem

$$\max_{X \geq X_0} \left[\Pi_P(X) - \frac{1-\delta}{\delta}I(X - X_0) \right].$$

$\Pi_D < \tilde{\Pi}(X^*)$ implies (by continuity) that in a neighborhood of X^* the net (long-run average) payoff of P is

$$\Pi_P(X) - \frac{1-\delta}{\delta}I(X - X_0) = \tilde{\Pi}(X) - \frac{1-\delta}{\delta}I(X - X_0) - \Pi_D$$

and X^* is a local maximum. Since we assume $\Pi_D < \tilde{\Pi}(X^*) - \frac{1-\delta}{\delta}I(X^* - X_0)$, it follows that X^* yields a strictly positive payoff to P and hence it is also the global maximum. ■

We may interpret Proposition 4 as follows. Producer and retailers realize that they can use the multiplicity of subgame perfect equilibria of the repeated game to enforce agreements that maximize the present value of the surplus. How the gains from trade are split depends on the "bargaining power" of the parties before the producer sinks quality-improving investments. Proposition 4 shows that a large set of distributions of the long-run surplus are consistent with implementing the efficient quality choice. The producer can guarantee a non-negative payoff by not investing in quality improvements (recall that $I(0) = 0$). This implies a "participation constraint" that bounds from above the share of the retailers.

6 Concluding Remarks

In this paper we have analyzed the producer-retailers relationship and the effects of buyer power on the incentives of a producer to invest in quality improvements. Buyer power of the retailers has been modelled as depending on fundamentals about technology and preferences that affect retailers' rivalry when dealing with the upstream supplier, namely the degree of substitutability of retailers' offers and the steepness of the marginal cost curve of the producer.

Contrary to most of the literature on this issue we did not adopt a cooperative solution to analyze the negotiation of retailers and producers; rather, 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, that is the increase in industry profits when one more retailer is supplied.

The profits left to the producer are an increasing function of the rivalry between retailers. We consider a demand and a supply channel that influence retailers' rivalry. 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 homogeneous supplies each one can replace the other and demand rivalry is most intense. In this case all the surplus goes to the producer.

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 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 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 contribu-

tion of each retailer to 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 highlighted the features of negotiation on the formation and distribution of industry profits, 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, that gets a larger fraction of profits, but also the retailers, that receive a smaller slice of a much bigger cake. Recall that, for given quality, the equilibrium allocation is the one that would obtain under vertical integration. Hence, more rivalry between retailers does not lead to lower final prices, but makes industry profits higher and consumers better off through an increase in the quality of the good due to a mitigation of the hold-up problem.

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 $CS^*(\sigma, k)$, $\tilde{\Pi}^*(\sigma, k)$ etc. From (10) it is easy to show that

$$\frac{\partial X^*(\sigma, k)}{\partial \sigma} = \frac{\frac{\partial^2 \Pi_P}{\partial X \partial \sigma}}{-\frac{\partial^2 \Pi_P}{\partial^2 X}} = \frac{\frac{kX^*}{(2k+1)} \frac{\partial \alpha_P}{\partial \sigma}}{\beta(\beta-1)(X^* - X_0)^{\beta-2} - \frac{k}{(2k+1)} \frac{\sigma+2k\sigma+1}{(4k+\sigma+2k\sigma+1)}} > 0 \quad (11)$$

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 (10), $\lim_{\sigma \rightarrow 0, k \rightarrow \infty} X^*(\sigma) = X_0$: when $k \rightarrow \infty$ there exists no supply-side rivalry between retailers as marginal costs of production tend to be constant. When $\sigma \rightarrow 0$, 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, when $\beta > 2$, $\lim_{\sigma \rightarrow 0, k \rightarrow \infty} \frac{\partial X^*(\sigma, k)}{\partial \sigma} = +\infty$.

From (6), in equilibrium consumer surplus is given by:

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

It is easy to show that:

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

By (7), it follows immediately that in equilibrium

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

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

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

Since the net producer profits, the gross profits of the vertical chain and consumers' surplus are increasing in σ , in equilibrium also total welfare is increasing

in σ . Finally, by (9),

$$\frac{\partial \Pi_{D_i}^*}{\partial \sigma} = \frac{1}{2} \left[(1 - \alpha_P) \frac{\partial \tilde{\Pi}}{\partial X} \frac{\partial X^*}{\partial \sigma} - \tilde{\Pi}^* \frac{\partial a_P}{\partial \sigma} \right] \quad (12)$$

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

$$= \frac{1}{2} \frac{\partial a_P}{\partial \sigma} \tilde{\Pi}^* \left[\frac{2(1 - \alpha_P) \frac{k}{2k+1}}{\beta(\beta-1)(X^* - X_0)^{\beta-2} - \frac{k}{(2k+1)}\alpha_P} - 1 \right]. \quad (14)$$

