Buyer Power and the "Waterbed Effect"*

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Abstract

We present a simple model where the growth of one downstream firm generates lower wholesale prices for this firm but higher wholesale prices for its competitors (the "waterbed effect"). Applied to a setting of Hotelling competition, we can derive precise conditions for when, even though firms compete in strategic complements, this harms consumers. This is more likely to be the case if differences in individual wholesale prices are already substantial.

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1 Introduction

In their repeated inquiries into the grocery retailing sector, the UK's competition authorities have coined the term "waterbed effect".[1] Broadly speaking, the "waterbed effect" is a shorthand term for a situation in which (non cost-related) price reductions are negotiated with suppliers by large buyers and result in higher prices being charged by suppliers to smaller buyers. If buyers are intermediary firms that compete in a final market, then the competitive position of smaller (or, in fact, generally less powerful) firms would deteriorate *both* as its larger competitors receive additional discounts and as they themselves have to pay a premium.[2]

Often, the "waterbed effect" is dismissed on the grounds that it would represent only a logically flawed "accounting exercise", which would not stand up to scrutiny under careful modelling. After all, why would a supplier that seemingly can increase the wholesale price to smaller buyers not have already done so in the past? From this perspective, one of the contribution of this paper is to provide a firm theoretical foundation for the "waterbed effect". In fact, though we will have to apply a particular model of negotiations and formalize only one possible source of buyer power, the underlying logic is both simple and robust. The large buyer's (additional) discount allows it to reduce prices and attract additional business. Some of that increased business will be at the expense of smaller firms. The scale of activity of smaller firms is therefore reduced and the discount they may themselves obtain from suppliers falls. As a consequence, prices paid to suppliers by a large buyer have indeed fallen and prices paid by smaller firms have risen.

Unless one believes that such a waterbed effect would force or at least hasten the exit of smaller downstream firms, from an antirust perspective the existence of a waterbed should, however, *per se* not give rise to concerns. This is so for two reasons. First, even if smaller firms' wholesale prices increase they may still be forced to cut final (retail) prices given that their

[1] For example: Competition Commission, "Supermarkets: A Report on the Supply of Groceries from Multiple Stores in the United Kingdom", Cm 4842, 2000). Competition Commission, 2003, Safeway Plc and ASDA Group Limited (owned by Wal-Mart Stores Inc); Wm Morrison Supermarkets Plc; J. Sainsbury Plc; and Tesco Plc: A report on the Mergers in Contemplation, Cm 5950.

[2] The possibility of such a "waterbed effect" is also explicitly acknowledged in the European Commission's Guidelines on horizontal agreements (European Commission, 2001, Guidelines on the Applicability of Article 81 of the EC Treaty to Horizontal Agreements, Office Journal C31/5-18, par. 126 and 135).

larger competitors charge themselves lower prices.[3] Second, even if smaller firms were to pass through some of the increase in their wholesale price into a higher retail price, then if the retail price of the large buyer dropped sufficiently total consumer surplus may still be higher.

Our model, in particular the working example of Hotelling competition, allows to derive exact conditions for when the identified waterbed effect is sufficiently strong so as to lead both to higher retail prices at smaller buyers and to lower overall consumer surplus. As the same forces that generate size-related discounts in the first place will also be responsible for the waterbed effect, we should expect the waterbed effect to be stronger if the wholesale prices differ already substantially. In this case, where smaller buyers' market share is already squeezed, we will also find that the likelihood of consumer harm is highest.

In the area of grocery retailing, one particular application of our model and results could be to the expansion of large multiples into what was previously the exclusive turf of smaller convenience stores. In a recent report, the UK's Office of Fair Trading writes that " ... evidence suggests that the grocery market is evolving rapidly. The four largest supermarkets ... have moved into the convenience store sector, competing directly with smaller chains and independent stores."[4] This trend is clearly not confined to the UK alone[5], though there it seems to have played a role in triggering yet another market inquiry into the grocery industry.

Importantly, in our model there need not be exit (or less entry) on either the up- or downstream level both for the waterbed effect and for consumer harm to arise. This is different in an alternative foundation for the waterbed effect, according to which the squeeze of suppliers' profits may force some suppliers to exit or may likewise make entry less attractive, which ends up making the offers received by smaller buyers less attractive. An argument along these lines is formalized in Majumdar (2005).[6] It is also worthwhile to mention an opposite theory that was

[3]Formally, this is the case if firms compete in strategic complements as it is typically the case under price competition.

[4]Office of Fair Trading, "Grocery Market: Proposed Decision to Make a Market Investigation Reference", March 2006.

[5]Though this only provides anecdotal evidence, it is telling that the UK's market leader Tesco seems to have finally decided to enter the US market via the convenience store segment ("Wal-Mart, Kroger, Safeway Better Watch Out. The British Are Coming!", CNNMoney.com, February 27, 2006).

[6]Somewhat related, Matthewson and Winter (1996) and Gans and King (2002) show how a buyer group with a first-mover advantage can benefit at the expense of smaller buyers, which move second. However, in their models

advanced in Chen (2003). In his model, a supplier sets the linear wholesale price for a fringe of small buyers before negotiating with a large buyer. As the large buyer becomes more powerful, which is modeled by a shift in the sharing rule for the Nash bargaining game, the supplier tries out recapture some of the lost profits by selling more to the fringe, which requires to lower the price.

There exists a growing literature on buyer power, both on its potential sources as well as on its economic consequences. Snyder (2005) and Inderst and Mazzarotto (2006) provide detailed surveys. As we discuss in detail below, the reason for why large buyers obtain a discount in the first place follows closely, at least in our basic model where growth is achieved by acquisition of other downstream firms, the analysis in Katz (1987). Moreover, we share the focus on linear contracts with, in particular, von Ungern-Sternberg (1996) and Dobson and Waterson (1997). Other papers that show that the exercise of buyer power may harm consumers, albeit through different channels that are not related to the waterbed effect, are Chen (2003) and Battigalli, Fumagalli, and Polo (2005), both of which analyze the impact on suppliers' investment incentives.[7]

The rest of this paper is organized as follows. Section 2 introduces and analyzes the basic model where all downstream firms are of the same size. Section 3 derives the waterbed effect if a larger buyer grows through further acquisitions. The discussion in Section 4 also extends the analysis to the case where downstream firms grow "organically" through increased efficiency of their own operations. Section 5 concludes.

2 The Basic Model

2.1 The Economy

We take the following stylized picture of a market where downstream firms engage in local competition. There are altogether $n = 1, ..., N$, where $N \geq 2$, symmetric final markets. In each market two downstream firms compete, to which we refer to as A_n and B_n. For now each downstream firm has the same constant *own* marginal cost $c \geq 0$. Downstream firms will

buyers do not compete downstream.

[7] On this see also Inderst and Wey (2003) as well as Vieira-Montez (2004)

procure, in equilibrium, from the same supplier, which operates at constant marginal costs $k \geq 0$. We stipulate that firms transform one unit of the purchased input into one unit of the output. The constant input price is given by $w(A_n)$ and $w(B_n)$, respectively. We denote a downstream firm's *total* marginal costs by $m(A_n) := c + w(A_n)$ and $m(B_n) := c + w(B_n)$, respectively.

