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Exclusive contracts and protection of investments

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We consider the effect of a renegotiable exclusive contract restricting a buyer to purchase from only one seller on the levels of noncontractible investments undertaken in their relationship. Contrary to some informal claims in the literature, we find that exclusivity has no effect when all investments are fully specific to the relationship (i.e., are purely ''internal''). Exclusivity does matter when investments affect the value of the buyer's trade with other sellers (i.e., have ''external'' effects). We examine the effects of exclusivity on investments and aggregate welfare, and the private incentives of the buyer-seller coalition to use it.

1. Introduction

■ A contract between a buyer and a seller is said to be exclusive if it prohibits one party to the contract from dealing with other agents. Although exclusivity provisions arise in many areas of economics (e.g., labor economics, economics of the family), they have attracted the most attention and controversy in the antitrust arena. A long-standing concern of courts, explored formally in a series of recent articles (Aghion and Bolton, 1987; Rasmusen, Ramseyer, and Wiley, 1991; Bernheim and Whinston, 1998; and Segal and Whinston, 2000), is that exclusive contracts can serve anticompetitive purposes. At the same time, antitrust commentators often argue that such contracts serve procompetitive, efficiency-enhancing ends and, in particular, that they can protect the exclusive-rightholder's relationship-specific investments against opportunistic hold-up.

A recent U.S. Department of Justice investigation into contracting practices in the computerized ticketing industry provides an example of this debate. In many major U.S. cities, the leading computerized ticketer, Ticketmaster, had exclusive contracts with

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concert venues having 80% to 95% of the available seating capacity in the city. To some observers, this fact raised a concern that these contracts limited competition in computerized ticketing services. Other observers, however, argued that these contracts were adopted instead to protect Ticketmaster's relationship-specific investments both in training a venue's personnel in the use of its computerized system and in tailoring its software to the specific configuration and ticketing needs of a venue.

Surprisingly, the economics literature contains no formal analysis of the role of exclusivity provisions in fostering specific investments. Moreover, the several (quite interesting) informal discussions of the issue that do exist make somewhat differing arguments. Klein (1988) and Frasco (1991) argue that exclusive contracts may be used instead of quantity contracts to protect a seller's relationship-specific investment when specification of quantities is too costly. Klein (1988), for example, attributes the 1919 exclusive contract in which GM promised to buy all of its closed metal bodies from Fisher to the need to protect Fisher's investments in stamping machines and dies that were specific to GM's car designs.[1] (Klein (1988) also discusses the eventual replacement of this contract by vertical integration due to Fisher's holdup of GM under the contract, a point we shall discuss further below.) In contrast, Marvel (1982) and Masten and Snyder (1993) also argue that exclusivity may be adopted to protect a seller's investments, but they focus on investments that the buyer can use in its dealings with *other* sellers. Masten and Snyder (1993), for example, suggest that the penalty clauses in the United Shoe Machinery Corporation's leases were in part a response to United's concern that its expenditures on educating shoe manufacturers in the efficient production of shoes could be used by these manufacturers in conjunction with competitors' shoe machines. Finally, Areeda and Kaplow (1988) argue that exclusives may be adopted by a manufacturer to induce retailer ''loyalty,'' that is, to encourage the retailer to tailor his promotional efforts toward the manufacturer's product. In this case, the investing party is the *buyer* in the relationship, who may make investments that affect his returns from purchasing various sellers' products.

In this article we examine formally the conditions under which exclusive contracts may be privately and/or socially valuable for protecting noncontractible investments. For this purpose, we develop a model in which a buyer (B) and a seller (S) initially contract, while facing the possibility that B may later wish to buy from an external source (E).[2] B and S can write an exclusive contract *ex ante*, which prohibits B from buying from E. After the contract is signed, but before trade, the parties may undertake noncontractible investments that affect the value of *ex post* trades.[3] We assume that an exclusive contract can be renegotiated *ex post* whenever trading with E is efficient. The role of exclusivity is therefore to establish the disagreement point for renegotiation. As in Grossman and Hart (1986) and Hart and Moore (1990), the disagreement point is important because it affects the allocation of *ex post* surplus, which in turn determines the parties' investment incentives.

Since the effect of an exclusivity provision may depend on the *other* terms included in B and S's contract, an important modelling choice concerns the set of feasible contract terms. In most of the article we focus on the ''incomplete contract'' setting in which the terms of future trade cannot be specified in advance (see Hart, 1995). Thus, the *only* possible term in the initial contract, aside from a lump-sum side payment, is

[1] See also the discussion in Klein, Crawford, and Alchian (1978).

[2] Our results apply equally well, with obvious alterations, to the case in which it is the seller who may later wish to sell to alternative buyers.

[3] Clearly, exclusivity can be necessary for protecting only those investments that cannot be specified directly in a contract, e.g., are nonverifiable.

the exclusivity provision. Although an extreme assumption (e.g., Ticketmaster's contracts did include price terms, as did the GM-Fisher contract), it is intended to capture—albeit in a stark form—the difficulty of contractually specifying all aspects of performance.[4] Our focus on this case allows us to study the effects of exclusivity in the simplest possible setting in which incompleteness is present, which still involves significant complications. In Section 6, however, we provide a preliminary discussion of the effects of exclusivity when more complicated contracts can be signed because some aspects of future trade are contractible. There we show how a number of our central conclusions generalize to such settings.

We begin in Section 2 by considering a simple example in which the seller may make a noncontractible *ex ante* investment that reduces his cost of serving the buyer *ex post* (along the lines discussed in Klein (1988) and Frasco (1991)). In this context we discover a surprising result: exclusivity provisions have *no effect whatsoever* on the level of relationship-specific investment undertaken by the seller. Although exclusivity does increase the seller's share of *ex post* surplus (in accord with the conventional wisdom), it does not increase the sensitivity of the seller's payoff to his investment.

In Section 3 we introduce a far more general model of investments and holdup. Using this model, we show that the key feature leading to the irrelevance result of Section 2 is that the investment we considered was *internal*; that is, it did not affect the value of trade between B and E. In any such case, exclusivity will have no effect, a finding that we label ''the irrelevance result.'' For exclusivity to matter for noncontractible investments in our model, these investments must have some *external* effects: they must affect the value of trade between B and E. Thus, the informal arguments of Klein (1988) and Frasco (1991)—in which investments are internal—find no support in our model. The investments envisioned by Marvel (1982), Masten and Snyder (1993), and Areeda and Kaplow (1988), in contrast, do have external effects.

In Section 4 we examine the effects of exclusivity when investments have an external effect for the special case in which one party invests and the investment is one-dimensional. We begin there with a comparative statics result establishing the direction of the effect of exclusivity on such an investment. We find that exclusivity encourages S to make investments that increase external value, but it discourages B and E from doing so. We then study the welfare effects of exclusivity. These effects depend critically not only on which party is making the investment, but also on the nature of the investment. Specifically, we highlight the differences in welfare results for cases in which investment moves the values of internal and external trade in the same direction (''complementary investment effects'') compared to cases in which investment moves these values in opposite directions (''substitutable investment effects''). These results are summarized in Figure 1, which appears at the end of the second subsection of Section 4.

Figure 1 marks the end of the central part of the article. The remainder of the article is concerned with extensions of this analysis. In the third subsection of Section 4, we begin by showing that some further welfare results are possible in cases in which we know something about the complementarity/substitutability of S and E's products

[4] Klein (1988, p. 201), for example, stresses how even contracts that attempt to specify the terms of exchange are often very incomplete. In discussing the GM-Fisher exclusive contract he notes that ''In spite of the existence of a long-term contractual arrangement with explicitly set price and price protection clauses, there is still some probability that a hold-up may occur. This is because not all elements of future performance are specified in the contract. Due to uncertainty and the difficulty of specifying all elements of performance in a contractually enforceable way, contracts will necessarily be incomplete to one degree or another.'' See also Hart (1995) for a discussion of this assumption and Segal (1999) for a formal justification.

in B's payoff function and the effect of the level of trade on the marginal returns to investment.

In reality, the investments undertaken by the contracting parties are often multidimensional, and often more than one party is making investments. In Section 5 we show how our results can be generalized to these cases. Central to our analysis in this section is a focus on the nature of complementarity or substitutability between internal and external activities. Because of the role of complementarities in the theory, the monotone comparative statics tools presented in Milgrom and Roberts (1990) are particularly helpful for our problem, and we rely on them extensively in our analysis in this section.

In Section 6 we provide a preliminary discussion of how our conclusions are affected when the buyer and seller can write more complex *ex ante* contracts, such as contracts that specify future trade or contracts that give the buyer an option to buy at a specified price (e.g., a requirements contract). We show how a number of our central conclusions (including our irrelevance result) extend to such settings, and we identify some that do not. The analysis in this section is closely related to the extensive recent literature on contractual solutions to the holdup problem (e.g., Hart and Moore, 1988; MacLeod and Malcomson, 1993; Edlin and Reichelstein, 1996; Che and Hausch, 1999; and Segal and Whinston, forthcoming). In particular, of central importance in this discussion is the question of the incremental benefit of an exclusivity provision when these other price and quantity provisions are possible.

Section 7 offers concluding remarks, including a discussion of related work in other literatures. The issue of exclusivity and investment incentives arises in a number of fields of economics (e.g., labor economics) in which our results may have fruitful application.

2. A simple example

■ Consider a situation in which a buyer (B) and a seller (S) initially contract, while facing the possibility that the buyer may later wish to buy from an external source (E). At the initial contracting stage, B and S can sign an exclusive contract that prohibits B from trading with E but cannot specify a positive trade because the nature of the trade is hard to describe in advance. Suppose that B demands either zero or one unit of the good, which she values at v, that S's cost of producing the good is c_S, and that E's cost of producing the good is c_E. While all three values can in general depend on the parties' *ex ante* investments, we begin by considering only S's investment in reducing his cost c_S. We denote by $\phi_S(c_S)$ the *ex ante* investment cost for S of achieving cost level c_S.

According to Frasco (1991) and Klein (1988), the seller's incentive to engage in this kind of specific investment is enhanced by an exclusive contract. The intuition behind their claims is simple: exclusivity enables the seller to extract a greater share of the available surplus in *ex post* bargaining, and thereby encourages the seller's *ex ante* investments. In this section we examine the validity of these claims in a very simple model (we generalize the model substantially in Section 3).

We assume that after E appears, the three parties renegotiate to an *ex post* efficient outcome (we assume that c_S, v, and c_E are observable).[5] In particular, if E is the more efficient supplier, renegotiation results in B buying from E, even if an exclusive contract

[5] There is extensive evidence of renegotiation occurring during the life of long-term contracts. Joskow (1985), for example, notes that in his sample of long-term contracts between mine-mouth electric utilities and coal mines (which nearly always involved some form of exclusivity provision), many were amended during the life of the contract.

was written. The original contract is still important, however, because it affects the distribution of *ex post* surplus among the parties, which affects *ex ante* investment incentives.

We assume a very specific formulation of *ex post* bargaining. First, we suppose that E receives no surplus in the bargaining. This would happen, for example, if there was competition among many identical external suppliers. Second, we assume that B and S split their renegotiation surplus 50/50 over the disagreement point, which is determined by the original contract. Let $e = 1$ denote an exclusive contract and $e = 0$ denote a nonexclusive one (or, equivalently, the absence of any contract), and let $U_S^0(c_S, e)$ and $U_B^0(c_S, e)$ denote the two parties' disagreement utilities, which may in general depend on S's *ex post* cost c_S and the contract term e.[6] Then the renegotiation surplus can be written as $TS(c_S) - U_S^0(c_S, e) - U_B^0(c_S, e)$, where $TS(c_S) = \max\{v - c_S, v - c_E, 0\}$ is the total available *ex post* surplus. Ignoring any *ex ante* side payments (which have no effect on investment incentives), S's *ex post* utility can be written as

$$U_S(c_S, e) = U_S^0(c_S, e) + \frac{1}{2}[TS(c_S) - U_S^0(c_S, e) - U_B^0(c_S, e)]. \tag{1}$$

The seller's *ex ante* investment decision is to choose c_S to maximize $U_S(c_S, e = 1) - \phi_S(c_S)$ under an exclusive contract, and $U_S(c_S, e = 0) - \phi_S(c_S)$ under a nonexclusive one.

Consider first a nonexclusive contract. In this case, the parties' utilities at the disagreement point are $U_S^0(c_S, e = 0) = 0$ and $U_B^0(c_S, e = 0) = \max\{v - c_E, 0\}$ (B can buy from E at price c_E whenever she desires). Observe that these disagreement utilities do not depend on c_S; hence, the only term in (1) that is sensitive to c_S is $\frac{1}{2}TS(c_S)$. Therefore, S captures only half of his investment's contribution to total surplus, which implies that his incentive to invest is socially suboptimal.

