EXCLUSIVE DEALING AND COMPATIBILITY OF INVESTMENTS[*]

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Abstract

We examine a final product manufacturer's incentives to engage in exclusive dealing with an input supplier when both market sides invest in quality and bargain over their trading terms. Taking into account that the investments' compatibility can be higher under exclusive dealing we find, in contrast to previous literature, that bargaining power distribution plays a crucial role both for investment incentives and for incentives to adopt exclusive dealing. We also find that there exist cases in which although investments are higher under exclusive dealing, the manufacturer chooses non-exclusive dealing. Our welfare analysis indicates that the manufacturer's choice of exclusive dealing in equilibrium is never welfare detrimental.

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1 Introduction

In a world in which technology has considerably reduced transaction and search costs, firms would have been expected to shop around among various suppliers for the best deal. In contrast to this expectation, there is growing evidence that large manufacturing firms, such as IBM, John Deere & Co., and Harley-Davidson, do not tend to do so.[1] They tend, instead, to restrict upstream competition by developing exclusive partnerships with their input suppliers.[2]

One of the arguments commonly used to explain this trend is that firms are placing an increased emphasis on product quality and that their dealing with a single supplier enables them to develop tighter relations that result in better coordination of their investments in product quality. In fact, several field studies of buyer-supplier relations have demonstrated the advantages that smaller and tighter supplier networks have in quality and responsiveness, as well as in innovation and information exchange.[3] For example, according to a survey paper on the car-manufacturing industry, exclusive suppliers provide their costumers with detailed information about their processes and products and this "information helps automakers ensure that their component designs are *compatible* with suppliers' processes, thus improving productivity and quality."[4]

In this paper, we investigate the incentives of a final product manufacturer to develop an exclusive dealing relation with an input supplier, taking the above argument into account. To do so, we consider a simple environment in which a downstream monopolist - an input buyer - decides at the outset whether or not it will offer an exclusive dealing contract to one of two potential input suppliers. Both the buyer and the suppliers invest in the quality improvement of their products before bargaining over the terms of a non-linear contract. In order to capture the better coordination of the buyer's and the supplier's investments

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[1] See e.g., Moore et al. (2002), Cusumano and Takeishi (1991), Helper (1991), as well as "Who's more passionate about Harley-Davidson than its motorcycle riders? The tight knit members of its $1 billion supply chain," *Forbes*, 09/10/2001, and "Deer takes a giant leap," *Purchasing*, 09/06/2001.

[2] E.g., "IBM used to have a couple dozen mechanical and cabel suppliers; now it has one for each commodity" in "Reinventing purchasing wins the medal for big blue," *Purchasing*, 09/09/1999.

[3] See e.g., Cusumano and Takeishi (1991), Helper (1991), and Helper and Sako (1995). According to Moore et al. (2002, p.158): "When it comes to establishing closer ties with suppliers, Tennant [a leader in manufacturing cleaning machineries] has discovered that two is more than enough company, three a definite crowd, and has come to prefer single-sourcing in most instances."

[4] See Helper and Sako (1995, p. 79).

under exclusive than under non-exclusive dealing, we assume that the compatibility of their investments is full only in the former case.[5]

According to our first main result not only the compatibility of investments, but also the bargaining power distribution plays an important role for investment incentives. Despite the fact that the compatibility of investments is full only under exclusive dealing, investments are higher under exclusive than under non-exclusive relations only when the buyer's bargaining power is sufficiently high. Otherwise, both the buyer's and the supplier's investments are higher under non-exclusive dealing. Why is this so? Under non-exclusive dealing, the buyer does not enjoy the full compatibility of its investments, but it enjoys a compensation for its 'outside option', that is, for having the option to deal with an alternative supplier. While the lack of full compatibility has a negative impact on the buyer's investment incentives, its compensation for the outside option has a positive impact as its investments augment the outside option's value. When the buyer's bargaining power is low, the 'outside option effect' dominates because the buyer retains a larger share of its outside option. Strategic complementarity between the buyer's and the supplier's investments leads to a similar behavior of the supplier's investments.

Our second main result refers to the equilibrium supply chain structure. We find that exclusive buyer-supplier relations arise in equilibrium whenever the buyer's bargaining power is high enough. This is intuitive since as we mentioned above the quality-enhancing investments behave in a similar way. What is though less intuitive is that there exist cases in which although the investments are higher under exclusive dealing, the buyer chooses non-exclusive dealing. In other words, the quality-enhancing investments are not the only force at work. The buyer's decision is also affected by the fact that competition among the suppliers is present only in the case of non-exclusive dealing. Due to the suppliers' competition, the buyer has effectively higher bargaining power during the contract terms negotiations under non-exclusive dealing than under exclusive dealing where the outside option is absent.

Our welfare analysis reveals, first, that the manufacturer's choice of exclusive dealing in equilibrium is never detrimental to welfare. And, second, that there exist circumstances in which although welfare is higher under exclusive dealing, the manufacturer chooses not

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[5]In Section 6, we relax this assumption and endogenize the compatibility of investments.

to engage in an exclusive dealing relation. Therefore, from an antitrust policy's perspective, although our results indicate that the social and the private incentives do not always coincide, they still provide an argument against the view that exclusive dealing is an anti-competitive practice, in the cases at least that exclusive dealing is initiated by downstream manufacturers.

Extending our model by endogenizing the compatibility of investments, we provide conditions under which our assumption regarding compatibility holds, that is, we provide conditions under which compatibility turns out to be full only in the case of exclusive dealing. In particular, we show that this can happen when the buyer's bargaining power is sufficiently high. The main force that drives this result is the following. Under non-exclusive dealing, a supplier has lower incentives to increase the compatibility of its investments with those of the buyer, through opening a specific research line for the buyer, because the higher compatibility leads to higher buyer's investments and thus to a higher value of the outside option for which the supplier has to compensate the powerful buyer.

The impact of exclusive contracts on investment incentives was first studied by Segal and Whinston (2000).[6] Using a cooperative bargaining framework, they show that exclusivity has a positive impact on investment incentives when investments are "external" (i.e. when they increase the value of trade with a third firm), and no impact whatsoever when investments are "internal". Segal and Whinston (2000) differ from us not only because they model bargaining in a cooperative way, but, more importantly, because they do not consider the role of the compatibility of investments. Two more recent papers by De Meza and Selvaggi (2003) and Che and Sákovics (2004) also examined the impact of exclusivity on investments. These papers, however, do not allow both the buyer and the suppliers to undertake investments, and they too do not take into account the compatibility of investments. Note that in contrast to our paper, Segal and Whinston (2000) as well as De Meza and Selvaggi (2003) and Che and Sákovics (2004) have *not* identified the crucial role of the bargaining power distribution for the investment incentives.

The incentives to adopt exclusive dealing, both in the presence and in the absence of

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[6]For an informal discussion of the potential impact of exclusivity on investments see e.g., Klein (1988), and Klein et al. (1978). For an in depth analysis of firms' incentives to undertake noncontractible investments in only bilateral monopoly settings see e.g., Williamson (1985), Tirole (1986), Grossman and Hart (1986), Hart and Moore (1988), Che and Sákovics (2004a).

investments, have been analyzed by the vertical restraints literature (see e.g., Marvel, 1982, Besanko and Perry, 1993, Bernheim and Whinston, 1998). In contrast to us, most of this literature has analyzed the supplier's, and not the buyer's, decision regarding exclusive dealing, and has not considered the role of bargaining in this decision. Moreover, while the vertical restraints literature on exclusive dealing has focused on settings in which under non-exclusive dealing, the buyers are multi-product retailers that sell the competing products of all the suppliers, we focus on settings in which the buyer is always a single-product firm. Undoubtedly this literature has shed some light on the antitrust issues arising in cases with supplier-initiated exclusive contracts, but has not examined the antitrust implications of buyer-initiated exclusive contracts.

The rest of the paper is organized as follows. We describe our model in Section 2. We analyze the non-exclusive dealing case in Section 3 and the exclusive dealing case, along with the impact of exclusivity on investments, in Section 4. In Section 5, we consider the buyer's decision regarding exclusive dealing and examine its welfare implications. In Section 6, we extend the model by endogenizing the compatibility of investments. We conclude and discuss possible extensions in Section 7. All the proofs are included in the Appendix.