Note that for the moment we treat each downstream firm as operating independently. Section 3 will introduce large buyers that operate multiple downstream firms. Furthermore, in Section 4 we further allow for differences in size that arise from the fact that firms have different own marginal costs.

Downstream firms compete in prices, which we denote by $p(A_n)$ and $p(B_n)$. We stipulate that all cost parameters are common knowledge. We further assume that there is a unique equilibrium in prices and denote the realized profits by $\pi(m(A_n), m(B_n))$ for firm A_n and, symmetrically, by $\pi(m(B_n), m(A_n))$ for firm B_n. We further make the following assumptions on the derived profit functions.

Assumption 1. *The derived profit function is strictly decreasing in own marginal costs with* $\pi_1(\cdot) < 0$*, while the second derivatives satisfy* $\pi_{11} > 0$ *and* $\pi_{12} < 0$.

We postpone a discussion of the second part of Assumption 1 until later. For the moment, we only want to note that these conditions are commonly invoked in the literature and satisfied by many functional specifications. For instance, Athey and Schmutzler (2001) provide a list of such specifications.[8] In particular, Assumption 1 will hold in our working example, namely that of Hotelling competition.

Before continuing with the specification of the model, some comments are in order. First, our model may be particularly suited for retailing. There, markets are indeed often locally segmented. Though there may be different competing chains, in a given local market consumers may only choose between few different outlets.[9] Second, our choice of price competition may also be particularly suitable for retailing.

In what follows, we make furthermore the following assumption.

[8] In Athey and Schmutzler (2001) the assumption is made in condition (2). Alternatively, see Katz (1986).

[9] In retailing, in particular in the "one-stop-shopping" segment of super- or hypermarkets, the assumption of a tight local oligopoly (and, in particular, no further entry) is also often realistic given local planning restrictions.

Assumption 2. *Prices are strategic complements.*

Importantly, Assumption 2 will not be crucial to derive the existence of a waterbed effect. However, when analyzing the impact on final (retail) prices, from Assumption 2 there will be an important countervailing effect for the final price of the (negatively) affected firm. Finally, note that we have already implicitly assumed that contracts with the supplier prescribe a simple linear tariff i.e., a constant marginal purchasing price of $w(A_n)$ or $w(B_n)$. We comment on this in detail in the next Section.

If a downstream firm rejects the incumbent supplier's offer, it can access the alternative source of supply. This comes at the additional expenditure of $F > 0$. The by now "classical" interpretation, following the seminal contribution of Katz (1987), is to suppose that a downstream firm has the alternative to integrate backwards. In Katz (1987), this alternative is only sufficiently attractive for the largest buyer, while in our analysis it will represent a credible alternative for all downstream firms. In the context of retailing, we may also interpret this alternative as an investment in the production and marketing of a private-label good.[10] Alternatively, we may suppose that another supplier bids against the incumbent. In this case, the costs F would represent a fixed switching costs. Finally, we could also imagine that after rejecting the incumbent's offer, a downstream firm has to incur search expenditures F to locate a new source of supply.

Importantly, the costs of F are unrelated to the volume sold before and the volume sold after switching the source of supply. As analyzed in detail below, this feature will generate a simple and, as we think, natural source of a volume discount. Our following results hold as long as such a volume discount is obtained, i.e., even if some of the costs of substitution were proportional to the realized volume. We next stipulate that when accessing the alternative source of supply, a downstream firm can operate at total marginal costs of $m^{AL} := c + k^{AL}$. We further assume that both inputs have the same quality, though the analysis can be extended in this direction.[11]

Finally, our working example will be that of Hotelling competition. There, each local market

[10] There are many cases where retail chains have indeed substituted a branded good for a private-label alternative. For instance, the German discounter ALDI is famous for this strategy. An alternative strategy, which our model does not intend to capture, is that where a retailer stocks a private-label good next to that of a branded supplier, thereby putting more price pressure on the branded good.

[11] One special case is that where one unit of the alternative good can be transformed into ϕ units of the final

is characterized by the unit interval, with the mass one of consumers being uniformly distributed over it. As is well known, this implies that the mass $x_n = 1/2 + [p(B_n) - p(A_n)]/(2t)$ of consumers shop at outlet A_n, provided that this gives a solution $0 \leq x_n \leq 1$. If there is an equilibrium where market n is fully covered and where both firms are active, the equilibrium price for firm A_n is then

$$p(A_n) = t + \frac{2m(A_n) + m(B_n)}{3},$$

while profits are given by

$$\frac{1}{2t}\left[t + \frac{m(B_n) - m(A_n)}{3}\right]^2.$$

The expressions for B_n are symmetric.

2.2 Wholesale Contracts

As noted above, we stipulate that wholesale contracts are linear. This deserves some comments. As we are interested in the pass-through of discounts to final consumers, this is a natural assumption. Admittedly, supply contracts are indeed often much more complex than the simple linear contracts we study, e.g., as they specify quantity discounts and a wide range of additional fees such as slotting fees, pay-to-stay fees, or display fees in retailing. On the other hand, however, also the notion that the distribution of bargaining power should have no effect on the marginal input prices and thereby on final sales, e.g., as it only affects the fixed part of a two-part tariff contract, is extreme. Both casual evidence and more systematic data collection seem to suggest that discounts given to particular retailers are at least partially passed on to consumers.

One case in place are the "banana wars" between the UK's main retailing chains in 2002-2003. It is understood that following a huge volume discount negotiated by Asda, a fully owned subsidiary of Wal-Mart, with DelMonte, Asda started a prolonged price war by cutting the price of loose bananas from 1.08 to 0.94 pounds per kilo.[12] More systematic evidence for the UK was

good. Another alternative is that where the alternative good is inferior in the eyes of all consumers. We allow for the latter possibility in our working paper version, though only in the Hotelling model.

[12] See also "Concentration in Food Supply and Retail Chains", August 2004, WP Department for International Development (DFID), UK. The price of bananas plays an important role in grocery retailing both as bananas have become the most popular fruit in the UK and as they are a "known-value" item, on the basis of which

gathered in the Competition Commission's 2000 Supermarket report[13], documenting how large retailers received substantial discounts, which ultimately showed up in lower shelf prices.[14]

Our main analysis assumes that contracts are determined by simultaneous and publicly observable take-it-or-leave-it offers that the (incumbent) supplier makes to all downstream firms. Again, this deserves some comments. In what follows, the costs of substitution F will always be assumed to be sufficiently small to ensure that the presence of the alternative supply option effectively constrains the incumbent. Furthermore, if the threat of such demand-side substitution is sufficiently strong, the supplier will only be able to charge a small margin above costs. For this case we could argue that are specification is less restrictive than it may seem at first. This follows from the famous "outside option principle" in bargaining theory. One implication of this principle is that if the alternative to an agreement is sufficiently attractive to one party, then the outcome of negotiations is already pinned down by the value of this alternative even when bargaining power is more equally distributed than in our setting.[15] We also discuss alternative bargaining solutions in Section 4.

Given our specifications, including also that for the moment all downstream firms are independent, the supplier thus faces for each local market the following set of (participation)

consumers decide where to shop. The role of Asda's discount on bananas is also discussed in a recent inquiry by the UK's Competition Commission (see Competition Commission, "Safeway plc and Asda Group Limited (owned by Wal-Mart Stores Inc); Wm Morrison Supermarkets plc; J Sainsbury's plc; and Tesco plc: A Report on the Mergers in Contemplation," 2003).