Can this underinvestment be mitigated with an exclusive contract? Under such a contract, the parties' disagreement utilities are $U_S^0(c_S, e = 1) = U_B^0(c_S, e = 1) = 0$ (B cannot buy from anyone without S's permission). Substituting into (1), we can write

$$U_S(c_S, e = 1) = U_S(c_S, e = 0) + \frac{1}{2}\max\{v - c_E, 0\}. \tag{2}$$

Equation (2) tells us that the functions $U_S(c_S, e = 1)$ and $U_S(c_S, e = 0)$ differ by an amount that is *independent of* c_S. Hence, we see that exclusivity is *irrelevant* for the seller's optimal investment level.[7] Recall that the claims of Frasco (1991) and Klein (1988) are based on the intuition that exclusivity enables S to extract a higher share of the total surplus in *ex post* bargaining. While this intuition by itself is correct (S's payoff is indeed larger under an exclusive contract), under our assumptions the additional surplus extracted by S due to exclusivity is not sensitive to his investment, and therefore it does not affect his investment incentives.

This simple model, and its result, can be related in an interesting way to the asset ownership model of Hart and Moore (1990). Imagine a situation in which there is a single asset that B must have access to in order to trade with E. Then, ownership of

[6] Note that we suppress their dependence on v and c_E since we assume that these values are constant.

[7] Our analysis assumes that the seller's ability to enforce exclusivity is independent of his investment. For example, even when S's production cost is infinite, his payoff with an exclusive equals ½ $\max\{v - c_E, 0\}$ (while his payoff without an exclusive is zero). Conditioning exclusivity on some aspects of S's investment would presumably require a court to be able to verify these aspects of S's investment, but in such a case the parties would be able to specify them directly in their contract.

this asset by S is equivalent to the exclusive contract considered above, while a nonexclusive contract corresponds to ownership of the asset by B or E. In the present example, only S makes an investment, while B is indispensable for trade. It follows from the results of Hart and Moore (1990) that ownership of the asset by either S or B is optimal—that is, that exclusivity is irrelevant. This ''asset interpretation'' of exclusivity will apply in our general model as well. However, our analysis in later sections will concern environments that fall outside the settings considered by Hart and Moore (1990).[8]

It is natural to wonder precisely what is responsible for the irrelevance of exclusivity for investment incentives in this simple model. We observe first that this irrelevance depends on two assumptions about bargaining. The first of these is that exclusivity may be renegotiated *ex post*. Suppose, instead, that while B and S are able to negotiate their terms of trade *ex post*, they cannot renegotiate the exclusivity provision itself. In this case, exclusivity would affect not only B's disagreement utility—which would still be $U_B^0(c_S, e = 1) = 0$ under an exclusive—but also the total surplus available to the parties, which would now be given by the function $\overline{TS}(c_S) = \max\{v - c_S, 0\}$. This differs from $TS(c_S)$ whenever $c_E < c_S < v$, and in such cases we have

$$\partial\overline{TS}(c_S)/\partial c_S = -1 < 0 = \partial TS(c_S)/\partial c_S.$$

As a result, unless trade with S is always efficient (regardless of investments), a nonrenegotiable exclusive contract may increase S's cost-reducing investment by increasing the frequency of trade between B and S.[9] Of course, in the present environment, B and S must negotiate *ex post* in order to trade. Given this fact, it is difficult to see why they would negotiate terms of trade but forgo any opportunities for mutual benefit through procurement from E.[10]

The second assumption is that B and S split the surplus available over their disagreement payoffs in fixed proportions. The leading alternative treatment of bargaining would involve B and S engaging in ''outside option bargaining'' (see Binmore, Rubinstein, and Wolinsky, 1986). Under outside option bargaining, the parties split total surplus in fixed proportions (say, 50/50) as long as both receive more than their disagreement utilities (outside options); otherwise, one party's outside option binds and it receives its disagreement utility level while the other party receives the remaining surplus. In the present setting, this means that B receives $U_B(c_S, e) = \max\{½TS(c_S), U_B^0(c_S, e)\}$, and S receives $U_S(c_S, e) = TS(c_S) - U_B(c_S, e)$. The fundamental difference between this bargaining outcome and that considered above is that it depends on the disagreement utilities in a nonlinear way. Assume for simplicity that we always have $c_S < c_E < v$, and consequently $TS(c_S) = v - c_S$ and $U_B^0(c_S, e = 0) = v - c_E$. Then we have

$$\frac{\partial U_S(c_S, e = 0)}{\partial c_S} = \begin{cases} -\dfrac{1}{2} & \text{when } \dfrac{1}{2}(v - c_S) > (v - c_E), \\ -1 & \text{when } \dfrac{1}{2}(v - c_S) < (v - c_E). \end{cases}$$

[8] In particular, we will consider more general bargaining solutions, investments that benefit coalitions of which the investing agent is not a member, investments that are multidimensional, and investments that have opposing (substitutable) effects on different coalition values.

[9] Note, however, that a nonrenegotiable exclusivity provision will also involve a cost in terms of trade forgone with E, except in the special case in which trade with S is always efficient given the equilibrium level of c_S.

[10] Note, however, that renegotiation of exclusivity can be prevented if a technological commitment is possible that eliminates the possibility of trade with E.

In words, in the absence of an exclusive contract, S extracts half of his investment's marginal contribution to total surplus when B's outside option is not binding, and all of this contribution when B's outside option is binding. The effect of an exclusive contract is to reduce B's outside option to zero, in which case S always receives half of total surplus: $U_S(c_S, e = 1) = ½(v - c_S)$. Therefore, with outside option bargaining, even though exclusivity still increases S's share of *ex post* surplus, it actually *discourages* S's cost-reducing investment (contrary to the claims of Klein (1988) and Frasco (1991)).[11,12]

In the remainder of the article, however, we maintain (in a generalized way) the bargaining structure of the simple example above and focus on two other dimensions of the contracting environment: the nature of the investments and the identities of the investing parties. These two dimensions turn out to have important ramifications for the equilibrium use and efficiency properties of exclusive contracts. We begin in the next section by introducing a substantially more general model and using it to identify the feature of S's investment decision that was responsible for the irrelevance result above.

3. The general model and the irrelevance result

■ **The model.** As before, the model has three parties, B, S, and E. At date 0, B and S sign a contract. We continue to make the ''incomplete contracting'' assumption that future trades cannot be described in advance. For this reason, B and S cannot specify a positive trade in an *ex ante* contract. At the same time, we assume that it is possible to describe *ex ante* and verify *ex post* the fact that B does not conduct *any* trade with another seller, which makes exclusive contracts possible. Specifically, along with a lump-sum side payment, which has no effect on investment incentives and will thus be ignored throughout the article, the contract specifies a variable $e \in \{0, 1\}$ that indicates whether S has exclusive rights over trade with B *ex post* (as before, $e = 1$ indicates an exclusive contract).

At date 1 (*ex ante*), each party $j \in N = \{B, S, E\}$ makes an investment choice $a_j \in A_j$ that stochastically affects valuations for future trades, at a cost of $\psi_j(a_j)$.

At date 2 (*ex post*), the state of nature $\theta \in \Theta$ is revealed and negotiations over trade occur. B can potentially purchase both from S and from E. We denote by $q_j \in Q_j$ the quantity B buys from seller $j \in \{S, E\}$. The parties' *ex post* payoffs are determined by these trades, the *ex ante* investments, the monetary transfers among the parties, and the realization of uncertainty. Letting t_j denote the monetary payment from B to party $j \in \{S, E\}$, these payoffs are as follows:

Buyer:	$v(q_S, q_E, a_B, a_S, a_E, \theta) - \psi_B(a_B) - t_S - t_E,$
Seller:	$t_S - c_S(q_S, a_B, a_S, \theta) - \psi_S(a_S),$
External supplier:	$t_E - c_E(q_E, a_B, a_E, \theta) - \psi_E(a_E).$

[11] Similar points are made by de Meza and Lockwood (1998) and Chiu (1998) (who note the reversal of some of Hart and Moore's (1990) results under outside option bargaining), Felli and Roberts (2000) (who discuss the role of competition in encouraging investments with Bertrand bidding), and Bolton and Whinston (1993) (who show that competition for inputs may induce first-best investments by buyers in a model with outside option bargaining).

[12] MacLeod and Malcomson (1993) study outside option bargaining in a model in which the price for trade can be contracted in advance and show that the first best can be attained (without exclusivity) when only one party invests. In our model, with incomplete contracts, the first best is unattainable with outside option bargaining whenever $\phi(\cdot)$ is differentiable and there is a positive probability that $½(v - c_S) > (v - c_E)$.

Note that we allow for B's valuation to be affected both by B's own investments and by the investments of S and E; likewise, the production cost of seller $j \in \{S, E\}$ may be affected both by j's own investments and by B's investments. We let

$$(0, 0) \in Q = Q_S \times Q_E$$

stand for "no trade," and we assume (for notational convenience) that

$$v(q_S = 0, q_E = 0, a_B, a_S, a_E, \theta) = c_S(q_S = 0, a_S, a_B, \theta) = c_E(q_E = 0, a_B, a_E, \theta) = 0.$$

We assume that the *ex post* allocation $(q_j, t_j)_{j \in \{S,E\}}$ arises from a three-party bargaining process. We model this bargaining using cooperative game theory, by assuming that each player receives an *ex post* payoff that is a linear function of the player's marginal contributions to the various possible coalitions of which it can be a member.[13] This approach encompasses as special cases a number of bargaining models, both cooperative and noncooperative, that have been used previously in the literature.

Absent an *ex post* agreement on trade, the default trade and transfer outcome is $q_j = t_j = 0$ for all $j \in \{S, E\}$. Thus, under a nonexclusive contract ($e = 0$) the surplus that can be achieved *ex post* through an efficient agreement among the members of coalition J given investments $a = (a_B, a_S, a_E)$ and state θ, denoted by $\hat{V}_J(a, \theta)$, is

$$\begin{aligned}
\hat{V}_{SE}(a, \theta) &= \hat{V}_j(a, \theta) = 0 \quad \text{for all } j \in N, \\
\hat{V}_{BS}(a, \theta) &= \max_{q_S \in Q_S} [v(q_S, q_E = 0, a, \theta) - c_S(q_S, a, \theta)], \\
\hat{V}_{BE}(a, \theta) &= \max_{q_E \in Q_E} [v(q_S = 0, q_E, a, \theta) - c_E(q_E, a, \theta)], \\
\hat{V}_{BSE}(a, \theta) &= \max_{(q_S, q_E) \in Q} [v(q_S, q_E, a, \theta) - c_S(q_S, a, \theta) - c_E(q_E, a, \theta)].
\end{aligned} \tag{3}$$

In contrast, under an exclusive contract ($e = 1$), the members of coalition J can agree to a positive trade level if and only if coalition J includes S. Moreover, if S is a member of J, the existence of the exclusive contract in no way limits the set of trades that J's members can agree to. Thus, letting $\overline{V}_J(a, \theta)$ denote the surplus achievable by coalition J under an exclusive contract given investments a and state of the world θ, we have $\overline{V}_J(a, \theta) = \hat{V}_J(a, \theta)$ for $J \neq \{BE\}$, and $\overline{V}_{BE}(a, \theta) = 0$. Note, in particular, that the only difference in achievable surplus occurs for coalition BE, which cannot trade in the presence of an exclusive contract. We can therefore define coalition J's value under a contract with exclusivity provision e given investments a and state of the world θ by

$$V_J(a, e, \theta) \equiv (1 - e)\hat{V}_J(a, \theta) + e\overline{V}_J(a, \theta) = \begin{cases} \hat{V}_J(a, \theta) & \text{for } J \neq \{BE\}, \\ (1 - e)\hat{V}_{BE}(a, \theta) & \text{for } J = \{BE\}. \end{cases} \tag{4}$$

Define $M_j^J(a, e, \theta) = [V_{J \cup j}(a, e, \theta) - V_J(a, e, \theta)]$ to be agent j's marginal contribution to coalition J. We assume that agent j's bargaining payoff, denoted by $f_j(a, e, \theta)$, is a nonnegatively weighted linear combination of its marginal contributions:

[13] For an introduction to cooperative game theory, see Mas-Colell, Whinston, and Green (1995).

$$f_j(a, e, \theta) = \sum_{J \subset N \setminus j} \alpha_j^J M_j^J(a, e, \theta), \tag{5}$$

where the α_j^J's are nonnegative parameters satisfying the adding-up restriction (introduced below for our specific model) that the sum of the agents' payoffs always equals $V_{BSE}(a, e, \theta)$.[14] In the present setting, where $V_j(a, \theta, e) = 0$ for all $j \in N$ and $V_{SE}(a, \theta, e) = 0$, the bargaining solution (5) reduces to

$$\begin{aligned} f_B(a, e, \theta) &= \alpha_B^{SE} V_{BSE}(a, e, \theta) + \alpha_B^S V_{BS}(a, e, \theta) + \alpha_B^E V_{BE}(a, e, \theta), \\ f_S(a, e, \theta) &= \alpha_S^{BE}[V_{BSE}(a, e, \theta) - V_{BE}(a, e, \theta)] + \alpha_S^B V_{BS}(a, e, \theta), \\ f_E(a, e, \theta) &= \alpha_E^{BS}[V_{BSE}(a, e, \theta) - V_{BS}(a, e, \theta)] + \alpha_E^B V_{BE}(a, e, \theta). \end{aligned} \tag{6}$$

