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ABSTRACT

Buyer Power and Supplier Incentives

This Paper investigates how the formation of larger buyers affects a supplier's profits and, by doing so, their incentives to undertake non-contractible activities. We first identify two channels of buyer power, which allows larger buyers to obtain discounts. We subsequently examine the effects of buyer power on the supplier's incentives and social welfare. Contrary to some informal claims in the policy debate on buyer power, we find that the exercise of buyer power – even though reducing supplier's profits – may often increase a supplier's incentive to undertake welfare enhancing activities.

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1 Introduction

In many industries, suppliers face increasingly powerful buyers. A prominent example is the European retailing industry, in particular fast-moving consumer goods. According to studies of the European Commission (Dobson Consulting 1999) and the OECD (OECD 1999), 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 Consequently, the retailers' grip on suppliers has played a major role in recent antitrust cases in Europe (e.g., Kesko/Tuko and Carrefour/Promodes).² In the UK, this has led to the introduction of a Code of Practice that is supposed to regulate contracts between large retailers and their suppliers (Competition Commission 2000).³

Though market concentration in retailing is less extreme in the US, recently there have been increasing concerns about retail mergers and buyer power (e.g., FTC 2001). Casual evidence also suggests that suppliers' bargaining power has eroded in numerous other manufacturing industries such as automobiles as well as in service industries such as healthcare (e.g., Gaynor and Haas-Wilson 1999).

Judging from the aforementioned policy reports, antitrust authorities seem to be particularly concerned that the formation of larger and stronger buyers stifles suppliers' incentives to invest in product and process innovation. Buyer power is thought to force manufacturers "to reduce investment in new products or product improvements, advertising and brand building" (Dobson Consulting 1999, p. 4). Consumers, it is feared, "could be adversely affected by the exercise of buyer power in the longer run, if prices to suppliers are reduced below a competitive level and if the suppliers respond by under-investing in innovation or production" (FTC 2000, p. 57).⁴

The aim of this paper is to critically assess the view that, by extracting more profits from suppliers, buyer power necessarily reduces suppliers' incentives for product improvement and process innovation and, thereby, reduces welfare. We address this issue in a model where buyer power is derived *endogenously*. In Particular, we focus on a buyer's

¹As reported in Dobson (2002), after a series of cross-border mergers and acquisitions, the top ten retailers in the EU account now for more than 30% of food sales.

²Kesko/Tuko (EC/DGIV, 1999, Case No. IV/M.784) and Carrefour/Promodes (EC/DGIV, 2000, Case No. COMP/M.1684). In the UK, buyer power was also an important consideration in the recent finding against the acquisition of Safeway by one of the other three big retailers (Competition Commission 2003). The findings of the Competition Commission revealed, amongst other things, a significant inverse correlation between the prices paid by multiple grocery retailers and their share of total purchases.

³A similar code, though on a voluntary basis, was recently drafted in Australia (ACCC 2001).

⁴While such concerns have been mainly expressed in the case of retailing, the US health service is another industry where the impact of buyer power on quality and investment has been addressed (e.g., Pitofsky 1997).

size as the main determinant of his bargaining power. While we show that - under relatively standard assumptions - the formation of larger buyers *reduces* suppliers' profits, this may actually *increase* their incentives.

Precisely, we consider a simple model where a single supplier serves a fixed number of downstream firms, all of which serve independent markets.⁵ Contracts are determined in bilateral negotiations. Abstracting from other sources of power differentials between sellers and buyers, we study the formation of larger buyers. The first step in the analysis is to show that, under relatively standard conditions, larger buyers can indeed obtain a discount.⁶ In a second step, we analyze how the formation of larger buyers affects the supplier's incentives. Hence, our model comprises both an analysis of the *origins* of buyer power and an analysis of its (welfare) *consequences*.

We can isolate two channels of buyer power. First, if revenues at downstream firms are concave, we show that the supplier's loss from a disagreement increases more than proportionally with the size of the respective buyer. The threat to withhold demand is thus more effective for larger buyers, allowing them to obtain a discount. Second, if the supplier's costs are convex, the quantity purchased by a larger buyer spans a wider interval of production, reducing the average incremental cost incurred by serving this buyer in addition to all other buyers. 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. For product innovation, the first channel, building on the concavity of revenues, is important. For process innovation, it is the second channel, building on the convexity of the supplier's costs.

If a supplier faces fewer but larger buyers, his outside option in negotiations is more valuable the better he can cope with being cut out from a large fraction of the total market following a disagreement. This in turn is the case if a relatively large increase in the supply to all remaining markets does not substantially reduce the prevailing price and, thereby, total revenues. We show that a supplier's optimal response to the formation of larger buyers may then be *more* product innovation. Regarding the choice of technology, we show that in bilateral negotiations with large buyers a supplier can "roll over" relatively less of his incremental costs at high (or "marginal") quantities and relatively more of his incremental costs at low (or "inframarginal") quantities. Consequently, in the presence

⁵The formation of larger buyers may often have no or little impact on downstream competition. For instance, the merging companies may serve geographically different markets. In the case of retailing, merging retailers may also have to divest outlets in overlapping markets (e.g., Balto 1999).

⁶Bilateral negotiations and individual discounts stand in contrast to the "textbook" view of monopsonistic power (e.g., Blair and Harrison 1993 or Scherer and Ross 1990, Chapter 14). Our view on the exercise of buyer power follows, for instance, OECD (1981), which defines buyer power as the ability of strong buyers to obtain more favorable terms (see also FTC 2001).

of larger buyers the supplier has more incentives to choose a production technology with lower incremental costs at high quantities. Importantly, this is likely to increase welfare as it tends to increase output, which is typically inefficiently low from a welfare perspective.

