Available online at www.sciencedirect.com
ScienceDirect
European Economic Review 51 (2007) 647–667
EUROPEAN ECONOMIC REVIEW
www.elsevier.com/locate/eer

Buyer power and supplier incentives

Roman Inderst[a,*], Christian Wey[b,c,d]

[a]Department of Economics and Department of Accounting and Finance, London School of Economics, Houghton Street, London WC2A 2AE, UK
[b]Deutsches Institut fuer Wirtschaftsforschung (DIW Berlin), Koenigin-Luise-Str. 5, 14195 Berlin, Germany
[c]Technische Universitaet Berlin, Berlin, Germany
[d]CEPR, London, UK

Received 4 August 2004; accepted 2 February 2006
Available online 2 May 2006

Abstract

This paper analyzes the origins and welfare consequences of buyer power. We show that if suppliers are capacity constrained or have strictly convex costs, there are two different channels through which large buyers can obtain more favorable terms from their suppliers. In particular, we show how the presence of large buyers can then erode the value of suppliers' outside option. Somewhat surprisingly, we show how this can induce suppliers to undertake strategies that lead to higher output and potentially higher welfare.

JEL classification: L12; L41; D43

Keywords: Buyer power; Merger; Retailing

1. Introduction

In many industries, suppliers are confronted with increasingly powerful buyers. According to studies of the European Commission and the OECD, the grocery retail market in several states of the European Union is now dominated by a small number of large retailers, which are also increasingly active across borders.[1] Retailers' buyer power has also played a major role in recent antitrust cases in Europe (e.g., Kesko/Tuko and

*Corresponding author. Tel. : +44 20 7955 7291.
E-mail addresses: r.inderst@lse.ac.uk (R. Inderst), wey@wz-berlin.de (C. Wey).
[1]See European Commission (1999) and OECD (1999).

0014-2921/$ - see front matter © 2006 Published by Elsevier B.V.
doi:10.1016/j.euroecorev.2006.02.002

Carrefour/Promodes),[2] while in the U.K. antitrust authorities thought it necessary to introduce a Code of Practice to protect suppliers from the supposedly opportunistic behavior of dominant retailers.[3] Though market concentration in retailing is generally lower in the U.S., concern about buyer power has also been on the rise.[4]

This paper isolates two sources of buyer power: one related to the demand side and one related to the supply (or production) side. Both channels are present whenever suppliers either have strictly convex costs or are capacity constrained. First, under relatively standard conditions on demand, we find that the supplier's loss from a disagreement increases *more than proportionally* with the size of the respective buyer. The threat of not purchasing is thus more effective for larger buyers. Intuitively, this follows as disagreement with a larger buyer ''frees up'' more of the supplier's capacity, which the supplier can then only sell by marching far more down the remaining buyers' declining marginal surplus functions.[5] By the second channel, if a supplier has strictly convex costs then a large buyer essentially negotiates over a range of production where average incremental costs are lower. Again, this allows a larger buyer to obtain a discount.

Our subsequent analysis of the supplier's incentives follows these two channels of buyer power. If a supplier faces fewer but larger buyers, his bargaining position depends crucially on how well the supplier can cope with being cut off from a *large* fraction of the market following disagreement. Consequently, when facing larger buyers a supplier will want to invest more in product or process innovation that allows to accommodate even the loss of a large individual order by increasing the sales to other buyers. We show how this can lead to more product innovation. Following our alternative channel of buyer power, when negotiating with fewer but larger buyers a supplier can share less of its incremental costs at high quantities and more of its incremental costs at low quantities. We show how this can stimulate process innovation, leading to an increase in total output and thus to a decrease in deadweight loss.

Summing up, the paper's contributions are thus twofold. First, we isolate two sources of buyer power that are present when suppliers have strictly convex costs or are capacity constrained. Secondly, we investigate how the formation of larger buyers can affect a supplier's investment strategies. Formally speaking, with few large buyers a supplier has more incentives to both ''flatten'' his cost function (or, likewise, to increase capacity) and to ''flatten'' buyers' revenue functions. As we illustrate with two examples, this may lead to more investment and may potentially increase welfare. Our results thus suggest that claims of how buyer power can reduce upstream investment incentives may have to be qualified.[6] As discussed at length below, a potentially important distinction may have to be made between incentives for incremental innovations and incentives to undertake ''big'' innovations. While the presence of larger buyers may stimulate incremental

[2]Kesko/Tuko (EC/DGIV, 1999, Case no. IV/M.784) and Carrefour/Promodes (EC/DGIV, 2000, Case no. COMP/M.1684).

[3]See Competition Commission (2000).

[4]See, for instance, FTC (2001). Recently, there has also been increasing interest in understanding negotiations between powerful media companies (the ''retailers'') and providers of content or advertisers (e.g., Dukes and Gal-Or, 2003).

[5]We owe this formulation for our first result to the survey in Snyder (2005).

[6]For instance, a report prepared for the European Commission suggests that when facing powerful buyers suppliers may ''reduce investment in new products or product improvements, advertising and brand building'' (European Commission, 1999, p. 4).

investments, it may stifle non-incremental investments including new product development and entry.

There is a growing literature on the origins and consequences of buyer power.[7] In one part of the literature, buyer power and its effects rest squarely on the use of linear (wholesale) prices (e.g., von Ungern-Sternberg, 1996; Dobson and Waterson, 1997). In another strand of the literature, buyers' size creates power as either buyers or suppliers are risk averse (Chae and Heidhues, 2004; DeGraba, 2003). Further, in Katz (1987) and Inderst and Wey (2005) a larger buyer can more credibly threaten to integrate backwards, while in Snyder (1996) the larger buyer's order can destabilize collusion among suppliers. There are also some theories that are more focused on retailing as buyer power derives, for instance, from performing a "gatekeeping" role in local markets (Mazzarotto, 2003) or from committing to stock only one good (in a given category) at all outlets (Inderst and Shaffer, 2003). Finally, the role of convex costs in our model is similar to Chipty and Snyder (1999) and Inderst and Wey (2003).[8] On the other hand, the demand-side channel of buyer power is to our knowledge entirely new to the literature. As we discuss below, this is due to previous restrictions to only two buyers, single-unit supply, or certain types of contracts.[9]

The rest of this paper is organized as follows. Section 2 presents the model and derives conditions under which buyer power arises. Section 3 applies these results to study the investment incentives of a supplier. Section 4 contains a discussion of our results and Section 5 concludes.

2. A model of buyer power

2.1. The economy

We consider a single supplier producing the quantity x of some input to an intermediary industry. The supplier's production technology is described by the twice continuously differentiable cost function $C(x)$ with $C(0) = 0$. We allow both for the case where x is unconstrained and for the case where the supplier's capacity has an upper boundary denoted by X. Inputs are used by $N \geqslant 2$ downstream firms. Firms in the intermediary industry have identical production functions. As in Katz (1987), we assume that firms transform one unit of the input into one unit of the output at no additional costs.[10] The N downstream firms serve N independent markets characterized by the same inverse demand function $P(x)$, which satisfies $P(0) > 0$ and is twice continuously differentiable and strictly decreasing where positive. We denote revenues generated at each outlet by $R(x) := xp(x)$.

[7] Recent surveys are Snyder (2005) and Inderst and Shaffer (2005).

[8] More generally, what drives the discount is the concavity of the surplus function. This concept has also been used outside the buyer power literature, e.g., by Stole and Zwiebel (1996) for intra-firm bargaining. Interestingly, both Stole and Zwiebel (1996) and Inderst and Wey (2003) use the Shapley value, which Inderst and Wey (2003) also derive endogenously. Under the Shapley value, with more than two downstream firms convex costs are no longer sufficient to obtain a discount for large buyers.

[9] More generally, the interaction of market structure and investment incentives has also been studied in the literature on vertical integration (e.g., Bolton and Whinston, 1993), though our focus on the formation of larger buyers is different.

[10] Given symmetry of production functions, this specification is not important for our results. A natural example where this specification is reasonable is that of retailing.

Importantly, some downstream firms (or outlets) may belong to the same owner. Given symmetry, the market for inputs is thus fully described by some set of buyers $i = 1, \ldots, I$ and the corresponding numbers r_i of firms that each buyer i controls.