2   The Model

We consider an industry consisting of a downstream firm - input buyer, denoted by B, and two upstream firms - potential input suppliers, each denoted by S_i, with $i = 1, 2$.[7] We assume that there is an one-to-one relation between the input and the final product produced by the buyer, and that each input supplier faces a constant marginal cost of production $c \geq 0$.

We analyze a full information four-stage game (see Fig. 1). In stage one, the buyer decides whether or not it will engage in an exclusive relation with one of the suppliers. The exclusive relation can be established through the use of an exclusive dealing contract that specifies a prohibitive compensation that the buyer must pay to its exclusive supplier in case it obtains the input from the non-exclusive supplier.

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[7]As it will become clear later, the same results would have been obtained in a model with n suppliers, where $n \geq 2$.

In stage two, the buyer B and its potential suppliers S_1 and S_2 simultaneously and independently choose their investment levels, b, s_1, and s_2 respectively. Each firm's investments lead to an increase in the quality of its own product. We assume that the higher is the quality of the input used in the final product, the higher is the latter's quality. Moreover, we assume that consumers have a higher willingness to pay for products of higher quality. In particular, the inverse demand function for the final product is:

$$p = a + \vartheta(b + s_i) - q \tag{1}$$

where $a > c$ and q and p are respectively the quantity and the price of the final product. The subscript i, $i = 1, 2$, indicates the supplier from which the buyer obtains the input. The parameter ϑ captures the degree of compatibility of the buyer's and its input supplier's investments. Low values of ϑ reflect low compatibility of the outcomes of their research projects (e.g., bad matching due to lack of coordination). We assume that compatibility is full only under exclusive dealing. In particular, $\vartheta = 1$ under exclusive dealing and $\vartheta = \theta$, with $0 \leq \theta < 1$, under non-exclusive dealing. The investments of both the buyer and the suppliers are subject to diminishing returns to scale, captured by the quadratic form of their cost functions: $b^2/2$ and $s_i^2/2$.

In stage three, non-cooperative bargaining over a two-part tariff contract, consisting of a wholesale price w_i and a franchise fee F_i, takes place among the buyer and its potential input suppliers. While under exclusive dealing the buyer bargains only with its exclusive supplier, under non-exclusive dealing it bargains simultaneously with both S_1 and S_2. In modeling the bargaining game, we adopt the approach used by De Fraja and Sákovics (2001), Chemla (2003), Rey and Tirole (2003), and Che and Sákovics (2004).[8] In particular, in the exclusive dealing case, a take-it-or-leave-it offer over w_i and F_i is made with probability β by the exclusive supplier S_i and with probability $1 - \beta$ by the buyer. Similarly, in the non-exclusive dealing case, take-it-or-leave-it offers over w_i and F_i, are made simultaneously and independently by S_1 and S_2 with probability β and with probability $1 - \beta$ by the buyer.[9]

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[8] We would have obtained exactly the same results if we had instead employed the Nash bargaining solution.

[9] Similarly to the paper by De Fraja and Sákovics (2001) when the buyer makes the offer, after observing the quality levels of both suppliers, it chooses one of the suppliers to which it makes the offer.

The parameter β, with $0 < \beta < 1$, denotes the supplier's bargaining power.

Finally, in stage four, the buyer chooses the quantity of its final good and produces it using the input obtained according to the terms of trade specified in the previous stage.

We derive the subgame perfect Nash equilibria in pure strategies of the above four-stage game. Since the upstream firms are identical, there are two second-stage subgames to consider, the subgame with non-exclusive dealing and the subgame with exclusive dealing. In what follows, we start by analyzing the two subgames separately and then move to the analysis of stage one.

3   Non-Exclusive Dealing

In this section, we deal with the case in which the buyer is free to obtain its input from any of the two suppliers.

In stage four, the buyer chooses the quantity that maximizes its gross profits:

$$\underset{q}{Max} \;\; \pi_B(q, w_i, b, s_i) = [a + \theta(b + s_i) - q - w_i]\, q, \tag{2}$$

where the subscript i, $i = 1, 2$, simply specifies the supplier from which the buyer obtains its input.[10] From the first order condition of (2), we obtain the equilibrium quantity:

$$q(w_i, b, s_i) = \frac{a + \theta(b + s_i) - w_i}{2}. \tag{3}$$

In stage three, where the bargaining takes place simultaneously among the buyer and its potential suppliers, we distinguish among the following two cases, for $i, j = 1, 2$ and $i \neq j$:

(a) $s_i = s_j \geq 0$: When the suppliers offer the same input quality, competition among them results not only in both of them making the same offer, but also in making an offer that leaves them with zero profits. Formally, each S_i makes an offer that maximizes the

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[10] We assume w.l.o.g. that the buyer always buys all its input quantity from one supplier. When the buyer is indifferent between purchasing from any one of the two suppliers, we can distinguish among two cases: (1) if the suppliers offer different input qualities, the buyer will always buy from the high quality supplier – this is a reasonable tie-breaking rule, and (2) if the two suppliers offer the same input quality and the same terms of trade, it makes no difference for our analysis if the buyer buys all the input quantity from one of them or if it splits this quantity between the two in any arbitrary way. Perry and Sákovics (2003) show that with a fixed number of suppliers the buyer prefers a sole-source auction to a split-award auction.

buyer's profits subject to the constraint that its own profits are non-negative:

$$\underset{w_i,F_i}{Max}\ [q(w_i,b,s_i)]^2 - F_i \quad \text{s.t.} \quad (w_i - c)q(w_i,b,s_i) + F_i \geq 0. \tag{4}$$

The constraint in (4) is binding, and thus, the supplier's maximization problem becomes equivalent to the maximization problem of the buyer's and the supplier's joint profits. As a result, both suppliers end up offering wholesale prices which are equal to the marginal cost of production, $w_i = w_j = c$, and franchise fees which are equal to zero, $F_i = F_j = 0$.

When the buyer makes the offer, it chooses w_i and F_i in order to maximize its profits subject to the constraint that S_i's profits are non-negative. In other words, the buyer's problem is equivalent to (4). Thus, the buyer offers the same contract terms with the suppliers.

It follows that the expected net profits of the two suppliers are zero in the case that they have not undertaken any investments, and negative otherwise.

(b) $s_i > s_j \geq 0$: When one of the suppliers offers a higher input quality than its competitor, then the two suppliers face two different maximization problems. While the high input quality supplier maximizes its profits subject to the constraint that the buyer has no incentives to buy from the low input quality supplier, i.e.

$$\underset{w_i,F_i}{Max}\ (w_i - c)q(w_i,b,s_i) + F_i \quad \text{s.t.} \quad [q(w_i,b,s_i)]^2 - F_i \geq [q(w_j,b,s_j)]^2 - F_j, \tag{5}$$

the low input quality supplier maximizes the buyer's profits subject to its own profits being non-negative. Just like in case (a), this translates into optimally setting $w_j = c$ and $F_j = 0$. Due to this and to the fact that the constraint in (5) is binding, the maximization problem of the high input quality supplier reduces to:

$$\underset{w_i,F_i}{Max}\ (w_i - c)q(w_i,b,s_i) + [q(w_i,b,s_i)]^2 - [q(w_j,b,s_j)]^2. \tag{6}$$

This is equivalent to the maximization of the buyer's and the high input quality supplier's incremental joint profits (i.e. those above the buyer's 'outside option') and it is easy to see that it leads again to $w_i = c$. However, it does not lead to a zero franchise fee, it leads

instead to:

$$F_i = [q(w_i, b, s_i)]^2 - [q(w_j, b, s_j)]^2. \tag{7}$$

It is important to note that when the supplier with the high input quality makes the contract offer, it cannot extract through the franchise fee all the buyer's profits. Instead, it has to compensate the buyer for its 'outside option', that is, for the profits that the buyer would make in case it accepted the contract offered by the other supplier.[11]

When the buyer makes the contract offer, it maximizes its profits subject to the constraint that S_i's profits are non-negative. In other words, the buyer's maximization problem is given again by (4), and thus, the contract terms offered by B are again $w_i = c$ and $F_i = 0$.