Our paper contributes to the growing literature on buyer power. A larger buyer can obtain a discount as he can more credibly threaten to integrate backwards (Katz 1987)⁷, as he may break collusion among suppliers (Snyder 1995), or if the supplier is risk averse (DeGraba 2003). In von Ungern-Sternberg (1996), Dobson and Waterson (1997), and Mazzarotto (2003) a supplier loses bargaining power by the merger of two competing downstream firms⁸, while in Inderst and Shaffer (2003) a downstream merger facilitates the switch to a single-sourcing strategy, which increases upstream competition. The role of the curvature of the surplus function has been recognized in a number of papers, including Horn and Wolinsky (1988) and Stole and Zwiebel (1996) for negotiations between firms and workers and Chipty and Snyder (1999) and Inderst and Wey (2003) for negotiations between buyers and sellers. The latter two papers have focused on the role of convex costs - our second channel of buyer power. On the other side, the demand-side channel of buyer power has not been recognized so far due to several restrictions employed in different papers, namely the consideration of at most two buyers, single-unit supply, or quantity-forcing contracts.⁹

The major focus of this paper is, however, on the *consequences* of buyer power. Here, our major contribution is to question the prevailing view that the presence of more powerful buyers reduces suppliers' incentives. In essence we criticize this view on two accounts. First, it is necessary to model buyer power from primitives, i.e., to clearly identify what are the origins of buyer power. In this paper, it is a buyer's size that allows him to obtain better terms.¹⁰ (See, however, the conclusion for alternatives.) Second, while a supplier's total profits may be the key determinant of some large-scale investment decisions, e.g.,

⁷Fumagalli and Motta (2000) extend this by modelling the co-ordination problem among small buyers.

⁸A somewhat symmetric situation arises in O'Brien and Shaffer (2003), who consider mergers between upstream firms that sell substitutes to a downstream monopolist. They show that a horizontal merger has only an impact on equilibrium quantities and payoffs if the merged firm can not negotiate jointly over the supply of all controlled goods.

⁹We discuss the limitations of quantity-forcing contracts in some detail in Section 4. Chipty and Snyder (1999) consider Nash negotiations over quantity-forcing contracts. The special case where buyers have all bargaining power is considered in the experimental paper by Normann, Ruffle, and Snyder (2003). Inderst and Wey (2003) use the Shapley value and consider a bilateral duopoly, for which they study the equilibrium market structure and the choice between two linear production technologies. Incidentally, with the Shapley value convex costs are *not* sufficient to generate large-buyer discounts for arbitrary numbers of buyers with different size.

¹⁰The alternative model would be to just assume that a more powerful buyer can capture a larger share of the surplus. In our model, this would be equivalent to increasing the buyer's weight in the Nash bargaining solution.

market entry, for many other types of more incremental investment decisions total profits provide a very misleading picture. Modelling buyer power from principles and focusing on more incremental decisions, we can identify reasonable cases where buyer power may actually spur suppliers' incentives. The analysis of supplier's incentives relates to the hold-up literature (Grout 1984, Grossman and Hart 1986). In different contexts, this literature has more recently shown that hold-up may even increase incentives, depending on how the investment affects the party's outside option (e.g., DeMeza and Lockwood 1998, Chiu 1998). While this is reminiscent of our discussion of product innovation, the novelty of our analysis is the interaction of the supplier's incentives with the number and size of buyers.¹¹ Moreover, while some papers in the hold-up literature analyze buyer competition (e.g., Felli and Roberts 2001), they typically consider only bilateral matches and the supply of a single unit, which does not allow to capture most of the effects highlighted in this paper.¹²

The rest of this paper is organized as follows. Section 2 presents the model and derives conditions for when larger buyers obtain a discount. Section 3 applies these results to study the supplier's incentives. Section 4 discusses the chosen bargaining solution. 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. 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 $N \geq 2$ downstream firms. For simplicity, we assume that the downstream firms' technology converts each unit of the supplier's input into a unit of the final good at zero additional costs. 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 $R(x) := xp(x)$. The specification of the simple production technology and the

¹¹In Stole and Zwiebel (1996) a firm that negotiates with its workers without commitment can choose its production technology to enhance its bargaining position.

¹²In addition, Spulber (2002) studies how incentives to invest depend on the market microstructure, while Kranton and Minehart (2000) analyze incentives to invest into the exchange network. The interaction of market structure and investment incentives has also been studied in the literature on vertical integration (e.g., Bolton and Whinston 1993).

symmetry assumption are made to facilitate the exposition of our results. The restriction to independent markets for final goods allows us to focus exclusively on the input market (see also footnote 5 above).

Some downstream outlets may belong to the same owner. Given symmetry of outlets, the market for inputs is thus fully described by specifying the number of outlets r_i that are controlled by the same buyer (or owner) $i = 1, \dots, I$. Note that $\sum_{i=1}^I r_i = N$.

2.2 Negotiations

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 , who purchases inputs for r_i firms (or markets), specifies a menu of prices $t_i(x)$ as a function of the supplied quantity x .¹³ It proves convenient to subsequently let the supplier choose a vector of quantities from the respective menus. As there is no uncertainty, in equilibrium each buyer will receive a deterministic quantity. We denote this choice by \bar{x}_i and the respective transfer by $\bar{t}_i = t_i(\bar{x}_i)$. The supplier's agents, i.e., his various "account managers", negotiate simultaneously and independently over the respective menu $t_i(x)$, forming rational expectations about the outcomes in all other negotiations. The transfer \bar{t}_i is chosen such that the respective buyer receives the fraction $\rho \in (0, 1]$ of the generated net surplus.¹⁴

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 now require that $t_i(x)$ is chosen to truthfully reflect the valuation of the respective buyer i . To formalize this specification, note first that, by optimality, 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 requirement¹⁵

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

¹³An example would be a percentage quantity discount, where the size of the discount is a function of total sales to a particular buyer. For instance, contracts with retailers are often highly complex, specifying promotional allowances, volume discounts, up-front or pay-to-stay fees, or the provision of additional services by the supplier. The choice of menus in supply contracts is common in the literature. See, for instance, O'Brien and Shaffer (1997, 2003).