Substituting from (4) into (6), we obtain

$$\begin{aligned} f_B(a, e, \theta) &= \alpha_B^{SE} \hat{V}_{BSE}(a, \theta) + \alpha_B^S \hat{V}_{BS}(a, \theta) + \alpha_B^E (1 - e)\hat{V}_{BE}(a, \theta), \\ f_S(a, e, \theta) &= \alpha_S^{BE}[\hat{V}_{BSE}(a, \theta) - (1 - e)\hat{V}_{BE}(a, \theta)] + \alpha_S^B \hat{V}_{BS}(a, \theta), \\ f_E(a, e, \theta) &= \alpha_E^{BS}[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)] + \alpha_E^B (1 - e)\hat{V}_{BE}(a, \theta). \end{aligned} \tag{7}$$

The adding-up restriction then requires that

$$\alpha_B^{SE} + \alpha_S^{BE} + \alpha_E^{BS} = 1, \qquad \alpha_B^S + \alpha_S^B = \alpha_E^{BS}, \quad \text{and} \quad \alpha_B^E + \alpha_E^B = \alpha_S^{BE}. \tag{8}$$

Our primary motivation for taking this approach to bargaining is that it nests a number of bargaining models previously used in the literature, most notably split-the-surplus bargaining with a competitive external source and the Shapley value. The former solution, used in the simple example of Section 2, arises when $\alpha_E^J = 0$ for all nonempty $J \subset N \setminus E$, and $\alpha_S^B = \alpha_B^S = 0$. The Shapley value is obtained by imposing the symmetry property that α_j^J is only a function of $|J|$, and not of the identities of player j or coalition J's members. Then (8) implies that $\alpha_j^J = 1/3$ if $|J| = 2$, $1/6$ if $|J| = 1$.[15]

Let $A^*(e) \subset A = \prod_{j \in N} A_j$ denote the set of Nash equilibria in the game in which each party j's strategy is its investment choice $a_j \in A_j$, and j's payoff is $U_j(a, e) = E_\theta(f_j(a, \theta, e)) - \psi_j(a_j)$. Formally, $a^* = (a_B^*, a_S^*, a_E^*) \in A^*(e)$ if and only if

$$a_j^* \in \arg\max_{a_j \in A_j} U_j(a_j, a_{-j}^*, e) \quad \text{for every } j \in N. \tag{9}$$

Note that in general the investment game can have multiple Nash equilibria, so that $A^*(e)$ need not be single-valued.

[14] This bargaining solution can be characterized by the linearity, dummy, monotonicity, and Pareto optimality axioms (Weber (1988)). It can also be implemented in a noncooperative game in which the players are randomly ordered (with a distribution chosen to implement the desired weights on marginal contributions (Weber (1988)), and sequentially make take-it-or-leave-it offers to all preceding players. Note that this noncooperative implementation need not involve direct communication between S and E (which may be prohibited by antitrust law) since there are no gains from trade between the sellers, and whenever one seller (say, S) is preceded by the complementary coalition (BE), he can extract his marginal contribution by making an offer to B and then letting B make an offer to S.

[15] Our bargaining solution also covers some cases of the noncooperative bargaining model of Spier and Whinston (1995).

Finally, up to this point, we have restricted attention to either a fully exclusive ($e = 1$) or a fully nonexclusive ($e = 0$) contract. In what follows, we treat exclusivity continuously by letting $e \in [0, 1]$ denote the *probability* that S has an exclusive right. This change leads to no alteration in the specification of our bargaining payoffs in (7).[16] In a model in which many periods of trade follow the parties' investments, one could (more realistically) interpret e as representing the *duration* of the exclusivity provision.

□ **The irrelevance result.** Given this general model of investment and holdup, we can now state more general conditions under which the irrelevance result of our simple example (in Section 2) holds.

Proposition 1 (the irrelevance result). If $v(q_S = 0, q_E, a, \theta)$ and $c_E(q_E, a, \theta)$ do not depend on the investments $a = (a_B, a_S, a_E)$, then $A^*(e)$ does not depend on the degree of exclusivity e.

Proof. Under the stated conditions, $\hat{V}_{BE}(a, \theta)$ does not depend on a. Given this, and the payoffs in (7), it is immediate that the set of Nash equilibria is unaffected by e. *Q.E.D.*

The idea behind the result is simple. Recall that the exclusivity parameter e effects only the value of coalition BE. If investments do not affect the value of BE, then exclusivity does not affect the marginal returns to investment for any of the agents. This was precisely the case in the simple example of Section 2: there, S's investment lowered S's production cost but had no effect on either E's cost or B's value from consuming E's product. Hence, S's investment in that example had no impact on the value of coalition BE, and consequently exclusivity had no effect on investment incentives. Proposition 1, of course, applies to more cases than just investment by S in cost reduction; we may for example have investment by S that enhances his product or investments by B in learning to use S's product more effectively. As long as investments do not affect the value of trade between B and E, exclusivity will be irrelevant for investment incentives.

4. Effects of exclusivity with one-dimensional investment

■ According to Proposition 1, for exclusivity to affect *ex ante* investments, these investments must affect the value of trade between B and E. In the remainder of the article we study the effect of exclusivity in such cases. The investments discussed by Marvel (1982), Masten and Snyder (1993), and Areeda and Kaplow (1988) all have this feature (recall that in Marvel (1982) and Masten and Snyder (1993) a seller's investment raises the buyer's payoff from trading both with that seller and with others; in Areeda and Kaplow (1988), a retailer (the buyer) chooses which seller to favor in making promotional investments). Similarly, in the GM-Fisher relationship discussed by Klein (1988), GM (the buyer in its relation with Fisher) was presumably making substantial general investments in the production, distribution, and marketing of automobiles, whose value did not depend greatly on the source of GM's automobile bodies.

We focus in this section on the simplest possible case, in which only one party invests and its investment is one-dimensional, i.e., $A \subset \Re$. In the next section we show that our results can be extended to cases in which more than one party may have investment choices and these choices may be multidimensional.

To see the effect of exclusivity on a one-dimensional investment that affects external value, consider again the parties' *ex post* payoffs (7), which we restate here:

[16] The realization of the randomly determined exclusivity provision occurs before bargaining commences, and our bargaining payoffs correspond to the players' expected payoffs prior to this realization.

$$f_B(a, e, \theta) = \alpha_B^{SE}\hat{V}_{BSE}(a, \theta) + \alpha_B^S\hat{V}_{BS}(a, \theta) + \alpha_B^E(1 - e)\hat{V}_{BE}(a, \theta),$$
$$f_S(a, e, \theta) = \alpha_S^{BE}[\hat{V}_{BSE}(a, \theta) - (1 - e)\hat{V}_{BE}(a, \theta)] + \alpha_S^B\hat{V}_{BS}(a, \theta),$$
$$f_E(a, e, \theta) = \alpha_E^{BS}[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)] + \alpha_E^B(1 - e)\hat{V}_{BE}(a, \theta).$$

Examination of these payoffs suggests that an increase in e will increase S's incentive to make an investment that raises $\hat{V}_{BE}$ and will lower the incentives of B or E to do so. We formalize this intuition in Proposition 2 below.

For expositional purposes, throughout the remainder of this section we shall assume that the set A is compact, the functions $\hat{V}_J(\cdot)$ are continuously differentiable, and the equilibrium investment level for any level of exclusivity e is unique.[17] We denote this equilibrium investment level by $a^*(e)$.

In Proposition 2, we assume that $\partial E_\theta[\hat{V}_{BE}(a, \theta)]/\partial a > 0$. The key assumption is that the sign of this derivative is unchanging (the fact that the derivative is positive merely reflects the way we choose to measure the investment). In addition, for exclusivity to affect party j's investment, the party's payoff must be *responsive to external value*; that is, changes in the level of $E_\theta[\hat{V}_{BE}(a, \theta)]$ must change the payoff of party j. Formally, this requires that $\alpha_j^{\{BE\}\setminus j} > 0$. When this is so, we can state the comparative static effects of exclusivity as follows:

Proposition 2. Suppose that $A \subset \Re$, the investing party's payoff is responsive to external value, $\partial E_\theta[\hat{V}_{BE}(a, \theta)]/\partial a > 0$ for all $a \in A$, and $a^*(e) \in \text{int}A$ for all e.[18] Then

(i) if only S invests, $a^*(e)$ is increasing in e.

(ii) if only B invests, $a^*(e)$ is decreasing in e.

(iii) if only E invests, $a^*(e)$ is decreasing in e.

Proof. In case (i), the investing party's expected payoff has increasing marginal returns in (a, e) (that is, $\partial^2 E_\theta[f_S(a, e, \theta)]/\partial a \partial e > 0$), while in cases (ii) and (iii) it has decreasing marginal returns in (a, e). The results follow by Theorem 1 of Edlin and Shannon (1998). *Q.E.D.*

Using the analogy to asset ownership introduced in Section 2, these findings are related to the idea of Hart and Moore (1990) that asset ownership increases a party's incentive to invest. Thus, transferring the ''exclusivity asset'' from B or E to S increases S's investment but reduces B's or E's.

In general, a party's investment may affect the values of both external and internal trades. An important distinction then arises between cases in which investment moves the values of external and internal trade in the same direction and cases in which they move in opposite directions. For example, in Marvel (1982) and Masten and Snyder (1993), as well as the case of GM's general investments, investment moves external and internal values in the same direction. Formally, in these cases, investment increases (at least weakly) all coalitional values: $\hat{V}_{BE}$, $\hat{V}_{BS}$, and $\hat{V}_{BSE}$. In such cases, we will say that the investment has *complementary (internal and external) effects.* (A set of sufficient

[17] All the results in this section apply to the case in which the set of equilibrium investments $A^*(e)$ is not a singleton by interpreting $a^*(\cdot)$ as any single-valued selection from the set of equilibrium investments. The assumptions that A is compact and the functions $\hat{V}_J(\cdot)$ are continuously differentiable can be dispensed with at the cost of a slightly more complicated assumption in Propositions 3(ii), 4(i), and 6 (we must still assume that the investing party's payoff is differentiable in a).

[18] If $a^*(e) \notin \text{int}A$, then a small change in e could leave the optimal investment unchanged. Nevertheless, it is still true that when exclusivity does have an effect, it is in the direction we identify here. In Section 5 we will formulate weak comparative statics results that do not rely on differentiability of the objective function or interiority of the equilibrium investments.

conditions for complementary investment effects is given by $\partial v(q_S, q_E, a, \theta)/\partial a \geq 0$, $\partial c_S(q_S, a, \theta)/\partial a \leq 0$, and $\partial c_E(q_E, a, \theta)/\partial a \leq 0$.) According to Proposition 2, with complementary investment effects, internal value will increase with exclusivity if S is the investing party and will decrease if B or E is.

In contrast, in Areeda and Kaplow's (1988) discussion of a retailer's allocation of promotional effort, investment moves external and internal values in opposite directions. In this case, if investment is normalized to increase the value of external trade $\hat{V}_{BE}$, then it (at least weakly) reduces the value $\hat{V}_{BS}$ of internal trade, and its effect on total *ex post* surplus $\hat{V}_{BSE}$ is in general ambiguous. In such cases, we will say that the investment has *substitutable (internal and external) effects.* (A set of sufficient conditions for substitutable investment effects is given by $\partial v(q_S = 0, q_E, a, \theta)/\partial a \geq 0$, $\partial c_E(q_E, a, \theta)/\partial a \leq 0$, $\partial v(q_S, q_E = 0, a, \theta)/\partial a \leq 0$, and $\partial c_S(q_S, a, \theta)/\partial a \geq 0$.) With substitutable investment effects, internal value is decreased by exclusivity if S is the investing party and is increased if B or E is.

The distinction between complementary and substitutable investment effects not only determines the direction of the effect of exclusivity on internal values, but also has important effects on the incentive of the buyer-seller coalition to write an exclusive contract, as well as on the aggregate welfare effects of this arrangement. We analyze these effects in the remainder of this section.

□ **Welfare effects of exclusivity with complementary investment effects.** In this subsection, we examine the effects of exclusive contracts on total welfare, on the joint payoff of B and S (to determine the private incentives to write an exclusive contract), and on E's payoff (to determine the external effect of an exclusive contract) in situations of complementary investment effects. Letting $U_J(a, e) = \sum_{j\in J} U_j(a, e)$ denote the total *ex ante* surplus of a coalition $J \subset N$,[19] we have the following result:

Proposition 3. Suppose that $A \subset \Re$, the investing party's payoff is responsive to external value, $\partial E_\theta[\hat{V}_{BE}(a, \theta)]/\partial a > 0$ for all $a \in A$, and $a^*(e) \in \text{int}A$ for all e. If investment has complementary effects, it follows that

(i) if only S invests, then $U_{BS}(a^*(e), e)$ is increasing in e.