It follows that the expected net profits of the low input quality supplier are zero in the case that it has not undertaken any investments, and negative otherwise. Instead, the expected net profits of the high input quality supplier and of the input buyer are:

$$E_{S_i}(b, s_i, s_j) = \beta \left[[q(c, b, s_i)]^2 - [q(c, b, s_j)]^2 \right] - \frac{s_i^2}{2}, \tag{8}$$

$$E_B(b, s_i, s_j) = (1 - \beta) [q(c, b, s_i)]^2 + \beta [q(c, b, s_j)]^2 - \frac{b^2}{2}. \tag{9}$$

We can conclude from the above analysis that only one of the suppliers will invest in the quality improvement of its product. Formally:

Lemma 1 *Under non-exclusive dealing, only one supplier undertakes quality-enhancing investments.*

Given Lemma 1, it is important to note at this point that the buyer's and the supplier's investments are strategic complements. This holds both for the buyer and for the investing supplier. In particular:

$$\frac{\partial^2 E_{S_i}(b, s_i, 0)}{\partial b \partial s_i} = \frac{\theta^2 \beta}{2} > 0; \quad \frac{\partial^2 E_B(b, s_i, 0)}{\partial s_i \partial b} = \frac{\theta^2 (1 - \beta)}{2} > 0.$$

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[11]Bolton and Whinston (1993) show that the equilibrium of an alternating offer bargaining game with three players is also identical to the equilibrium of an outside option bargaining game between the parties with the largest joint surplus where the party with the alternative trading partner has an outside option of trading with its less preferred partner and obtaining the entire surplus from that trade. It is well known that in the solution to the outside option bargaining game the buyer not only obtains the corresponding to its bargaining power share of the largest surplus but it is also compensated for the surplus it could get from its outside option (see Rubinstein, 1982).

Using Lemma 1 and equations (8) and (9), we obtain the equilibrium investments and the equilibrium profits under non-exclusive dealing, which are summarized in the following Lemma.

Lemma 2 *Under non-exclusive dealing, the investment levels of the buyer and the suppliers as well as their respective expected net profits, for $i, j = 1, 2$ and $i \neq j$, are:*

$$b^N = \frac{\theta(a-c)(2-\beta^2\theta^2)}{4+\beta^2\theta^4-2\theta^2-2\beta\theta}; \quad s_i^N = \frac{2\beta\theta(a-c)}{4+\beta^2\theta^4-2\theta^2-2\beta\theta}; \quad s_j^N = 0 \qquad (10)$$

$$E_B^N = \frac{(a-c)^2(8+2\beta^3\theta^4-8\beta^2\theta^2-\theta^6\beta^4+4\theta^4\beta^2-4\theta^2)}{2(4+\beta^2\theta^4-2\theta^2-2\beta\theta)^2} \qquad (11)$$

$$E_{S_i}^N = \frac{\beta^2\theta^2(a-c)^2(2-\beta\theta^2)}{(4+\beta^2\theta^4-2\theta^2-2\beta\theta)^2}; \quad E_{S_j}^N = 0. \qquad (12)$$

Differentiating the investment levels given by equation (10) with respect to θ, one can see that, just like expected, an increase in the compatibility of investments has a positive effect both on the buyer's and the supplier's investments. The effect though of an increase in the supplier's bargaining power on investments is not so straightforward and it is included in the following Proposition.

Proposition 1 *While under non-exclusive dealing the supplier's investments s_i^N are always increasing in its bargaining power β, the buyer's investments b^N are decreasing in its bargaining power $(1-\beta)$ when $\beta < \beta_c(\theta)$, with β_c increasing in θ.*

Surprisingly, an increase in the buyer's bargaining power $(1-\beta)$ leads to a *decrease* in the buyer's investments, provided that the buyer's bargaining power is sufficiently high. The intuition for this result comes from the buyer's compensation for its outside option. While the value of the outside option is increasing in the buyer's investments, the buyer's share of the outside option is decreasing in the buyer's bargaining power (see second term of equation (9)). As a result, a decrease in the buyer's bargaining power has two opposite effects on the buyer's investment incentives. While, on the one hand, it decreases the buyer's incentives because the buyer appropriates a smaller share of its own profits in the bargaining game, on the other hand, it increases them because the buyer increases its compensation for its outside option by undertaking higher investment levels. Provided that the bargaining power of the buyer is sufficiently high, the 'outside option effect' dominates the first effect,

and thus, a decrease in the buyer's bargaining power has a positive impact on the buyer's investments.

The result regarding the supplier's investments under non-exclusive dealing is more intuitive. The higher is the supplier's bargaining power, the higher is the supplier's share of the surplus, and thus, the higher are the supplier's incentives to increase the surplus through its own investments

4 Exclusive Dealing

We turn now to the analysis of the exclusive dealing case, assuming without loss of generality that S_1 is the exclusive supplier.

The last stage of the game is the same as under non-exclusive dealing with only one difference, the compatibility of investments is now full. Hence, the quantity that maximizes the buyer's profits is given again by equation (3) from before with $\theta = 1$:

$$q(w_1, b, s_1) = \frac{a + b + s_1 - w_1}{2}. \tag{13}$$

In stage three, the bargaining game takes place only among buyer B and its exclusive supplier S_1. Given that S_1's offer is the only offer received by B, S_1 solves the following maximization problem:

$$\underset{w_1, F_1}{Max} \ (w_1 - c)q(w_1, b, s_1) + F_1 \quad \text{s.t.} \ [q(w_1, b, s_1)]^2 - F_1 \geq 0. \tag{14}$$

The constraint is binding, and thus S_1 ends up maximizing the buyer's and the supplier's joint profits:

$$\underset{w_1}{Max} \ (w_1 - c)q(w_1, b, s_1) + [q(w_1, b, s_1)]^2. \tag{15}$$

From the first order condition of (15), it follows that $w_1 = c$. The corresponding franchise fee is $F_1 = [q(w_1, b, s_1)]^2$. Note that the franchise fee is now equal to the buyer's gross profits. In other words, under exclusive dealing, when the supplier makes the contract offer, it extracts through the franchise fee all the buyer's profits since the latter has no outside option.

In the case that B makes the contract offer to S_1, B chooses w_1 and F_1 in order to

maximize its profits subject to the constraint that S_1's profits are non-negative:

$$\underset{w_1, F_1}{Max} \ [q(w_1, b, s_1)]^2 - F_1 \quad \text{s.t.} \ (w_1 - c)q(w_1, b, s_1) + F_1 \geq 0. \tag{16}$$

Since the constraint is binding, the buyer's problem reduces to (15). Hence, B also offers $w_1 = c$. Setting $w_1 = c$ in the constraint of (16), it follows that $F_1 = 0$.

In stage two, S_1 and B choose s_1 and b respectively in order to maximize their expected net profits:[12]

$$\underset{s_1}{Max} \ E_{S_1}(b, s_1) = \beta \left[q(c, b, s_1)\right]^2 - \frac{s_1^2}{2}; \quad \underset{b}{Max} \ E_B(b, s_1) = (1 - \beta) \left[q(c, b, s_1)\right]^2 - \frac{b^2}{2}. \tag{17}$$

Note that again the buyer's and the supplier's investments are strategic complements. The equilibrium values under exclusive dealing derived by solving the above maximization problems are included in Lemma 3.

Lemma 3 *Under exclusive dealing, the investment levels of the buyer and of its exclusive supplier as well as their respective expected net profits are:*

$$s_1^E \ = \ \beta(a - c); \quad b^E = (1 - \beta)(a - c) \tag{18}$$

$$E_B^E \ = \ (1 - \beta)(a - c)^2 \frac{1 + \beta}{2}; \quad E_{S_1}^E = \beta(a - c)^2 \frac{2 - \beta}{2}. \tag{19}$$

An inspection of the equilibrium values under exclusive dealing reveals that contrary to the non-exclusive dealing case, both the buyer's and the exclusive supplier's investments increase in their own bargaining power.

Having in hand the equilibrium investments under both exclusive and non-exclusive dealing, we can now examine the effect of exclusivity on investments. Our main findings are summarized in the following Proposition.

Proposition 2 *There exist $\beta_b(\theta)$, $\beta_s(\theta)$ and $\beta_e(\theta)$, decreasing in θ and with $\lim_{\theta \to 1} \beta_b(\theta) = \lim_{\theta \to 1} \beta_s(\theta) = \lim_{\theta \to 1} \beta_e(\theta) = 0$, such that*

(i) $b^E > b^N$ if and only if $\beta < \beta_b(\theta)$,

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[12] Note that it follows immediately from our analysis that the non-exclusive supplier will not undertake any investments.