¹⁴Hence, we make use of a hybrid solution concept, employing the asymmetric Nash bargaining solution to determine how total surplus is split.

¹⁵For the truthfulness requirement see Bernheim and Whinston (1986).

The truthfulness requirement seems reasonable for a number of reasons. As we show below, it implies that supplies are chosen to maximize industry profits both on and off equilibrium, i.e., both if all negotiations were successful and in case there was disagreement with a subset of buyers. Hence, there is never scope for mutually beneficial renegotiations. (In Section 4 we discuss alternative specifications, where this does not hold.) An alternative way to justify the truthfulness requirement would be to appeal to ex-ante uncertainty about some unverifiable parameter of the supplier's cost function. The truthfulness requirement then ensure that, regardless of the realization of the uncertain cost parameter, the chosen quantity x_i maximizes the bilateral surplus.¹⁶

Before proceeding to the analysis, it is useful to note that in our model buyers negotiate separately with the supplier and can, therefore, obtain different deals. This is clearly a prerequisite for the exercise of buyer power, i.e., for larger buyers to obtain more favorable terms.¹⁷

2.3 Equilibrium Analysis

To state our results in a convenient way, we need some additional notation. Suppose the supplier serves only n out of the total N downstream firms. Suppose also that, given this restriction, quantities are always chosen to maximize total industry profits. It is further convenient to assume that the total quantity that maximizes industry surplus is uniquely determined and strictly positive. For given n , we denote the optimal quantity by x_n^* and the respective revenues realized at each firm by $R_n^* := (x_n^*/n)P(x_n^*/n)$. Total realized industry profits are denoted by $\Pi_n^* := nR_n^* - C(x_n^*)$. Though it is only economically meaningful to consider discrete values $n \geq 1$, note that Π_n^* is defined for all positive real values. This will be convenient for some of our results.

By the truthfulness requirement, the supplier fully internalizes all incremental revenues and costs when choosing his production volume and supplies. As a consequence, in equilibrium he produces the total quantity x_N^* and supplies $\bar{x}_i = x_N^*r_i/N$ to buyer i . The analogous results holds in case of disagreement with a subset of buyers.

Lemma 1. *If there is agreement with a (sub)set of buyers $I' \subseteq I$, the total quantity*

¹⁶The use of uncertainty to pin down equilibrium menus in this way is well known in the literature and used, for instance, in the seminal work of Klemperer and Meyer (1989) and, relying on ex-ante private information, by Martimort and Stole (2003).

¹⁷While such discounts may offend the spirit of the U.S. Robinson-Patman Act, antitrust authorities and courts seem to have become less eager to enforce it in a narrow sense. An illustrative case, which is discussed in Scherer and Ross (1990), is that of the retailer A&P in 1979. A&P threatened to withdraw its demand from the milk producer Borden unless it obtained a sufficiently large discount. Even though the discount gave A&P a substantial cost advantage compared to other buyers, it was not objected in the final court decision.

x_n^* is produced, where $n = \sum_{i \in I'} r_i$. Moreover, buyer $i \in I'$ receives the quantity $x_n^* r_i / n$.

Note that, as an implication of Lemma 1, the downstream market structure has no implications for equilibrium quantities. We obtain next the following result for equilibrium payoffs.

Proposition 1. *A buyer controlling r_i outlets obtains the fraction ρ of his respective incremental contribution to total industry profits, i.e., he realizes the payoff $\rho[\Pi_N^* - \Pi_{N-r_i}^*]$. Consequently, the supplier's total profits equal*

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

Proof. See Appendix.

Note that for $\rho = 0$, where the supplier has all bargaining power, his own profits are just equal to total industry profits, Π_N^* . At the other extreme, where $\rho = 1$, each buyer can extract his full net contribution. As can be easily seen, the outcome for $\rho = 1$ is equivalent to that of a first-price auction where buyers bid with truthful menus.

The derivation of Proposition 1 comes with one caveat. It is assumed that the supplier's profits in (2) are non-negative. This is surely the case if industry profits Π_n^* are concave in n . Below we derive conditions when this holds. Moreover, we specified that a buyer realizes zero profits in case of a disagreement. It is, however, straightforward to allow for the presence of some (inferior) alternative source of supply. Precisely, if an alternative source of supply generated the profits $U \geq 0$ at each firm, buyer i 's payoff would transform to $\rho[\Pi_N^* - \Pi_{N-r_i}^*] + (1 - \rho)r_i U$.

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 equals

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

Larger buyers thus 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 that in this case a merger between buyers is also strictly profitable and reduces the supplier's profits. An alternative - and less extreme - way to form a larger buyer is the sale of assets (firms) by a smaller buyer to a larger buyer. If buyer i sells to buyer j the number r of firms, where $r_j \geq r_i \geq r$,

straightforward calculations from Proposition 1 reveal that this makes the supplier strictly worse off if and only if

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

For (4) to hold generally, we need a stronger condition than monotonicity of $[\Pi_N^* - \Pi_{N-r_i}^*] / r_i$. As is easily seen, it is sufficient to require that total industry profits Π_n^* are strictly concave in the number of firms n .¹⁸ We have thus arrived at 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 complete 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 his size. We next relate the shape of industry profits to the characteristics of final demand and the characteristics of the supplier's technology.