From $\lim_{\sigma \rightarrow 0, k \rightarrow \infty} \frac{dX^*(\sigma)}{d\sigma} = +\infty$ and $\lim_{\sigma \rightarrow 0, k \rightarrow \infty} X^*(\sigma) = X_0$, $\lim_{\sigma \rightarrow 0, k \rightarrow \infty} \alpha_P(\sigma) = 0$, $\lim_{\sigma \rightarrow 0, k \rightarrow \infty} \frac{da_P}{d\sigma} = \frac{1}{2}$ it follows that

$$\lim_{\sigma \rightarrow 0, k \rightarrow \infty} \frac{\partial \Pi_{D_i}^*}{\partial \sigma} = +\infty.$$

Hence, retailers' profits are increasing in σ when rivalry is very weak (σ small and k large). Moreover, $\lim_{\sigma \rightarrow \infty} \Pi_{D_i}^* = 0$, 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 (10),

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

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:

$$\begin{aligned} \frac{\partial CS(\sigma, k)}{\partial k} &= \frac{k^2 X^*}{(2k+1)^2} \frac{\partial X^*(k)}{\partial k} + \frac{X^{*2} k}{(2k+1)^3} > 0 \\ \frac{\partial \tilde{\Pi}^*(\sigma, k)}{\partial k} &= \frac{kX^*}{(2k+1)} \frac{\partial X^*(k)}{\partial k} + \frac{X^{*2}}{2(2k+1)^2} > 0 \\ \frac{\partial \Pi_{D_i}^*(\sigma, k)}{\partial k} &= \frac{1}{2} \left[(1 - \alpha_P) \frac{\partial \tilde{\Pi}^*(X)}{\partial X} \frac{\partial X^*}{\partial k} - \tilde{\Pi}^* \frac{\partial a_P}{\partial k} \right] > 0 \end{aligned}$$

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

latters' profits cannot but increase.

By the envelope theorem,

$$\begin{aligned}
\frac{\partial \Pi_P^*}{\partial k} &= \frac{\partial a_P}{\partial k} \tilde{\Pi}^* + \alpha_P \frac{\partial \tilde{\Pi}(k)}{\partial k} \\
&= \frac{-4(\sigma + 1)}{(4k + \sigma + 2k\sigma + 1)^2} \frac{X^{*2}k}{2(2k + 1)} + \frac{\sigma + 2k\sigma + 1}{(4k + \sigma + 2k\sigma + 1)} \frac{X^{*2}}{2(2k + 1)^2} \\
&= \frac{X^{*2}(4k^2(\sigma^2 - 2) + 4k\sigma(\sigma + 1) + (\sigma + 1)^2)}{2(2k + 1)^2(4k + \sigma + 2k\sigma + 1)^2}
\end{aligned}$$

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

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

Lemma 1.

Proof. Fix a division of the surplus $(\Pi_P(X), \Pi_{D_1}(X), \Pi_{D_2}(X))$ (with $\Pi_P(X) + \Pi_{D_1}(X) + \Pi_{D_2}(X) = \tilde{\Pi}(X)$). We construct equilibrium strategies such that in every period the retailers offer contracts implementing $(\Pi_P(X), \Pi_{D_1}(X), \Pi_{D_2}(X))$, P accepts and chooses quantities accordingly. Strategies are represented as automata²² with three states: the normal state \mathcal{N} , the producer's punishment state \mathcal{P} , and the retailers' punishment state \mathcal{D} . Roughly speaking, in state \mathcal{N} players play subgame perfect equilibrium strategies that implement $(\Pi_P(X), \Pi_{D_1}(X), \Pi_{D_2}(X))$; in state \mathcal{P} players play strategies implementing the lowest subgame perfect equilibrium payoff for P ; similarly, in state \mathcal{D} players play strategies implementing the minimum subgame perfect equilibrium payoff for D_1 and D_2 . Play starts in the normal state \mathcal{N} and, from any state, play switches to the state punishing deviator i as soon as i has deviated.

We describe the candidate equilibrium strategies as finite automata. In state $\mathcal{S} \in \{\mathcal{N}, \mathcal{P}\}$ each retailer D_i is supposed to offer "locally truthful" contracts of the form

$$t_i^{\mathcal{S}}(q_1, q_2) = \begin{cases} R_i(q_1, q_2) - \Pi_{D_i}^{\mathcal{S}}, & \text{if } q_j > 0 \\ R_i(q_1, q_2) - \bar{\Pi}(X), & \text{if } q_j = 0 \end{cases}$$

where $\Pi_{D_i}^{\mathcal{N}} = \Pi_{D_i}(X)$, $\Pi_{D_i}^{\mathcal{P}} = \frac{1}{2}\tilde{\Pi}(X)$, and P is supposed to accept such offers and choose (q_1, q_2) optimally, yielding the instantaneous payoff distribution $(\tilde{\Pi}(X) - \Pi_{D_1}(X) - \Pi_{D_2}(X), \Pi_{D_1}(X), \Pi_{D_2}(X))$ in state \mathcal{N} and distribution $(0, \frac{1}{2}\tilde{\Pi}(X), \frac{1}{2}\tilde{\Pi}(X))$ in state \mathcal{P} . If a retailer deviates in state \mathcal{N} or \mathcal{P} the transition to state \mathcal{D} is immediate.