The specification of the simple production technology and the symmetry assumption are made to facilitate the exposition of our results. The restriction to a single supplier and to independent downstream markets allows us to focus exclusively on the interaction on the upstream market. In Section 4 we show how our results still hold if downstream firms have access to another, albeit inferior, source of supply. However, we do not consider the case where multiple suppliers can invest in a race to gain patronage at different buyers (see also the Conclusion).

2.2. Negotiations

Supply contracts are determined in bilateral negotiations.[11] Each buyer negotiates separately with the supplier. We allow bilateral contracts to be sufficiently complex to rule out problems of double marginalization. A contract with buyer i, which purchases inputs for the r_i firms (or markets) that it controls, specifies a menu of prices $t_i(x)$ as a function of the supplied quantity x.[12] After signing the contracts, we let the supplier choose a vector of supply quantities. This feature of our model is discussed below. As there is no uncertainty in our model, in equilibrium each buyer will receive a deterministic quantity of supply. We denote this quantity by $\bar{x}_i$ and the respective transfer by $\bar{t}_i = t_i(\bar{x}_i)$.

To model simultaneous negotiations between the supplier and the various buyers we can imagine that the supplier employs I agents (or "account managers"). Each agent negotiates independently over the respective menu $t_i(x)$, forming rational expectations about the outcomes in all other negotiations. In equilibrium, the transfer $\bar{t}_i$ is chosen such that the respective buyer receives the fraction $\rho \in (0, 1]$ of the generated net surplus.[13]

Our specifications do not yet fully pin down a unique equilibrium. This follows as, given the deterministic nature of the model, transfers $t_i(x)$ for all quantities $x \neq \bar{x}_i$ are irrelevant in equilibrium. They are, however, relevant off equilibrium as they determine the supplier's outside option if there is disagreement with an individual buyer. We require that $t_i(x)$ is chosen so as to truthfully reflect the valuation of the respective buyer i. To formalize this specification, note first that optimally buyer i will allocate a supplied quantity x symmetrically over all r_i markets. Hence, to truthfully reflect the buyer's valuation, $t_i(x)$ must for all quantities x' and x'' satisfy the requirement[14]

$$t_i(x'') - t_i(x') = r_i[R(x''/r_i) - R(x'/r_i)]. \tag{1}$$

Imposing the truthfulness requirement (1) is natural in our model. As we show below, it implies that bilateral supplies are chosen to maximize total industry profits both on and

[11] Bilateral negotiations stand in sharp contrast to the " textbook" view of monopsonistic power. Under the latter view, buyer power is exercised by withholding demand so as to reduce the (uniform) purchase price prevailing on the upstream market. In contrast, our view is that buyer power manifests itself via more favorable terms for the more powerful buyer. See Inderst and Shaffer (2005) for a more detailed discussion.

[12] The choice of menus in supply contracts is common in the literature. See, for instance, O'Brien and Shaffer (1997). See also the discussion in Section 2.5.

[13] We combine both non-cooperative and cooperative concepts, which is common in the literature and allows us to obtain a parsimonious model of negotiations.

[14] The use of the truthfulness requirement follows Bernheim and Whinston (1986).

off equilibrium, i.e., both if all negotiations were successful and in case there was disagreement with a subset of buyers. Hence, there will be no scope for mutually beneficial renegotiations.[15]

2.3. Equilibrium

Suppose the supplier serves only n out of the total N downstream firms—a case that will not arise in equilibrium but that is important off equilibrium as it determines the supplier's outside option. Denote by $x_n^*>0$ for $n>0$ the respective quantity that maximizes total industry profits, where we assume for simplicity that x_n^* is uniquely determined. By symmetry and as the inverse demand function is downward sloping, total industry profits are maximized by supplying x_n^*/n to each of the remaining n firms. The revenues that are realized at each firm equal $R_n^*:=(x_n^*/n)P(x_n^*/n)$ and total industry profits equal $\Pi_n^*:=nR_n^* - C(x_n^*)$.

By the truthfulness requirement, the supplier fully internalizes all changes to revenues and costs when choosing supplies. As a consequence, in equilibrium each buyer i will purchase the supply $\bar{x}_i = x_N^* r_i/N$, while the analogous result holds off equilibrium for all buyers $i \in I'$ if there was only agreement with these buyers.

Lemma 1. *If there is agreement (only) with a set of buyers $I' \subseteq I$, the total quantity x_n^* is produced, where $n = \sum_{i \in I'} r_i$, and buyer $i \in I'$ purchases the quantity $x_n^* r_i/n$.*

By Lemma 1 the distribution of the N downstream firms over some I buyers has no implications for equilibrium quantities. However, it will be important for how industry profits are shared between buyers and the supplier.

Proposition 1. *A buyer controlling r_i downstream firms obtains the fraction ρ of the respective incremental contribution to total industry profits, which equals $\rho[\Pi_N^* - \Pi_{N-r_i}^*]$. The supplier's total profits are then given by*

$$\Pi_N^* - \rho \sum_{i=1}^{I} [\Pi_N^* - \Pi_{N-r_i}^*]. \tag{2}$$

Proof. See Appendix.

Note that for $\rho = 0$, where the supplier has all bargaining power, the supplier's profits are just equal to total industry profits, Π_N^*. At the other extreme, where $\rho = 1$, each buyer can extract its full net contribution. The derivation of Proposition 1 comes, however, with one caveat. It is assumed that the supplier's profits in (2) are non-negative. This is in turn surely the case if industry profits Π_n^* are concave in n. In what follows, this is the case to which we want to restrict our analysis. As we show below, the condition that Π_n^* is concave is also both necessary and sufficient to ensure that the formation of larger buyers reduces the supplier's profits. Proposition 2 below derives conditions on when Π_n^* is indeed concave.

[15]Following Klemperer and Meyer (1989), we could also justify the truthfulness requirement by introducing some (ex ante) uncertainty. In our case, this uncertainty would have to be over the supplier's costs of production. Condition (1) would then guarantee that total industry profits are maximized irrespective of the realized shock to $C(x)$.

2.4. The origins of buyer power

Using Proposition 1, we now ask when a larger buyer can obtain a more favorable deal. Denote by τ_i the average (or unit) price paid by buyer i. From Proposition 1 we obtain that the buyer's margin is then equal to

$$P(x_N^*/N) - \tau_i = \rho \frac{\Pi_N^* - \Pi_{N-r_i}^*}{r_i} \frac{N}{x_N^*}. \tag{3}$$

Hence, we have from (3) that larger buyers obtain a discount whenever the term $[\Pi_N^* - \Pi_{N-r_i}^*]/r_i$ strictly increases in the number of controlled firms r_i. Note also that the average purchase price of some buyer i is independent of the size of other buyers. Hence, the model does not support the argument of a "waterbed" effect, according to which a supplier that must leave a discount to large (or otherwise more powerful) buyers will try to make up for this by charging higher prices to smaller buyers. Likewise, in our model the "countervailing power" of large buyers does also not confer benefits on smaller buyers.[16]

A larger buyer can be formed through a merger among, say, a subset I' of buyers, in which case the buyers in I' are replaced by a single new buyer controlling the number $\sum_{i\in I'} r_i$ of firms. In a more subtle way, a larger buyer can also arise if a smaller buyer sells assets (i.e., firms in our model) to a larger buyer. Precisely, suppose buyer i sells to buyer j the number r of firms, where $r_j \geqslant r_i \geqslant r$. Using Proposition 1, this change makes the supplier strictly worse off, if and only if

$$\Pi_{N-r_i+r}^* - \Pi_{N-r_i}^* < \Pi_{N-r_j}^* - \Pi_{N-r_j-r}^*. \tag{4}$$

For (4) to hold we need a stronger condition than monotonicity of $[\Pi_N^* - \Pi_{N-r_i}^*]/r_i$, which merely guaranteed the existence of a discount to larger buyers. For (4) to hold it is sufficient that industry profits Π_n^* are strictly concave in the number of firms n.[17] We thus have the following implications of Proposition 1.