Demand Characteristics

To isolate the demand-side channel of buyer power, suppose the supplier has zero product costs and only low capacity X such that $\Pi_n^* = nR(X/n)$ for all 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 revenues by the amount

$$NR(X/N) - (N - r_i)R(X/(N - r_i)). \quad (5)$$

Recall now that, due to the truthfulness requirement, the supplier fully bears this loss in revenues. Consequently, a larger buyer obtains a more favourable deal if the loss inflicted by breakdown of negotiations increases *more than proportionally* with the buyer's size, r_i . As is easily checked from (5) - and formalized below - this holds if revenues $R(x)$ are strictly concave.

Incidentally, the notion that larger buyers have more bargaining power as they can inflict a more than proportional damage on a seller by withholding demand was used in the consideration of Aetna's acquisition of Prudential's health insurance assets in the

¹⁸Formally, using that Π_n^* is twice continuously differentiable given the assumptions on $P(x)$, $C(x)$, and x_n^* , we have that (4) can be written as $\int_0^r \left[\int_{N-r_j-r+y}^{N-r_i+y} \frac{d^2 \Pi_n^*}{dn^2} dn \right] dy < 0$.

U.S.¹⁹ Our model shows that this effect arises under the relatively standard conditions of concave revenues.

Technology Characteristics

To isolate this channel of buyer power, suppose that at each firm the quantity $\tilde{x} > 0$ can be sold at any price that does not exceed $\tilde{p} > 0$, while it is not possible to further increase sales by lowering the price. Furthermore, \tilde{x} is sufficiently small to make it always optimal to serve all available demand. Hence, we now have that $\Pi_n^* = n\tilde{x}\tilde{p} - C(n\tilde{x})$. When negotiating with a buyer who controls r_i firms, the net surplus created by an agreement is now

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

of which the buyer extracts the fraction ρ . We can decompose the buyer's profits into the share ρ of revenues $r_i\tilde{x}\tilde{p}$ minus the share ρ of incremental costs $C(N\tilde{x}) - C((N - r_i)\tilde{x})$. Given our specification of demand, revenues now increase only *proportionally* with the buyer's size. However, if $C(x)$ is strictly convex, we now find that the incremental costs increase *less than proportionally* with the buyer's size, i.e., $[C(N\tilde{x}) - C((N - r_i)\tilde{x})]/r_i$ is decreasing in r_i . In the case of convex costs, we obtain again a discount for large buyers. Intuitively, 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.

Generalization

Using these arguments, we can now ask 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 contains also the following intuitive insights. First, if revenues $R(x)$ are only linear, i.e., not strictly concave, all buyers obtain the same terms,

¹⁹United 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."

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 without losses in profits. 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 optimal quantity depend on the outcomes of other negotiations.

How big is the discount obtained by a larger buyer? By (3) the difference of 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 influencing surplus sharing between the supplier and buyers, the large-buyer discount is thus higher the more powerful buyers already are.

3 Supplier Incentives and Welfare

3.1 General Discussion

We can now build on the identified 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 a supplier’s incentives of product and process innovation?

The main assumption in the following analysis is that the supplier’s choices are *non-contractible*. This may be, for instance, the case as it is hard to ex-ante specify and to ex-post verify particular changes in the product technology. Likewise, ex-ante contracting may be difficult due to free-riding or co-ordination problems among the many different buyers. It is now convenient to suppose that the supplier can choose to shift between two action profiles, say from α to β , possibly by incurring some additional investment costs. We make the dependency of industry profits on the supplier’s actions explicit by writing $\Pi_n^*(\alpha)$ and $\Pi_n^*(\beta)$, respectively.

Take now a given downstream market structure and transform it by shifting assets (firms) away from smaller buyers to larger buyers. (Note that this includes a full merger of buyers.) If a market structure can be derived from another market structure by a sequence of such transformations, we say that the former is more concentrated.

Proposition 3. *Suppose the downstream market structure becomes more concentrated.*

²⁰For instance, we could imagine that each firm is located in a different country where it acts as a pure price taker given the amount that it can procure from the supplier.

Then the supplier has more incentives to switch from α to β if, for all n ,

$$\frac{d^2}{dn^2}\Pi_n^*(\beta) > \frac{d^2}{dn^2}\Pi_n^*(\alpha). \quad (6)$$

Likewise, the supplier's incentives to switch are strictly lower under the more concentrated market structure if the converse to (6) holds strictly.

Proof. See Appendix.

A supplier's incentives to switch to β depend on the downstream market structure and on how the switch affects the curvature of the profit function Π_n^* . This is intuitive by our previous discussion. We know that larger buyers extract more of the incremental surplus at lower values of n , while a small buyer's incremental contribution is right at the "margin". If (6) holds, this *relatively* increases the incremental profits at higher n , which would relatively improve the position of smaller buyers. Consequently, in this case the supplier's incentives to switch to β are muted under a less concentrated market structure.

Unfortunately, Proposition 3 is not very instructive about what kind of activities, i.e., what kind of process or product innovations, would be dampened or spurred under different downstream market structures. To obtain more insights, we have to be more specific about how the supplier's alternatives, α and β , 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, $C(x)$. At this level, we will also analyze welfare implications.