(ii) if only B invests, E is competitive, and $\partial E_\theta \hat{V}_{BSE}(a, \theta)/\partial a > 0$, then $U_{BS}(a^*(e), e)$ is decreasing in e for e close enough to one.

(iii) if only E invests, then $U_E(a^*(e), e)$ is decreasing in e.

Proof. Take $e', e'' \in [0, 1]$, with $e'' > e'$, and let $a' \equiv a^*(e')$ and $a'' \equiv a^*(e'')$.

(i) By Proposition 2, $a'' > a'$, hence with complementary investment effects, we must have $U_B(a'', e'') \geq U_B(a', e'')$. Also, by S's revealed preference,

$$U_S(a'', e'') > U_S(a', e'').$$

Therefore, we can write

$$U_{BS}(a'', e'') \equiv \sum_{j\in\{B,S\}} U_j(a'', e'') > \sum_{j\in\{B,S\}} U_j(a', e'') \geq \sum_{j\in\{B,S\}} U_j(a', e') \equiv U_{BS}(a', e'),$$

where the last inequality follows from the fact that $\sum_{j\in\{B,S\}} U_j(a, e)$ is nondecreasing in e holding a fixed.

[19] Observe that the *ex ante* aggregate social welfare $U_{BSE}(a) = E_\theta \hat{V}_{BSE}(a, \theta) - \sum_{j\in N} \psi_j(a_j)$ does not depend on e directly.

(ii) Let $R \in (0, \infty)$ denote an upper bound on $(\partial E_\theta \hat{V}_{BE}(a, \theta)/\partial a)/(\partial E_\theta \hat{V}_{BSE}(a, \theta)/\partial a)$ (such a bound exists under our assumptions, since A is compact and $\hat{V}_{BE}(\cdot)$ and $\hat{V}_{BSE}(\cdot)$ are continuously differentiable). Define $\overline{e} < 1$ such that $[1 - (1 - \overline{e})R] = 0$. Then for any $e \in (\overline{e}, 1]$,

$$\begin{aligned}
\frac{\partial}{\partial a} U_S(a, e) &= \alpha_S^{BE} \frac{\partial}{\partial a}[E_\theta \hat{V}_{BSE}(a, \theta) - (1 - e)E_\theta \hat{V}_{BE}(a, \theta)] + \frac{\partial}{\partial a} \alpha_S^B E_\theta \hat{V}_{BS}(a, \theta) \\
&\geq \alpha_S^{BE} \frac{\partial}{\partial a} E_\theta \hat{V}_{BSE}(a, \theta) \left[1 - (1 - e)\frac{\partial}{\partial a} E_\theta \hat{V}_{BE}(a, \theta) \Big/ \frac{\partial}{\partial a} E_\theta \hat{V}_{BSE}(a, \theta)\right] \\
&\geq \alpha_S^{BE} \frac{\partial}{\partial a} E_\theta \hat{V}_{BSE}(a, \theta)[1 - (1 - \overline{e})R] = 0.
\end{aligned}$$

By Proposition 2, $a'' < a'$. Also, by B's revealed preference, $U_B(a', e') > U_B(a'', e')$. Therefore, if $e' \in (\overline{e}, 1]$, we can write

$$U_{BS}(a', e') \equiv \sum_{j \in \{B,S\}} U_j(a', e') > \sum_{j \in \{B,S\}} U_j(a'', e') = U_{BS}(a'', e''),$$

where the last equality uses the assumption that E is competitive.

(iii) We can write

$$U_E(a', e') > U_E(a'', e') \geq U_E(a'', e''),$$

where the first inequality is by E's revealed preference and the second inequality uses the fact that $U_E(a, e)$ is nonincreasing in e keeping a fixed. *Q.E.D.*

The proof of part (i) is based on the fact that S's investment has a positive externality on B; by raising this investment, exclusivity increases B and S's joint surplus. This result corresponds well with the arguments of Marvel (1982) and Masten and Snyder (1993) that a buyer and seller may sign an exclusive contract to encourage the seller's investment that has an external benefit for the buyer. Note, moreover, that when E is competitive, we have $U_{BS} \equiv U_{BSE}$, and the exclusive arrangement is necessarily efficient. (When E is not competitive and the arrangement reduces E's payoff, it may not be socially efficient.)

The assumption in part (ii) that $\partial E_\theta \hat{V}_{BSE}(a, \theta)/\partial a > 0$ represents a slight strengthening of the condition that $\partial E_\theta \hat{V}_{BSE}(a, \theta)/\partial a \geq 0$, which holds with complementary investment effects. The proof of part (ii) is based on the fact that under the assumptions of the proposition, B's investment has a positive externality on S when e is close to one. Hence, by reducing this investment, exclusivity reduces B and S's joint surplus. In such a case, B and S never find it optimal to sign a fully exclusive contract. The result seems consistent with the difficulties, noted by Klein (1988), that arose under the GM-Fisher exclusive contract. If, as seems likely, GM was making important general investments, this result provides support for GM's conclusion that the exclusive contract was not working to its advantage.[20]

[20] GM responded to this concern by vertically integrating with Fisher, a possibility not present in our model. This feature could be incorporated, however, by also introducing some asset of Fisher's that vertical integration might shift to GM's control. The advantage of this shift would be that GM's external investments would no longer be expropriated by Fisher; the disadvantage, presumably, would be some loss of motivation on the part of Fisher's managers (as in Grossman and Hart (1986)).

Part (iii) of the proposition tells us that when E's investment is an entry cost, exclusivity will discourage entry, as in Aghion and Bolton (1987). The social effect of exclusivity in this case is unclear: it may be socially optimal to prevent entry by E that is motivated by ''business stealing'' concerns (as in Mankiw and Whinston, 1986). What we do know is that because of the negative externality that exclusivity has on E, B and S have a socially excessive incentive to use it, just as in Aghion and Bolton (1987).[21]

□ **Welfare effects of exclusivity with substitutable investment effects.** Welfare results in the case of substitutable investment effects are more limited, and a number of our results rely on the assumption that it is never *ex post* optimal to use the external source, so that $\hat{V}_{BS}(a, \theta) \equiv \hat{V}_{BSE}(a, \theta)$. Since the proofs of this and the remaining results of this section are very similar to that of Proposition 3, we relegate them to the Appendix.

Proposition 4. Suppose that $A \subset \Re$, the investing party's payoff is responsive to external value, $\partial E_\theta \hat{V}_{BE}(a, \theta)/\partial a > 0$ for all $a \in A$, and $a^*(e) \in \text{int}A$ for all e. If investment has substitutable effects, it follows that

(i) if only S invests, E is competitive, external trade is never optimal, $\alpha_B^{SE} + \alpha_B^S > 0$, and $\partial \hat{V}_{BS}(a, \theta)/\partial a < 0$, then $U_{BS}(a^*(e), e)$ is decreasing in e for e close enough to one.

(ii) if only B invests and external trade is never optimal, then $U_{BS}(a^*(e), e)$ is increasing in e.

(iii) if only E invests, then $U_E(a^*(e), e)$ is decreasing in e.

The conclusion of part (ii) of the proposition is consistent with the dealer loyalty motivation for exclusive dealing discussed by Areeda and Kaplow (1988). It establishes that when B invests, its investment has substitutable effects, and external trade is never optimal, B and S will sign a fully exclusive contract. When E is competitive, B and S's decision is also socially optimal, although when E is not competitive the effect on aggregate welfare is in general ambiguous. Continuing our analogy to Hart and Moore's (1990) model of asset ownership, note that this result indicates that with substitutable investments rather than the complementary investments assumed by Hart and Moore, it may be optimal to give ownership of the ''exclusivity asset'' to a noninvesting party.[22]

The assumption in part (i) that $\partial \hat{V}_{BS}(a, \theta)/\partial a < 0$ represents a slight strengthening of the condition that $\partial \hat{V}_{BS}(a, \theta)/\partial a \leq 0$, which holds with substitutable investment effects, while $\alpha_B^{SE} + \alpha_B^S > 0$ implies that S's payoff is increasing in $\hat{V}_{BS}$. Part (i) of the proposition tells us that when S invests and its investment has substitutable effects, E is competitive, and external trade is never optimal *ex post*, B and S will not sign a fully exclusive contract. (We are unaware of any discussion in the literature of a case in which S makes such a substitutable investment.)

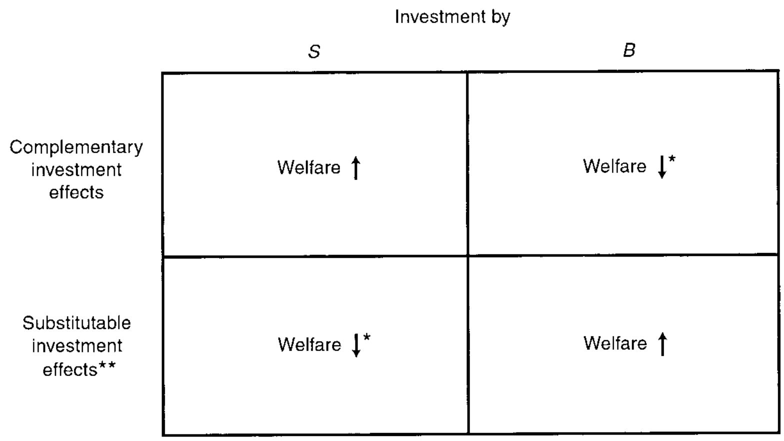
Finally, part (iii) tells us that when E is the investing party, E is worse off when B and S sign an exclusive contract (just as in the complementary effects case).

For convenience, in Figure 1 we summarize the welfare effects identified so far for investments having external effects for the case in which E is a competitive external source.

[21] This is not the only negative externality that can arise from exclusive contracts; Rasmusen, Ramseyer, and Wiley (1991) and Segal and Whinston (2000) consider the externalities that exclusive contracts have on other buyers (which are absent from our model).

[22] Rajan and Zingales (1998) observe that welfare may be increased by taking an asset away from the only investing party when Hart and Moore's (1990) assumptions on complementarity of investments are not satisfied. Cai (1998) makes the related observation that joint ownership can be optimal in such cases when more than one party invests.

FIGURE 1



*When $e \approx 1$.
**The results in this row hold when external trade is never optimal.

With a competitive external source, the welfare effect of an increase in e is equal to its effect on the joint surplus of B and S (that is, $U_{BSE}(a^*(e)) = U_{BS}(a^*(e), e)$ for all e). Thus, for example, Proposition 3 part (i) tells us that when E is competitive, an increase in exclusivity raises welfare when S is the party investing and S's investments display complementary investment effects.

Overall, the figure provides a simple checklist for evaluating the logical consistency of efficiency-based claims for exclusive contracts when the supply side of the market is argued to be competitive and the investment has an external effect. To use the figure, one need only ask "Who is making the investment?" and "Does the investment have complementary or substitutable effects?" Given the answers to these two questions, Figure 1 indicates whether efficiency concerns would in fact lead to the adoption of an exclusivity provision.

The results up to this point constitute the core of our study of the effects of exclusivity on noncontractible investments. The remaining sections of the article can all be viewed as extensions of this analysis. We begin these efforts at generalization in the next subsection by deriving some further welfare results for cases in which we know something about the complementarity/substitutability of S and E's products in B's payoff function, and the effect of the level of trade on the marginal returns to investment.

□ **Further welfare results.** The welfare results in the previous two subsections rely only on whether investment has complementary or substitutable effects (along with various differentiability assumptions). For example, they hold regardless of whether S and E's products are complements or substitutes. However, in some situations we may know more about the underlying valuations and costs of the parties and about the effects of the investment. In this subsection we derive some further welfare results based on assumptions about how the investment a affects the marginal contributions $[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)]$ and $[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BE}(a, \theta)]$.

Before presenting these results, we first identify conditions on the underlying valuation and cost functions that imply that these marginal contributions are either increasing or decreasing in a. To do so, we make assumptions about two basic types of interactions:

(i) Interaction of the two products in the buyer's payoff function. This is captured in the differentiable case by the cross-partial derivative $\partial^2 v(q_S, q_E, a, \theta)/\partial q_S \partial q_E$. If the products are complements, this cross-partial is positive; it is negative if they are substitutes.