(ii) $s_1^E > s_i^N$ *for all* β *when* $0 \leq \theta \leq 0.839$ *and if and only if* $\beta < \beta_s(\theta)$ *when* $0.839 < \theta < 1$,

(iii) $b^E + s^E > \theta(b^N + s^N)$ *for all* β *when* $0 \leq \theta \leq 0.766$ *and if and only if* $\beta < \beta_e(\theta)$ *when* $0.839 < \theta < 1$.

Proposition 2 reveals that the impact of exclusivity on investment incentives depends crucially on the distribution of the bargaining power. In particular, according to part (i), exclusivity has a negative impact on the buyer's investment incentives only when the buyer's bargaining power is sufficiently low (Fig. 2 illustrates the result). Intuitively, under non-exclusive dealing, the buyer does not enjoy the full compatibility of its investments but it does enjoy a compensation for its outside option. While the lack of full compatibility has a negative impact on the buyer's incentives to invest, its compensation for the outside option has a positive impact since its investments increase the value of its outside option. Under exclusive dealing, the outside option is absent but the buyer enjoys the full compatibility of its investments which in turn increases its incentives to invest. When the buyer's bargaining power is sufficiently high, the effect of the compatibility dominates and the buyer's investments are higher under exclusive than under non-exclusive dealing. In contrast, when the buyer's bargaining power is low, the effect of the outside option dominates and the previous result is reserved. This is so because when the buyer's bargaining power is low, the buyer retains a larger share of its outside option under non-exclusive dealing and thus its incentives to invest become even stronger.

Part (ii) of Proposition 2 states that exclusivity has a negative impact on the supplier's investments only when both the degree of compatibility and the supplier's bargaining power are high (Fig. 3 illustrates the result). The intuition for this last result is as follows. When θ takes values close to 1 (i.e. high degree of compatibility under non-exclusive dealing), the investments' compatibility does not differ significantly across the two cases. At the same time, when the supplier's bargaining power is sufficiently high, then in accordance with part (i), the buyer's investments are lower under exclusive than under non-exclusive dealing. Strategic complementarity between the buyer's and supplier's investments implies that the lower buyer's investments under exclusive dealing lead to also lower supplier investment incentives.

What about the the total 'effective' investments, that is, the final product's total quality

level, which are equal to $b^E + s_1^E$ under exclusive dealing and to $\theta(b^N + s_i^N)$ under non-exclusive dealing?[13] As stated in part (iii) of Proposition 2, the comparison of the total effective investments is similar to that of the supplier's investments (see also Fig. 5).

5 Exclusive vs. Non-Exclusive Dealing

In this section, we analyze the buyer's decision regarding exclusive dealing along with its welfare implications.

Proposition 3 *There exists* $\beta_E(\theta)$, *decreasing in* θ *and with* $\lim_{\theta \to 1} \beta_E(\theta) = 0$, *such that the buyer prefers exclusive to non-exclusive dealing if and only if* $\beta < \beta_E(\theta)$ *and* $\beta_E(\theta) < 0.707$.

Proposition 3 implies that exclusive dealing will be observed only when the buyer's bargaining power is sufficiently high (see Fig. 4).[14] The intuition behind this result is straightforward. When the buyer's bargaining power is low, the buyer appropriates a small share of its own profits under both exclusive and non-exclusive dealing. However, recall from Proposition 2 that when the buyer's bargaining power is low, the total effective investments, and thus, the final good's quality level is lower under exclusive than under non-exclusive dealing. Given that a higher product quality leads to higher sales, it follows that when the buyer's bargaining power is low, its own net profits (not even taking into account its compensation for its outside option) are greater under non-exclusive than under exclusive dealing.

Interestingly enough the cases in which the buyer chooses non-exclusive dealing exceed the cases in which the total effective investments are higher under non-exclusive dealing than under exclusive dealing (see Fig. 5). This result is due to the fact that under non-exclusive dealing the buyer is always compensated for its outside option. Hence, for the same level of total effective investments in the two cases, exclusive and non-exclusive dealing, the

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[13]This comparison will be useful for the analysis of the buyer's decision regarding exclusive dealing.

[14]Note that in the case that the buyer decides to offer an exclusive dealing contract to a supplier in stage one, then the contract will always be accepted by the supplier. This is so because when $\beta < \beta_E(\theta)$ (i.e. when the buyer does offer an exclusive dealing contract), then the exclusive supplier's profits exceed the profits of any of the two suppliers under non-exclusive dealing, $E_{S_1}^E > E_{S_i}^N$.

'effective' bargaining power of the buyer in the case of non-exclusive dealing is higher than that in the case of exclusive dealing.

Next, we turn to a welfare comparison of the two supply chain structures. Defining welfare as the sum of producers' and consumers' surplus, we find the following.

Proposition 4 *There exists $\beta_W(\theta)$, decreasing in θ and with $\lim_{\theta \to 1} \beta_W(\theta) = 0$, such that welfare is always higher under exclusive than under non-exclusive dealing when $0 \leq \theta \leq 0.748$ and if and only if $\beta < \beta_W(\theta)$ when $0.748 < \theta < 1$.*

Proposition 4 states that when the compatibility of investments in the case of non-exclusive dealing is sufficiently low, exclusive dealing is always preferable from a social point of view. The same holds for high degrees of compatibility as long as the bargaining power of the suppliers is sufficiently low. This welfare result is, to a great extent, due to the behavior of the total effective investments. This becomes clear from an inspection of Fig. 6. In Fig. 6, the bold line represents the critical for welfare value of the supplier's bargaining power, $\beta_W(\theta)$. In the area to the left of this line welfare under exclusive dealing exceeds that under non-exclusive dealing, while the opposite holds in the area to the right of the line. The dashed line in Fig. 6 represents the critical for the total effective investments value of the supplier's bargaining power, $\beta_e(\theta)$. To the left of the dashed line the total effective investments are higher under exclusive than under non-exclusive dealing, while the opposite holds to the right of the dashed line. As it can be easily seen the two lines are quite close to each other. Thus, the total effective investments and the social welfare are higher under exclusive than under non-exclusive dealing for quite similar parameter configurations.

Having in hand both the buyer's choice and the welfare comparison we can now answer the following question: does the buyer choose the supply chain structure that is preferable from the social point of view? The answer to this question is *not always*, and it is included in the following statement which is a Corollary of Propositions 3 and 4.

Corollary 1 *When $0 \leq \theta \leq 0.748$ and $\beta > 0.707$ the buyer chooses non-exclusive dealing while welfare is higher under exclusive dealing.*

Corollary 1 simply states that there exist cases in which although welfare is higher under exclusive dealing, the buyer chooses non-exclusive dealing. In particular, this holds for all the parameter values between the lines $\beta_E(\theta)$ and $\beta_W(\theta)$ in Fig. 6.

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From an antitrust policy's perspective, although our results indicate that the social and the private incentives do not always coincide, they still provide an argument against the view that exclusive dealing is an anticompetitive practice, in the case at least that exclusive dealing is initiated by downstream producers. In fact our welfare analysis reveals that whenever the buyer adopts exclusive dealing, welfare is also higher under exclusive dealing. This can be seen easily in Fig. 6 where the $\beta_E(\theta)$ line always lies to the left of the $\beta_W(\theta)$ line. In other words, there exist no cases in which the buyer's choice of exclusive dealing in equilibrium is welfare detrimental.

6 Compatibility of Investments

So far we have assumed that $\bar{\beta} = 1$ under exclusive dealing and $\bar{\beta} = \theta$, with $0 \leq \theta < 1$, under non-exclusive dealing. In this section, we relax this assumption by considering a model in which full compatibility is the outcome of an input supplier's strategic choice. The compatibility between the supplier's and the buyer's investments depends now on the input supplier's decision to open a specific research line for the buyer. In particular, if a supplier opens a specific research line for B then the compatibility between its investments and those of the buyer is full, $\bar{\beta} = 1$, otherwise, $\bar{\beta} = \theta$. Since the opening of a specific line, might be costly, we assume that in order for a supplier to achieve full compatibility with the buyer, it has to incur a fixed cost $A > 0$.