[13] See Competition Commission, "Supermarkets: A Report on the Supply of Groceries from Multiple Stores in the United Kingdom," Report Cm-4842, 2000. Some of the key results have been recently summarized in Dobson (2005).

[14] From a theoretical perspective, two recent papers by Iyer and Villas-Boas (2003) and Milliou, Petrakis and Vettas (2004) support the assumption of linear contracts by showing that two-part tariffs may either aggravate opportunism problems between suppliers and retailers or exacerbate competition across vertical chains.

[15] More precisely, according to the "outside option principle" there are only two possible scenarios. In the first case, the bargaining payoff without the outside option already exceeds the value of the latter, in which case the outside option has no effect. In the other case, where the outside option is sufficiently attractive, the value of the latter already fully pins down the bargaining solution. It is also well-known that different results are obtained if the alternative option is triggered mechanically by an exogenous risk of breakdown during prolonged negotiations. With two sophisticated negotiators, this approach seems less suitable. (See Binmore, Rubinstein, and Wolinsky (1989).)

constraints:

$$\pi(m(A_n), m(B_n)) \geq \pi(m^{AL}, m(B_n))) - F \tag{1}$$

for firm A_n and

$$\pi(m(B_n), m(A_n)) \geq \pi(m^{AL}, m(A_n))) - F \tag{2a}$$

for firm B_n, where we used each time that in case of rejecting the supplier's offer the respective downstream firm can operate at total marginal costs of m^{AL}.

2.3 Analysis

The (participation) constraints (1) and (2a) need clearly not bind generally. In particular, this is the case if either F or k^{AL} and thus m^{AL} are high, making the alternative option very unattractive. In this case, increasing the wholesale price until the contraints bind would result in too low purchases to be optimal for the supplier. In what follows, we want to exclude this case and focus, instead, on the case where the alternative option is sufficiently attractive so as to effectively constrain the supplier's optimal choice of wholesale prices. We do this by stipulating that the marginal costs from the outside option, k^{AL}, are just equal to those of the (incumbent) supplier. For simplicity, we can then abbreviate the resulting total marginal costs for a downstream firm by $m = k + c$. Furthermore, in what follows we will always keep F sufficiently low. We have the following result.

Proposition 1. *Consider the benchmark case where all downstream firms are symmetric, both in size and own marginal costs. Then for low F the supplier's symmetric equilibrium offer w_I to each retailer is uniquely determined and strictly increasing in F.*

Proof. See Appendix.

The result that the equilibrium wholesale price for each of the symmetric and independent downstream firms, w_I, is strictly increasing in F is intuitive. For the specific example of Hotelling competition, we also obtain an explicit characterization.

Proposition 2. *Consider the benchmark case with Hotelling competition. Then the supplier charges a margin of*

$$w_I - k = 3t\left[\sqrt{1 + 2F/t} - 1\right], \tag{3}$$

which is also strictly increasing in t.

Proof. See Appendix.

In addition to the comparative result in F in Proposition 1, for the Hotelling competition the supplier's margin $w_I - k$ is also strictly higher the less competitive the downstream market is, as measured by the "shoeleather costs" t.[16]

3 The Model with Multiples

3.1 Extending the Model

To develop the key insights on the waterbed effect, it is sufficient to introduce a single large downstream firm. We do this by supposing that one company now operates $2 \leq n_L \leq N$ downstream firms (or outlets in the case of retailing), each in a separate local market. To be precise, let this be firms A_n with $n \in \{1, ..., n_L\}$.

To streamline the exposition, we already take as given the following. In equilibrium, there will now be three different wholesale prices. As the large buyer purchases jointly for the n_L firms it controls, it will secure a single price w_L such that $w(A_n) = w_L$ for all $n \in \{1, ..., n_L\}$. The competing small firms in these n_L markets will all face a the same wholesale pice of w_S, i.e., $w(B_n) = w_S$ for $n \in \{1, ..., n_L\}$. Finally, it is intuitive that the wholesale price for all other downstream firms in markets $n > n_L$ will be unaffected and thus still equal to w_I. Hence, we still have that $w(A_n) = w(B_n) = w_I$ for $n > n_L$.

As noted already above, we will introduce further below another way how one firm can grow in size, namely through "organic growth" in its existing market due to an increase in efficiency. Presently, where growth is only by expansion into new independent market, the three wholesale

[16] It should be noted, however, that one can not choose in equation (3) the differentiation parameter t arbitrarily small without simultaneously reducing F. The derivation of the equilibrium relies on the assumption that switching to the alternative supply option represents a credible alternative for both downstream firms. If we let $t \to 0$ while F remains bounded away from zero, however, then in case of rejecting w_I the respective downstream firm would be better off to seize operations instead of incurring $F > 0$ and earning almost no margin on its sales.

prices must satisfy the following (participation) constraints:

$$\begin{aligned}\text{for } w_I &: \quad \pi(m_I, m_I) \geq \pi(m, m_I) - F, \\ \text{for } w_S &: \quad \pi(m_S, m_L) \geq \pi(m, m_L) - F, \\ \text{for } w_L &: \quad n_L\pi(m_L, m_S) \geq n_L\pi(m, m_S) - F.\end{aligned} \tag{4}$$

3.2 The Waterbed Effect on Wholesale Prices

As in Proposition 1, for low F all participation constraints in (4) will be binding. We then have the following characterization.

Proposition 3. *Consider the case with a large (multiple) downstream firm. Then the multiple's wholesale price w_L is strictly smaller than the benchmark wholesale price w_I from Proposition 1, while the wholesale price of competing smaller firms w_S is now strictly larger than w_I. Moreover, the differences $w_I - w_L > 0$ and $w_S - w_I > 0$ are strictly increasing in the multiple's size n_L.*

Proof. See Appendix.

The intuition for Proposition 3 has two parts. The first part, namely for why $w_L < w_I$ holds, is relatively straightforward. The second part, namely for why $w_S > w_I$ holds, is more subtle. Turning first to why an increase in $n_L > 1$ lowers the large buyer's purchasing price, note that when substituting away from the incumbent supplier the multiple now only incurs the costs F once for all its n_L firms.[17] In other word, as a switching large buyer can roll over the costs F over a strictly larger volume, changing the source of supply is thus less costly per unit, which forces the supplier to reduce the wholesale price so as to still satisfy the large buyer's participation constraint.

Having established that the large buyer obtains a discount, we turn next to the small firms that compete with the large buyer. As the large buyer obtains a discount, making him more competitive, he will take away market share from the smaller firms. A first intuition for why the small firms' wholesale price $w_S > w_I$ must go up is that when switching they would incur

[17] Recall at this point the various interpretations that, following Katz (1987), we have given for these costs in Section 2.

the same costs F on the basis of a *smaller* volume, i.e., the *per-unit* costs from switching would go up such that their participation constraint would be relaxed.