(ii) Interactions between investment and trades. These are captured by the cross-partial derivatives $\partial^2 v(q_S, q_E, a, \theta)/\partial q_S \partial a$, $\partial^2 v(q_S, q_E, a, \theta)/\partial q_E \partial a$, $-\partial^2 c_S(q_S, a, \theta)/\partial q_S \partial a$, and $-\partial^2 c_E(q_E, a, \theta)/\partial q_E \partial a$. In what follows, we assume that internal (external) trades are complementary to investment changes that raise internal (external) values. This means that the investment's effect on the parties' marginal valuations for internal (external) trade is of the same sign as its effect on their total valuations for this trade. With complementary investment effects, this involves all of the above cross-partial derivatives being positive. With substitutable investment effects, this involves instead negative cross-partial derivatives between q_S and a.

Assumptions on these interactions allow us to sign the effects of investment on the two sellers' marginal contributions to the grand coalition:[23]

Lemma 1. Suppose that internal (external) trades are complementary with investment changes that raise internal (external) value. If S and E's products are complements in the complementary investment effects case, then

$$\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)]/\partial a \geq 0 \quad \text{and} \quad \partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BE}(a, \theta)]/\partial a \geq 0.$$

If S and E's products are substitutes in the substitutable investment effects case, then

$$\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)]/\partial a \geq 0 \quad \text{and} \quad \partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BE}(a, \theta)]/\partial a \leq 0.$$

Lemma 1 tells us that these marginal contributions will be increasing when products are complementary and we are in a situation of complementary investment effects, while they will be decreasing if products are substitutes and we are in a situation of substitutable investment effects.

We should emphasize that the conditions in Lemma 1 are sufficient, but not necessary, for signing the effects of investment on these marginal contributions. For example, suppose that q_S and q_E are substitute products and that B wishes to consume at most one unit. Suppose also that B's valuations are $v_S(a)$ for S's good and $v_E(a)$ for E's good, and that $v_S'(a) > v_E'(a) > 0$. Costs are unaffected by investments. Finally, assume as well that external trade is never efficient. Then we have

$$\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)]/\partial a = 0$$

and $\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BE}(a, \theta)]/\partial a = [v_S'(a) - v_E'(a)] > 0$ even though S and E's products are substitutes.

For the complementary investments effects case, we have the following additional welfare results when these marginal contributions are increasing in the investment a:

Proposition 5. Suppose that $A \subset \Re$, the investing party's payoff is responsive to external value, $\partial E_\theta[\hat{V}_{BE}(a, \theta)]/\partial a > 0$ for all $a \in A$, and $a^*(e) \in \text{int}A$ for all e. Suppose, in addition, that investment has complementary effects and that

[23] These interactions also play a prominent role in our discussion of comparative statics with multidimensional investments in the next section.

$$\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)]/\partial a \geq 0$$

and $\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BE}(a, \theta)]/\partial a \geq 0$. Then

(i) if only S invests, then $U_{BSE}(a^*(e), e)$ is increasing in e.

(ii) if only B invests, then $U_{BSE}(a^*(e), e)$ is decreasing in e and $U_E(a^*(e), e)$ is nonincreasing in e.

(iii) if only E invests, then $U_{BSE}(a^*(e), e)$ is decreasing in e.

Proposition 5's primary contribution relative to Proposition 3 is its provision of results on aggregate welfare. (Proposition 3 provided these only when E was competitive so that $\hat{V}_{BSE} = \hat{V}_{BS}$.) Under the assumptions of Proposition 5, aggregate welfare U_{BSE} increases with exclusivity if and only if S is the party who invests externally. Intuitively, in these cases, each party's investment increases other parties' marginal contributions to all coalitions, thus raising their *ex post* bargaining payoffs. Because of this positive externality, all of the parties have socially suboptimal investment incentives. The effect of exclusivity on aggregate welfare then simply depends on whether exclusivity increases or decreases the investment, which depends on the identity of the investing party by Proposition 2. Using the analogy to asset ownership introduced in Section 2, the assumptions and results of Proposition 5 are analogous to those of Hart and Moore (1990).[24] The result for situations in which B invests provides conditions in which the conclusion in the northeast corner of Figure 1 holds globally.

For the case of substitutable investment effects, we have the following additional welfare results when S and E's marginal contributions to the grand coalition are decreasing in the level of the investment a:

Proposition 6. Suppose that $A \subset \Re$, the investing party's payoff is responsive to external value, $\partial E_\theta[\hat{V}_{BE}(a, \theta)]/\partial a > 0$ for all $a \in A$, and $a^*(e) \in \operatorname{int} A$ for all e. Suppose, in addition, that investment has substitutable effects and that $\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BS}(a, \theta)]/\partial a \geq 0$ and $\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BE}(a, \theta)]/\partial a < 0$. If only B invests, then $U_{BS}[a^*(e), e]$ is increasing in e for e close to zero and $U_E[a^*(e), e]$ is nonincreasing in e.

Proposition 6 shows that with substitutable investment effects when

$$\partial E_\theta[\hat{V}_{BSE}(a, \theta) - \hat{V}_{BE}(a, \theta)]/\partial a$$

is strictly negative, B and S will always sign an exclusive contract when B invests. Our previous result in Proposition 4 (summarized in the southeast corner of Figure 1 for the case of a competitive E) established that B and S would sign a fully exclusive contract, but it held only when external trade was never optimal. Intuitively, the result holds because B's investment then has a negative externality on S. Exclusivity raises their joint payoff by reducing B's investment incentives. In addition, Proposition 6 tells us that in this case E is necessarily made (weakly) worse off by such an arrangement, and so B and S have a socially excessive incentive to sign an exclusive contract.

5. Effects of exclusivity with multidimensional investments

■ While the effects of exclusivity are easiest to see when one party makes a one-dimensional investment, this setting is quite restrictive. In reality, the parties often will

[24] However, in contrast to Hart and Moore (1990), when S is the only investing party, it may be uniquely optimal to give S ownership rights (i.e., have exclusivity) even though B is essential for trade. The reason for this difference is that here there is an agent (S) whose investment affects the value of a coalition (coalition BE) that he does not belong to, which is ruled out by Hart and Moore's assumptions.

have investment choices whose effects on internal and external values are not related in a simple one-to-one fashion. For example, a retailer who may be able to allocate his time to promote either of S or E's products may instead choose to promote neither product. Similarly, if S is training B how to use its product, S may be able to vary his emphasis on topics that benefit B when she procures from E. In addition, in many actual cases more than one party may have the opportunity to make investments. In this section we extend the analysis of the previous section to such cases.

In the study of multidimensional investments, it is convenient to separate each party j's investments a_j into two components, ''internal'' investments a_j^i and ''external'' investments a_j^e, so that internal/external investments affect only internal/external values respectively. Specifically, we suppose that $v(q_S = 0, q_E, a^i, a^e, \theta)$ and $c_E(q_E, a^i, a^e, \theta)$, and therefore $\hat{V}_{BE}(a, \theta)$, do not depend on a^i, and that $v(q_S, q_E = 0, a^i, a^e, \theta)$ and $c_S(q_S, a^i, a^e, \theta)$, and therefore $\hat{V}_{BS}(a, \theta)$, do not depend on a^e.[25] We write $A_j = A_j^i \times A_j^e$ for each $j \in N$, where A_j^i and A_j^e are the sets of party j's internal and external investments respectively, and we define $A^i = \prod_{j\in N} A_j^i$ and $A^e = \prod_{j\in N} A_j^e$.

The key to understanding the effects of exclusivity lies in understanding the ways in which internal and external investments interact. Although exclusivity has no direct effect on internal investments (Proposition 1), it does have a direct effect on external investments, which in turn can indirectly induce changes in internal investments. There are three potential sources of such interactions:

Interactions in the investment cost functions $\psi_j(a_j^i, a_j^e)$. This is, perhaps, the most immediate form of interaction between internal and external investments. We can represent the one-dimensional investment case in this framework as the special case in which internal and external investments are perfect investment cost complements (the complementary investment effects case) or substitutes (the substitutable investments effects case) in the following sense:[26]

Definition 1. The internal and external investments of party j are perfect investment cost complements if there exist a scalar variable $r \in R$ and nondecreasing functions $\tilde{a}_j^i$: $R \to A_j^i$ and $\tilde{a}_j^e$: $R \to A_j^e$ such that $\psi_j(a_j^i, a_j^e)$ takes finite values for all

$$(a_j^i, a_j^e) \in \overline{A} \equiv \{(\tilde{a}_j^i(r), \tilde{a}_j^e(r)) : r \in R\}$$

and infinite values for all $(a_j^i, a_j^e) \notin \overline{A}$. They are perfect investment cost substitutes if $\tilde{a}_j^i(\cdot)$ is instead a nonincreasing function of r.

As we have seen in Proposition 2, in these extreme cases the direction of the indirect effect of exclusivity on internal investments is fully determined by whether we have perfect investment cost substitutes or complements. More generally, however, internal and external investments may have a weaker form of cost interaction. For example, the retailer who can devote a^i hours a day to promoting S's product and a^e hours a day to promoting E's product may have a disutility cost of promotional effort that depends only on the total hours devoted to promotion, $c(a^i + a^e)$. In such cases, two other kinds of interaction between internal and external investments can also be relevant for the direction of the indirect effect of exclusivity on internal investments.

[25] If an investment affects both $\hat{V}_{BE}(a, \theta)$ and $\hat{V}_{BS}(a, \theta)$, as in the previous section, we formally split it in two, and assume that the investment cost function displays perfect complementarity (or substitutability) between these two investments.

[26] Observe that this condition differs from the usual perfect complements/substitutes assumption in production theory. In our model a Leontieff-like assumption on B's investment technology is not strong enough to insure the relationship between internal and external investments that we assume here.

Interactions of investments (a^i, a^e) in the buyer's valuation $v(\cdot)$. This type of interaction can arise in a number of ways. As one example, consider a situation in which a buyer can receive training in the use of both S and E's products from each of the two different sellers. If training in the use of one product reduces B's difficulty of learning about the other product, then this introduces a complementarity between these internal and external investments in $v(\cdot)$. On the other hand, if B's disutility of receiving one type of training is increased by having received the other (e.g., the disutility is time-related and B has decreasing marginal benefit for leisure), then these internal and external investments will be substitutes in $v(\cdot)$.

Interactions of trades (q_S, q_E) in the buyer's valuation $v(\cdot)$. This is the most subtle form of interaction between internal and external investments. Of primary concern in antitrust analysis is the case in which q_S and q_E are substitutes in the buyer's valuation. This gives rise to an indirect substitutability between internal and external investments. For example, suppose again that B is a retailer, and q_S and q_E are her sales of two competing brands. Suppose also internal/external investments are complementary to internal/external trades respectively. Then B's promotion of the external brand increases the brand's optimal sales q_E, thereby reducing the optimal sales of the internal brand q_S, which in turn reduces B's marginal benefit of promoting the internal brand.

In general, all three of these types of interaction between internal and external activities will matter. To obtain definitive comparative statics results we need to identify conditions under which these effects do not counteract each other. To do so, we identify cases in which we can represent the investment game as a supermodular game, and we apply the monotone comparative statics results of Milgrom and Roberts (1990).[27]

In some cases, all three types of interactions will reinforce each other. These are the cases of *full internal/external complementarity* and *substitutability*. Formally:

Definition 2. We have full internal/external complementarity [substitutability] if

(i) $v(\cdot)$, $-c_S(\cdot)$, $-c_E(\cdot)$ are supermodular in (q, a) [in $(-q_S, q_E, -a^i, a^e)$],

(ii) all $-\psi_j(\cdot)$ are supermodular in a [in $(-a^i_j, a^e_j)$].

The supermodularity conditions for the case of full complementarity mean that: (a) internal and external goods are complements for the buyer; (b) investments increase the buyer's marginal valuations for trades and reduce the sellers' marginal costs; and (c) investments are investment cost complements. The conditions for the case of full substitutability mean that (a) internal and external goods are substitutes for the buyer; (b) internal (external) investments increase the buyer's marginal valuations for internal (external) trades, reduce the buyer's marginal valuation for external (internal) trades, and reduce the sellers' marginal costs of internal (external) trades; and (c) internal investments are investment cost substitutes to external investments.

The case of full complementarity corresponds closely to the conditions assumed by Hart and Moore (1990). This case is of limited interest in antitrust analysis, however, which mainly concerns itself with situations in which the two sellers' goods are substitutes. When investments are complements in investment cost functions, but the goods are substitutes in the buyer's valuation, investment interactions of the third kind may counteract interactions of the first kind and rule out definitive comparative statics predictions. The case of perfect investment cost complements provides one setting in which internal and external investments must move together regardless of interactions

[27] Since strict monotone comparative statics results for supermodular games have not been formulated in the literature, we content ourselves here with formulating weak comparative statics results, which do not rule out the possibility that exclusivity has no effect on investments.

of the third kind. Another such setting arises when the levels of efficient trade for all coalitions are independent of investments:

Definition 3. Trades are independent of investments if for all $\theta \in \Theta$ there exists a triple $(q^*(\theta), q_S^*(\theta), q_E^*(\theta)) \in Q \times Q_S \times Q_E$ such that for all $a \in A$ we have

$$q^*(\theta) \in \underset{(q_S, q_E) \in Q}{\arg\max}\ v(q_S, q_E, a, \theta) - c_S(q_S, a^i, \theta) - c_E(q_E, a^e, \theta),$$

$$q_S^*(\theta) \in \underset{q_S \in Q_S}{\arg\max}\ v(q_S, 0, a^i, \theta) - c_S(q_S, a^i, \theta),$$

$$q_E^*(\theta) \in \underset{q_S \in Q_E}{\arg\max}\ v(0, q_E, a^e, \theta) - c_S(q_E, a^e, \theta).$$

This condition is encountered, for example, when the buyer wants at most a single indivisible unit of either good and external trade is never efficient. This assumption has been made in the models of Holmström and Tirole (1991) and Hart (1995). More generally, whether external or internal trade is efficient may depend on the realization of uncertainty θ, but not on the parties' investments a.

