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Vertical Integration and Market Foreclosure

FEW PEOPLE would disagree that horizontal mergers have the potential to restrict output and raise consumer prices, but there is much less agreement about the anticompetitive effects of vertical mergers. Some commentators have argued that a purely vertical merger will not affect a firm's monopoly power, because the merger of an upstream and a downstream firm, each of which controls, say, 10 percent of its market, does not change market shares: other firms continue to possess 90 percent of each market.[1] Other commentators have responded by developing models in which vertical integration can lead to the foreclosure of competition in upstream or downstream markets. These models, however, rely on particular assumptions about contractual arrangements between nonintegrated firms (for example, that pricing must be linear) or about the ability of integrated firms to make commitments (for example, that an integrated supplier can commit not to undercut a rival). Thus at this stage the debate about the conditions under which vertical mergers are anticompetitive is far from settled.

The purpose of this paper is to develop a theoretical model showing how vertical integration changes the nature of competition in upstream and downstream markets and identifying conditions under which market

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1. See, in particular, Bork (1978, pp. 232–33).

foreclosure will be a consequence or a purpose, or both, of such integration. In contrast to much of the literature, the paper does not restrict upstream and downstream firms to particular contractual arrangements, but instead allows them to choose from a full set of arrangements both when they are integrated and when they are not (so, for example, two-part tariffs are permitted).[2] We also allow nonintegrated firms to respond optimally to the integration decisions of other firms, either by remaining nonintegrated, exiting the industry, or themselves integrating. We use the analysis to shed some light on prominent vertical mergers involving the cement industry, computer reservation systems for airlines, and the St. Louis Terminal Railroad.

The paper follows the recent literature on ownership and residual control rights in the way vertical integration is formalized. We assume that the upstream and downstream firms do not know ex ante which type of intermediate good will be the appropriate one to trade and that the large number of potential types makes it too costly to write contingent forward contracts. As a result, the only way to influence ex post behavior is through the allocation of residual rights of control over assets.[3] Moreover, we take the point of view that the shift in residual control rights that occurs under integration permits profit sharing between upstream and downstream units. As a consequence, all conflicts of interest about prices and trading policies are removed. In this respect, vertical integration does not differ formally from a profit-sharing scheme between independent contractors. Profit sharing may be difficult to implement in the absence of integration, however, because independent units can divert money and misrepresent profits. In contrast, the owner of a subordinate unit, because he or she has residual rights of control over the unit's assets, may be able to prevent diversion and enforce profit sharing.[4]

2. This means that the elimination of the double marginalization of prices is not a motive for integration in our model. For a discussion of this issue, see Tirole (1988).

3. Grossman and Hart (1986). For discussions of how this approach compares with others on integration, see Hart (1989) and Holmström and Tirole (1989).

4. On this, see Williamson (1985) and, for formal models, Hart (1988), Hölmstrom and Tirole (1989), and Riordan (1989). As an extreme example, consider an independent unit, A, that has signed a profit-sharing agreement with firm B. One way A can misrepresent and divert its profits is by purchasing an input at an inflated price from another company in which A's owners have an interest. It may be hard for B to write an enforceable contract ex ante to prevent such a diversion, even though B may be well aware of the practice ex

Although integration removes conflicts of interest about pricing and trading policies, it is accompanied by costs. First, after integration, a subordinate manager may have lower incentives to come up with good ideas to reduce production costs or to raise quality because this investment is expropriated by the owner of the firm.[5] Second, there may be a loss in information about the subordinate's performance, and therefore less incentive to make improvements, because vertical integration reduces or eliminates the fluidity of the market for the stock of the newly subordinate unit.[6] Third, there may be legal costs associated with the merger. We do not explicitly formalize these costs of integration, although it is easy to do so. Instead, it will be enough to represent them by a fixed amount E.

Description of the Model

The basic model consists of two potential suppliers or upstream firms, U_1 and U_2, and two potential buyers or downstream firms, D_1 and D_2.[7] The downstream firms compete on the product market and sell perfect

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post (the information that the input is overpriced is observable but not verifiable). On the other hand, if A and B are integrated, B can refuse ex post A's manager's request to spend company resources on the expensive input, thus effectively blocking the transaction. This is because B now possesses residual rights of control over company A's resources by virtue of integration.

Of course, diversion problems are not completely eliminated by integration. In particular, if B owns A, B can use its residual control rights to divert money from A. However, as long as B diverts on a proportionate basis from both units A and B—and as long as this diversion is less than 100 percent—A's subordinate manager can be given a compensation package that is some fraction of A's and B's joint profit. Given this, A's subordinate manager will have an incentive to choose pricing and trading policies that are in the interest of the company as a whole.