This rough intuition does, however, not go all the way towards proving why $w_S > w_I$. Importantly, the fact that a competing firm becomes now more competitive as $w_L < w_I$ affects a small firm's profits both on and off equilibrium, i.e., both when accepting and when rejecting the supplier's offer of w_S. However, using Assumption 1 we can show that after a reduction in w_L the on-equilibrium profits $\pi(m_S, m_L)$ are *less* affected than the off-equilibrium profits $\pi(m, m_L)$, implying that the small firms' participation constraint is indeed relaxed. A reduction of w_L, which the supplier is forced to make as the large buyer's option of switching becomes more attractive, thus allows the supplier to set a wholesale price for the small firms that previously would not have been compatible with their participation constraint.

From the role that F plays both for the discount of the large buyer and the premium paid by smaller firms, the following comparative result is intuitive.

Corollary 1. *While both w_L and w_S are strictly increasing in F, so is also the difference $w_S - w_L > 0$.*

Proof. See Appendix.

Note next that for our theory of the waterbed effect it is crucial that the negatively affected firms are in direct competition with the firms controlled by the large buyer. In contrast, the wholesale prices of all other firms in markets $n > n_L$ is not affected. Note that in our model, where buyer power derives from changes in buyers' outside options, his would also not be different if the supplier had a different, non-linear cost function.

In contrast to the case of Section 2 where all buyers were of equal size, with asymmetric buyers we can no longer obtain an explicit characterization of equilibrium wholesale prices even for the Hotelling case. However, the set of the two binding participation constraints that jointly determine w_L and w_S has now a simple structure, which we use later for our numerical example. Using in addition the notation that

$$M_L := w_L - k \text{ and } M_S := w_S - k,$$

we can substitute into (4) to obtain the two quadratic expressions

$$
\begin{aligned}
2M_S M_L + 6tM_S - (M_S)^2 &= 18tF, \\
2M_S M_L + 6tM_L - (M_L)^2 &= 18tF/n_L.
\end{aligned}
\tag{5}
$$

As following an increase in n_L the large buyer's wholesale price decreases, the resulting change for the small firms can be simply derived from implicit differentiation of their binding participation constraint, namely the first line in (5). This (only partial) analysis of the waterbed effect yields

$$
\frac{\partial M_S}{\partial M_L} = \frac{\partial w_S}{\partial w_L} = -\frac{1}{6t}\frac{M_S}{y_S}, \tag{6}
$$

where y_S denotes the market share of the small firm in the respective local market.

From (6) we have already a key insight that will prove important later on when analyzing the impact on final prices and consumer surplus, namely that the waterbed effect is stronger the more disadvantaged (or "squeezed") smaller firms already are. More formally, it is stronger if they pay a relatively higher price such that both w_S is higher and their market share y_S is lower. To formalize this, we can conduct a comparative analysis in F and use Corollary 1.

Proposition 4. *In the Hotelling model, the waterbed effect as measured by $\partial w_S/\partial w_L$ and as given by* (6)*, is stronger if the difference in wholesale prices $w_S - w_L > 0$ is already large, which in turn is the case for high F.*

Proof. See Appendix.

3.3 Analysis of Retail Prices and Consumer Surplus

Recall now from Assumption 1 that prices are strategic complements. This clearly complicates an analysis of final (retail) prices as for the small firms, which face higher wholesale prices, there are now two conflicting forces at work. First, holding all else constant small firms would optimally pass on some of the wholesale price increase into higher retail prices. However, as their competitors, namely the firms controlled by the large buyer, face lower wholesale prices and thus compete more aggressively, this creates incentives for small firms to lower their retail prices. We analyze in this Section how these two forces play out and what this ultimately entails for consumer surplus.

As noted in the previous Section, taking as given a reduction in w_L for the large buyer, we can obtain the respective change in w_S simply by moving along the binding participation constraint of small firms in (4). Along this trajectory, the change in the small firms' retail price, which we denote by $p_S = p(B_n)$ for $n \in \{1, ..., n_L\}$, is then given by

$$\frac{dp_S}{dw_L} = \frac{\partial p_S}{\partial w_L} + \frac{\partial p_S}{\partial w_S}\frac{\partial w_S}{\partial w_L}. \tag{7}$$

The fact that the first term in (7) is positive and the second term negative captures the previously mentioned two conflicting effects. Consequently, if along the whole trajectory we had that

$$\frac{\partial p_S}{\partial w_L} < -\frac{\partial p_S}{\partial w_S}\frac{\partial w_S}{\partial w_L}, \tag{8}$$

then following an increase in n_L and thus a *reduction* in w_L the waterbed effect would dominate. In contrast, if the converse of (8) holds, then the competitive pressure exerted by the large buyer's firms, which produce at lower total marginal costs following a reduction of w_L, dominates.

For the general analysis, we can show that if F is sufficiently small, implying that there is altogether little scope for discounts to arise in the first place, then the further growth of the large buyer will reduce *all* retail prices.

Proposition 5. *If the large buyer's advantage $w_S - w_L > 0$ is sufficiently small, i.e., if F is sufficiently small, then an increase in the large buyer's size, through the acquisition of additional firms, leads to a reduction of all retail prices.*

Proof. See Appendix.

To go beyond Proposition 5, we have to turn again to our working example of Hotelling competition. There, we can easily derive that (7) becomes

$$\frac{dp_S}{dw_L} = \frac{\partial p_S}{\partial w_L} + \frac{\partial p_S}{\partial w_S}\frac{\partial w_S}{\partial w_L} = \frac{1}{3}\left[1 + 2\frac{\partial w_S}{\partial w_L}\right].$$

Hence, the waterbed effect now dominates such that condition (8) holds if

$$\frac{\partial w_S}{\partial w_L} < -\frac{1}{2}. \tag{9}$$

Moreover, we know already know from Proposition 4 that (9) is more easily satisfied if the discount of the large buyer is large, i.e., if F is not too small. Intuitively, this is just the opposite of what was required for Proposition 5 to hold. More precisely, substituting from (6) we can transform condition (9) into the requirement that

$$y_S < \frac{w_S - k}{3t}, \tag{10}$$

where y_S denotes again the respective market share of a small firm.

In the numerical example that we analyze below, we show that condition (10) can be indeed satisfied with parameter values that give also rise to reasonable values for the margins of both downstream firms and the supplier. Note, however, that when using (10) we have to be aware that y_S and $w_S - k$ are clearly *not* independent. In fact, as $F \to 0$ we have that $y_S \to 1/2$, while $w_S - k \to 0$, in which case the converse of (10) holds, bringing us back to Proposition 4.

Though an increase in p_S would clearly harm all consumers that still purchase from small firms (and, in addition, those consumers that have switched to the large firm), total consumer surplus may still increase. In the Hotelling model with critical consumer type x_n in market n, i.e., where the mass x_n of consumers purchase from the large buyer's firm A_n, total consumer surplus equals

$$\Omega := u - [x_n p_L + (1 - x_n) p_S] - t \left[\int_0^{x_n} x dx + \int_{x_n}^1 x dx \right]. \tag{11}$$

We calculate again the marginal impact of a reduction of w_L, both directly and via its (waterbed) effect on w_S, where the latter is again derived from the binding participation constraint of small firms. Differentiating (11) and noting that by definition of the critical consumer type x_n the marginal impact of a change in x_n is zero, we then have that

$$\frac{d\Omega}{dw_L} = - \left[y_S \left(\frac{\partial p_S}{\partial w_L} + \frac{\partial p_S}{\partial w_S} \frac{\partial w_S}{\partial w_L} \right) + (1 - y_S) \left(\frac{\partial p_L}{\partial w_L} + \frac{\partial p_L}{\partial w_S} \frac{\partial w_S}{\partial w_L} \right) \right].$$

That is, the change in consumer surplus is just equal to the change in the average price, where we have now substituted y_S for the market share of the small firm. After substitution, we obtain that, through the waterbed effect, a reduction of the large buyer's wholesale price reduce total consumer surplus if

$$2y_S \frac{2 - y_S}{1 + y_S} < \frac{w_S - k}{3t}. \tag{12}$$

Note first that (12) is clearly stricter than condition (9), which only ensures that a small firm's retail price increases. Moreover, for $y_S \leq 1/2$, which is clearly the case, the left-hand side of (12) is strictly increasing in y_S. Hence, in analogy to (9) also condition (12) is more easily satisfied the lower the small firms' market share already is. We summarize our results as follows.