Corollary 1. *If total industry profits are strictly concave in the number of served firms, a larger buyer gets a discount, which is higher the larger his share of the supplier's business. Formally, $r_i > r_j$ implies $\tau_i < \tau_j$. Moreover, the supplier is strictly worse off after the creation of a larger buyer, either through a merger or through a (partial) sale of assets (firms).*

The role of the concavity of Π_n^* is intuitive. If Π_n^* is concave, a buyer's net contribution to industry profits increases more than proportionally with the buyer's size. What we would like to know, however, are the conditions under which Π_n^* is concave. In what

[16] Interestingly, Chen (2003) shows that under specific assumptions also the opposite to a "waterbed" effect can arise if firms compete downstream. In his model, the supplier first sets a linear price for a fringe market before negotiating with a single, large buyer. Chen (2003) models buyer power by varying the fraction of the large buyer's share ρ and shows that an increase induces the supplier to offer a lower (uniform) wholesale price to the competitive fringe.

[17] Formally, using that Π_n^* is twice continuously differentiable given the assumptions on $P(x)$, $C(x)$, and x_n^*, (4) can be written as

$$\int_0^r \left[\int_{N-r_j-r+y}^{N-r_i+y} \frac{\mathrm{d}^2 \Pi_n^*}{\mathrm{d}n^2} \, \mathrm{d}n \right] \mathrm{d}y < 0.$$

Note that we use here that Π_n^* is well defined for all real $n > 1$.

follows, we discuss separately conditions relating to demand and conditions relating to supply (costs).

2.4.1. Demand characteristics

To isolate our demand-side channel of buyer power, suppose the supplier has zero costs of production but only low total capacity X such that we have $\Pi_n^* = nR(X/n)$ for all $n \leqslant N$. Consequently, if negotiations with some buyer i break down, the supplier shifts the freed-up capacity to the remaining $N - r_i$ firms. As demand is strictly decreasing, this reduces the final price and ultimately reduces total revenues by the amount

$$NR(X/N) - (N - r_i)R(X/(N - r_i)), \tag{5}$$

i.e., by the difference between N times firm revenues if X/N is supplied to each firm and $N - r_i$ times firm revenues if $X/(N - r_i)$ is supplied to each firm. From the truthfulness requirement, the supplier fully bears this loss in revenues.[18] Consequently, larger buyers will obtain a discount in case the loss for the supplier—as expressed in (5)—increases more than proportionally with the buyer's size. As is easily checked and as we show formally below, this is always the case if revenues are strictly concave, which is a common assumption.

Summing up, our model supports the idea that larger buyers receive a discount as by withdrawing their business they can *inflict a more than proportional loss* on the supplier. Such a notion of buyer power has been frequently invoked in antitrust cases, e.g., in recent merger and acquisition cases in the U.S. health industry.[19]

2.4.2. Technology characteristics

To isolate this channel of buyer power, we want now to abstract from the previously identified demand-side channel. For this purpose, we make the following extreme assumptions on demand. Each firm can sell some small quantity $\tilde{x} > 0$ at any price that does not exceed $\tilde{p} > 0$, while any price below $\tilde{p}$ will also not push up demand above $\tilde{x}$. (That is, demand at each firm has a "rectangular" shape.) Total industry profits are then $\Pi_n^* = n\tilde{x}\tilde{p} - C(n\tilde{x})$.

When negotiating with a buyer that controls r_i firms, the net surplus that is at stake is then

$$r_i\tilde{x}\tilde{p} - [C(N\tilde{x}) - C((N - r_i)\tilde{x})], \tag{6}$$

i.e., the additional revenues $r_i\tilde{x}\tilde{p}$ from selling $\tilde{x}$ more units minus the additional costs incurred by producing these units. We know that the supplier extracts the fraction ρ of the incremental surplus (6), which can be decomposed into the share ρ of revenues $r_i\tilde{x}\tilde{p}$ minus the share ρ of incremental costs $C(N\tilde{x}) - C((N - r_i)\tilde{x})$. Note that our extreme assumptions on the demand function ensure that revenues are now exactly proportional to the buyer's

[18] This argument also suggests that the demand-side channel will still be there even if the supplier does not extract (or lose) all of the incremental revenues, as implied by the truthfulness requirement. See also the discussion in Section 2.5.

[19] For instance, this was the case in Aetna's acquisition of Prudential's health insurance business (United States, et al. v. Aetna, Inc, et al., no. 3-99CV1398-H (N.D. Tex.) (complaint filed June 21, 1999)). According to Schwartz (1999, p. 8), it was argued that "a physician's costs of replacing patients unexpectedly can increase by more-than-proportionally with the number of patients that must be replaced. ... (T)he physician's increased prospective loss per patient if dropped by Aetna increases Aetna's ability to force the physician to accept a lower price post merger."

size. This shuts down our demand-side channel of buyer power. On the other side, if $C(x)$ is strictly convex the incremental costs it takes to serve the buyer increase *less than proportionally* with the buyer's size. Formally, for convex costs we have that $[C(N) - C((N - r_i))\tilde{x}]/r_i$ is decreasing in r_i and that large buyers again obtain a discount. This result has again a straightforward intuition. A small buyer negotiates more "on the margin", where incremental costs are high. In contrast, the purchase volume of a larger buyer spans a wider production interval, where average incremental costs are smaller.

It is important to note that this "supply-side" channel of buyer power does not work through the outside options. This can be contrasted with the preceding "demand-side" channel, which works through the supplier's outside option. In Section 4 we compare both channels to alternative theories, including those where size generates a discount through affecting the *buyers*' outside option.

2.4.3. Generalization

Using our previous arguments, we ask now more generally when the conditions of Corollary 1 are satisfied such that a larger buyer obtains a discount.

Proposition 2. *We obtain the following sufficient conditions for buyer power to arise, i.e., for Corollary* 1 *to hold*:

(i) *It is sufficient that the supplier's costs are strictly convex and revenues at downstream firms are strictly concave.*
(ii) *It is also sufficient that total capacity is sufficiently constrained, while costs are convex* (*including linear*) *and revenues strictly concave.*

Proof. See Appendix.

The proof of Proposition 2 yields also the following intuitive insights. First, if revenues $R(x)$ are linear, all buyers obtain the same terms, irrespective of the shape of the cost function.[20] This is intuitive as a linear revenue function implies that each firm can sell any quantity (in the relevant range) at a fixed price. With a constant price, however, each buyer is perfectly substitutable. Another insight of Proposition 2 is that there is no large-buyer discount if costs are linear and capacity is not (sufficiently) constrained. Intuitively, with unconstrained supply and linear costs the outcome of individual negotiations is fully independent of what happens at other negotiations. That is, neither the supplier's incremental costs nor the optimally supplied quantity depend on the outcomes of other negotiations.

How big is the discount obtained by a larger buyer? By (3) the difference in the respective margins is strictly increasing in ρ. That is, the discount increases with the share of the incremental surplus that is appropriated by each buyer. If ρ captures all not explicitly modeled factors that have an impact on how profits are shared in the vertical chain, the large-buyer discount should thus be higher the more powerful buyers already are. We have more to say on variations of ρ in the following section.

One caveat of our approach is that while it delivers clear and plausible results for when industry profits Π_n^* are concave in n, it cannot be generally extended to the case where Π_n^* is convex. One case where Π_n^* could become convex is that of strictly concave costs. With a

[20] For instance, we could imagine that each firm is located in a different country where it acts as a pure price taker.

strictly convex Π_n^* and high ρ, the supplier's profits in (2) may no longer be non-negative. This is intuitive as in each bilateral negotiation the respective buyer can extract a share of the incremental profits. If Π_n^* is strictly convex, then Π_N^* is strictly smaller than the sum of all respective increments over which the I buyers negotiate.[21]

2.5. Discussion

The chosen bargaining solution has two major features. First, as negotiations are over menus, disagreement with any individual buyer i leads to the adjustment of supplies made to other buyers $j \neq i$. Second, by the truthfulness requirement the supplier captures all incremental surplus from these adjustments. How important are these specifications?