3.2 The Case of Process Innovation

Suppose the supplier can invest to switch from the cost function $C(x, \alpha)$ to $C(x, \beta)$. It is helpful to suppose for a moment that we can represent the shift from α to β by a gradual increase, i.e., $\alpha < \beta$ are real numbers. We obtain from the proof of Proposition 2 that

$$\begin{aligned} \frac{d}{d\alpha} \left[\frac{d^2}{dn^2}\Pi_n^*(\alpha) \right] &= -\frac{(x_n^*)^2 [R''(x_n^*/n)]^2 C''(x_n^*, \alpha)}{n [R''(x_n^*/n) - nC'''(x_n^*, \alpha)]^2} \left[\frac{dC'''(x_n^*, \alpha)}{d\alpha} \right] \\ &\quad - \frac{dx_n^*}{d\alpha} \frac{d}{dx_n^*} \left[\frac{(x_n^*)^2 R''(x_n^*/n) C''(x_n^*, \alpha)}{R''(x_n^*/n) - nC'''(x_n^*, \alpha)} \right]. \end{aligned} \quad (7)$$

Hence, a shift to β satisfies condition (6) in Proposition 3, i.e., it convexifies the industry profit function, if (7) is strictly positive. The first term in (7) is in turn strictly positive if $dC'''(x_n^*, \alpha)/d\alpha < 0$. If we ignored the second term in (7), we could thus say that the formation of larger buyers induces the supplier to choose a production technology that has *relatively* lower incremental costs at high quantities. This is again intuitive from

our previous results. With each small buyer the supplier can roll over a fraction of his incremental production costs “at the margin”, i.e., close to the equilibrium volume x_N^* . For instance, in the case of N small buyers with $r_i = 1$, the supplier is only compensated for the incremental costs $C(x_N^*) - C(x_{N-1}^*)$.²¹ In contrast, more of “inframarginal” but less of “marginal” costs can be rolled over when negotiating with larger buyers.

Unfortunately, there is little general we can say about the sign of the second term in (7). We therefore illustrate the previous discussion with a particular case: the shift from a strictly convex to a linear technology.²²

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) Under a more concentrated market structure, the supplier has strictly higher incentives to switch technologies, i.e., he is willing to incur a higher investment cost.*
- ii) Whenever the supplier switches, this strictly increases welfare.*

Proof. See Appendix.

Figure 1 goes here!

We illustrate the choice between α in β in Figure 1. In the special case of Proposition 4, we can say (i) that the supplier has strictly higher incentives to switch technologies after the formation of larger buyers and (ii) that this shift in incentives improves welfare.

The second result on welfare is important as it stands in marked contrast to the argument that the presence of larger buyers reduces welfare by reducing suppliers’ incentives. For an intuition, note first that, by standard arguments, industry profits are maximized at a quantity x_N^* that is inefficiently low from a welfare perspective. As a reduction of the marginal production costs at x_N^* leads to an increase in output and consumer surplus, the welfare maximizing choice between various production technologies should put less weight on incremental costs at low quantities, i.e. on “inframarginal” costs, and more weight on

²¹If $N\rho > 1$, the supplier is in fact over-compensated for this cost increment.

²²We can think of β as being more “flexible”, with lower marginal costs at high production volumes. As can be easily seen, results would not change if we allowed for fixed costs and if the more flexible technology involved higher fixed costs. As long as $I \geq 2$, all fixed costs would be born exclusively by the supplier.

incremental costs “at the margin”. By our previous arguments, this is exactly what the supplier does if he faces larger buyers, i.e., his incentives shift more towards reducing marginal costs at high production volumes, which leads to an expansion in quantity and to higher consumer surplus.

3.3 The Case of Product Innovation

We next consider the supplier’s incentives for product innovation. Suppose the supplier can switch, possibly by incurring additional costs, 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 is gradual. Differentiating with respect to α , and denoting $R(x, \alpha) := xP(x, \alpha)$, we obtain from the proof of Proposition 2

$$\begin{aligned} & \frac{d}{d\alpha} \left[\frac{d^2}{dn^2} \Pi_n^*(\alpha) \right] \\ = & - \frac{(x_n^*)^2 C''(x_n^*) [R''(x_n^*/n, \alpha) - C'''(x_n^*)(1+n)] \left[\frac{dR''(x_n^*/n, \alpha)}{d\alpha} \right]}{[R''(x_n^*/n, \alpha) - nC''(x_n^*)^2]^2} \\ & - \frac{dx_n^*}{d\alpha} \frac{d}{dx_n^*} \left[\frac{(x_n^*)^2 R''(x_n^*/n, \alpha) C'''(x_n^*)}{R''(x_n^*/n, \alpha) - nC''(x_n^*)^2} \right]. \end{aligned} \quad (8)$$

A shift to β satisfies condition (6) in Proposition 3 and is thus more profitable under a more concentrated market structure if (8) is strictly positive. The first term in (8) is strictly positive if the shift to β increases $R''(x_n^*/n, \alpha) < 0$. This is once again intuitive as we know that, in the presence of larger buyers, the supplier’s bargaining position depends crucially on sustaining high revenues even if substantially more than the equilibrium quantity was supplied at some firms after a disagreement with a large buyer. In contrast, with small buyers the revenue function matters only relatively close to the equilibrium quantities, i.e., in the right-side neighborhood of x_N^*/N .

Again, we can not generally sign the second term on the right side of (8) 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 $\phi \geq 1$ products can be supplied. If x_n^j denotes the supply of good $1 \leq j \leq \phi$ at firm $n \leq N$, prices are given by

$$p_n^j = 1 - x_n^j - \gamma \sum_{1 \leq k \leq \phi, k \neq j} x_n^k \text{ with } 0 \leq \gamma \leq 1. \quad (9)$$

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 (9) the supply of x to any firm generates the revenues

$$R(x) = x \left[1 - \frac{1 + (\phi - 1)\gamma}{\phi} x \right]. \quad (10)$$

Using (10), 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 that the supplier has linear costs, $C(x) = cx$, but that capacity is sufficiently small (see Proposition 2).

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) Under a more concentrated market structure, the supplier has strictly higher incentives to switch technologies, i.e., he is willing to incur higher costs to switch.

ii) The supplier's incentives to switch are always inefficiently high, implying that a more concentrated market structure may reduce 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 now *not* beneficial. In our example, we find that 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 by accident as it involves two errors: (i) the supplier's incentives actually *increase*, but (ii) higher incentives are *bad* for welfare.²³

²³In contrast to the case of process innovation, we have, however, no good guidance as to whether an increase in incentives is more likely to increase or to reduce welfare. This is a well known problem in the literature on product innovation (e.g., Spence 1975, 1976).