Proposition 6. *In the Hotelling model, following a reduction in the large buyer's wholesale price after an increase in n_L the waterbed effect is sufficiently strong to ensure that the retail price of competing small firms goes up if condition (9) holds. Moreover, this also reduces total consumer surplus if the stricter condition (12) holds. Both condition are more easily satisfied if the large buyer's advantage $w_S - w_L > 0$ is sufficiently large, i.e., if F is sufficiently large.*

We conclude this Section with a numerical example. Originally, the large buyer controls $n_L = 2$ firms and doubles the number of firms to $n_L = 4$. We set $t = 0.7$ and $F = 0.2$, while choosing marginal costs $k = 7$ for the supplier and $c = 0$. We should note that, generally, the absolute values of these variables have no particular meaning as we can scale all expressions with any given factor. Consequently, we will report, in particular, ratios and percentages in what follows. Moreover, the parameter choices are made so as to obtain somewhat realistic values for margins, at least for the area of grocery retailing,

For the original situation, i.e., with $n_L = 2$, we obtain the respective wholesale prices $w_S \approx 8.43$ and $w_L \approx 7.38$. Hence, the large buyer obtains a discount of 12.4%. The respective retail prices are then $p_I \approx 8.78$ and $p_L \approx 8.43$ such that the margins of the two competitors are equal to 12.4% and 4%, respectively. As the large buyer further grows, we find that the discount increases from 12.4% to 26.4%. Precisely, w_L decreases to about 7.15, while w_S increases to about 9.04. The large buyer's margin is now 14.3%, while that of mall firms is down to below 1%. Finally, we find for this specification that the average retail price is indeed strictly higher after the further expansion of the large buyer, though only marginally. Precisely, the average price increases by slightly less than 1%.

Note finally that the criterion (12), which ensures that total consumer surplus is lower, is typically substantially stricter then criterion (9), which ensures only that the small firms' retail price increases. (Formally, the respective left-hand side is multiplied by $2y_S\frac{2-y_S}{1+y_S}$ in (12), which is always strictly larger than 2.) While for antitrust purposes total consumer surplus may be the decisive criterion, in particular with regard to retailing distributional considerations may also have some weight. For instance, if in the Hotelling model a consumer's "address" takes not only into consideration physical distance but also mobility, then clearly a rise in the retail prices of smaller outlets would more than proportionally harm less mobile consumers.

4 Discussion

4.1 Firm Growth and the Waterbed Effect

In the previous analysis we have simply captured the growth of one buyer by enlarging the number n_L of firms that this buyer controls. As we have shown in the working paper version, albeit only for the Hotelling model, one can also make the acquisition process endogenous in the sense that an already larger buyer has also a larger willingness to pay to acquire an additional firm. This is intuitive as the larger buyer can both lever an already smaller wholesale price into yet another market and as this dampens competition compared to the case where a previously smaller competitor becomes more equal in size.[18] On the other hand, our previous results do not cover the case where a buyer, even if it only controls one firm, grows "organically" by becoming more efficient and thereby taking away some of its competitor's market share. We show in this Section that this give also rise to a waterbed effect, though the formal argument is different and more subtle than that underlying Proposition 3.

For the sake of brevity we thus return to the case where each firm is operated independently, which allows us to analyze each of the N markets in isolation. Our departure from the perfectly symmetric case analyzed in Propositions 1-2 is, however, that now firms can still have different market shares and thus size as they differ in their own marginal costs c. More precisely, in the considered local market n we consider a reduction in the own marginal costs $c(A_n) < c(B_n)$ of the already more efficient firm A_n. Note that now firms' total marginal costs $m(A_n)$ and $m(B_n)$ may differ both because their wholesale prices $w(A_n)$ and $w(B_n)$ differ *and* because of the difference $c(A_n) < c(B_n)$. We also denote the respective total marginal costs after switching by $m^{Al}(A_n) := k + c(A_n)$ and likewise by $m^{Al}(B_n) := k + c(B_n)$.

The key equations that govern the derivation of the equilibrium wholesale prices are again the respective participation constraints for the two independent firms in market n. With the additional notation at hand, the constraints (1) and (2a) become now

$$\pi(m(A_n), m(B_n)) \geq \pi(m^{AL}(A_n), m(B_n))) - F \tag{13}$$

[18] Formally, in the Hotelling model total profits that are realized in one market increase as, holding *average* marginal costs fixed, we further increase the *difference* in marginal costs.

for firm A_n and

$$\pi(m(B_n), m(A_n)) \geq \pi(m^{AL}(B_n), m(A_n))) - F \tag{14}$$

for firm B_n.

We have the following result in analogy to Proposition 3.

Proposition 7. *If differences in firms' size are due to differences in their own efficiency, then the insights from Proposition 3 still survive. Precisely, if $c(A_n)$ further decreases such that the difference $c(B_n) - c(A_n) > 0$ and thus the difference in market share widen, then this further reduces $w(A_n)$ while it further increases $w(B_n)$.*

Proof. See Appendix.

In contrast to Proposition 3, where the arguments for why after its further growth the large buyer's wholesale price decreases and that of the small buyer increases were different, for Proposition 7 the same logic applies to changes in both $w(A_n)$ and $w(B_n)$. Take first A_n. Holding first all else equal, as we reduce $c(A_n)$ the participation constraint of A_n in (13) becomes stricter as the on-equilibrium profit on the left-hand side grows more slowly than the off-equilibrium profit on the right-hand side. From $w(A_n) > k$, which holds in turn whenever $F > 0$, this follows immediately from Assumption 1, namely that $\pi_{11} > 0$. The final step, namely that $w(B_n)$ increases, is then completely analogous to the argument in Proposition 3.

4.2 Nash Bargaining

Our theory for why larger buyers, either if they grow organically by becoming more efficient or if they grow by acquisition, obtain a discount compared to smaller buyers is driven by changes in the value of buyers' outside options. To focus on this effect it was thus convenient to suppose that the supplier can make simultaneous take-it-or-leave-it offers. Moreover, as we noted above, when appealing to the "outside option principle" the analysis also extends to less degenerate distributions of bargaining power.