When trades are independent of investments we can obtain definitive comparative statics results with assumptions only on the first two types of interactions between internal and external investments. Formally, we will use the following notions:

Definition 4. We have internal/external investment complementarity [substitutability] if
(i) $v(\cdot), -c_S(\cdot), -c_E(\cdot)$ are supermodular in a [in $(-a^i, a^e)$],
(ii) all $-\psi_j(\cdot)$ are supermodular in a [in $(-a_j^i, a_j^e)$].

Finally, our analysis in this section will make use of the following assumptions:

Assumption 1. $v(\cdot), -c_S(\cdot), -c_E(\cdot)$ are continuous and nondecreasing in a.

Assumption 2. Q_S, Q_E, and A_j for $j = B, S, E$ are complete lattices and min $Q_j = 0$ for $j \in \{S, E\}$.

Assumption 3. $|A_E^i| = 1$.

Assumption 1 says that investments increase B's utility and reduce S's costs. Assumption 1's continuity assumption and Assumption 2 are necessary for applying the theory of supermodular games of Milgrom and Roberts (1990), where the formal definition of a complete lattice can be found. Every compact product set in $\Re^k$ is a complete lattice: as one simple example, we could take $q_j \in [0, \overline{q}_j] \subset \Re_+$ for $j \in \{S, E\}$ and $a \in [0, \overline{a}]^k \subset \Re_+^k$ for some k. Alternatively, we might be in the often-studied situation in which quantities are indivisible, so that $q_j \in \{0, 1\}$. Assumption 3 says that E has no internal investment decision.

Before turning to our comparative statics results, recall that in general our model may have multiple Nash equilibria, so that $A^*(e)$ need not be single-valued. Because we are now dealing with investments by more than one agent, and because we employ weaker assumptions than in Section 4, we can no longer show that any equilibrium selection $a^*(\cdot)$ from $A^*(\cdot)$ is monotonic as in Section 4. For this reason, our comparative statics results in this section will involve a weaker notion of monotonicity. Specifically, letting X and Y be two partially ordered sets,[28] we say that:[29]

[28] A partial ordering is a transitive, reflexive, and antisymmetric binary relation: see Milgrom and Roberts (1990).

[29] The concept is adapted from Milgrom and Roberts (1990). Note that the definition applied to the correspondence $A^*(\cdot)$ makes sense only when the maximum and minimum points in the equilibrium set exist. In fact, our assumptions ensure that the set of equilibrium investments in nonempty and has a maximum and minimum point (see Milgrom and Roberts (1990)).

Definition 5. The correspondence $G: X \rightrightarrows Y$ is nondecreasing if whenever $x' \leq x''$, we have $\max G(x') \leq \max G(x'')$ and $\min G(x') \leq \min G(x'')$.

With these definitions, our general comparative statics result for complementary investments is given in the following proposition:

Proposition 7. Suppose that Assumptions 1–3 hold and that either (a) we have perfect investment cost complementarity, (b) we have full internal/external complementarity, or (c) we have internal/external investment complementarity and efficient trades are independent of investments.

(i) If only S has an external investment choice and a_S^e is a scalar, then $A^*(e)$ is nondecreasing in e.

(ii) If only B and/or E have external investment choices, then $A^*(e)$ is nonincreasing in e.

The proposition establishes that in all of the cases of complementarity defined in this section, exclusivity moves internal and external investments in the same direction, which is determined by the direct effects of exclusivity on external investments. It therefore serves as a multidimensional analog to Proposition 2 for the case of complementary investment effects (where exclusivity moved internal and external values in the same direction). For substitutable investments, our comparative statics result extends to the case of multidimensional investments as follows:

Proposition 8. Suppose Assumptions 1–3 hold and that either (a) we have perfect investment cost substitutability, (b) we have full internal/external substitutability, or (c) we have internal/external investment substitutability and efficient trades are independent of investments. Define $\overline{A}^*(e) = \{(-a_j^i, a_j^e): (a_j^i, a_j^e) \in A^*(e)\}$.

(i) If only S has an external investment choice and a_S^e is a scalar, then $\overline{A}^*(e)$ is nondecreasing in e.

(ii) If only B and/or E have external investment choices, then $\overline{A}^*(e)$ is nonincreasing in e.

The proposition establishes that when internal and external investments are substitutes in the sense defined above, exclusivity moves them in opposite directions.

Using the two above comparative statics results, we can also establish multidimensional analogs to all the welfare results of Section 4.[30] The only caveat concerns the local results stated in these propositions (i.e., the results that hold only when e is close enough to zero or to one). For these local results to hold with multidimensional investments, we need to know that all components of these investments have nonzero derivatives with respect to exclusivity.

6. More general contracts

■ Up to this point we have restricted our attention to an incomplete contracting setting in which B and S could specify only a probability e that external trade is not allowed. In this section, we consider the possibility that B and S might sign more elaborate contracts. In the first subsection we consider how our results are affected if B and S can specify a penalty that B must pay to S if B trades with E. Although we have not considered such terms up to now, they are in fact feasible under our informational assumptions. Then, in the second subsection we suppose that a court can verify trade, so that B and S can include not only an exclusivity provision in their

[30] These results are contained in the working paper version of this article, Segal and Whinston (1996), which is available upon request from the authors.

contract, but also a contractually specified trade (or, perhaps, more elaborate options regarding trade).

□ **Penalties for external trade.** Even when quantities cannot be described in advance, under our assumptions B and S can write a contract in which B must pay S a penalty P in compensation for the right to trade with E. In this case, a fully exclusive contract corresponds to $P = \infty$, while a nonexclusive contract (no contract) corresponds to $P = 0$. It is immediate that such a contract can have no effect on the players' investment levels in the case in which all investments are internal. To see why, note that given investments a, state of nature θ, and penalty P, B will choose the level of e to maximize $[\alpha_B^E \hat{V}_{BE}(a, \theta) - P]\,(1 - e)$.[31] When investments are internal, $\hat{V}_{BE}$ is independent of a, and therefore B's decision of whether to pay the penalty P must also be unaffected by a. Hence, this contract must create exactly the same incentives for investment as one that simply specifies a fixed level of exclusivity. Thus, allowing for such contracts preserves our irrelevance result.[32,33]

It is worth stressing the difference between this result and results for what may at first appear to be similar models in the literature on stipulated damages for breach of contract (see, for example, Chung (1992) and Spier and Whinston (1995)). In that literature, the level of damages *does* affect players' choices of internal investments (such as a seller's investment in cost reduction). The critical difference, however, is that in that literature quantities are verifiable, and so it is possible to specify a price for trade (i.e., the buyer faces an option of whether to trade with the seller or not, with different prices attached to each option). Here, in contrast, the buyer must still bargain with the seller if trade is to occur. We shall say more about this difference in the next subsection.

□ **When quantities can be specified in advance.** We now consider situations in which B and S can specify contractually not only an exclusivity term, but also the terms of trade between them (investments are still noncontractible). We begin by considering the role of exclusivity provisions in specific performance (i.e., fixed-quantity) contracts, and then we discuss more general contracts. Although a full analysis is beyond the scope of this article, here we seek to highlight a number of the issues that arise when contracts can include such provisions.

Specific performance contracts. Suppose that B and S sign a contract that specifies a fixed trade $\overline{q}_S$ between them and a probability $e \in [0, 1]$ that B is not allowed to trade with E (and possibly an upfront monetary transfer). We begin by showing how our irrelevance result generalizes to this setting. When B and S sign a contract $(\overline{q}_S, e)$, we have the following coalitional values:

[31] Here we have assumed that B must decide on the level of e prior to renegotiation. A similar irrelevance result holds if instead renegotiation occurs prior to B's choice of e (in this case, B will choose e in the event of a bargaining breakdown to maximize $[\hat{V}_{BE}(a, \theta) - P](1 - e)$).

[32] More generally, a contract can make exclusivity contingent on announcements (messages) made by B and S. Similar logic shows that the irrelevance result also holds with these more general contracts.

[33] When investments are not internal, direct extensions of our comparative static and welfare results are more difficult. Our results for $e = 0$ and $e = 1$ tell us what happens when $P = 0$ and $P = \infty$, respectively. More generally, in some cases the results of Segal and Whinston (forthcoming) show that for any contract that specifies a penalty P, there is an equivalent contract that specifies the exclusivity probability $e(P)$, where $e(P)$ is an increasing function. In these cases we can employ our previous comparative statics results directly to analyze the effects of any change in P.

$$V_B = v(\overline{q}_S, q_E = 0, a, \theta); \qquad V_S = V_{SE} = -c_S(\overline{q}_S, q_E = 0, a, \theta); \qquad V_E = 0$$

$$V_{BS} = \hat{V}_{BS}(a, \theta); \qquad V_{BE} = V_B + (1-e)\max_{q_E \in Q_E}[v(\overline{q}_S, q_E, a, \theta) - c_E(q_E, a, \theta) - V_B]$$

$$V_{BSE} = \hat{V}_{BSE}(a, \theta).$$

Observe that, as before, exclusivity matters only through its effect on V_{BE}.

Our irrelevance result for internal investments extends to this setting for investments that are internal in the sense that: (a) they do not affect E's cost (i.e., $c_E(q_E, a, \theta)$ is independent of a), and (b) B's value function can be written in the following separable form:

$$v(q_S, q_E, a, \theta) = v^i(q_S, a, \theta) + \hat{v}(q_S, q_E, \theta).$$

As in the incomplete contracts case, investments that affect only S's cost are internal. Now, however, investments that affect $v(\cdot)$ are internal only if they have no effect on B's willingness to pay for units of q_E holding q_S fixed (in the incomplete contracts case, this had to hold only when $q_S = 0$).[34] When investments are internal in this sense, we have

$$V_{BE} = V_B + (1-e)\max_{q_E \in Q_E}[\hat{v}(\overline{q}_S, q_E, \theta) - c_E(q_E, \theta) - \hat{v}(\overline{q}_S, q_E = 0, \theta)],$$

and so V_{BE} is independent of a. Hence, for any given level of $\overline{q}_S$ specified in the contract, exclusivity is irrelevant.

To consider the effects of exclusivity in cases in which investments are not internal, we focus in the rest of this section on an extension of the simple example in Section 2. Specifically, we suppose that B needs at most one unit, and that B's valuations of S and E's products given investments a are given by the (deterministic) functions $v_S(a)$ and $v_E(a)$. We assume also that S's cost given investments a is $c_S(a)$ and that E is competitive with stochastic cost level $\tilde{c}_E$. For simplicity we suppose as well that B and S have equal bargaining power. Finally, we assume that trade with E is always more efficient than no trade, i.e., that $\Pr(\tilde{c}_E < v_E(a)) = 1$ for all a. Letting $\overline{q}_S \in [0, 1]$ denote a contractually specified probability that S must deliver a unit of his good to B,[35] the expected *ex post* payoffs for B and S are

$$E[f_B(a, e, \tilde{c}_E)] = \frac{1}{2}E[TS(a, \tilde{c}_E)] + \frac{1}{2}\{\overline{q}_S(v_S(a) + c_S(a)) + (1-\overline{q}_S)(1-e)(v_E(a) - E[\tilde{c}_E])\}$$

$$E[f_S(a, e, \tilde{c}_E)] = \frac{1}{2}E[TS(a, \tilde{c}_E)] - \frac{1}{2}\{\overline{q}_S(v_S(a) + c_S(a)) + (1-\overline{q}_S)(1-e)(v_E(a) - E[\tilde{c}_E])\},$$

where $TS(a, c_E) = \max_{q_S \in \{0,1\}} \{q_S(v_S(a) - c_S(a)) + (1 - q_S)(v_E(a) - c_E)\}$.

[34] For example, an investment that effectively augments the units of S's product [i.e., for which the value function takes the form $v(aq_S, q_E, \theta)$] would be purely internal if and only if $\partial^2 v(\cdot)/\partial q_S \partial q_E = 0$, that is, if the products are independent. As an example in which investments are internal while products are not independent, B may be a retailer who sells q_S and q_E in separate markets, but who incurs joint inventory costs (equal to $-\hat{v}(q_S, q_E, \theta)$) that are unaffected by investments.