We consider a similar timing with that in the basic model, modifying it only by decomposing stage one into two substages, stage 1(a) and stage 1(b). Stage 1(a) is exactly the same as stage 1 of the basic model. In stage 1(b), after the choice among exclusive and non-exclusive dealing has been made, the input suppliers S_1 and S_2 simultaneously and independently decide whether or not they will open a specific line of research for B.[15]

Examining the supplier's incentives to open a specific research line, we obtain the following result.

Proposition 5 *There exist $A_E > 0$ and $A_N > 0$, with $A_E > A_N$ when β is sufficiently low, such that (i) under exclusive dealing the exclusive supplier opens a specific line of research*

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[15] We would have obtained qualitatively similar results under an alternative model in which in stage 1(b) B decides how many specific lines it will open given that in the case that it does not open any $\bar{\beta} = \theta$ for both suppliers, while when it opens a specific line only for S_i, S_j's product has no value for B.

if and only if $A < A_E$, and (ii) under non-exclusive dealing none of the suppliers opens a specific line of research if $A > A_N$.

Fig. 7 depicts the result included in Proposition 5. In particular, in the area under the curve, the critical value of A below which the supplier opens a specific line under exclusive dealing exceeds the respective critical value above which none of the suppliers opens a specific line under non-exclusive dealing.

An important implication of Proposition 5 is that when the buyer's bargaining power is sufficiently high, there is a range of values of the fixed cost such that a supplier opens a specific line for the buyer only under exclusive dealing. Clearly, the higher is the compatibility of investments, the higher are the investment incentives both under exclusive and non-exclusive dealing, and thus, the larger is the surplus for the supply chain. Why then the incentives for increasing the compatibility of investments differ across exclusive and non-exclusive dealing? Because under non-exclusive dealing there exist two additional forces that are absent under exclusive dealing. The first force is the previously mentioned 'outside option effect' which leads to higher investment incentives. The second force is related to the fact that under non-exclusive dealing the supplier has to compensate the buyer for its outside option. The higher is the compatibility of investments, the higher are the buyer's investments, and thus, the higher is the value of the outside option that the supplier has to compensate the buyer for. Obviously, while the first force, the 'outside option effect', strengthens the supplier's incentives to open a specific line under non-exclusive dealing, the second force weakens them. Now why is the 'outside option effect' dominated when the buyer's bargaining power is sufficiently high (i.e. when β is low enough)? This is so because, as mentioned in the intuition of Proposition 2, when the buyer's bargaining power is sufficiently high, the 'outside option effect' is weaker.

Corollary 2 simply summarizes the above implication.

Corollary 2 *If $A_N < A < A_E$, then $\hat{\theta} = 1$ under exclusive dealing and $\hat{\theta} = \theta$ under non-exclusive dealing.*

In other words, there exists a range of values of the cost of opening a specific research line, such that our basic model with its compatibility assumption can be justified as a reduced form of the more general model analyzed here. It follows that in this range our

previous analysis applies.

Finally, it is important to examine whether the cases that the buyer chooses exclusive dealing in the basic model, correspond to the cases that compatibility can be full only under exclusive dealing in the extended model. In particular, we know from the basic model that the buyer opts for exclusive dealing when its bargaining power is sufficiently high, that is, in the area below the $\beta_E(\theta)$ curve in Fig. 8. In addition, we know from the extended model that compatibility could, under some circumstances, turn out to be full only under exclusivity in the area below the $\beta_A(\theta)$ curve in Fig. 8. It follows that exclusive dealing with full compatibility could emerge in equilibrium in the intersection of the areas, provided however that the costs of a specific research line take some intermediate value.

7 Conclusion

We have studied the incentives of final product manufacturers to develop exclusive relations with their input suppliers taking into account the fact that such relations are usually characterized by high buyer-supplier coordination.

Contrary to the existing literature on buyer-initiated exclusive dealing (see e.g., Segal and Whinston, 2000), which has not considered the high compatibility of buyer's and supplier's investments under exclusive relations, we have showed that an input buyer's incentives for exclusive dealing depend crucially on the distribution of bargaining power. In particular, we have showed that the buyer opts for exclusive dealing only when its bargaining power is sufficiently high. This finding clearly suggests that the observed existence of both exclusive and non-exclusive supply chain structures could be also due to differences in the final product manufacturers' bargaining positions relative to their input suppliers.

Interestingly enough we have found that there exist cases in which although investments are higher under exclusive dealing, the buyer chooses non-exclusive dealing. This occurs because the buyer's decision is affected by the fact that competition among the suppliers is present only under non-exclusive dealing. This, of course, allows us to put forward the point that investments are not the only force at work in the buyer's decision whether or not it will adopt exclusive dealing.

From a policy perspective, we have found that the buyer's choice of exclusive dealing

in equilibrium is never harmful to welfare. Hence, our results provide an argument against the view that exclusive dealing is an anticompetitive practice, in the cases at least that exclusive dealing is initiated by downstream final product manufacturers.

In sum, we have provided a simple theoretical foundation for the frequently observed buyer-initiated exclusive relations in supply chains. Our paper is just a first step towards this direction. In future work we plan to extend our analysis by considering unobservable degrees of compatibility as well as by examining the strategic incentives for exclusive dealing in a setting with downstream competition.[16]

8   Appendix

Proof of Lemma 1: Case (a), with $s_i = s_j \geq 0$, cannot be an equilibrium because one of the suppliers will always have incentives to deviate. In particular, when $s_i = s_j = 0$ both suppliers have zero profits and one of them always has incentives to deviate and undertake positive investments because by doing so it will earn positive profits. Similarly, when $s_i = s_j > 0$ both suppliers make negative profits and one of them always has incentives to deviate by not undertaking any investments so that its profits are equal to zero. Given that one of the suppliers will undertake higher investments than the other and thus that it will offer a higher quality input, we can conclude that the supplier with the lower quality input will undertake zero investments because otherwise, it will make negative profits. Q.E.D.

Proof of Lemma 2: We know from Lemma 1 that the equilibrium will take the following form: $(b, s_i, s_j) = (b^N, s_i^N, 0)$, with $i, j = 1, 2$, $i \neq j$ and $s_i^N > 0$. W.l.o.g. we assume that S_1 is the supplier that undertakes positive investments. In order to find the equilibrium levels of b and s_1 we proceed in the following way. We start by assuming that S_2 deviates and chooses $s_2 > s_1$. If $s_2 > s_1$, then in accordance with case (b), in stage three, $w_2 = c$ and

$$F_2 = \frac{[a + \theta(b + s_2) - c]^2}{4} - \frac{[a + \theta(b + s_1) - c]^2}{4} \tag{20}$$

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[16]Fumagalli and Motta (2004) use a setting with downstream competition in order to analyze the effect of supplier-initiated exclusive dealing on entry.

with probability β. The respective expected profits of the deviating supplier are:

$$E_{S_2}(b, s_1, s_2) = \beta \frac{[a + \theta(b + s_2) - c]^2}{4} - \frac{[a + \theta(b + s_1) - c]^2}{4} - \frac{s_2^2}{2} \qquad (21)$$

From the first order condition of (21) w.r.t. s_2, it follows that S_2's profits in case of deviation are maximized when it chooses the following level of investments:

$$s_2^* = \beta\theta \frac{a - c + \theta b}{2 - \beta\theta^2} \qquad (22)$$

In order for S_2 not to have incentives to deviate, it is sufficient that $s_1 \geq s_2^*$. This is so because when $s_1 \geq s_2^*$, the deviation profits of S_2 are negative. The last thing for determining the equilibrium in stage two is to find the investment levels that S_1 and B choose in order each to maximize their profits under the constraint that $s_1 \geq s_2^*$. Formally, S_1 and B solve the following maximization problems:

$$\underset{s_1}{Max} \ E_{S_1}(b, s_1, s_2) = \beta \frac{[a + \theta(b + s_1) - c]^2}{4} - \frac{[a + \theta b - c]^2}{4} - \frac{s_1^2}{2} \quad \text{s.t.} \ s_1 \geq s_2^*$$

$$\underset{b}{Max} \ E_B(b, s_1, s_2) = (1 - \beta)\frac{[a + \theta(b + s_1) - c]^2}{4} + \beta\frac{[a + \theta b - c]^2}{4} - \frac{b^2}{2}.$$

From the first order conditions of the two maximization problems, we have:

$$s_1(b) = \beta\theta \frac{a - c + \theta b}{2 - \beta\theta^2}; \quad b(s_1) = \theta \frac{a - c + \theta(1 - \beta)s_1}{2 - \theta^2} \qquad (23)$$

Solving the above system of equations, we obtain the investment levels of B and S_1 given by equation (10). It is easy to check that these are the equilibrium investment levels, since the value of s_1 given by equation (10) does satisfy the constraint $s_1 \geq s_2^*$. Finally, substituting (10) in the expected net profits of B and S_1 we obtain their equilibrium profits under non-exclusive dealing, given by equations (11) and (12) respectively. Q.E.D.