In this Section we take, in contrast, a bargaining solution for which the "outside option principle" does not hold. Namely, we take the asymmetric Nash bargaining solution where the outside options are the threatpoints. More precisely, take first all other wholesale prices as given and suppose that, for simplicity, an independent firm negotiates with the supplier over the respective wholesale price. To avoid confusion with our previous analysis while abbreviating the notation, denote the respective wholesale price by w_a. We also refer to the fixed wholesale price of the competing firm in the same market simply by w_b.To obtain the Nash product, denote for the supplier's profits $\mu(m_i, m_j) := (w_i - k)D(m_i, m_j)$, where $i, j \in \{a, b\}$ and where $D(\cdot)$ denotes the by assumption symmetric derived demand function, after substitution of the respective equilibrium prices. Then the Nash product is

$$\begin{aligned} & [\pi(m_a, m_b) - \pi(m, m_b) + F]^\alpha \left[\mu(m_a, m_b) + \mu(m_b, m_a) - \mu(m_b, m)\right]^{1-\alpha} \\ = & \; U^\alpha V^{1-\alpha}, \end{aligned}$$

where α represents the bargaining power of firm a and $1 - \alpha$ that of the supplier. Note that U denotes the firm's net surplus and V that of the supplier, subtracting each time the respective payoff without an agreement. Assuming that the Pareto (bargaining) frontier is strictly concave, the Nash bargaining solution satisfies

$$\frac{\alpha}{1-\alpha} \frac{dU/dw_a}{dV/dw_a} = \frac{U}{V}, \tag{15}$$

giving rise to a unique value w_a. Moreover, under these assumptions (and using the second-order condition of the Nash product) we then obtain that

$$\begin{aligned} & \frac{\partial w_a}{\partial w_b} \leq 0 \qquad (16) \\ \iff \alpha \left[V \frac{d^2 U}{dw_a dw_b} + \frac{dU}{dw_a} \frac{dV}{dw_b} \right] + (1-\alpha) \left[U \frac{d^2 V}{dw_a dw_b} + \frac{dV}{dw_a} \frac{dU}{dw_b} \right] & \leq 0. \end{aligned}$$

Our first observation is that for the case with $\alpha = 0$ we are back to our original case with a waterbed effect from $\partial w_a / \partial w_b < 0$. To see this, note that for $\alpha = 0$ we also have that the net payoff of the downstream firm U is equal to zero. The term in (16) thus reduces to

$$\frac{dV}{dw_a} \frac{dU}{dw_b} < 0,$$

which in turn holds from $dV/dw_a > 0$ at the equilibrium choice of w_a together with $dU/dw_b = \pi_2(m_a, m_b) - \pi_2(m, m_b) < 0$ by Assumption 1 and $m < m_a$.

For higher α we *may* now, however, get a countervailing effect, which works *against* the waterbed effect effect. To see this, note that in case $w_b > w_a$ a still higher w_b makes it increasingly costly for the supplier to reduce w_a as this further reduces the more profitable sales to b. Likewise, for $w_b < w_a$ a further increase in w_a may be relatively more beneficial for the supplier as the thereby cannibalized sales to b are less profitable.

Unfortunately, the complexity of *simultaneous* Nash bargaining over linear contracts with competing buyers does not allow us to generally go further in our analysis. In fact, also in the working example of Hotelling competition the analysis becomes no longer tractable. However, there is one particular case that proves to be tractable and that allows us to establish, at least in its narrow limits, the robustness of the waterbed effect for *all* $\alpha < 1$. (Clearly, for $\alpha = 1$ the wholesale price for all downstream firms is equal to the supplier's own marginal costs and thus independent of all other parameters of the model.)

The particular case we are looking at under Hotelling competition is that where the two firms, a and b, are again symmetric. At the symmetric Nash solution $w_a = w_b = w$ we can then establish the following. If we were now to exogenously decrease one of the two wholesale prices, say w_b, then for *all* $\alpha < 1$ in the negotiations with firm a the resulting wholesale price w_a becomes strictly higher, as postulated by the waterbed effect. We relegate a formal derivation of this result to the Appendix. Future work, we hope, may be able to provide more general results, in particular on whether and when one could also find the opposite of a waterbed effect, namely that a discount to one firm must in equilibrium be matched by a similar discount to its competitors.

5 Conclusion

The objective of this paper is to study how through a change in buyer power, a downstream firm's expansion may affect both wholesale and retail prices and ultimately consumer surplus. Our particular application is to retailing, where the expansion of chains through the acquisition of previously independent outlets is of increasing concern to antitrust authorities. Our analysis focuses thereby on the short run, where product variety and quality as well as the number and location of outlets was taken to be fixed. Absent such long-run consideration and absent direct monopolization effects from acquisitions, the identified waterbed effect and its possible consequences may thus often be the only channel through which consumers could be harmed.

The model allowed to derive conditions for when consumer harm is more likely. Consumer harm is more likely if smaller (or otherwise less powerful) buyers are already substantially disadvantaged vis-a-vis their larger competitors. In this case, where wholesale prices may substantially differ across firms, a further discount to large buyers is more likely to give rise to a substantial waterbed effect and thereby also to an increase in the average final price.

As noted in the Introduction, a different theory of the waterbed effect builds on the observation that as suppliers' profits get more squeezed by the exercise of buyer power, there will either be consolidation in the upstream industry or less entry and thus overall less competition for small buyers' business. Majumdar (2005) has a model along these lines. Extending also the present model to incorporate such a more dynamic theory of the waterbed effect may allow to better differentiated between implications in the short and in the long run. Also, carrying out a similar analysis based, however, on different theories of buyer power seems valuable. For instance, in grocery retailing the increasing introduction of private labels by large retailers could, one may argue, negatively affect competing retailers through its implications on the variety as well as the price and quality of goods that they can themselves purchase from the remaining independent suppliers.

6 Appendix

Proof of Proposition 1. We start with some technical observations. We will use throughout that the supplier optimally sets both wholesale prices not below marginal costs k. (This property is easily established.) Also, we will use that we can restrict consideration to some bounded interval $[k, \overline{w}]$ such that both $w(A_n)$ and $w(B_n)$ must lie in this interval. Finally, we will use that derived profit functions are continuous in marginal costs.

We show now that for $F \to 0$ both (A_n) and $w(B_n)$ must become arbitrarily close to k. Suppose to the contrary that along a sequence of equilibria where $F \to 0$ this would not hold such that the respective values of, say, $w(A_n) > k$ remained bounded away from k. Then the right-hand side of (1) would clearly exceed the left-hand side for all sufficiently low F.