Another argument can be given as to why a merger reduces conflicts of interest over prices and trading policies. Under integration, a subordinate manager will act in the interest of the parent company, since otherwise he or she will be dismissed. But the pressure on the manager of an independent unit to act in the interest of another independent contractor is less because the only sanction available to the independent contractor is to sever the whole relationship with the unit (the contractor cannot fire the unit's manager alone). On this, see Hart and Moore (1988).

5. See Grossman and Hart (1986) or Hart and Moore (1988). We assume that effort costs cannot be reimbursed as part of a profit-sharing scheme.

6. See Holmström and Tirole (1990).

7. The model could easily be generalized to the case of more than two upstream or downstream firms, however.

substitutes. The upstream firms produce the same intermediate good at constant, although perhaps different, marginal costs, c_1 and c_2, subject possibly to a capacity constraint.

Three variants of the basic model are developed, each of which illustrates a different motive for integration. Variant 1, called *ex post monopolization*, focuses on the incentive for a relatively efficient upstream firm to merge with a downstream firm to restrict output in the downstream market. To understand the idea, consider the special case in which one of the upstream firms, U_2 say, has infinite marginal cost. It is sometimes claimed that in this case U_1 would never have an incentive to merge with a downstream firm, D_1 say, because U_1 is already a monopolist in the upstream market.[8] This claim is false unless enforceable exclusive-dealing contracts are feasible, or unless the offers of U_1 to D_1 and D_2 are public. In particular, in the absence of exclusive-dealing contracts, U_1 has an incentive to supply both D_1 and D_2 and, in so doing, to produce more than the monopoly output level. For example, suppose U_1 tries to monopolize the downstream market by selling the monopoly output (q^m) to D_1 for a lump-sum fee equal to monopoly profit. It is not an equilibrium for D_1 to accept such an offer because the firm knows that U_1 has an incentive to sell an additional amount to D_2, thus causing D_1 to make a loss. On the other hand, suppose U_1 tries to monopolize the downstream market by offering $\frac{1}{2} q^m$ to each of D_1 and D_2 at a fee equal to half the monopoly profit. It is not an equilibrium for U_1 to make and D_1 and D_2 to accept these offers either, because if D_1, say, is expected to accept, U_1 has an incentive to increase its supply to D_2 above $\frac{1}{2} q^m$, and D_1 again makes a loss.

Integration can be a way around the inability of U_1 to restrict output. If U_1 and D_1 merge, U_1 has no incentive to supply D_2. The reason is that under integration the profits of U_1 and D_1 are shared, and every unit sold to D_2 reduces the combined profit of U_1-D_1 by depressing price. Thus the unique equilibrium now is for U_1 to supply q^m to D_1 and nothing to D_2.

Why could U_1 not achieve the same outcome by writing an exclusive-dealing contract with D_1? There are several answers to this. First,

8. For example, as Posner and Easterbrook (1981, p. 870) have written, "there is only one monopoly profit to be made in a chain of production."

exclusive dealing may be unenforceable for informational reasons. In particular, it may be difficult for D_1 to monitor or control shipments by U_1 to other parties without having residual rights of control over the assets of U_1, including buildings, trucks, and inventories. And even if shipments can be monitored, if there are third parties outside the industry with whom U_1 can realize gains from trade and who could bootleg its product to D_2, a strict enforcement of exclusive dealing requires not trading with these third parties, which may prove costly. Second, exclusive dealing may be unenforceable for legal reasons: the courts have taken a harsh stance on those exclusive-dealing contracts they think may result in foreclosure.

In addition, exclusive dealing, even if it is feasible, is not generally a perfect substitute for integration.[9] In particular, if supply costs of U_2 are finite rather than infinite, then it is no longer optimal for an integrated U_1-D_1 pair not to supply D_2 at all. Instead U_1-D_1 will want to offer D_2 the same amount that U_2 would offer D_2, but at a slightly lower price. An exclusive-dealing contract will not achieve this. Moreover, a contract that limits the amount that U_1 can sell D_2 may be very difficult to enforce: given that U_1 is supplying D_2 anyway, it may be hard for D_1 to verify that supplies equal 100, say, rather than 200.[10] Integration avoids this problem: profit sharing between U_1 and D_1 means that U_1 automatically finds it in its interest to supply the profit-maximizing level and quality of service to D_2.