[35] Note that we could have described an equivalent model in which B consumes a continuous quantity up to an amount 1 and has utility that is linear in the amount consumed. In this case, $\overline{q}_S$ would be a quantity rather than a probability.

Several points of interest follow from these expressions. First, note that if v_E is independent of a, then exclusivity is irrelevant for *ex ante* investment incentives. Since in this case investment is internal, this is just the irrelevance result formulated in the beginning of this subsection.

Second, in some cases the optimal contract takes the form $\overline{q}_S = 0$, in which case we are back to the incomplete contract setting considered earlier in the article. Specifically, suppose that only S invests and that his investments a_S is a general investment in B's value from trade, i.e., $v_S(a_S) = v_E(a_S) \equiv v(a_S)$. Then S's *ex post* expected payoff is

$$E[f_S(a_S, \tilde{c}_E)] = \frac{1}{2}\{E[TS(a_S, \tilde{c}_E)] - [\overline{q}_S + (1 - \overline{q}_S)(1 - e)]v(a_S) + \overline{q}_S c_S - (1 - \overline{q}_S)(1 - e)E[\tilde{c}_E]\}.$$

This expression implies that S's optimal choice of a_S is weakly decreasing in $\overline{q}_S$. Since B's payoff is increasing in a_S (holding e fixed), it follows that any contractual change that increases a_S increases U_{BS} (since a_S has a positive externality on B; the formal argument parallels those in Sections 4 and 5). Hence, we conclude that it is optimal for B and S to write a contract that sets $\overline{q}_S = 0$. (This is a simple extension of the result in Che and Hausch (1999).) Given this fact, we can directly apply Proposition 3 to conclude that B and S optimally set $e = 1$.

Finally, in contrast to the two cases discussed above, in other cases the possibility of including a quantity provision in the contract can materially alter our conclusions about the use of exclusive contracts. To see this, suppose that B's investment $a_B \in \Re$ affects only $v_S(\cdot)$ and $v_E(\cdot)$, and S's investment $a_S \in \Re$ affects only $c_S(\cdot)$. Then the efficient investments (a_B°, a_S°) must satisfy the first-order conditions

$$q_S^\circ v_S'(a_B^\circ) + (1 - q_S^\circ)v_E'(a_B^\circ) - \psi_B'(a_B^\circ) = 0, \qquad -q_S^\circ c_S'(a_S^\circ) - \psi_S'(a_S^\circ) = 0,$$

where $q_S^\circ \equiv \Pr(v_S(a_B^\circ) - c_S(a_S^\circ) \geq v_E(a_B^\circ) - \tilde{c}_E)$. Observe now that by setting $\overline{q}_S = q_S^\circ$ and $e = 0$, B and S are faced with precisely these first-order conditions. (This is a simple extension of Proposition 6 in Edlin and Reichelstein (1996), which also implies that given the contract, efficient investment choices are *globally* optimal for the parties.) Hence, B and S can implement efficient investment levels without resorting to an exclusivity provision. Thus, while in this case exclusives can serve an efficiency-enhancing purpose in the incomplete contracting setting (for example, when $v_S'(\cdot)$ and $v_E'(\cdot)$ have different signs, so that B's investment has substitutable effects), once B and S can include a quantity provision in their contract, exclusives are no longer needed.

Price contracts. Once quantities can be specified, a wide range of contractual terms can be included in B and S's contract. As a general matter, we can imagine that the quantity, price, and extent of exclusivity can depend on announcements made by B and S. Here we restrict attention to one relatively simple contractual form, ''option-to-buy'' contracts, and maintain our focus on the example introduced in the previous subsection. An option-to-buy contract (p, e) specifies a price p at which B may elect to take delivery of a unit from S, and a probability e that B is allowed to procure from E. The timing is that $\tilde{c}_E$ is first realized, then B decides whether to exercise the option, then the exclusivity realization occurs, and finally B and S can renegotiate with the option exercise decision as the default outcome.

Given a contract (p, e) and realization $\tilde{c}_E$, B will exercise the option if and only if doing so increases his utility at his default outcome, i.e., if and only if

$$v_S(a) + c_S(a) - p \geq (1 - e)[v_E(a) - \tilde{c}_E].$$

Let $\overline{q}_S(a, e, p, \tilde{c}_E)$ denote the realized quantity given B's optimal exercise decision. Now, B's and S's expected *ex post* payoffs are

$$E[f_B(a, e, p, \tilde{c}_E)] = \frac{1}{2}E[TS(a, \tilde{c}_E)] + \frac{1}{2}W(a, e, p),$$

$$E[f_S(a, e, p, \tilde{c}_E)] = \frac{1}{2}E[TS(a, \tilde{c}_E)] - \frac{1}{2}W(a, e, p),$$

where

$$W(a, e, p) = E\{\overline{q}_S(a, e, p, \tilde{c}_E)(v_S(a) + c_S(a)) + (1 - \overline{q}_S(a, e, p, \tilde{c}_E))(1 - e)(v_E(a) - \tilde{c}_E)\}.$$

Suppose now that $a \in \Re$. Assuming that the distribution of $\tilde{c}_E$ is nonatomic so that the function $W(\cdot)$ is differentiable in a, by the envelope theorem (see Milgrom and Segal (forthcoming)) we have

$$\frac{\partial W(a, e, p)}{\partial a} = E[\overline{q}_S(a, e, p, \tilde{c}_E)]\{v_S'(a) + c_S'(a) - (1 - e)v_E'(a) + (1 - e)v_E'(a)\}.$$

Thus, the option price p affects the equilibrium level of investment through its effect on $E[\overline{q}_S(a, e, p, \tilde{c}_E)]$, the expected quantity exercised by the buyer under the option-to-buy clause (this is precisely the effect identified in the literature on stipulated damages). Now, let $\hat{q}_S = E[\overline{q}_S(a^*, e, p, \tilde{c}_E)]$, where a^* is the equilibrium investment level under the contract. Then it is simple to see that the first-order condition for a would be unchanged if instead B and S wrote the specific performance contract $(\hat{q}_S, e)$. Thus, with one-dimensional investment, we can always find a specific performance contract that is equivalent to any option-to-buy contract as long as second-order conditions are satisfied.[36] This implies that the effects of exclusivity when the parties optimally adjust price in option-to-buy contracts are the same as when the parties optimally adjust quantity in specific performance contracts. In particular, the ''irrelevance result'' continues to hold here: if investments are internal, banning exclusives would have no effect on investments when the parties can optimally adjust contractual price.

This conclusion stands in contrast to results presented in Gilbert and Shapiro (1997), who also study the effects of exclusivity on investments in settings in which price terms can be included in contracts. Gilbert and Shapiro argue that exclusives do increase the level of the seller's cost-reducing investment (which is internal). The difference in results is due to the fact that Gilbert and Shapiro identify the results of changing *e holding all other contract terms fixed.* However, in response to a change in the level of exclusivity, B and S can be expected to *alter* these other terms. In the case of a seller investing in cost reduction, what we have shown is that by altering the price term appropriately (specifically, by keeping the expected contractual trade $E[\overline{q}_S(a, e, p, \tilde{c}_E)]$ unchanged), B and S can achieve the same outcome regardless of the level of e.[37]

[36] Segal and Whinston (forthcoming) establish this fact for arbitrary message-contingent contracts, of which option-to-buy contracts are just one example.

[37] Moreover, the result of Edlin and Reichelstein (1996) discussed in the previous subsection suggests that, in this case, by ensuring that the expected contractual trade equals the expected efficient trade, the parties can implement efficient cost-reducing investment by S without resorting to an exclusivity provision.

7. Conclusion

■ The foregoing analysis provides a number of results regarding the effects of exclusivity on noncontractible investments and welfare. On a very practical level, these results can be used to evaluate claims about the use of exclusive contracts to protect investments. For example, consider the investments of Ticketmaster in personnel training and software configuration described in the Introduction. Because of the proprietary nature of Ticketmaster's system, these investments could not be used by the buyer in conjunction with other systems, so they were internal in our terminology. Our irrelevance result therefore casts doubt on the claimed efficiency motivation for Ticketmaster's exclusive contracts. More generally, when investments do have an external effect, our analysis identifies when a buyer and seller would and would not wish to sign an exclusive contract, and it also indicates when such arrangements are socially efficient. Figure 1, in particular, provides a checklist for evaluating the logical consistency of efficiency-based claims for exclusive contracts for cases in which the supply side of the market is argued to be competitive.

Our findings relate to some arguments that have been made in the literatures on transfer pricing, second sourcing, human capital investments, and outsourcing. In their study of transfer pricing, Holmström and Tirole (1991) investigate the investment incentives of division managers under various organizational arrangements, including those that prohibit external trade. Their model differs from ours in several respects: first, it considers the effect of imposing exclusivity on both the buyer and seller at once, second, it allows explicit compensation schemes, and third, it is substantially more specialized. Despite these differences, our results are reminiscent of some of the effects identified by Holmström and Tirole. For example, they find that prohibiting external trade may be beneficial because it discourages managers' rent-seeking investments in external activities. This parallels our result on the beneficial effect of exclusivity when the buyer's external and internal investments are substitutes (see the southeast cell of Figure 1). Holmström and Tirole also find that ''nonintegration'' may be good because it encourages general investments by managers, which parallels our result that exclusivity is harmful when *B*'s internal and external investments are complements (see the northeast cell of Figure 1).

The northeast cell of Figure 1 also has parallels to cases of second-sourcing (Farrell and Gallini, 1988; Shepard, 1987) in which a supplier elects to establish a competitive source of supply to elicit greater levels of general investments by *B*. The main difference is that in the second-sourcing literature the seller either shares the licensing surplus with the licensee or licenses unilaterally at a zero fee. To analyze the optimality of these decisions, we would need to consider the effect of exclusivity (nonlicensing) on the *ex ante* surplus of coalitions *SE* and *S*.

In his classic treatise on human capital, Becker (1964) observes that firms have a socially suboptimal incentive to invest in general training of their employees. He also notes that a firm's incentive to make such investment is increased when it has a degree of monopsony over employees (exemplified by an isolated company town).[38] Interpreting the firm as a ''seller'' who competes with other firms (''external sellers'') for a worker (the ''buyer''), this parallels our finding that exclusivity may be good when the seller's internal and external investments are complements (the northwest cell of Figure 1).

Another application of this result to labor economics concerns union contracts that restrict outsourcing. While it is common to attribute such restrictions to unions' attempt

[38] For a recent development of this idea, see Acemoglu and Pischke (1999).

to maintain their ‘‘power,’’ Baron and Kreps (1999) argue that such contracts enhance efficiency, by encouraging cooperation between workers and the firm. Our analysis suggests another efficiency justification for outsourcing restrictions: it encourages union members to invest in improving the firm’s profitability in ways that would be appropriable by the firm absent the restrictions.

Appendix

■ Proofs of Proposition 4–8 and Lemma 1 follow.

Proof of Proposition 4. Take $e', e'' \in [0, 1]$, with $e'' > e'$, and let $a' \equiv a^*(e')$ and $a'' \equiv a^*(e'')$.

(i) Let $R \in (-\infty, 0)$ denote a lower bound on $(\partial/\partial a)E_\theta\hat{V}_{BE}(a,\theta)/(\partial/\partial a)E_\theta\hat{V}_{BS}(a, \theta)$. Define $\overline{e} < 1$ such that $[\alpha_B^{SE} + \alpha_B^S + (1 - \overline{e})\alpha_B^E R] = 0$. Then, since external trade is never optimal, with substitutable investment effects we can write for any $e \in (\overline{e}, 1]$,

$$\begin{aligned}\frac{\partial}{\partial a}U_B(a, e) &= (\alpha_B^{SE} + \alpha_B^S)\frac{\partial}{\partial a}E_\theta\hat{V}_{BS}(a, \theta) + (1 - e)\frac{\partial}{\partial a}\alpha_B^E E_\theta\hat{V}_{BE}(a, \theta)\\ &= \frac{\partial}{\partial a}E_\theta\hat{V}_{BS}(a, \theta)\left[\alpha_B^{SE} + \alpha_B^S + (1 - e)\alpha_B^E\frac{\partial}{\partial a}E_\theta\hat{V}_{BE}(a, \theta)\Big/\frac{\partial}{\partial a}E_\theta\hat{V}_{BS}(a, \theta)\right]\\ &\le \frac{\partial}{\partial a}E_\theta\hat{V}_{BS}(a, \theta)[\alpha_B^{SE} + \alpha_B^S + (1 - \overline{e})\alpha_B^E R] = 0.\end{aligned}$$

By Proposition 2, $a'' > a'$. By S’s revealed preference, $U_S(a', e') > U_S(a'', e')$. Therefore, when $e' \in (\overline{e}, 1]$, we can write

$$U_{BS}(a', e') \equiv \sum_{j\in\{B,S\}} U_j(a', e') > \sum_{j\in\{B,S\}} U_j(a'', e') = U_{BS}(a'', e''),$$

where the last inequality follows from the assumption that E is competitive.