²²See, for example, Osborne and Rubinstein (1990).

diate. This means that if the state is \mathcal{N} (or \mathcal{P}) when P has to respond, the offered pair of contracts must be $(t_1^{\mathcal{N}}, t_2^{\mathcal{N}})$ (or $(t_1^{\mathcal{P}}, t_2^{\mathcal{P}})$), otherwise the state should be \mathcal{D} . On the other hand, if a retailer deviates in state \mathcal{D} , the state does not change; therefore any pair of offers (t_1, t_2) can be on the table in state \mathcal{D} when P has to respond. The candidate equilibrium prescribes that in state \mathcal{D} each retailer D_i offers $t_i^{\mathcal{D}}(q_1, q_2) = R_i(q_1, q_2)$, and that P accepts (t_1, t_2) in state \mathcal{D} if and only if it can obtain the whole surplus $\tilde{\Pi}(X)$. The following table describes the candidate equilibrium:

State	Pl.	Stage-game strategy	transition
\mathcal{N}	D_i	offer $t_i^{\mathcal{N}}(q_1, q_2)$	if D_i deviates, go to \mathcal{D}
\mathcal{N}	P	accept $t_1^{\mathcal{N}}$ and $t_2^{\mathcal{N}}$, choose (q_1, q_2) optimally	if P deviates, go to \mathcal{P}
\mathcal{P}	D_i	offer $t_i^{\mathcal{P}}(q_1, q_2)$	if D_i deviates, go to \mathcal{D}
\mathcal{P}	P	accept $t_1^{\mathcal{P}}$ and $t_2^{\mathcal{P}}$, choose (q_1, q_2) optimally	stay in \mathcal{P}
\mathcal{D}	D_i	offer $t_i^{\mathcal{D}}(q_1, q_2) = R_i(q_1, q_2)$	stay in \mathcal{D}
\mathcal{D}	P	accept t_1, t_2 iff $\max_{q_1, q_2} \sum_i t_i(q_1, q_2) - C(q_1 + q_2) \geq \tilde{\Pi}(X)$	if P deviates, go to \mathcal{P}

If no player can profit from one-shot deviations, the one-shot-deviation principle implies these strategies form a subgame perfect equilibrium of the repeated game. We therefore verify that no player can profit from one-shot deviations. If a retailer deviates the state switches immediately to \mathcal{D} , P accepts only if it gets at least $\tilde{\Pi}(X)$, and the continuation value from the following period is zero. Therefore the value of a retailer's deviation is at most zero whereas the value of the equilibrium offer is at least zero.

The candidate equilibrium strategies are defined so that, if P accepts only one contract in state \mathcal{N} and \mathcal{P} , it gets zero instantaneous profit and zero continuation payoff. Thus the value of rejecting one contract or both is zero. It follows that in state \mathcal{P} the producer is indifferent because it gets zero whatever it does. In state \mathcal{N} the producer is (weakly or strictly) better off accepting both contracts.

We now consider P 's incentives in state \mathcal{D} . Clearly P is worse off by rejecting a pair of contracts that yield at least $\tilde{\Pi}(X)$. If the the offered contracts yield less than $\tilde{\Pi}(X)$, then the value of acceptance is bounded above by $\tilde{\Pi}(X)$, whereas the value of rejection is $\frac{\delta}{1-\delta}\tilde{\Pi}(X)$. Therefore P is better off rejecting (as the candidate equilibrium prescribes) if $\delta \geq \frac{1}{2}$. ■

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:

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

The FOCs are given by:

$$\begin{aligned} \frac{\partial \Pi_P}{\partial X} &= \alpha_P \frac{\partial \tilde{\Pi}(X, k)}{\partial X} - \beta(X - X_0)^{\beta-1} = 0 \\ &= X \frac{k}{(2k+1)} \frac{\sigma + 2k\sigma + 1}{(4k + \sigma + 2k\sigma + 1)} - \beta(X - X_0)^{\beta-1} = 0 \end{aligned} \quad (15)$$

$$\begin{aligned} \frac{\partial \Pi_P}{\partial k} &= \alpha_P \frac{\partial \tilde{\Pi}(X, k)}{\partial k} + \tilde{\Pi} \frac{\partial \alpha_P}{\partial k} - r = 0 \\ &= \frac{X^2 (4k^2(\sigma^2 - 2) + 4k\sigma(\sigma + 1) + (1 + \sigma)^2)}{2(2k+1)^2(4k + \sigma + 2k\sigma + 1)^2} - r = 0 \end{aligned} \quad (16)$$

Inspection of (16) 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 (15), one obtains the optimal level of quality for given k , denoted as $X(k)$. Similarly, from (16), 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

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

Since $\frac{\partial^2 \Pi_P}{\partial^2 k} < 0$ in a neighborhood of the optimal level of k , and since equation (16) implies $4k^2(\sigma^2 - 2) + 4k\sigma(\sigma + 1) + (1 + \sigma)^2 > 0$, it follows that $\frac{dk(X)}{dX} > 0$.

In turn, we have already proved that

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

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 (11) we already know that an increase in σ shifts upward $X(k)$. From (16) it follows that an increase in σ shifts upward also $k(X)$:

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

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

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