In extensions of this first variant, we consider the possibility that it may not be known in advance whether U_1 or U_2 is the more efficient supplier and that the upstream and downstream firms must make ex ante industry-specific investments before trading ex post. We show that the more efficient (in a stochastic sense) upstream firm will have a greater incentive to merge to monopolize the market ex post. Also, if U_1 and D_1 merge, the profits of D_2 will typically fall, because if U_1 turns out to be the more efficient firm ex post, it will channel supplies toward D_1 at the expense of D_2. This fall in the profits of D_2 may cause it to stop investing or to exit the industry. To the extent that exit by D_2 reduces the profits of U_2 by lowering the total demand for its product,

9. An analysis of exclusive-dealing contracts is contained in appendix C.

10. The enforcement problem becomes even greater if U_1 wants to commit itself not to supply D_2 with *quality* of service above that provided by U_2.

U_2 may have an incentive to rescue D_2 by merging with it and paying part of its investment cost (via profit sharing). In other words, bandwagoning may occur.

This first variant assumes that upstream firms engage in Bertrand competition in the price and quantity offers they make to downstream firms. The second variant, called *scarce needs*, supposes instead that upstream and downstream firms bargain over the gains from trade in such a way that each upstream firm obtains on average a positive share of these gains. In addition we now assume for simplicity that $c_1 = c_2$: the upstream firms are equally efficient.

Under these conditions, there is a new motive for integration. An upstream firm may merge with a downstream firm to ensure that the downstream firm purchases its supplies from this upstream firm rather than from others. In particular, if U_1 and D_1 merge, then, rather than sometimes buying input from U_1 and sometimes from U_2 as under nonintegration, D_1 will now buy all its input all the time from U_1. Thus U_1 gains a valuable trading opportunity and U_2 loses one. (Scarce needs refers to the fact that D_1 and D_2 have limited input requirements.)

If U_2 remains in the industry (continues to invest), the only effect of the merger is to increase the U_1-D_1 share of industry profit and reduce the U_2-D_2 share. In particular, there is *no* ex post monopolization effect in this second variant: given that U_2 is as efficient as U_1, there is no reason for U_1 to restrict its supplies to D_2, because U_2 will make up the difference anyway. However, if the reduction in the profits of U_2 causes it to quit the industry, U_1 is left as the only supplier (we refer to this as ex ante monopolization) and, given that it is merged with D_1, it will be able to use this power to completely monopolize the market ex post (as part of a merged firm, it has no incentive to supply D_2). Thus total quantity supplied will fall and the price consumers pay will rise.

Bandwagoning does not occur in equilibrium in this second variant. However, U_2-D_2 may try to preempt U_1-D_1 by merging first. In real time, the upstream firm with lower investment costs will win this preemption game by merging early.

The third variant, *scarce supplies*, reverses the role of upstream and downstream firms. Suppose that the upstream firms are capacity-constrained relative to downstream firms' needs, with upstream and downstream firms again bargaining over the terms of trade. Under these conditions, a third incentive to integrate arises: a downstream firm and an upstream firm may merge to ensure that the upstream firm channels its scarce supplies to its downstream partner rather than to other downstream firms.

If U_1 and D_1 merge, D_2 suffers because under nonintegration D_2 obtains some profit from being able to purchase supplies from U_1, whereas under integration U_1 channels all its supplies to D_1. The decline in its profits may cause D_2 to quit the industry. In this case U_2's profits will also fall because it faces only one purchaser for its output: D_1. Hence U_2 may cease to invest. If this happens, capacity will be eliminated from the market, consumer price will rise, and the effect of the U_1-D_1 merger will have been to monopolize the market ex ante.

To avoid exit by D_2, firm U_2 may merge with it. Thus, as in the first variant, bandwagoning is a possible outcome. Also U_2 and D_2 may try to preempt a U_1-D_1 merger by merging first. The preemption game will lead to premature merger by U_1-D_1 or U_2-D_2.

Table 1 summarizes the three variants.

Welfare Analysis of Vertical Mergers

Our theory has a number of implications for the welfare analysis of vertical mergers. The model shows three sources of social loss from mergers and two sources of social gain. First, in variant 1 a merger of U_1 and D_1 raises consumer prices to the extent that it allows U_1-D_1 to monopolize the market ex post. This reduces the sum of consumer and producer surplus for the usual reasons. Second, in all three variants of the model, a merger of U_1 and D_1 may cause exit by U_2 or D_2 or both. This ex ante monopolization effect again gives U_1-D_1 greater market power ex post, causing consumer prices to rise and consumer plus producer surplus to fall. Third, mergers involve incentive and legal costs, which we have represented by a fixed amount E.