We argue next that for low F it holds from optimality for the supplier that both participation constraints bind. Instead of appealing to some form of concavity restriction imposed on the supplier's problem, our argument uses again only that F shall be small. (Note, however, that this is thus only a sufficient but by no means a necessary assumption.[19])

Denote now for the supplier's profits $\mu(m(A_n), m(B_n)) := (w(A_n) - k)D(m(A_n), m(B_n))$ and likewise $\mu(m(B_n), m(A_n)) := (w(B_n) - k)D(m(B_n), m(A_n))$, where $D(\cdot)$ denotes the by assumption symmetric derived demand function. The supplier's total profits is thus given by $\widehat{\mu}(m(A_n), m(B_n)) := \mu(m(A_n), m(B_n)) + \mu(m(A_n), m(B_n))$. Clearly, if $w(B_n) = k$ and $m(A_n)$ is sufficiently small, then $d\widehat{\mu}(m(A_n), m(B_n))/dm(A_n) > 0$. This also clearly extends to the case where $w(B_n)$ is close to k (instead of being equal to k). By these observations, it then follows immediately that for low F at least one participation constraint must bind. Suppose next that only the constraint of B_n was binding but not that of A_n. When marginally increasing $m(A_n)$ while adjusting $m(B_n)$ to still satisfy the constraint for A_n with equality, the supplier's total profits change by

$$\begin{aligned}&\left[D(m(A_n), m(B_n)) + (m(A_n) - k)\frac{dD(m(A_n), m(B_n))}{dm(A_n)}\right] \\ &+(m(B_n) - k)\frac{dD(m(B_n), m(A_n))}{dm(A_n)}\frac{dm(B_n)}{dm(A_n)},\end{aligned} \tag{17}$$

where

$$\frac{dm(B_n)}{dm(A_n)} = \frac{dw(B_n)}{dw(A_n)} = \frac{\pi_2(m, m(A_n)) - \pi_2(m(B_n), m(A_n))}{\pi_1(m(B_n), m(A_n))}. \tag{18}$$

Given that for low F we have that $w(B_n)$ is close to k and thus $m(B_n)$ close to m, we have that (18) must be close to zero. (Note that we also use here that both $w(B_n)$ and $w(A_n)$ stay in some bounded interval $[k, \overline{w}]$, which implies that the denominator is bounded away from zero.) But then the sign of (17) is determined by the first expression in rectangular brackets, which for $w(A_n)$ close to k is again strictly positive.

We have thus established that an optimal pair of offers must satisfy the system of the two binding constraints, which we rewrite as

$$\begin{aligned}\pi(m, m(B_n))) - \pi(m(A_n), m(B_n)) - F &= 0, \\ \pi(m, m(A_n))) - \pi(m(B_n), m(A_n)) - F &= 0.\end{aligned} \tag{19}$$

We show now that for low F there is only a single solution.[20] This follows if the Jacobian

[19] While our key results on consumer surplus will only be derived for low F in the general case, for the Hotelling model, where we need not invoke such low boundaries for F, we also derive results for higher values of F.

[20] Note that existence of a solution is immediate from the two observations that the suppliers' maximization problem clearly has a solution and that by Claim 1 both constraints must bind.

matrix of the system (19) is strictly positive definite, which holds in turn if all principal minors are positive. To see this, note that the derivative of the first line of (19) w.r.t. $m(A_n)$ and the derivative of the second line of (19) w.r.t. $m(B_n)$ are strictly positive from $-\pi_1(\cdot) > 0$. Next, the determinant is given by

$$\begin{aligned} & \pi_1(m(A_n), m(B_n))\pi_1(m(B_n), m(A_n)) \\ & -[\pi_2(m, m(B_n))) - \pi_2(m(A_n), m(B_n))]\,[\pi_2(m, m(A_n))) - \pi_2(m(B_n), m(A_n))] \\ > \; & 0, \end{aligned}$$

which follows for low F as the second line must go to zero while the first line remains bounded away from zero. (Note that we use again that both $m(A_n)$ and $m(B_n)$ must become close to m.)

We have thus established that in the currently considered symmetric case there is a unique optimal offer to both firm in a given market, w_I, such that $m_I = c + w_I$ satisfies

$$\pi(m, m_I) - \pi(m_I, m_I) - F = 0. \tag{20}$$

Implicit derivation of (20) yields then

$$\frac{dm_I}{dF} = \frac{1}{-\pi_1(m_I, m_I) + [\pi_2(m, m_I) - \pi_2(m_I, m_I)]} > 0. \tag{21}$$

Note that in order to sign (21), we could use again only that $\pi_1 < 0$ and that F becomes small, which allows to ignore the second term in the denominator. However, from Assumption 1 (21) clearly holds more generally as, given that $m_I > m$ and $\pi_{12} < 0$, we have also have that $\pi_2(m, m_I) - \pi_2(m_I, m_I) > 0$.**Q.E.D.**

Proof of Proposition 2. Substituting the expressions for profits (at an interior equilibrium) from the Hotelling model into (20), we have the requirement that

$$(w_I - k)^2 + 6t(w_I - k) = 18tF, \tag{22}$$

which transforms to (3). It is immediate that (3) is strictly decreasing in F. Differentiating (3) w.r.t. t, we have next that

$$\frac{dw_I}{dt} = 3\frac{3F - (w_I - k)}{3t + (w - k)} > 0. \tag{23}$$

where we use that from (22) that $3F > w_I - k$. **Q.E.D.**

Proof of Proposition 3. The argument why, for low F, the optimal pair of offers is characterized again by the system of binding constraints and why this has a unique solution is perfectly analogous to that in the proof of Proposition 1 and therefore omitted. Denote now for convenience $F_L := F/n_L$ such that the binding constraints become

$$\begin{aligned} \pi(m, m_L) - \pi(m_S, m_L) - F &= 0, \\ \pi(m, m_S) - \pi(m_L, m_S) - F_L &= 0. \end{aligned} \tag{24}$$

Total differentiation of (24) yields now

$$\begin{pmatrix} -\pi_1(m_S, m_L) & \pi_2(m, m_L) - \pi_2(m_S, m_L) \\ \pi_2(m, m_S) - \pi_2(m_L, m_S) & -\pi_1(m_L, m_S) \end{pmatrix} \begin{pmatrix} dm_S \\ dm_L \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix} dF_L$$

such that by Cramer's rule

$$\begin{aligned} \frac{dm_L}{dF_L} &= \frac{-\pi_1(m_S, m_L)}{Det} > 0, \\ \frac{dm_S}{dF_L} &= -\frac{\pi_2(m, m_L) - \pi_2(m_S, m_L)}{Det} < 0. \end{aligned}$$

Note that the signs follow from Assumption 1 and as the determinant satisfies $Det > 0$, which we already showed in the proof of Proposition 1. **Q.E.D.**

Proof of Corollary 1. Proceeding now as in the proof of Proposition 3, we have again from Cramer's rule that

$$\begin{aligned} \frac{dm_L}{dF} &= \frac{-\pi_1(m_S, m_L)/n_L - [\pi_2(m, m_S) - \pi_2(m_L, m_S)]}{Det} > 0, \\ \frac{dm_S}{dF} &= \frac{-\pi_1(m_L, m_S) - [\pi_2(m, m_L) - \pi_2(m_S, m_L)]/n_L}{Det} > 0. \end{aligned}$$

Finally, we have for the difference that $d(m_S - m_L)/dF > 0$ holds if

$$\begin{aligned} & -n_L \pi_1(m_L, m_S) - [\pi_2(m, m_L) - \pi_2(m_S, m_L)] \\ > \; & -\pi_1(m_S, m_L) - n_L [\pi_2(m, m_S) - \pi_2(m_L, m_S)], \end{aligned} \tag{25}$$

which from $n_L > 1$ holds surely if F is sufficiently low. **Q.E.D.**

Proof of Proposition 4. As the assertion uses Corollary 1 also for F that are not close to zero, we have to establish that the result also holds more generally with Hotelling competition. Substituting the respective expressions into requirement (25), we have after some transformations the requirement that

$$n_L[3t + m_S - m] > 3t + m_L - m. \tag{26}$$

Note first that for $n_L = 1$ this holds just with equality as also $m_S = m_L$. Condition (26) thus holds for all $n_L > 1$ as m_S is strictly increasing and m_L strictly decreasing in n_L. **Q.E.D.**