Proof of Proposition 1: We differentiate the equilibrium values given by equation (10) with respect to β and our result follows immediately. Q.E.D.

Proof of Lemma 3: The first order conditions of (17) with respect to s_1 and b are:

$$s_1(b) = \beta \frac{a - c + b}{2 - \beta}; \quad b(s_1) = (1 - \beta)\frac{a - c + s_1}{1 + \beta}.$$

Solving the above system of equations, we obtain the equilibrium levels of investments given by (18). Finally, substituting these equilibrium values into the profit functions of S_1 and B, we obtain their equilibrium expected net profits included in equation (19). Q.E.D.

Proof of Proposition 2: (i) Taking the difference of equations (18) and (10), we have:

$$b^E - b^N = \frac{(a-c)N_b}{D} = K_1,$$

where $D = 4 + \beta^2\theta^4 - 2\theta^2(1+\beta)$ and $N_b = 4 - 4\beta - 2\theta - 2\theta^2 + \beta^2\theta^2(2 + \theta^2 - \beta\theta^2 + \theta)$. The denominator, D, is always positive. Setting the numerator, equal to zero and solving for the critical value of β in terms of θ, we obtain:

$$\beta_b(\theta) = \frac{1}{3\theta^2}\left[2 + \theta^2 + \theta - \sqrt[3]{R + 3\sqrt{W}} - \frac{5\theta^2 + 4\theta + \theta^4 + 2\theta^3 - 8}{\sqrt[3]{R + 3\sqrt{W}}}\right] > 0$$

where $R = 28 + 6\theta - 54\theta^2 + 14\theta^3 + 18\theta^4 - \theta^6 - 3\theta^5$ and $W = 144 - 48\theta - 396\theta^2 + 72\theta^3 + 516\theta^4 - 132\theta^5 - 213\theta^6 + 21\theta^8 + 66\theta^7 - 6\theta^{10} - 24\theta^9$. Next we calculate K_1 at the extreme values of β:

$$\lim_{\beta\to 0} K_1 = \frac{(a-c)(2+\theta)(1+\theta)}{2-\theta^2} > 0 \quad \text{and} \quad \lim_{\beta\to 1} K_1 = \frac{(a-c)\theta}{\theta^2 - 2} < 0.$$

It follows from the above that $K_1 > 0$ iff $\beta < \beta_b(\theta)$. Moreover, differentiating K_1 w.r.t. θ we find that $\partial K_1/\partial\theta < 0$. Thus, we also have that $\partial\beta_b(\theta)/\partial\theta$ for all values of θ. Finally, in order to show that $\lim_{\theta\to 1}\beta_b(\theta) = 0$, we calculate the $\lim_{\theta\to 1}(b^N/b^E)$. It can be checked that the latter is strictly increasing in β and that it is equal to zero for $\beta = 0$.

(ii) Taking the difference of equations (18) and (9), we have:

$$s_1^E - s_i^N = \frac{(a-c)N_s}{D} = K_2,$$

where $N_s = 4 - 2\beta\theta^2 - 2\theta^2 + \beta^2\theta^4 - 2\theta$. The denominator, D, is always positive. Regarding the numerator, differentiating it w.r.t. β we have: $\partial N_s/\partial\beta = 2\theta^2(\beta\theta^2 - 1) < 0$. Thus, it takes its maximum value when $\beta \to 0$ and its minimum value when $\beta \to 1$. In particular: $\lim_{\beta\to 0} N_s = 2(1+\theta)(2+\theta) > 0$ and $\lim_{\beta\to 1} N_s = (\theta-2)(\theta^3 + 2\theta^2 - 2)$. Setting the latter

equal to zero and solving for θ, we have:

$$\theta = \frac{1}{3}\left[\sqrt[3]{19 + 3\sqrt{33}} + \frac{4}{\sqrt[3]{19 + 3\sqrt{33}}} - 2\right] \simeq 0.839.$$

Since $\lim_{\beta \to 1} N_s > 0$ iff $0 \leq \theta \leq 0.839$, it follows that $N_s > 0$ when $0 \leq \theta \leq 0.839$ for all the values of β. Setting $N_s = 0$ and solving for the critical value of β, we have:

$$\beta_s(\theta) = \frac{1 - \sqrt{2\theta + 2\theta^2 - 3}}{\theta^2}.$$

Since we know from the above that when $0.839 < \theta < 1$, $\lim_{\beta \to 0} N_s > 0$ and $\lim_{\beta \to 1} N_s < 0$, it follows that when $0.839 < \theta < 1$, $N_s > 0$ iff $\beta < \beta_s(\theta)$. Moreover, we find that $\partial\beta_s(\theta)/\partial\theta < 0$. It follows from this that $\beta_s(\theta)$ takes its minimum value when $\theta \to 1$. Since $\lim_{\theta \to 1} \beta_s(\theta) = 0$, it follows that $\beta_s(\theta) > 0$ when $0.839 < \theta < 1$.

(iii) Taking the difference of the effective total investments, we have:

$$b^E + s_1^E - \theta(b^N + s_i^N) = (a - c)\frac{N_e}{D} = (a - c)K_3, \tag{24}$$

where $N_e = 2(2 - 2\beta\theta^2 - 2\theta^2 + \beta^2\theta^4)$. Differentiating K_3 w.r.t. θ, we find that $\partial K_3/\partial\theta < 0$. Moreover we have that while $\lim_{\beta \to 0} K_3 > 0$ holds always, $\lim_{\beta \to 1} K_3 > 0$ holds iff $0 \leq \theta \leq 0.766$. Thus, when $0 \leq \theta \leq 0.766$, then $K_3 > 0$. Setting $K_3 = 0$ and solving for the critical value of β in terms of θ, we have:

$$\beta_e(\theta) = \frac{1 - \sqrt{(-1 + 2\theta^2)}}{\theta^2}.$$

Since we know from above that when $0.766 < \theta < 1$, $\lim_{\beta \to 0} K_3 > 0$ and $\lim_{\beta \to 1} K_3 > 0$, it follows that when $0.766 < \theta < 1$, then $K_3 > 0$ iff $\beta < \beta_e(\theta)$. Moreover, we find that $\lim_{\theta \to 1} \beta_e(\theta) = 0$ and that for $0.766 < \theta < 1$, we have $\partial\beta_e(\theta)/\theta < 0$. Q.E.D.

Proof of Proposition 3: Taking the difference of equations (19) and (10), we have the following:

$$E_B^E - E_B^N = \frac{(a - c)^2 N_E}{2D^2} = (a - c)^2 K_4,$$

where $N_E = 8 + 4\beta^2\theta^4 - 16\beta\theta^2 + 8\beta\theta^4 - 4\beta^3\theta^6 - 12\theta^2 + 4\theta^4 - 4\theta^6\beta^2 + \beta^4\theta^8 - 12\beta^4\theta^4 +$

$16\beta^3\theta^2 - 10\beta^3\theta^4 + 4\beta^5\theta^6 - 16\beta^2 + 24\beta^2\theta^2 + 5\theta^6\beta^4 - \beta^6\theta^8$. Differentiating K_4 w.r.t. θ we find that $\partial K_4/\partial\theta < 0$. Moreover we find that while $\lim_{\theta\to 1} K_4 < 0$ holds always, $\lim_{\theta\to 0} K_4 < 0$ holds iff $\beta > 1/\sqrt{2} \simeq 0.707$. Thus, when $\beta > 0.707$, we have $K_4 > 0$. It is easy to show that $\partial K_4/\partial\beta < 0$ when $0 < \beta < 0.707$, as well as that $\lim_{\beta\to 0.707} K_4 < 0$ and $\lim_{\beta\to 0} K_4 > 0$. It follows then that when $0 < \beta < 0.707$, there exists $\beta_E(\theta) > 0$ such that $K_4 > 0$ iff $\beta < \beta_E(\theta)$. Since $\partial K_4/\partial\theta < 0$, we also have that $\partial\beta_E(\theta)/\partial\theta < 0$. Finally, in order to show that $\lim_{\theta\to 1}\beta_E(\theta) = 0$, we calculate the $\lim_{\theta\to 1}(E_B^N/E_B^e)$. It can be checked that the latter is strictly increasing in β and that it is equal to zero for $\beta = 0$. Q.E.D.