Suppose first that supplies to other buyers cannot be adjusted after disagreement with one buyer. In the terminology of bilateral markets, we thus assume "quantity-forcing" contracts, which specify a fixed transfer t_i in exchange for a fixed quantity x_i. It is straightforward to show that there still exists an equilibrium where total industry profits are maximized as each buyer i purchases the quantity $r_i(x_N^*/N)$.[22] The corresponding transfer t_i is chosen such that the buyer obtains the fraction ρ of the respective net surplus, which given that supplies are not adjusted after disagreement is now equal to

$$r_i R\left(\frac{x_N^*}{N}\right) - \left[C(x_N^*) - C\left(x_N^* \frac{N - r_i}{N}\right)\right]. \tag{7}$$

Using (7), it follows from our previous arguments that convex costs are now a sufficient condition for large buyers to obtain a discount. But the demand-side channel of buyer power is no longer present with quantity-forcing contracts. This is intuitive as the supplier realizes the same revenues $r_i R(x^*/N)$ with each buyer i regardless of whether the supplier was successful in negotiating with all other buyers or whether some negotiations resulted in disagreement. However, it seems quite an extreme assumption that despite potentially large gains after disagreement with one buyer the supplier does not renegotiate contracts with all other buyers. We can show that once we allow for renegotiations, the demand-side channel of buyer power opens up again.[23]

Finally, one may more generally question the assumption of contracting over menus. The opposite assumption that one encounters in the literature is that of linear contracts (or wholesale prices), which leads to a well-known problem of double marginalization. It is also well known that with linear contracts profits can only be shifted towards downstream firms by reducing the purchasing price per unit, which in turn reduces the double-marginalization problem and thus reduces the deadweight loss. As an example,

[21] This problem is shared with many other multi-party bargaining solutions. For a particular application to worker-firm bargaining, Horn and Wolinsky (1988) suggest a modification, which essentially allows the "affected" parties to still reject *all* deals. With simultaneous negotiations, this would, however, result in multiple equilibria.

[22] Uniqueness can be ensured with concave demand and convex costs. (See also O'Brien and Shaffer (1997), where a single buyer negotiates with several suppliers.)

[23] The omitted material was included in the working paper version and can be obtained from the authors upon request. There, we show that when allowing for one round of renegotiations, Proposition 2 continues to hold. Importantly, when renegotiating contracts the respective parties must take the existing contract (t_i, x_i) as their outside option. This stands in contrast to an approach adopted by DeFontenay and Gans (2001), where in the spirit of the worker-firm bargaining model in Stole and Zwiebel (1996) a single disagreement renders all old contracts void.

contracts between large manufacturers and large retailers seem to be often very complex and include, for instance, volume discounts, slotting fees (to obtain shelf space), pay-to-stay fees (for continuation of stocking), display fees (e.g., for end-aisle caps), or presentation fees (for making a sales presentation). Moreover, recent econometric studies by Bonnet et al. (2004) for bottled water in France and by Berto Villas-Boas (2004) for yoghurt in the U.S. suggest that non-linear pricing is pervasive.[24]

3. Supplier incentives and welfare

3.1. General analysis

We now build on the two channels of buyer power to investigate the key question this paper seeks to address: How does the formation of larger and stronger buyers affect the supplier's incentives for product and process innovation?

The main assumption in the following analysis is that the supplier's choice is non-contractible. This rules out bilateral or multilateral agreements with a subset of buyers by which the supplier could be bribed into choosing particular technologies or products. One justification is that our focus is more on incremental changes and less on one-off discretionary events (see also further below). Furthermore, ex ante contracting may be difficult due to free-riding or co-ordination problems among many different buyers.[25]

We suppose that the supplier can choose between two strategies, α and β. We make the dependency of industry profits on the supplier's actions explicit by writing $\Pi_n^*(\alpha)$ and $\Pi_n^*(\beta)$, respectively. Suppose the downstream market structure is transformed by moving assets (firms) away from smaller buyers and towards larger buyers. (Note that this includes a full merger of buyers.) For such a shift, we have the following result.

Proposition 3. *Suppose there is a shift from smaller to larger buyers. Then this increases the supplier's incentives to switch from α to β if, for all $n \leqslant N$,*

$$\frac{d^2}{dn^2}\Pi_n^*(\beta) > \frac{d^2}{dn^2}\Pi_n^*(\alpha). \tag{8}$$

Likewise, the supplier's incentives to switch from α to β decrease if the converse to (8) *holds strictly for all $n \leqslant N$.*

Proof. See Appendix.

Note that for condition (8) we treat n again as a continuous variable, which is possible as Π_n^* is defined for all real values $n > 0$. The intuition for Proposition 3 builds squarely on our previous results. We know that a small buyer's incremental contribution is more at the "margin" (e.g., $\Pi_N^* - \Pi_{N-1}^*$ if $r_i = 1$), while a large buyer's incremental contribution arises

[24]Theoretically, it is still an open question under which circumstances we should expect contracts to be "more or less" complex or linear. An exception is Milliou et al. (2004), who consider a model where competing vertical chains first negotiate over a choice of contractual forms, while subsequent negotiations are then only over the precise conditions (e.g., the prevailing uniform price with linear contracts). They show how linear contracts can arise endogenously in such a setting.

[25]In particular for process innovation, it seems also reasonable to appeal to a more standard justification in the incomplete contracting literature, according to which it may be hard and even impossible to contractually stipulate ex ante the specific changes, while outside parties such as courts may lack the special knowledge to verify ex post whether the supplier breached the contract.

more "inframarginally" and thus comprises increments $\Pi_n^* - \Pi_{n-1}^*$ for lower values of n. Note next that if (8) holds, the switch to β leads to a relative increase in incremental profits at higher n, which improves the bargaining position of smaller buyers. But then the switch to β is relatively less attractive for the supplier if there are indeed many small buyers in the market, instead of fewer large buyers.

Unfortunately, Proposition 3 is not very instructive about what kind of strategies, i.e., what kind of process or product innovations, would be spurred in the presence of smaller or larger buyers. To obtain more insights, we have to be more specific about how the supplier's choices affect revenues and costs. We next study separately the case of product innovation, which affects the revenue function $R(x)$ at each firm, and the case of process innovation, which affects the supplier's cost function, $C(x)$.

3.2. *The case of process innovation*

Suppose the supplier can make an investment to switch from the cost function $C(x, \alpha)$ to the cost function $C(x, \beta)$. It is helpful to suppose for a moment that we can represent the shift from α to β by a sequence of more gradual changes, i.e., we take $\alpha < \beta$ to be two real numbers. We obtain that[26]

$$\frac{\mathrm{d}}{\mathrm{d}\alpha}\left[\frac{\mathrm{d}^2}{\mathrm{d}n^2}\Pi_n^*(\alpha)\right] = -\frac{(x_n^*)^2[R''(x_n^*/n)]^2 C''(x_n^*, \alpha)}{n[R''(x_n^*/n) - nC''(x_n^*, \alpha)]^2}\left[\frac{\mathrm{d}C''(x_n^*, \alpha)}{\mathrm{d}\alpha}\right] - \frac{\mathrm{d}x_n^*}{\mathrm{d}\alpha}\frac{\mathrm{d}}{\mathrm{d}x_n^*}\left[\frac{(x_n^*)^2 R''(x_n^*/n) C''(x_n^*, \alpha)}{R''(x_n^*/n) - nC''(x_n^*, \alpha)}\right]. \tag{9}$$

Hence, a shift to β satisfies condition (8) in Proposition 3, i.e., it convexifies the industry profit function, if (9) is strictly positive. Importantly, the first term in (9) is in turn strictly positive if we have that $\mathrm{d}C''(x_n^*, \alpha)/\mathrm{d}\alpha < 0$. If we ignored the second term in (9), we could thus say that the presence of larger buyers makes the supplier want to choose a production technology that has relatively lower incremental costs at high quantities, possibly with the trade-off that the technology has relatively higher (incremental) costs at lower quantities. With each small buyer the supplier can roll over a fraction of the incremental production costs "at the margin", i.e., close to the equilibrium volume x_N^*. For instance, in the case of N small buyers each controlling $r_i = 1$ firms, the supplier is (only) compensated for a fraction of the incremental costs $C(x_N^*) - C(x_{N-1}^*)$.[27] In contrast, more of "inframarginal" but less of "marginal" costs can be rolled over in case the supplier negotiates with fewer but larger buyers.