Offsetting these losses are two potential gains from mergers. First, a merger of U_1 and D_1 that causes exit by U_2 or D_2 or both leads to a saving in investment costs. To the extent that these costs were incurred by U_2 and D_2 to increase their aggregate profit at the expense of U_1-D_1, with no price effects, this represents a social gain. In other words, a merger-induced exit can be beneficial to the extent that it leads to a reduction in rent-seeking behavior.

Table 1. Summary of Three Variants

Item	*Variant 1: ex post monopolization*	*Variant 2: scarce needs*	*Variant 3: scarce supplies*
Output contraction	Yes	No	No
Bargaining effect	No	Yes	Yes
Possible circumstances	No capacity constraints upstream and downstream	Downturn in D industry, or excess capacity in U industry	Downturn in U industry, or excess capacity in D industry
Direct victim of vertical integration	Nonintegrated D	Nonintegrated U	Nonintegrated D
Indirect victim (if direct victim exits)	Nonintegrated U (under certain conditions)	Nonintegrated D	Nonintegrated U
Trade between integrated unit and nonintegrated direct victim	Yes (but price squeeze)	No[a]	No[b]
Incentive to integrate larger for	More efficient U firm	More efficient D firm	Larger U firm
Possible industry structures	Nonintegration; partial integration; bandwagon; integration and exit (downstream or downstream and upstream)	Nonintegration; integration and exit (upstream or upstream and downstream)[c]	Nonintegration; partial integration; bandwagon; integration and exit (downstream or downstream and upstream)

a. As long as integrated U does not operate at full capacity. Otherwise the integrated D may still buy some supplies from nonintegrated U.
b. As long as integrated D does not operate at full capacity. Otherwise, the integrated U may sell some of its supplies to a nonintegrated D.
c. If the downstream firms have the same demands. If they have different demands, say, because they have different storage or marketing facilities, then the same industry structures as in the scarce supplies case may emerge.

Second, there may be pure efficiency gains from mergers. In all three variants of the model, upstream and downstream firms make ex ante investments. Although these investments are taken to be industry-specific, given that the industry is imperfectly competitive, they have many of the characteristics of the relationship-specific investments emphasized by Williamson and Klein, Crawford, and Alchian.[11] In par-

11. Williamson (1975, 1985); and Klein, Crawford, and Alchian (1978). See also Grossman and Hart (1986).

ticular, an upstream firm, say, might be unwilling to invest, given that the absence of a perfectly competitive market for its product can cause it to be held up. Thus one motive for a merger between an upstream and downstream firm may be to encourage investments by reducing holdup problems. A merger carried out for these reasons will increase competition and reduce consumer prices. For simplicity, the formal model supposes that firms are prepared to invest under nonintegration and so holdup problems are not a motive for merger; it would be easy to relax this assumption, however.

Given these conflicting effects, it is hard to deliver clear-cut prescriptions for antitrust policy on vertical mergers. Any industry in which investments are industry-specific rather than relationship-specific (the particular cases we consider later all fit into this category) is either competitive, in which case neither holdup nor foreclosure effects should be important and vertical mergers should be irrelevant, or imperfectly competitive, in which case both holdup and foreclosure effects are potentially important and it is hard to distinguish between them. The theory can, however, give some guidance as to when the foreclosure effects are likely to be significant, so that the onus might be on the merging firms to show that there are substantial efficiency gains offsetting the anticompetitive effects. According to our variants, restriction of competition is most likely to be a factor when the merging firms are efficient (have low marginal costs or investment costs) or are large (have high capacities) relative to nonmerging firms. Because there is no strong reason to think that holdup problems will be more serious for efficient or large firms, the theory sugests that vertical mergers involving efficient or large firms should be subject to particular scrutiny by the antitrust authorities. The model also suggests that the antitrust authorities should only be suspicious of vertical mergers that significantly harm rivals. Thus a merger between an upstream and a downstream firm that have had substantial dealings with outside firms is potentially more damaging than one between those that have primarily traded with each other and where the foreclosure effect on rivals will be small.