Proof of Proposition 4: Calculating welfare both under exclusive dealing and under non-exclusive dealing, we have:

$$W^E = (a-c)^2(1+\beta-\beta^2) \text{ and } W^N = (a-c)^2\frac{12 - 4\theta^2 - 4\theta^2\beta^2 + 4\theta^4\beta^2 - \theta^6\beta^4}{2(4 - 2\theta^2 - 2\beta\theta^2 + \beta^2\theta^4)^2}.$$

Their difference is given by:

$$W^E - W^N = (a-c)^2\frac{N_W}{D_W} = (a-c)^2 K_5,$$

where $D_W = 2[4 - 2\theta^2(1+\beta) + \beta^2\theta^4]^2 > 0$ and $N_W = 2(1+\beta-\beta^2)[4 - 2\theta^2(1+\beta) + \beta^2\theta^4]^2 - 12 + 4\theta^2(1+\beta^2) - 4\beta^2\theta^4 + \beta^4\theta^6$. It is easy to check that $K_5 > 0$ when $0 \le \theta \le 0.748$ for all β, and that $\lim_{\theta\to 1} K_5 < 0$ and $\lim_{\theta\to 0} K_5 < 0$. In order to define the critical value of β, for $0.748 < \theta < 1$, we set $N_W = 0$. Taking the total derivative of $N_W = 0$, we have $d\beta/d\theta = -(\partial N_W/\partial\theta)/(\partial N_W/\partial\beta)$, substituting $N_W = 0$ in the latter, one can check that it is always negative. It follows that when $0.748 < \theta < 1$, there exists $\beta_W(\theta) > 0$ such that $K_5 > 0$ iff $\beta > \beta_W(\theta)$ with $\beta_W(\theta)$ strictly decreasing in θ. In order to show that $\lim_{\theta\to 1}\beta_W(\theta) = 0$, we calculate the $\lim_{\theta\to 1}(W^N/W^E)$. It can be checked that the latter is strictly increasing in β and equal to zero for $\beta = 0$. Q.E.D.

Proof of Proposition 5: (i) In the case of exclusive dealing, when S_1 opens in stage 1(b) a specific line for B, the continuation of the game is exactly the same as the one included in section 4. Thus, the profits of S_1 are given by the difference of equation (19) and the fixed cost A. We denote this profits with $E_{S_1}^{EA}$. When S_1 does not open a specific line for B in stage 1(b), we follow exactly the same procedure as the one included in section 4 with

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the only difference that we no longer assume that $\beta = 1$. Doing so, we obtain the profits of S_1 when it does not open the specific line:

$$E_{S_1}^{EN} = \beta(a-c)^2 \frac{2-\theta^2\beta}{2(2-\theta^2)^2}.$$

Taking the difference of the profits, setting it equal to zero, $E_{S_1}^{EA} - E_{S_1}^{EN}$, and solving for A, we find:

$$A_E = \beta(a-c)^2(1-\theta^2)\frac{6-4\beta+\theta^2\beta-2\theta^2}{2(2-\theta^2)^2}.$$

Since the $E_{S_1}^{EN}$ profits are always lower than that given by equation (19), it follows that S_1 opens a specific line of research for B, when $A < A_E$.

(ii) In the case of non-exclusive dealing when none of the suppliers opens a specific line, the analysis is exactly the same as the one included in section 3. Thus, the profits of S_j are zero while those of S_i are positive and are given by equation (12). In order for this to be the equilibrium, that is, in order none of the suppliers to open a specific line it is sufficient to show that S_j does not have incentives to deviate and open a specific line. W.l.o.g. we assume for the rest of the proof, that in the case where none of the suppliers opens a specific line, S_2 is the supplier with the zero profits and S_1 is the supplier with the positive profits. In case that S_2 deviates and incurs A, then the continuation of the game is similar to that in section 3. The only difference is that the degree of compatibility is now asymmetric for the two suppliers, that is, $\beta = 1$ for the investments of S_2, and $\beta = \theta$ with $0 \leq \theta < 1$, for the investments of S_1. Next we provide the continuation of the game in the case of deviation. In stage four, B chooses its output in order to maximize its gross profits: $\pi_B = [a + \beta(b+s_i) - q - w_i]q$. The equilibrium quantity of the final good is:

$$q(w_i, b, s_i) = \frac{a + \beta(b+s_i) - w_i}{2},$$

where the subscript $i = 1, 2$ indicates the supplier from which B obtains the input. In case it obtains the input from S_2, $\beta = 1$, while in the case it obtains it from S_1, $\beta = \theta$. In stage three, we distinguish among the following three cases:

(a) $b + s_2 = \theta(b+s_1)$: Similarly to the case with symmetric β we have $(w_i, F_i) = (c, 0)$.

(b) $b + s_2 > \theta(b+s_1)$: In this case $w_1 = w_2 = c$ for both suppliers, however while $F_1 = 0$,

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F_2 with probability β is equal to:

$$F_2 = \frac{(a + b + s_2 - c)^2}{4} - \frac{(a + \theta(b + s_1) - c)^2}{4},$$

and with the rest of the probability is equal to zero.

(c) $b + s_2 < \theta(b + s_1)$: In this case $w_1 = w_2 = c$ for both suppliers, however while $F_2 = 0$, F_1 is with probability $1 - \beta$ equal to zero and with probability β equal to:

$$F_1 = \frac{[a + \theta(b + s_1) - c]^2}{4} - \frac{(a + b + s_2 - c)^2}{4}.$$

It follows from the above that Lemma 1 holds here too. Next, we analyze the case in which S_2 is the supplier that undertakes the positive investment levels. Later on we will show that indeed in equilibrium S_2 and not S_1 will be the supplier that undertakes the positive investment levels. In order to find the equilibrium levels of b and s_2 we proceed in the following way. We start by assuming that S_1 deviates and chooses s_1 such that $b + s_2 < \theta(b + s_1)$, that is, $s_1 > [s_2 + b(1 - \theta)]/\theta$ and then we follow the same procedure as the one in the proof of Lemma 2. Doing so, we find the following investment levels:

$$s_2^{NA} = \frac{(a - c)\beta(2 + \beta\theta - \beta\theta^2)}{2 - 2\beta\theta^2 + \beta^2\theta^2} \quad \text{and} \quad b^{NA} = \frac{(a - c)(2 + 2\beta\theta - 2\beta - \beta^2\theta)}{2 - 2\beta\theta^2 + \beta^2\theta^2}.$$

The respective expected net profits of supplier S_2 are:

$$E_{S_2}^{NA} = \frac{\beta(a - c)^2 N_A}{2 - 2\beta\theta^2 + \beta^2\theta^2} - A,$$

where $N_A = 6 - \beta^3\theta^4 + 2\beta^3\theta^3 - 4\beta^2\theta - \beta^3\theta^2 + 4\beta^2\theta^2 + 12\beta\theta - 4\beta^2\theta^3 - 4\beta\theta^2 - 4\beta + 2\beta^2\theta^4 - 2\theta^2 - 4\theta$. Setting $E_{S_2}^{NA} = 0$ and solving for A, we find:

$$A_N = \frac{\beta(a - c)^2 N_2}{2(2 - 2\beta\theta^2 + \beta^2\theta^2)^2}.$$

It follows that S_2 does not open a specific line of research for B, when $A > A_N$.