We illustrate this insight with an example. Precisely, we suppose that the switch is from a strictly convex to a linear cost function. We then have the following results.

Proposition 4. *Suppose the supplier can switch—possibly by incurring a strictly positive investment cost—from some strictly convex cost function $C(x, \alpha)$ to a linear cost function $C(x, \beta)$. We have the following results*:

(i) *In the presence of larger buyers the supplier has strictly higher incentives to switch technologies, i.e., the supplier is willing to incur a strictly higher investment cost.*
(ii) *Whenever the supplier switches this strictly increases welfare.*

[26] This is immediate from results in the proof of Proposition 2.
[27] If $N\rho > 1$, the supplier is in fact over-compensated for this cost increment.

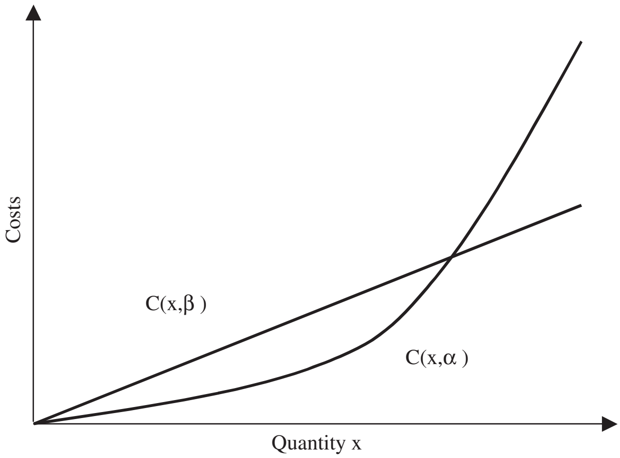

Fig. 1. Technology choice.

Proof. See Appendix.

We may think of β in Proposition 4 as being a more "flexible" technology with respect to an expansion of quantities.[28] Fig. 1 illustrates the choice between technologies α in β. By assertion (ii) we also have that if the presence of larger buyers affects the choice of technology, this unambiguously increases welfare. Intuitively, as total output x_N^* is strictly below the first-best benchmark, a reduction in marginal costs at high quantities that pushes up total output leads to a reduction in deadweight loss.

3.3. The case of product innovation

We next consider the supplier's incentives for product innovation. Suppose the supplier can make an investment to switch from a product with inverse demand $P(x,\alpha)$ to a product with inverse demand $P(x,\beta)$. Again, it is helpful to first suppose that this shift was gradual. Differentiating with respect to α and using $R(x,\alpha):=xP(x,\alpha)$, we obtain that

$$\frac{\mathrm{d}}{\mathrm{d}\alpha}\left[\frac{\mathrm{d}^2}{\mathrm{d}n^2}\Pi_n^*(\alpha)\right] = -\frac{(x_n^*)^2C''(x_n^*)[R''(x_n^*/n,\alpha)-C''(x_n^*)(1+n)]}{[R''(x_n^*/n,\alpha)-nC''(x_n^*)^2]^2}\left[\frac{\mathrm{d}R''(x_n^*/n,\alpha)}{\mathrm{d}\alpha}\right] - \frac{\mathrm{d}x_n^*}{\mathrm{d}\alpha}\frac{\mathrm{d}}{\mathrm{d}x_n^*}\left[\frac{(x_n^*)^2R''(x_n^*/n,\alpha)C''(x_n^*)}{R''(x_n^*/n,\alpha)-nC''(x_n^*)^2}\right]. \tag{10}$$

A shift to β satisfies condition (8) in Proposition 3 if (10) is strictly positive. Recall that in this case the shift is more profitable if buyers are larger. Note next that the first term in (10) is strictly positive if the shift to β increases the derivative $R''(x_n^*/n,\alpha)<0$. This follows again intuitively from our previous discussion of the demand-side channel of buyer power. In the presence of large buyers, the supplier's bargaining position depends crucially on sustaining high revenues even after disagreement with one of the large buyers, i.e., even if

[28]Our results would also not change if we allowed for fixed costs and if the more flexible technology involved higher fixed costs. In particular, as long as $I\geqslant 2$ all fixed costs are always born by the supplier.

the supplier has to sell to the remaining firms quantities that may be substantially above the equilibrium quantities x_N^*/N. In contrast, with small buyers the supplier's outside option is determined only by how well the supplier can cope with losing a small percentage of the total market. Consequently, all that matters for the outside option is how the revenue function looks like relatively "close" to the equilibrium quantity, i.e., in the right-side neighborhood of x_N^*/N.

Again, we cannot generally sign the second term on the right side of (10) and, therefore, proceed with a specific case. In a slight deviation from our original set-up, we now suppose that a downstream firm can use the input x to produce heterogeneous products. The more "versatile" the supplier's input is made, the more heterogeneous are the final products, which expands demand. Precisely, suppose that at each firm $\phi \geqslant 1$ products can be supplied. If x_n^j denotes the supply of good $1 \leqslant j \leqslant \phi$ at firm $n \leqslant N$, prices are given by

$$p_n^j = 1 - x_n^j - \gamma \sum_{1 \leqslant k \leqslant \phi, k \neq j} x_n^k \quad \text{with } 0 \leqslant \gamma \leqslant 1. \tag{11}$$

One unit of the supplier's input is required to produce one unit of product j. For $\gamma < 1$, symmetry implies that a firm optimally allocates a given supply x in equal fractions among the ϕ different products. (For $\gamma = 1$, the allocation is irrelevant as goods are homogeneous.) Consequently, by the inverse demand system (11) the supply of x to any firm generates the revenues

$$R(x) = x\left[1 - \frac{1 + (\phi - 1)\gamma}{\phi} x\right]. \tag{12}$$

Using (12), we can apply all our previous results. Denote now $\psi := [1 + (\phi - 1)\gamma]/\phi$ such that $R(x) = x(1 - \psi x)$. Note that ψ is strictly lower the more heterogeneous (γ) and the more numerous (ϕ) are the uses of the supplier's input. We capture product innovation by letting the supplier switch at costs from α and β, where $\psi_\beta < \psi_\alpha$. To focus on the role of the revenue side, we suppose as in Proposition 2 that the supplier has linear costs, $C(x) = cx$, but that capacity is sufficiently small.

Proposition 5. *Consider the linear example where the supplier can switch at costs from the less versatile product α to the more versatile product β. We have the following results*:

(i) *In the presence of larger buyers the supplier has strictly higher incentives to switch technologies, i.e., the supplier is willing to incur a strictly higher investment cost.*
(ii) *The supplier's incentives to switch are always inefficiently high, implying that the presence of large buyers may lead to a reduction of welfare by increasing the supplier's incentives.*

Proof. See Appendix.

With a more versatile input, revenues at all quantities are higher, but the effect is stronger at large quantities. This, in turn, increases relatively more the supplier's outside option when negotiating with large buyers. In contrast to the case of process innovation in Proposition 4, however, higher incentives for the supplier are not welfare increasing. In fact, the supplier has always inefficiently high incentives to innovate, which are further distorted by the presence of larger buyers. In this sense, the conjecture that buyer power reduces welfare by affecting the supplier's incentives is true, but this is only so *by accident* as the conjecture involves two errors: firstly, in the example the supplier's incentives actually increase and, secondly, higher incentives are bad for welfare.

This highlights also an important difference between the two considered cases of process and product innovation. In the case of process innovation, the presence of larger buyers made the supplier focus more on reducing incremental costs at high quantities, which then pushed up output and reduced deadweight loss. In contrast, in the case of product innovation there is no good guidance as to whether the shift in incentives is likely to increase or to reduce welfare. In fact, in our example it was socially inefficient for the supplier to spend the additional resources. This ambiguity is a well known problem in the literature on product innovation (e.g., Spence, 1976).

4. Discussion

4.1. Alternative sources of buyer power

As discussed in the Introduction, there is a growing literature that tries to identify alternative sources of buyer power. One channel operates through the buyer's *outside option*. That is, depending on its size r_i a buyer has now an outside option of value $V(r_i)\geqslant 0$. It is easy to show that, provided the option is inferior to an agreement with the supplier, the buyer's profits are now given by $\rho[\Pi_N^* - \Pi_{N-r_i}^*] + (1-\rho)V(r_i)$.