4 Discussion of the Bargaining Solutions

Our 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 to other buyers $j \neq i$. Second, by the truthfulness requirement the supplier captures all incremental surplus from these adjustments.²⁴ In what follows, we discuss the importance of these two assumptions.

Suppose first that adjustments are not possible after a disagreement. That is, negotiations with each buyer i are over *quantity-forcing* contracts, specifying a transfer t_i and a fixed quantity x_i . There exists an equilibrium in which buyer i purchases the quantity $r_i(x_N^*/N)$, which maximizes total industry surplus.²⁵ This quantity is unaffected by whether the supplier's negotiations with other buyers were successful. The transfer t_i is chosen such that the buyer obtains the fraction ρ of the respective net surplus, which is now

$$r_i R \left(\frac{x_N^*}{N} \right) - \left[C(x_N^*) - C \left(x_N^* \frac{N - r_i}{N} \right) \right]. \quad (11)$$

By (11) and our previous arguments we now have that convex costs are sufficient for large buyers to obtain a discount, regardless of the curvature of revenues. In fact, with quantity-forcing contracts only the cost-side channel of buyer power exists.²⁶ This is intuitive as the supplier realizes the same revenues $r_i R(x^*/N)$ with buyer i regardless of whether he was successful in negotiating with all other buyers or whether some negotiations resulted in disagreement. Consequently, with quantity-forcing contracts only our insights on the supplier's incentives for process innovation are preserved,²⁷ while downstream market structure has *no* impact on product innovation.

An unattractive feature of quantity-forcing contracts is that, in case of disagreement with some buyer i , the supplier is still constrained to ship exactly the quantities $r_j x_N^*/N$ to all other $j \neq i$ buyers. Unless capacity is constrained and costs are linear, this may be widely inefficient. In the remainder of this section we argue that renegotiations again open up the demand-side channel of buyer power. For a formal analysis of renegotiations, we continue to assume that in any round of (re-)negotiations a buyer receives the fraction ρ of the respective net surplus.

²⁴As noted previously, these two features also ensure that supplies always maximize total industry profits, regardless of which negotiations were successful.

²⁵Uniqueness can be ensured by, for instance, requiring that costs are convex and revenues concave. This is reminiscent of conditions imposed in O'Brien and Shaffer (2003), who consider negotiations between a single buyer and several suppliers.

²⁶We thank a referee for suggesting this discussion.

²⁷In particular, it is easy to see that Proposition 4 still holds.

In case of renegotiations, the parties do not start from scratch, but each side has always recourse to the previously signed contract (t_i, x_i) .²⁸ The fact that previously signed contracts act as outside options heavily complicates the analysis. In fact, allowing for arbitrary rounds of renegotiations, following any further disagreements, turns out to become quickly intractable as the number of buyers (of different size) increases. Consequently, we restrict attention to only a single round of renegotiations. That is, following disagreement at the renegotiation stage, there is no further recontracting. In Appendix B we solve for equilibrium profits and show that the demand-side channel of buyer power is again present, while also Proposition 5 continues to hold. These results are again intuitive. Following disagreement with some buyers, supply contracts with the remaining buyers are optimally adjusted and the supplier captures the fraction $1 - \rho$ of the newly created surplus.

5 Conclusion

This paper studies the impact of the formation of larger buyers on a supplier's profits and, thereby, his incentives to undertake non-contractible activities. We first isolate two sources of buyer power. If revenues at each downstream market are strictly concave, larger buyers can threaten the supplier with a loss in revenues that grows more than proportionally with the buyer's size. If production costs are convex, additional costs incurred by serving an individual buyer increase less than proportionally with the buyer's size.

While the presence of larger buyers reduces the supplier's profits, we argue that his incentives to undertake product or process innovation could in fact increase. Facing larger buyers, the supplier's bargaining position is enhanced if incremental costs are relatively lower at high production volumes and if incremental revenues are relatively higher at large supplies to individual markets. As, for instance, a reduction in marginal costs at high output levels may lead to an increase in supply - in contrast to a reduction in inframarginal costs - a supplier facing larger buyers may invest more in a production technology that increases total welfare.

This paper focuses squarely on buyers' size as the sole determinant of buyer power. Depending on the application, individual buyers may be able to obtain a discount for

²⁸This stands in contrast to an approach adopted by deFontenay and Gans (2001). In the spirit of worker-firm bargaining in Stole and Zwiebel (1996), it is assumed that any individual disagreement makes existing contracts void and leads to fresh negotiations. This approach yields the Shapley value. Interestingly, it can be shown that convex costs and concave demand are not sufficient to generally obtain a large-buyer discount under the Shapley value.

different reasons. For instance, in retailing buyers who stock private-label goods may have a distinctive advantage when negotiating with particular suppliers. Likewise, in certain industries more sophisticated buyers may switch to new procurement strategies, e.g., based on B2B platforms. Buyer power derived from such different sources may have entirely new and different effects on suppliers' incentives. One insight of the present paper is that any sweeping generalization about the "general" impact of buyer power may be highly misleading. Instead, we would argue that a thorough analysis of the (welfare) implications of buyer power requires a precise specification of its sources.

An alternative route to pursue is to introduce non-contractible (investment) choices of buyers. This would be a natural consideration if buyers are themselves manufacturers, who use the supplier's product as an input.