Proof of Proposition 5. To evaluate (8) note first that from implicit differentiation of the small firm's binding participation constraint we have that

$$\frac{\partial w_S}{\partial w_L} = \frac{\partial m_S}{\partial m_L} = \frac{\pi_2(m, m_L) - \pi_2(m_S, m_L)}{\pi_1(m_S, m_L)}.$$

As already noted in the proof of Proposition 1, where we used the same expression in (18), we have from $m_S \to m$ as $F \to 0$ that $\partial w_S / \partial w_L \to 0$. This implies that for the *converse* of (8) to hold strictly for low F, we only need that $\partial p_S / \partial w_L > 0$, where we use Assumption 2, must remain bounded away from zero. **Q.E.D.**

Proposition 7. Total differentiation of the binding constraints, as previously done for (24), yields now

$$\begin{aligned}
&\begin{pmatrix} -\pi_1(m(A_n), m(B_n)) & \pi_2(m^{AL}(A_n), m(B_n)) - \pi_2(m(A_n), m(B_n)) \\ \pi_2(m^{AL}(B_n), m(A_n)) - \pi_2(m(B_n), m(A_n)) & -\pi_1(m(B_n), m(A_n)) \end{pmatrix} \\
&\times \begin{pmatrix} dw(A_n) \\ dw(B_n) \end{pmatrix} \\
= \; & - \begin{pmatrix} \pi_1(m^{AL}(A_n), m(B_n) - \pi_1(m(A_n), m(B_n)) \\ \pi_2(m^{AL}(B_n), m(A_n)) - \pi_2(m(B_n), m(A_n)) \end{pmatrix} dc(A_n).
\end{aligned}$$

Note here again that, in particular, $m(A_n) = w(A_n) + c(A_n)$ and $m^{Al}(A_n) = k + c(A_n)$. Thus, we have from Cramer's rule that

$$\frac{dw(A_n)}{dc(A_n)} = -\frac{D_A}{Det},$$

where D_A is given by

$$\begin{aligned}
&-\pi_1(m(B_n), m(A_n)) \left[\pi_1(m^{AL}(A_n), m(B_n) - \pi_1(m(A_n), m(B_n))\right] \\
&- \left[\pi_2(m^{AL}(A_n), m(B_n)) - \pi_2(m(A_n), m(B_n))\right] \left[\pi_2(m^{AL}(B_n), m(A_n)) - \pi_2(m(B_n), m(A_n))\right].
\end{aligned}$$

For $dw(A_n)/dc(A_n) < 0$ to hold, we thus only need to show that

$$\pi_1(m^{AL}(A_n), m(B_n) - \pi_1(m(A_n), m(B_n)) < 0,$$

which follows from $\pi_{11} > 0$ in Assumption 1 together with $m^{AL}(A_n) < m(A_n)$. Next, we have that

$$\frac{dw(B_n)}{dc(A_n)} = -\frac{D_B}{Det},$$

where now D_B is given by

$$\begin{aligned}&\pi_1(m(A_n), m(B_n)) \left[\pi_2(m^{AL}(B_n), m(A_n)) - \pi_2(m(B_n), m(A_n))\right] \\ &- \left[\pi_1(m^{AL}(A_n), m(B_n) - \pi_1(m(A_n), m(B_n))\right] \left[\pi_2(m^{AL}(B_n), m(A_n)) - \pi_2(m(B_n), m(A_n))\right].\end{aligned}$$

To obtain $D_B > 0$ and thus $dw(B_n)/dc(A_n) < 0$, we can now use from Assumption 1 that $\pi_{11} < 0$. **Q.E.D.**

Omitted expressions for Nash bargaining with Hotelling competition. With Hotelling competition, we obtain first the following expressions, which we always calculate as well at $w_b = w_a = w$:

$$\begin{aligned}U &= \left[t + \frac{w_b - w_a}{3}\right]^2 - \frac{1}{2t}\left[t + \frac{w_b - k}{3}\right]^2 + F \\ &= \frac{1}{18t}[18tF - (w-k)(6t + (w-k))],\end{aligned}$$

$$\begin{aligned}V &= \frac{1}{2t}(w_a - k)(t + 2w_b - w_a - k) \\ &= \frac{1}{2t}(w-k)(t + w - k),\end{aligned}$$

$$\frac{dU}{dw_a} = -\frac{1}{3t}\left[t + \frac{w_b - w_a}{3}\right] = -\frac{1}{3},$$

$$\frac{dU}{dw_b} = -\frac{1}{9t}(w_a - k) = -\frac{1}{9t}(w-k),$$

$$\frac{dU}{dw_a dw_b} = -\frac{1}{9t},$$

$$\frac{dV}{dw_a} = \frac{1}{2t}(t + 2w_b - 2w_a) = \frac{1}{2},$$

$$\frac{dV}{dw_b} = \frac{1}{t}(w_a - k) = \frac{1}{t}(w-k),$$

$$\frac{dV}{dw_a dw_b} = \frac{1}{t}.$$

We can then substitute to obtain

$$\begin{aligned} & V\frac{d^2U}{dw_a dw_b} + \frac{dU}{dw_a}\frac{dV}{dw_b} \\ = & -\frac{1}{18t^2}(w-k)(t+w-k) - \frac{1}{3t}(w-k) \\ = & -\frac{1}{18t^2}(w-k)(7t+w-k) \end{aligned}$$

and

$$\begin{aligned} & U\frac{d^2V}{dw_a dw_b} + \frac{dV}{dw_a}\frac{dU}{dw_b} \\ = & \frac{1}{18t^2}[18tF - (w-k)(6t+(w-k))] - \frac{1}{18t}(w-k) \\ = & \frac{1}{18t^2}\left[18tF - (w-k)(7t+(w-k))\right]. \end{aligned}$$

Hence, the term on the left-hand side of (16) is given by

$$-\frac{1}{18t^2}(w-k)(7t+w-k) + (1-\alpha)\frac{F}{t}. \tag{27}$$

It is now convenient to once more transform this such that we finally have to show for all $\alpha < 1$ that

$$(1-\alpha)18tF < (w-k)[7t+(w-k)]. \tag{28}$$

We show this by using the first-order condition for the Nash product, $\alpha\frac{dU}{dw_1}V + (1-\alpha)\frac{dV}{dw_1}U = 0$, which after substitution becomes

$$\alpha\frac{1}{2t}(w-k)[t+(w-k)]\frac{1}{3} = (1-\alpha)\frac{1}{2}\frac{1}{18t}[18tF - (w-k)(6t+(w-k))]$$

and thus implies that

$$(1-\alpha)18tF = (w-k)\left[6t + (w-k) + \alpha 5(w-k)\right]. \tag{29}$$

Substituting (29), condition (28) thus holds surely whenever

$$t > \alpha 5(w-k). \tag{30}$$

The right-hand side of (30) is clearly non-monotonic in α, given that it is zero at $\alpha = 0$ and also zero at $\alpha = 1$, where we have that $w = k$. However, for given t and α, it holds surely for sufficiently low values of F as then also $w - k$ becomes arbitrarily close to zero.

7 References

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