Yet another approach to capture buyer power is to consider variations across buyers in the "sharing rule".[29] If we suppose that ρ is a function of (only) the buyer's size, we can thus assume more generally that buyer i can capture the fraction $\rho(r_i)$ of the respective net surplus. Summing up and extending Proposition 1, with these two additional channels of buyer power the margin (3) for buyer i would transform to

$$P(x_N^*/N) - \tau_i = \left[\rho(r_i)\left(\frac{\Pi_N^* - \Pi_{N-r_i}^*}{r_i}\right) + [1-\rho(r_i)]\frac{V(r_i)}{r_i}\right]\frac{N}{x_N^*}. \tag{13}$$

The discount to a larger buyer is thus even higher if $\rho(r_i)$ is strictly increasing and if $V(r_i)/r_i$ is strictly increasing. Importantly, the presence of these two alternative channels of buyer power does not affect the working of the two channels that were identified in this paper. This holds, in particular, for the identified "demand-side channel" of buyer power. This channel works through the outside option of the supplier and not that of the buyer, which is a key novelty in our paper.

To conclude this section, we want to briefly flesh out the buyers' outside option. So far, our supplier was an unconstrained monopolist. Suppose now instead that there was another source of supply. To switch to this source, a buyer has to incur fixed costs $F\geqslant 0$ and can subsequently purchase according to the respective cost function $C_2(x)$. To make agreement with the supplier profitable for all buyers, it must hold that

$$\Pi_N^* - \Pi_{N-r_i}^* \geqslant V(r_i) = \max\left\{\max_x [r_i R(x/r_i) - C_2(x)] - F, 0\right\} \tag{14}$$

[29] Dukes et al. (2006) is another paper that considers changes in both the outside option, to which they refer to as a change in the "bargaining position", and in the sharing rule, to which they refer to as a change in the "bargaining power". We are, however, not aware of formal work that would could link such a shift in the sharing rule to observable characteristics of buyers, say their size or the set of bargaining strategies they can deploy.

for all $i \in I$, where we used on the right-hand side of (14) that after disagreement with the supplier a buyer can always decide to seize operations and realize zero profits.[30] We know that for $V(r_i)$ to be a source of buyer power, $V(r_i)/r_i$ must be strictly increasing in r_i. Inspection of (14) reveals, however, that there are two opposing effects. If $F>0$, then the presence of fixed costs of switching makes the outside option more attractive the larger the buyer. If $C_2(x)$ is strictly convex, however, then this creates an opposing effect. The larger the buyer, the higher are the (off-equilibrium) costs *per unit* that are incurred when switching to an alternative source of supply with strictly convex costs. Consequently and possibly somewhat surprisingly, if alternative sources of supply also exhibit strictly convex costs, it is in general no longer clear whether the presence of a valuable outside option (through the alternative source of supply) creates a large-buyer discount or a large-buyer premium.[31] As noted already above, however, our results on the supplier's incentives are not affected by whether $V(r_i)/r_i$ is zero or whether it is strictly positive and increasing or decreasing.

4.2. *Incremental vs. non-incremental investments*

Our results show that lower profits for the supplier need not imply lower incentives for product or process innovation. For our results it is important that the considered investments are of a more incremental nature. That is, the supplier modifies an existing product or production technology. In stark contrast, the supplier's total profits and only these would matter if we considered "all-or-nothing" strategies such as introducing an entirely new product or entry and exit. Whether antitrust authorities should be more or less concerned with the exercise of buyer should thus hinge much on the relative importance of incremental vs. non-incremental investments, which may in turn depend on industry characteristics such as its maturity.

It is also interesting to compare how other sources of buyer power, which we briefly discussed in the preceding section, affect incentives for both incremental and non-incremental innovations. First, we discussed how a buyer's outside option $V(r_i)$ may depend on its size. While introducing a term $V(r_i)$ in our bargaining solution will thus in general change the level of profits of buyers and the supplier, it is important that these terms are unaffected by both the supplier's product and the supplier's process innovation. Therefore, our results in Propositions 3–5 are unaffected. On the other side, by lowering the supplier's total profits the presence of a more attractive outside option, in particular for large buyers, may reduce the supplier's incentives to introduce new products or to invest in order to stay in the market in the first place. In particular, if $V(r_i)$ is already large for all buyers as attractive substitutes are available, then the formation of a large buyer may "tip the balance" and may make the supplier choose to forego investments that would be necessary to ensure its long-term survival in the market.

We discussed as yet another possibility to account for buyer power an adjustment in the sharing rule $\rho(r_i)$. If $\rho(r_i)$ was strictly increasing, this would provide another source of size-

[30] One interpretation could be that there is a single alternative supplier, which has strictly convex costs $c(x)$ and already supplies $\overline{x}>0$ to other buyers but those in the set I such that $C_2(x) = c(x+\overline{x})$. As is standard in models of competition (or auctions), this alternative supplier "bids" according to its incremental cost function, i.e., again truthfully.

[31] Inderst (2005) explores this in more detail.

related discounts. Without a particular specification of how r_i affects the sharing rule $\rho(r_i)$, it is not possible to analyze to what extent an increase in $\rho(r_i)$ reduces the supplier's incentives. Generally, condition (8) in Proposition 3 is no longer sufficient to unambiguously determine how the supplier's incentives change with the formation of larger buyers.

4.3. Downstream competition

We have so far abstracted from competition on the downstream market. How restrictive is this assumption? Suppose in a first step that the considered N firms are exposed to competition, but that the considered upstream firm only supplies non-competing outlets. Then the N firms still serve independent markets, while the function $P^{-1}(x, \cdot)$ now describes the *residual* demand, taken the equilibrium actions of competitors as given.

Suppose thus next that the N firms compete with each other. A natural case to start with is once again that where contracts are not restricted. In particular, this would allow bilateral supply contracts to also condition on the supplies made to all other firms. This allows firms to jointly achieve the monopoly solution on the downstream market irrespective of the number of independently operating buyers I. Further, both channels of buyer power are also still present in this case.[32]

Admittedly, antitrust concerns may limit the feasibility of such contracts and, thereby, the extent to which the downstream market can be monopolized by contractual means alone. At the other extreme is the case where each contract can only condition on the respective supply and can also not be credibly communicated to other buyers. In this case, the supplier's "opportunistic" behavior across buyers can lead to profits far lower than the monopoly outcome (see McAfee and Schwartz, 1994). The formation of larger buyers will then increase total industry profits. Under these circumstances, the supplier's choice of technology could also be affected by an attempt to curb its own (subsequent) opportunism problem, the extent of which may in turn depend on the presence of large buyers. We must leave the analysis of buyer power and supplier incentives in such a setting to future analysis.

5. Conclusion

We study why larger buyers may obtain more favorable terms of supply and how this can affect welfare. While the presence of larger buyers may reduce the supplier's profits, we argue that the supplier's incentives to undertake certain types of product or process innovation could in fact increase. Facing larger buyers, the supplier cares more about reducing incremental production costs at high volumes and more about reducing the loss in revenues that could arise from a disagreement with a large buyer. For the case of process innovation we show that in case the presence of large buyers actually shifts the supplier's choice of technology, then this is likely to increase welfare. For product innovation, however, the supplier may always have too high incentives, which are further distorted upwards in the presence of larger buyers.

[32] To obtain this result one can employ an immediate extension of the truthfulness requirement (1) that takes into account the supply made to other buyers. This was formalized in a previous version, which can be obtained from the authors upon request.

This paper focuses on buyers' size as the sole determinant of buyer power. Depending on the considered industry, however, there may also be other reasons for why certain buyers are more powerful and obtain a discount. For instance, retail chains that also stock private-label goods may have a distinctive advantage when negotiating with particular suppliers. Likewise, in certain industries more sophisticated buyers may be able to use more competitive procurement strategies such as web-based auctions or B2B platforms. Buyer power that derives from these different sources may have quite different effects on suppliers' incentives and welfare. One insight of the present paper is that any sweeping generalization about the "general" impact of buyer power may be highly misleading. Instead, it is important to first derive buyer power from first principles in order to adequately determine both its static and its dynamic welfare implications.