(ii) When external trade is never optimal,

$$U_S(a, e) = (\alpha_S^{BE} + \alpha_S^B)E_\theta\hat{V}_{BS}(a, \theta) - (1 - e)\alpha_S^{BE}E_\theta\hat{V}_{BS}(a, \theta),$$

and with substitutable investment effects this expression is nonincreasing in a. By Proposition 2, $a'' < a'$, hence $U_S(a'', e'') \ge U_S(a', e'')$. Also, by B’s revealed preference, $U_B(a'', e'') > U_B(a', e'')$. Therefore, we can write

$$U_{BS}(a'', e'') \equiv \sum_{j\in\{B,S\}} U_j(a'', e'') > \sum_{j\in\{B,S\}} U_j(a', e'') \ge \sum_{j\in\{B,S\}} U_j(a', e') \equiv U_{BS}(a', e').$$

(iii) The proof is the same as that of Proposition 3. *Q.E.D.*

Proof of Lemma 1. Here we establish the result for the case of complementary investment effects and complementary products and the sign of $\partial E_\theta[V_{BSE}(a, \theta) - V_{BE}(a, \theta)]/\partial a$. The remaining claims follow similarly.

By the envelope theorem (see Milgrom and Segal (forthcoming)),

$$\partial E_\theta[V_{BSE}(a, \theta)]/\partial a = E_\theta\left[\frac{\partial}{\partial a}v(q_S^{**}(a, \theta), q_E^{**}(a, \theta), a, \theta) - \frac{\partial}{\partial a}c_S(q_S^{**}(a, \theta), a, \theta) - \frac{\partial}{\partial a}c_E(q_E^{**}(a, \theta), a, \theta)\right],$$

$$\partial E_\theta[V_{BE}(a, \theta)]/\partial a = E_\theta\left[\frac{\partial}{\partial a}v(0, q_E^{*}(a, \theta), a, \theta) - \frac{\partial}{\partial a}c_E(q_E^{*}(a, \theta), a, \theta)\right],$$

where

$$(q_S^{**}(a, \theta), q_E^{**}(a, \theta)) \in \underset{(q_S, q_E) \in Q}{\arg\max}\, v(q_S, q_E, a, \theta) - c_S(q_S, a, \theta) - c_E(q_E, a, \theta),$$

$$q_E^*(a, \theta) \in \underset{q_E \in Q_E}{\arg\max}\, v(0, q_E, a, \theta) - c_S(q_E, a, \theta).$$

By Topkis's monotonicity theorem (Topkis, 1978), $q_E^{**}(a, \theta) \geq q_E^*(a, \theta)$. The result follows from the assumptions on cross-partial derivatives. *Q.E.D.*

Proof of Proposition 5. Note first by examining (7) we see that under the hypotheses of the proposition $U_j(a, e)$ is nondecreasing in a_{-j}. As in the proof of Proposition 3, take $e', e'' \in [0, 1]$, with $e'' > e'$, and let $a' \equiv a^*(e')$ and $a'' \equiv a^*(e'')$.

(i) As in the proof of Proposition 3, we have $a'' > a'$, $U_B(a'', e'') \geq U_B(a', e'')$, and $U_S(a'', e'') > U_S(a', e'')$. Under the further hypotheses assumed here, we also have $U_E(a'', e'') \geq U_E(a', e'')$. Hence,

$$U_{BSE}(a'', e'') \equiv \sum_{j \in \{B,S,E\}} U_j(a'', e'') > \sum_{j \in \{B,S,E\}} U_j(a', e'') = \sum_{j \in \{B,S,E\}} U_j(a', e') \equiv U_{BS}(a', e').$$

(ii) In this case, we have $a'' < a'$. As in Proposition 3, revealed preference tells us that $U_B(a', e') > U_B(a'', e')$. Moreover, since $U_j(a, e)$ is nondecreasing in a_{-j}, we have $U_S(a', e') \geq U_S(a'', e')$ and $U_E(a', e') \geq U_E(a'', e')$. Since $U_E(a, e)$ is nonincreasing in e, the latter inequality implies that $U_E(a', e') \geq U_E(a'', e'')$. In addition, the three inequalities together imply that

$$U_{BSE}(a', e') \equiv \sum_{j \in \{B,S,E\}} U_j(a', e') > \sum_{j \in \{B,S,E\}} U_j(a'', e') = \sum_{j \in \{B,S,E\}} U_j(a', e'') \equiv U_{BSE}(a'', e'').$$

(iii) Again, $a'' < a'$. Since E is the party investing, we know that $U_B(a', e') \geq U_B(a'', e')$ and $U_S(a', e') \geq U_S(a'', e')$. In addition, by revealed preference, $U_E(a', e') > U_E(a'', e')$. Hence,

$$U_{BSE}(a', e') \equiv \sum_{j \in \{B,S,E\}} U_j(a', e') > \sum_{j \in \{B,S,E\}} U_j(a'', e') = \sum_{j \in \{B,S,E\}} U_j(a', e'') \equiv U_{BSE}(a'', e'').$$

Q.E.D.

Proof of Proposition 6. As in the proof of Proposition 4, take $e', e'' \in [0, 1]$, with $e'' > e'$, and let $a' \equiv a^*(e')$ and $a'' \equiv a^*(e'')$ and note that when B invests we have $a'' < a'$.

For the first result, we know that $U_B(a', e') > U_B(a'', e')$ by revealed preference. Define

$$\bar{e} = \min_{a \in A} \frac{\partial E_\theta \hat{V}_{BE}(a, \theta)/\partial a - \partial E_\theta \hat{V}_{BSE}(a, \theta)/\partial a}{\partial E_\theta \hat{V}_{BE}(a, \theta)/\partial a}.$$

Note that $\bar{e} > 0$ under our assumptions. For all $e \in [0, \bar{e})$ we have

$$\begin{aligned}
\frac{\partial}{\partial a} U_S(a, e) &= \alpha_S^{BE} \frac{\partial}{\partial a} [E_\theta \hat{V}_{BSE}(a, \theta) - (1 - e) E_\theta \hat{V}_{BE}(a, \theta)] + \frac{\partial}{\partial a} \alpha_S^B E_\theta \hat{V}_{BS}(a, \theta) \\
&= \alpha_S^{BE} \frac{\partial}{\partial a} E_\theta \hat{V}_{BE}(a, \theta) \left[\frac{\partial E_\theta \hat{V}_{BSE}(a, \theta)/\partial a - \partial E_\theta \hat{V}_{BE}(a, \theta)/\partial a}{\partial E_\theta \hat{V}_{BE}(a, \theta)/\partial a} + e \right] + \frac{\partial}{\partial a} \alpha_S^B E_\theta \hat{V}_{BS}(a, \theta) \\
&\leq \alpha_S^{BE} \frac{\partial}{\partial a} E_\theta \hat{V}_{BE}(a, \theta) [-\bar{e} + e] + \frac{\partial}{\partial a} \alpha_S^B E_\theta \hat{V}_{BS}(a, \theta) < \frac{\partial}{\partial a} \alpha_S^B E_\theta \hat{V}_{BS}(a, \theta) \leq 0.
\end{aligned}$$

Thus, we have

$$U_{BS}(a'', e') = \sum_{j \in \{B,S\}} U_j(a'', e'') > \sum_{j \in \{B,S\}} U_j(a', e'') \geq \sum_{j \in \{B,S\}} U_j(a', e') = U_{BS}(a', e').$$

For the second result, note that $U_E(a, e)$ is nonincreasing in a; hence, $U_E(a', e') \geq U_E(a'', e') \geq U_E(a'', e'')$. *Q.E.D.*

The proofs of Propositions 7 and 8 are based on a lemma that provides sufficient conditions on the coalitional value functions for unambiguous comparative statics. These requirements on the coalitional values may be satisfied even when the structural sufficient conditions we identify in the various propositions are not. With a slight abuse of notation, in Lemma A1 we write the arguments of the functions $V_J(\cdot)$ and $\psi_j(\cdot)$ as $(\overline{a}, \overline{e}, \theta)$ and $\overline{a}_j$ to allow later interpretations of $\overline{a}$ as either (a^i, a^e) or $(-a^i, a^e)$ and of $\overline{e}$ as either e or $-e$.

Lemma A1. Suppose that

(i) Assumptions 1–3 hold.

(ii) for all $\theta \in \Theta$ every marginal contribution $M_j^J(\overline{a}, \overline{e}, \theta) = [V_{J\cup j}(\overline{a}, \overline{e}, \theta) - V_J(\overline{a}, \overline{e}, \theta)]$ is continuous in $\overline{a}$, supermodular in $\overline{a}_j$, and has increasing differences between $\overline{a}_j$ and $(\overline{a}_{-j}, \overline{e})$,[39]

(iii) the investment cost functions have the property that $-\psi_j(\overline{a}_j)$ is supermodular in $\overline{a}_j$ for $j \in \{B, S, E\}$.

Then the set $\overline{A}^*(\overline{e})$ of Nash equilibrium investment vectors $\overline{a}$ is nondecreasing in $\overline{e}$.

Proof. A nonnegatively weighted sum of functions preserves the properties of continuity, supermodularity, and increasing differences. Each player j's *ex post* payoff in state θ given $(\overline{a}, \overline{e})$, $U_j(\overline{a}, \overline{e}, \theta)$, is a nonnegatively weighted sum of marginal contributions and the negative of investment costs. In turn, player j's *ex ante* payoff given $(\overline{a}, \overline{e})$, $U_j(\overline{a}, \overline{e})$, is a nonnegatively weighted sum of the functions $U_j(\overline{a}, \overline{e}, \theta)$. Therefore, the investment game is supermodular and the result follows from the corollary to Theorem 6 in Milgrom and Roberts (1990). *Q.E.D.*

Proof of Proposition 7. For each case, the proof consists of establishing that the conditions of Lemma A1 hold for the appropriately chosen $(\overline{a}, \overline{e})$.

Consider part (i) first with full internal/external complementarity (case (b)). We shall show that the requirements of Lemma A1 are satisfied taking $(\overline{a}, \overline{e}) = (a, e)$. Note that in this case $|A_E| = 1$, so that every marginal contribution of E, $M_E^J(a, e, \theta)$, trivially satisfies the assumptions of Lemma A1.

Now consider the marginal contributions of B and S. Note first that since $M_S^E(a, e, \theta) = 0$, this marginal contribution trivially satisfies the requirements of Lemma A1. For the remaining marginal contributions, recall that Topkis (1998) establishes that if a function $f: X \times Y \rightarrow \Re$ is supermodular on a sublattice $X \times Y$, then the function $g(x) = \max_{y \in Y} f(x, y)$ is supermodular on X. This tells us that under full internal/external cost complementarity, every coalitional value $\hat{V}_J(a, \theta)$ is supermodular in a. Since $M_j^J(a, e, \theta) = \hat{V}_{j\cup J}(a, \theta)$ for $(j, J) \in \{(S, B), (B, SE), (B, S)\}$, these marginal contributions are supermodular in (a, e) and so satisfy the requirements of Lemma A1 (a supermodular function satisfies increasing differences in all pairs of variables). Next, note that in part (i) we have $M_B^E(a, e, \theta) = (1 - e)\hat{V}_{BE}(a_S^e, \theta)$. Hence, $M_B^E(a, e, \theta)$ also trivially satisfies the conditions of Lemma A1. The final marginal contribution to consider is

$$M_S^{BE}(a, e, \theta) = [\hat{V}_{BSE}(a_S^i, a_B^i, a_S^e, \theta) - (1 - e)\hat{V}_{BE}(a_S^e, \theta)].$$

Since a_S^e is a scalar, $-(1 - e)\hat{V}_{BE}(a_S^e, \theta)$ is trivially supermodular in a. It also has increasing differences in a_S and e. Likewise, $\hat{V}_{BSE}(a_S^i, a_B^i, a_S^e, \theta)$ is supermodular in a and (trivially) has increasing differences in a_S and e. Since these properties are preserved under addition, this implies that $M_S^{BE}(a, e, \theta)$ has the properties required in Lemma A1. Thus, all of the requirements of Lemma A1 are met taking $(\overline{a}, \overline{e}) = (a, e)$.

The proof of part (ii) follows similarly but taking $(\overline{a}, \overline{e}) = (a, -e)$. The proofs for cases (a) and (c) follow similar lines. *Q.E.D.*

Proof of Proposition 8. Similar to that of Proposition 7, except that we take $(\overline{a}, \overline{e}) = (a^e, -a^i, e)$ for part (i) and $(\overline{a}, \overline{e}) = (a^e, -a^i, -e)$ for part (ii). *Q.E.D.*

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[39] See Milgrom and Roberts (1990) for definitions.

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