Finally, setting $A_E - A_N = 0$, we can implicitly define $\beta_A(\theta)$. Since it is impossible to get an analytical expression for $\beta_A(\theta)$, in order to show that $A_E > A_N$, we need to evaluate

instead the following limit:

$$\lim_{\beta \to 0} \frac{A_E}{A_n} = \frac{4(3 - \theta^2)(1 + \theta)}{(3 + \theta)(\theta^2 - 2)^2} > 1.$$

It follows from the above that for sufficiently small β, we have that $A_E > A_N$. Q.E.D.

9 References

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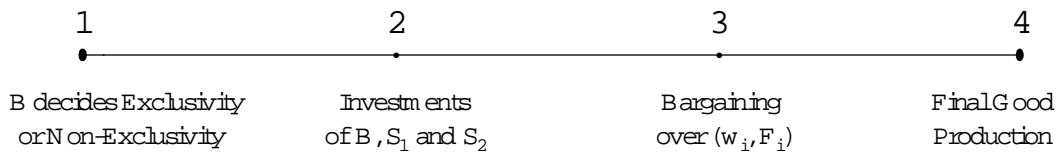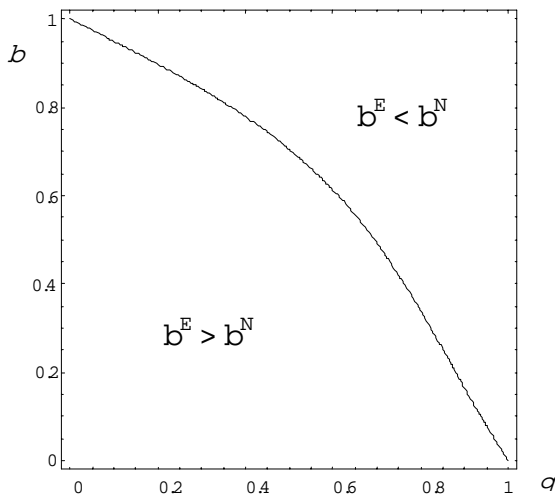
Fig. 1: Stages of the game
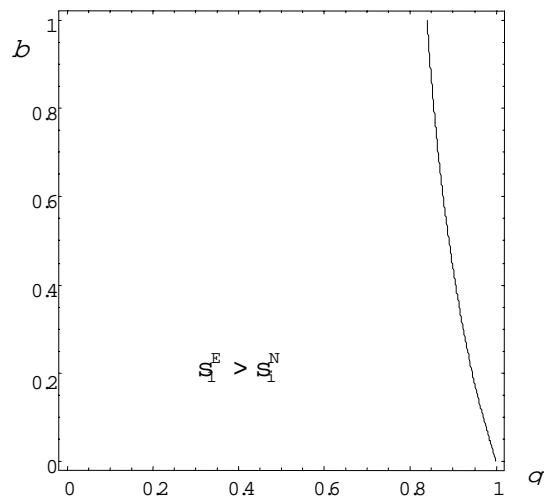

Fig. 2: Comparison of B's investments
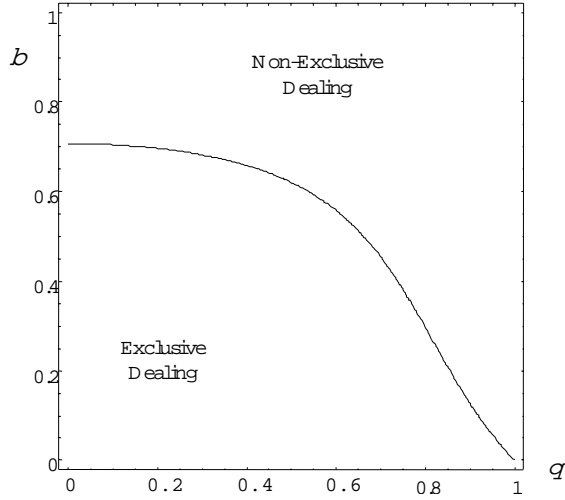

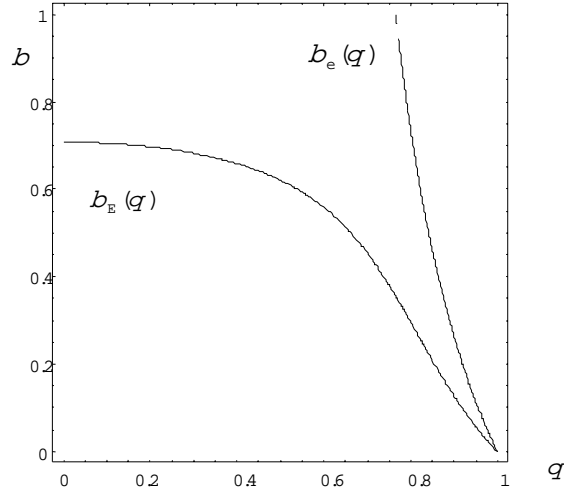Fig. 3: Comparison of S_i's investments

Fig. 4: Comparison of buyer's profits

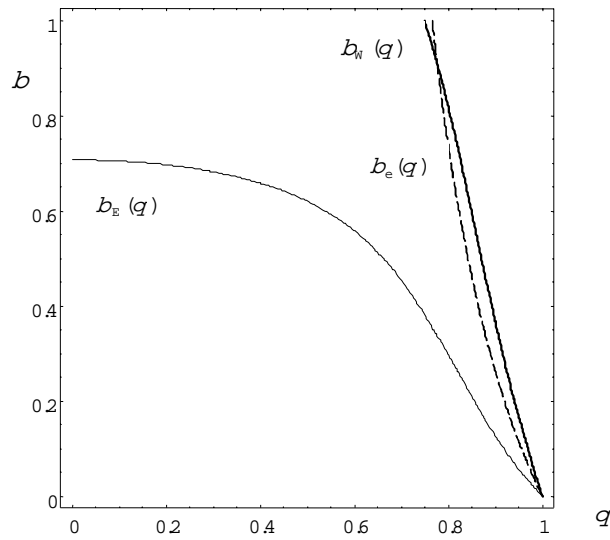Fig. 5: Critical values $\beta_E(\theta)$ and $\beta_e(\theta)$

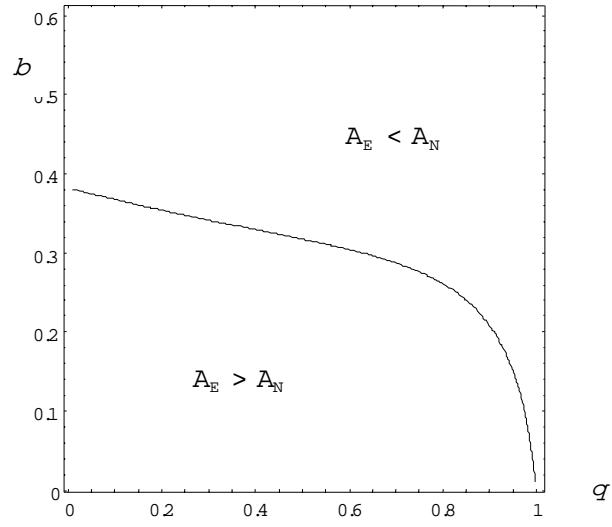Fig. 6: Critical values $\beta_W(\theta)$, $\beta_E(\theta)$ and $\beta_e(\theta)$

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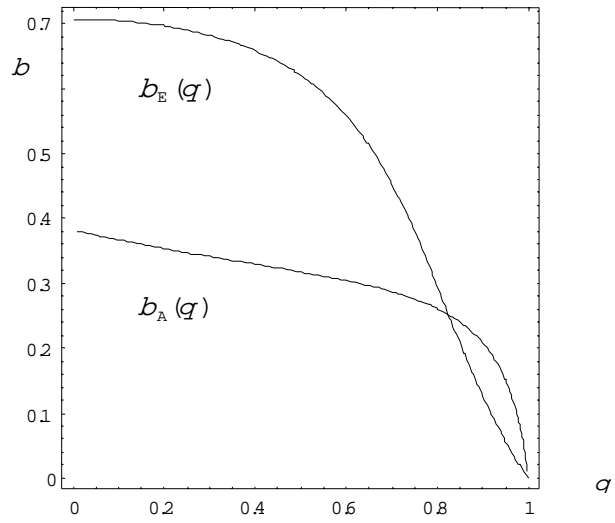Fig. 7: Comparison of the critical values of A

Fig. 8: Critical values $\beta_A(\theta)$ and $\beta_E(\theta)$