Somewhat related, it may also prove fruitful to tailor the model more specifically to a particular application, say retailing. There, buyers simultaneously stock multiple goods, some of which are even close substitutes. Analyzing the investment incentives of suppliers that actively have to compete for shelf space, both against other branded goods and against retailers' own-label goods, may be an important future step. Furthermore, an extension of our setting to one where multiple suppliers can and in equilibrium do serve different buyers and outlets, where consumer preferences may differ, seems to be warranted. Finally, our model is silent about incentives at downstream firms. It seems to be a natural extension to analyze how the formation of larger buyers affects their own incentives to invest, e.g., in more cost-effective distribution systems or in building up customer awareness for the supplier's product.

Acknowledgements

We would like to thank participants at various seminars and conferences as well as the associate editor and two referees for helpful comments. Inderst acknowledges financial support from the ESRC grant on "Buyer Power in Retailing".

Appendix

Proof of Proposition 1. We denote the supplier's equilibrium payoff by U^* and that of buyer i by V_i^* for $i \in I$. Moreover, if there is no agreement with a subset $I' \subseteq I$, the supplier realizes $U^*(I')$. By Lemma 1, we know that the vector of supplies to all buyers with whom an agreement was reached is chosen to maximize industry profits.

Take now negotiations with some buyer i. In case of disagreement, buyer i realizes zero and the supplier realizes

$$U^*(i) = \sum_{j \in I \setminus \{i\}} t_j\left(x^*_{N-r_i} \frac{r_j}{N-r_j}\right) - C(x^*_{N-r_i}). \tag{15}$$

Substituting from the truthfulness requirement (1), we know that $t_j(x^*_{N-r_i} r_j/(N-r_j))$ is the sum of $\bar{t}_j$ and the difference in revenues, $r_j[R(x^*_{N-r_i}/(N-r_j)) - R(x^*_N/N)]$. Substitution into (15) gives

$$U^*(i) = \sum_{j \in I \setminus \{i\}} \bar{t}_j + \Pi^*_{N-r_i} - (N-r_i) R\left(\frac{x^*_N}{N}\right). \tag{16}$$

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

$$\sum_{j\in I\setminus\{i\}} \bar{t}_j + R\left(\frac{x_N^*}{N}\right) - C(x_N^*). \tag{17}$$

Subtracting the supplier's outside option $U^*(i)$ in (16) from the total surplus after disagreement with i in (17), we have the net surplus $\Pi_N^* - \Pi_{N-r_i}^*$. As the buyer's outside option is zero and as he obtains the fraction ρ of the net surplus, we have that $V_i^* = \rho(\Pi_N^* - \Pi_{N-r_i}^*)$. Summing up over all buyers and noting that $U^* + \sum_{i\in I} V_i^* = \Pi_N^*$, we finally obtain for U^* the result in (2). □

Proof of Proposition 2. Though it is only economically meaningful to consider discrete values $n \geqslant 1$, note that Π_n^* is defined for all positive real values. We take now assertion (i), where capacity is unconstrained. Denote $\tilde{x}_n = x_n^*/n$ and note that it satisfies the first-order condition $R'(\tilde{x}_n) - C'(n\tilde{x}_n) = 0$. Applying to this the implicit function theorem, we then obtain

$$\frac{\mathrm{d}\tilde{x}_n}{\mathrm{d}n} = \frac{\tilde{x}_n C''(n\tilde{x}_n)}{R''(\tilde{x}_n) - nC''(n\tilde{x}_n)}. \tag{18}$$

We next differentiate industry profits $\Pi_n^* = n\tilde{x}_n p(\tilde{x}_n) - C(n\tilde{x}_n)$ with respect to n. Using the envelope theorem, we obtain $\mathrm{d}\Pi_n^*/\mathrm{d}n = \tilde{x}_n[p(\tilde{x}_n) - C'(n\tilde{x}_n)]$. Differentiating a second time and using the first-order condition for $\tilde{x}_n$, we obtain

$$\frac{\mathrm{d}^2\Pi_n^*}{\mathrm{d}n^2} = -C''(n\tilde{x}_n)\tilde{x}_n\left[\tilde{x}_n + n\frac{\mathrm{d}\tilde{x}_n}{\mathrm{d}n}\right]. \tag{19}$$

Substituting (18) into (19) finally yields

$$\frac{\mathrm{d}^2\Pi_n^*}{\mathrm{d}n^2} = -\frac{C''(n\tilde{x}_n)(\tilde{x}_n)^2 R''(\tilde{x}_n)}{R''(\tilde{x}_n) - nC''(n\tilde{x}_n)},$$

which is strictly negative if revenues are strictly concave and costs are strictly convex.

For assertion (ii) note first that if capacity is sufficiently constrained, the optimal choice satisfies $x_n^* = X$ for all n. Industry profits are then given by $\Pi_n^* = nR(X/n) - C(X)$. Differentiating twice yields in this case $\mathrm{d}\Pi_n^*/\mathrm{d}n = R(X/n) - XR'(X/n)/n$ and $\mathrm{d}^2\Pi_n^*/\mathrm{d}n = X^2R''(X/n)/n^3$. □

Proof of Proposition 3. Suppose it costs K to switch from α to β. We then have for a any given set of values $(I, \{r_i\}_{i\in I})$ a threshold $\overline{K}$ such that the supplier prefers to switch if $K < \overline{K}$ and prefers not to switch if $K > \overline{K}$. (For simplicity we choose not make the dependency of $\overline{K}$ on $(I, \{r_i\}_{i\in I})$ explicit.) By definition, a set $(I, \{r_i\}_{i\in I})$ that has more larger buyers is obtained from another set $(I', \{r_i'\}_{i\in I'})$ by a sequence of changes where each time some buyer i sells to some buyer j the number r of firms with $r_j \geqslant r_i \geqslant r$. By (4) this transformation changes the supplier's profits by the amount

$$\Delta = \rho[(\Pi_{N-r_i+r}^* - \Pi_{N-r_i}^*) - (\Pi_{N-r_j}^* - \Pi_{N-r_j-r}^*)]. \tag{20}$$

Differentiating Π_n^* twice, (20) transforms to

$$\Delta = \rho\int_0^r \left[\int_{N-r_j-r+y}^{N-r_i+y} \frac{\mathrm{d}^2\Pi_n^*}{\mathrm{d}n^2}\mathrm{d}n\right]\mathrm{d}y. \tag{21}$$

If (8) is satisfied, we have from (21) that Δ is strictly higher under β than under α. If this holds, the supplier's loss from the change in the downstream market structure is smaller under β, implying finally that the respective threshold $\overline{K}$ is strictly higher with $(I, \{r_i\}_{i\in I})$ than with $(I', \{r'_i\}_{i\in I'})$. If the converse to (8) holds strictly, we have that Δ is strictly smaller after the shift, implying that $\overline{K}$ is strictly lower with $(I', \{r'_i\}_{i\in I'})$. □

Proof of Proposition 4. As in the proof of Proposition 3, we want to show that (20) is strictly higher after the switch in technologies, which implies that the respective threshold $\overline{K}$ is strictly larger with $(I, \{r_i\}_{i\in I})$ than with $(I', \{r'_i\}_{i\in I'})$. With the linear technology β and unconstrained capacity, we have that (20) is equal to zero. Finally, for the strictly convex technology α we know that, under the conditions of Proposition 2, (20) is strictly negative.