6 Appendix A: Omitted Proofs

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

$$U^*(i) = \sum_{j \in I \setminus \{i\}} t_j \left(x_{N-r_i}^* \frac{r_j}{N-r_j} \right) - C(x_{N-r_i}^*). \quad (12)$$

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 (12) gives

$$U^*(i) = \sum_{j \in I \setminus \{i\}} \bar{t}_j + \Pi_{N-r_i}^* - (N - r_i)R \left(\frac{x_N^*}{N} \right). \quad (13)$$

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

$$\sum_{j \in I \setminus \{i\}} \bar{t}_j + R \left(\frac{x_N^*}{N} \right) - C(x_N^*). \quad (14)$$

Subtracting the supplier's outside option $U^*(i)$ in (13) from the total surplus after disagreement with i in (14), 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 $V_i^* = \rho(\Pi_N^* -$

$\Pi_{N-r_i}^*$). 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). **Q.E.D.**

Proof of Proposition 2. In what follows, it is convenient to treat n as a continuous variable. Take first case (i) where capacity is unconstrained. It is now convenient to denote $\tilde{x}_n = x_n^*/n$, which is given by the first-order condition $R'(\tilde{x}_n) - C'(n\tilde{x}_n) = 0$. Applying the implicit function theorem, we then obtain

$$\frac{d\tilde{x}_n}{dn} = \frac{\tilde{x}_n C''(n\tilde{x}_n)}{R''(\tilde{x}_n) - nC''(n\tilde{x}_n)}. \quad (15)$$

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 $d\Pi_n^*/dn = \tilde{x}_n [p(\tilde{x}_n) - C'(n\tilde{x}_n)]$. Differentiating a second time and using the first-order condition for \tilde{x}_n , we obtain

$$\frac{d^2\Pi_n^*}{dn^2} = -C''(n\tilde{x}_n)\tilde{x}_n \left[\tilde{x}_n + n \frac{d\tilde{x}_n}{dn} \right]. \quad (16)$$

Substituting (15) into (16) finally yields

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

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 $d\Pi_n^*/dn = R(X/n) - XR'(X/n)/n$ and $d^2\Pi_n^*/dn = X^2 R''(X/n)/n^3$. **Q.E.D.**

Proof of Proposition 3. If it costs K to switch, for a given market structure there is a threshold \bar{K} such that the supplier prefers to switch if $K < \bar{K}$ and prefers not to switch if $K > \bar{K}$.²⁹ By definition, the transition to a more concentrated market structure can be decomposed into individual transactions where some buyer i sells to some buyer j the number r of firms with $r_j \geq r_i \geq r$. By (4) this transformation changes the supplier's profits by the amount

$$\rho \left[\left(\Pi_{N-r_i+r}^* - \Pi_{N-r_i}^* \right) - \left(\Pi_{N-r_j}^* - \Pi_{N-r_j-r}^* \right) \right]. \quad (17)$$

Differentiating Π_n^* twice, (17) transforms to

$$\Delta = \rho \int_0^r \left[\int_{N-r_j-r+y}^{N-r_i+y} \frac{d^2\Pi_n^*}{dn^2} dn \right] dy. \quad (18)$$

²⁹We allow also for $\bar{K} < 0$,

If (6) is satisfied, we have from (18) 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 \bar{K} is strictly higher under the more concentrated market structure. If the converse to (6) holds strictly, we have that Δ is strictly smaller after the shift, implying that \bar{K} is strictly lower under the more concentrated market structure. **Q.E.D.**

Proof of Proposition 4. As in the proof of Proposition 3, we want to show that (17) is strictly higher after the switch in technologies, which implies that the respective threshold \bar{K} is strictly larger under the more concentrated market structure. With the linear technology β and unconstrained capacity, we have that (17) is equal to zero. Finally, for the strictly convex technology α we know that, under the conditions of Proposition 2, (17) 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 $W_N^* := N \int_0^{\tilde{x}_N} P(x) dx - C(N\tilde{x}_N)$.³⁰ 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 we thus have that $\Pi_N^*(\beta) \geq \Pi_N^*(\alpha) + K$. If we denote the respective levels of welfare by $W_N^*(\alpha)$ and $W_N^*(\beta)$, respectively, it thus remains to show that $\Pi_N^*(\beta) \geq \Pi_N^*(\alpha) + K$ 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

$$N \int_0^{\tilde{x}_N(\beta)} [P(x) - P(\tilde{x}_N(\beta))] dx > N \int_0^{\tilde{x}_N(\alpha)} [P(x) - P(\tilde{x}_N(\alpha))] dx, \quad (19)$$

where $\tilde{x}_N(\alpha)$ and $\tilde{x}_N(\beta)$ denote the respective equilibrium supplies to individual firms. For (19) to hold, we need that $\tilde{x}_N(\beta) > \tilde{x}_N(\alpha)$. This, however, 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 industry profits are not lower after the switch, $\Pi_N^*(\beta) \geq \Pi_N^*(\alpha)$. **Q.E.D.**

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 (17) then transforms to

$$\Delta = \rho\psi X \left[\left(\frac{1}{N - r_i} - \frac{1}{N - r_i + r} \right) - \left(\frac{1}{N - r_j - r} - \frac{1}{N - r_j} \right) \right]. \quad (20)$$

³⁰We 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.

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 \bar{K} is strictly higher under the more concentrated market structure.

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

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

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 $K \leq \bar{K}_W$ with

$$\bar{K}_W := \frac{1}{2} \frac{X^2}{N} (\psi_\alpha - \psi_\beta). \quad (21)$$

We now compare \bar{K}_W with the respective threshold chosen by the supplier. By our previous result, we know that \bar{K} is lowest for the supplier if the downstream market is least concentrated, i.e., 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

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

which is still strictly higher than the threshold \bar{K}_W in (21). This completes the proof. **Q.E.D.**

7 Appendix B: Quantity-forcing Contracts with Renegotiations

We first derive equilibrium payoffs. In equilibrium, buyer i purchases the quantity $r_i x_N^*/N$. If there is breakdown with buyer i in the first-round negotiations, renegotiations lead to final sales of the quantities $r_j x_{N-r_i}^*/(N - r_i)$ to buyers $j \neq i$. Denote now again the equilibrium payoff of the supplier by U^* and that of buyer i by V_i^* . If there is break-down with buyer i , the supplier's resulting payoff is $U^*(i)$ and each of the remaining buyers $j \neq i$ realizes $V_j(i)$. (In what follows it is not necessary to specify payoffs for when there is breakdown with more than one buyer.) If renegotiations are successful with all buyers but i , denote the net surplus achieved by *additionally* renegotiating the original contract

with buyer $j \neq i$ by $S_j(i)$. (Below we derive this in detail.) We obtain for the first round of negotiations

$$\begin{aligned} U^* &= U^*(i) + (1 - \rho) [U^* - U^*(i) + V_i^*] \text{ for all } i \in I, \\ U^* &= \Pi_N^* - \sum_{i=1}^I V_i^*, \end{aligned} \tag{22}$$

while surplus sharing under renegotiations implies

$$\begin{aligned} V_j^*(i) - V_j^* &= \rho S_j(i) \text{ for all } i \in I, j \neq i, \\ U^*(i) &= \Pi_{N-r_i}^* - \sum_{j \neq i}^I V_j^*(i) \text{ for all } i \in I. \end{aligned} \tag{23}$$

Substituting (22)-(23), we obtain

$$V_i^* = \rho [\Pi_N^* - \Pi_{N-r_i}^*] + \rho^2 \sum_{j \neq i}^I S_j(i).$$

Using next

$$\begin{aligned} S_j(i) &= r_j \left[R \left(\frac{x_{N-r_i}^*}{N-r_i} \right) - R \left(\frac{x_N^*}{N} \right) \right] \\ &\quad - \left[C(x_{N-r_i}^*) - C \left(x_{N-r_i}^* \frac{N-r_i-r_j}{N-r_i} + x_N^* \frac{r_j}{N} \right) \right], \end{aligned}$$

we finally obtain

$$\begin{aligned} V_i^* &= \rho [\Pi_N^* - \Pi_{N-r_i}^*] + \rho^2 (N-r_i) \left[R \left(\frac{x_{N-r_i}^*}{N-r_i} \right) - R \left(\frac{x_N^*}{N} \right) \right] \\ &\quad - \rho^2 \sum_{j \neq i}^I \left[C(x_{N-r_i}^*) - C \left(x_{N-r_i}^* \frac{N-r_i-r_j}{N-r_i} + x_N^* \frac{r_j}{N} \right) \right]. \end{aligned} \tag{24}$$

As noted in the main text, we confine ourselves to the derivation of two results: (i) the illustration of the demand-side channel of buyer power with fixed and sufficiently small capacity (as in Proposition 2) and (ii) the extension of Proposition 5 to the new bargaining solution.

Assume thus that costs are linear with $C(x) = cx$, while capacity X is sufficiently small such that $x_n^* = X/n$ for all $n \geq 1$. We want to show that a sale of assets (firms) to a larger buyer makes the supplier strictly worse off. As under the previous bargaining solution, this is a stronger requirement than the requirement that a larger buyer obtains a discount.

Suppose therefore that buyer i sells r firms to buyer j , where $r_j \geq r_i \geq r$. We denote the payoffs under the original market structure by V_i^* and V_j^* , while those under the resulting market structure are denoted by \bar{V}_i^* and \bar{V}_j^* . (Note that $\bar{V}_i^* = 0$ holds trivially if $r = r_i$.) We thus want to show that

$$\bar{V}_i^* + \bar{V}_j^* > V_i^* + V_j^*. \quad (25)$$

Using (24) and substituting $C(x) = cx$, (25) transforms to the requirement

$$\begin{aligned} & \rho(1 - \rho) \left[(N - r_i + r)R\left(\frac{X}{N - r_i + r}\right) + (N - r_j - r)R\left(\frac{X}{N - r_j - r}\right) \right] \\ < & \rho(1 - \rho) \left[(N - r_i)R\left(\frac{X}{N - r_i}\right) + (N - r_j)R\left(\frac{X}{N - r_j}\right) \right]. \end{aligned} \quad (26)$$

Reordering the terms in (26), we thus have to show for $0 < \rho < 1$ that

$$\int_0^r \left[\int_{N-r_j-r+y}^{N-r_i+y} \frac{d^2}{dz^2} \left[zR\left(\frac{X}{z}\right) dz \right] \right] dy = X^2 \int_0^r \left[\int_{N-r_j-r+y}^{N-r_i+y} \frac{1}{z^3} R''\left(\frac{X}{z}\right) dz \right] dy < 0,$$

which finally holds by the assumed strict concavity of $R(x)$.

It remains to extend Proposition 5. For this we first have to redefine the change in the supplier's payoff under the more concentrated market structure, $\Delta := (\bar{V}_i^* + \bar{V}_j^*) - (V_i^* + V_j^*)$. Substituting from the previous results and using that $R(x) = x(1 - \psi x)$, we thus have that

$$\Delta = -\psi\rho(1 - \rho)X^2 \int_0^r \left[\int_{N-r_j-r+y}^{N-r_i+y} \frac{1}{z^3} dz \right] dy. \quad (27)$$

As in the proof of Proposition 5, $0 < \psi_\beta < \psi_\alpha$ and $\Delta < 0$ then imply that Δ is strictly higher under β than under α . Consequently, the respective threshold \bar{K} is strictly higher under the more concentrated market structure.

8 References

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Figure1: Technology Choice