To complete the proof of Proposition 4, it remains to show that, whenever the supplier switches technologies, this strictly improves welfare. We denote the welfare realized under the profit-maximizing choice of supplies by $W_N^* := N\int_0^{\tilde{x}_N} P(x)\,\mathrm{d}x - C(N\tilde{x}_N)$.[33] Note next that, by our previous results, the supplier's incentives to switch are greatest under the most concentrated market structure. In this case, i.e., for $N = 1$, the supplier realizes the profits $(1-\rho)\Pi_N^*$ and therefore prefers to switch if $\Pi_N^*(\beta) \geqslant \Pi_N^*(\alpha) + K$. Denote the respective levels of welfare by $W_N^*(\alpha)$ and $W_N^*(\beta)$, respectively. It thus remains to show that $\Pi_N^*(\beta) \geqslant \Pi_N^*(\alpha) + K$ implies $W_N^*(\beta) > W_N^*(\alpha) + K$. This holds if $W_N^*(\beta) - \Pi_N^*(\beta) > W_N^*(\alpha) - \Pi_N^*(\alpha)$, i.e., if

$$N\int_0^{\tilde{x}_N(\beta)} [P(x) - P(\tilde{x}_N(\beta))]\,\mathrm{d}x > N\int_0^{\tilde{x}_N(\alpha)} [P(x) - P(\tilde{x}_N(\alpha))]\,\mathrm{d}x, \tag{22}$$

where $\tilde{x}_N(\alpha)$ and $\tilde{x}_N(\beta)$ denote the respective equilibrium supplies to individual firms. For (22) to hold, we need that $\tilde{x}_N(\beta) > \tilde{x}_N(\alpha)$. This follows immediately from the fact that $C'(N\tilde{x}_N(\beta), \beta) < C'(N\tilde{x}_N(\beta), \alpha)$, which again holds as $C(x, \beta)$ is linear, $C(x, \alpha)$ is strictly convex, and as $\Pi_N^*(\beta) \geqslant \Pi_N^*(\alpha)$. □

Proof of Proposition 5. We adopt again the steps from Propositions 3 and 4. As capacity X is sufficiently constrained, we have $\Pi_n^* = X(1 - \psi X/n) - cX$. The difference (20) then transforms to

$$\Delta = \rho\psi X\left[\left(\frac{1}{N-r_i} - \frac{1}{N-r_i+r}\right) - \left(\frac{1}{N-r_j-r} - \frac{1}{N-r_j}\right)\right]. \tag{23}$$

As $0 < \psi_\beta < \psi_\alpha$ and as $\Delta < 0$, we have that Δ is strictly higher under β than under α. Consequently, the respective threshold $\overline{K}$ is strictly higher given $(I, \{r_i\}_{i\in I})$ than given $(I', \{r'_i\}_{i\in I'})$ (as used in Proposition 3).

Regarding welfare, as is standard we assume that at each firm the linear inverse demand function is generated by the quadratic utility function of a representative consumer. That is, if x_n^j is the quantity of good j consumed in the market n, consumer surplus equals

$$\sum_{1\leqslant j\leqslant \phi} x_n^j(1-p_n^j) - \frac{1}{2}\sum_{1\leqslant j\leqslant \phi}(x_n^j)^2 - \gamma\sum_{1\leqslant j\leqslant k\leqslant \phi} x_n^j x_n^k.$$

[33]We assume that $P(x)$ is generated by the utility of a representative consumer. Also, note that W_N^* is not the maximum feasible welfare. Our objective is to compare welfare under the two technologies given the equilibrium levels of supply.

In equilibrium, we know that all quantities are chosen symmetrically, i.e., that $x_n^j = X/(N\psi)$. Substitution of $\psi = [1 + (\phi - 1)\gamma]/\phi$ yields the welfare $W = X(1 - \frac{1}{2}\frac{X}{N}\psi - c)$. Consequently, it is efficient to switch from α to β if $K \leqslant \overline{K}_W$ with

$$\overline{K}_W := \frac{1}{2}\frac{X^2}{N}(\psi_\alpha - \psi_\beta). \tag{24}$$

We now compare $\overline{K}_W$ with the respective threshold chosen by the supplier. By our previous result, we know that $\overline{K}$ is lowest for the supplier if $I = N$ and $r_i = 1$. Using (2) in Proposition 1 for the supplier's payoff, it is straightforward to obtain for this case

$$\overline{K} = \frac{X^2}{N}(\psi_\alpha - \psi_\beta)\left[1 + \rho\frac{1}{N-1}\right],$$

which is still strictly higher than the threshold $\overline{K}_W$ in (24). This completes the proof. □

References

Bernheim, B.D., Whinston, M.D., 1986. Menu auctions, resource allocation, and economic influence. Quarterly Journal of Economics 101, 1–31.
Berto Villas-Boas, S., 2004. Vertical contracts between manufacturers and retailers: Inference with limited data. Mimeo.
Bolton, P., Whinston, M.A., 1993. Incomplete contracts, vertical integration and supply assurance. Review of Economic Studies 60, 121–148.
Bonnet, C., Dubois, P., Simioni, M., 2004. Two-part tariffs vs. linear pricing between manufacturers and retailers: Empirical tests on differentiated product markets. Mimeo.
Chae, S., Heidhues, P., 2004. Buyers' alliances for bargaining power. Journal of Economics and Management Strategy 13, 731–754.
Chen, Z., 2003. Dominant retailers and the countervailing-power hypothesis. Rand Journal of Economics 34, 612–625.
Chipty, T., Snyder, C.M., 1999. The role of outlet size in bilateral bargaining: A study of the cable television industry. Review of Economics and Statistics 81, 326–340.
Competition Commission, 2000. Supermarkets: A report on the supply of groceries from multiple stores in the United Kingdom. Report Cm-4842.
DeFontenay, C., Gans, J.S., 2001. Efficiency in multilateral vertical contracting: Bargaining and the nature of competition. Mimeo.
DeGraba, P., 2003. Quantity discounts from risk averse sellers. Mimeo.
Dobson, P., Waterson, M., 1997. Countervailing power and consumer prices. Economic Journal 107, 418–430.
Dukes, A., Gal-Or, E., 2003. Negotiations and exclusivity contracts for advertising. Marketing Science 222–245.
Dukes, A., Gal-Or, E., Srinivasan, K., 2006. Channel bargaining with retailer asymmetry. Journal of Marketing Research 43, 84–97.
European Commission, 1999. Buyer power and its impact on competition in the food retail distribution sector of the European Union. DG IV. Brussels.
FTC, 2001. Report on the Federal Trade Commission workshop on slotting allowances and other marketing practices in the grocery industry. Report by the Federal Trade Commission Staff, Washington, DC.
Horn, H., Wolinsky, A., 1988. Worker substitutability and patterns of unionization. Economic Journal 98, 484–497.
Inderst, R., 2005. Large buyer premium or discount? Mimeo.
Inderst, R., Shaffer, G., 2003. Retail mergers, buyer power, and product variety. Forthcoming Economic Journal.
Inderst, R., Shaffer, G., 2005. The role of buyer power in merger control. Mimeo.
Inderst, R., Wey, C., 2003. Market structure, bargaining, and technology choice in bilaterally oligopolistic industries. Rand Journal of Economics 34, 1–19.
Inderst, R., Wey, C., 2005. Countervailing power and upstream innovation. Mimeo.
Katz, M.L., 1987. The welfare effects of third degree price discrimination in intermediate goods markets. American Economic Review 77, 154–167.

Klemperer, P., Meyer, M.A., 1989. Supply function equilibria in oligopoly under uncertainty. Econometrica 57, 1243–1277.

McAfee, R.P., Schwartz, M., 1994. Opportunism in multilateral vertical contracting: Nondiscrimination. American Economic Review 84, 210–230.

Mazzarotto, N., 2003. Retail mergers and buyer power. Mimeo.

Milliou, C., Petrakis, E., Vettas, N., 2004. (In)efficient trading forms in competing vertical chains. Mimeo.

O'Brien, D.P., Shaffer, G., 1997. Nonlinear supply contracts. Exclusive dealing, and equilibrium market foreclosure. Journal of Economics and Management Strategy 6, 755–785.

OECD, 1999. Buying power of multiproduct retailers. Series Roundtables on Competition Policy DAFFE/CLP(99)21, Paris.

Schwartz, M., 1999. Buyer power concerns and the Aetna-Prudential merger. U.S. Department of Justice, Washington, DC.

Snyder, C.M., 1996. A dynamic theory of countervailing power. Rand Journal of Economics 27, 747–769.

Snyder, C.M., 2005. Countervailing power. Mimeo.

Spence, M., 1976. Product differentiation and welfare. American Economic Review 66, 407–414.

Stole, L.A., Zwiebel, J., 1996. Organizational design and technology choice under intrafirm bargaining. American Economic Review 86, 195–222.

von Ungern-Sternberg, T., 1996. Countervailing power revisited. International Journal of Industrial Organization 14, 507–520.