The paper is organized as follows. The next section describes the model. The first variant is explored in the sections titled "Ex Post Monopolization: The Case of Perfect Certainty and No Investment" and "Ex Post Monopolization: Uncertainty and Positive Investments." The second variant is discussed in the section "Bargaining Effects: Scarce Needs" and the third variant in "Bargaining Effects: Scarce

Supplies.'' (The section called ''Ex Post Monopolization: Uncertainty and Positive Investments'' is considerably more involved than the others, and the reader may wish to skip it on first reading.) These sections are followed by ''Extensions''; ''Applications,'' which applies the analysis to various industries; and ''Review of the Literature,'' which puts this paper in the context of previous research. Finally, the appendixes contain technical material and an analysis of exclusive-dealing contracts.

The Model

There are two potential suppliers or upstream firms, U_1 and U_2, and two potential buyers or downstream firms, D_1 and D_2. The downstream firms compete on the product market and sell perfect substitutes. The demand function for the final good is $Q = D(p)$ with concave inverse demand $p = P(Q)$. The upstream firms produce the same intermediate good at constant marginal cost, c_i ($i = 1, 2$). The intermediate good is transformed into the final good by the downstream firms on a one-for-one basis at zero marginal cost (the downstream firms are thus symmetric).

It is assumed that the upstream marginal costs, c_i, are sufficiently high relative to the downstream marginal cost (zero) that if the downstream firms, D_1 and D_2, have purchased quantities Q_1 and Q_2 in the ''viable range,'' the Nash equilibrium in prices in the downstream market has both firms charge the market-clearing price $P(Q)$, where $Q = Q_1 + Q_2$.[12] For this reason the Cournot revenue functions, profit functions, and reaction curves are relevant. Define

$$r(q, \hat{q}) \equiv P(q + \hat{q})q,$$

$$\pi^i(q, \hat{q}) \equiv [P(q + \hat{q}) - c_i]q,$$

and

$$R_i(\hat{q}) \equiv \arg\max_q \pi^i(q, \hat{q}).$$

12. See Tirole (1988, chap. 5) for more detail.

Assume that π^i is strictly concave in q and twice differentiable. $R_i(\hat{q})$ is then unique and differentiable. As is well known, the slope of a reaction curve is between -1 and 0: $-1 < dR_i/d\hat{q} < 0$.

We assume that for any costs (c_1, c_2), the reaction curves R_1 and R_2 have a unique intersection $[q_1^*(c_1, c_2), q_2^*(c_1, c_2)]$; that is, the Cournot equilibrium is unique. We also introduce the monopoly output $q^m(c)$ and monopoly profit

$$\pi^m(c) \equiv \max_Q \{[P(Q) - c]Q\} = \{P[q^m(c)] - c\}q^m(c)$$

at cost c. Last, for technical convenience, assume that firm i's marginal revenue is convex in firm j's output (as is the case, for instance, for linear demand curves). This assumption is needed only in the first variant and is a sufficient condition for contracts that induce random behavior by downstream firms not to be optimal for upstream firms.

The industry evolves in two stages: ex ante and ex post. The ex ante stage includes the decisions before uncertainty is resolved: vertical integration and industry-specific investments. The uncertainty is two-dimensional. First, the firms do not know ex ante which intermediate good will be the appropriate one to trade ex post. We adopt the Grossman and Hart (1986) methodology of presuming that the large number of potential technologies or products ex ante makes it too costly to write complete contracts and that the only way to influence ex post behavior is through the allocation of residual rights of control over assets. Second, the firms may not know which marginal cost structure (c_1, c_2) for the relevant product will prevail. Rather they have prior cumulative distribution functions $F_1(c_1)$ and $F_2(c_2)$ on $[\underline{c}, \bar{c}]$; for simplicity c_1 and c_2 are drawn from independent distributions.

The timing is as follows:

Ex Ante Stage

Step 1 (vertical integration). First, firms decide whether to integrate vertically. Antitrust statutes prevent any merger with a horizontal element. They thus allow only mergers between a U and a D, because a firm cannot include the two upstream units or the two downstream units. Assuming that the four parties are still active after the investment or exit stage (see step 2), four industry structures may emerge:

—*NI* (nonintegration). All four parties are separately run.

—PI_1 (U_1-D_1 integrated). Firms U_1 and D_1 have merged, firms U_2 and D_2 remain independent (without loss of generality one can assume that U_i merges with D_i, since the two downstream firms are symmetric).

—PI_2 (U_2-D_2 integrated). Only firms U_2 and D_2 have merged.

—FI (full integration). U_1 and D_1 have merged and so have U_2 and D_2. The industry has experienced bandwagon.

We also want to study the possibility of ex ante monopolization, in which vertical integration by a U and a D triggers exit by the other D, the other U, or both. We will denote these industry structures by M_d^i, M_u^i, and M_{ud}^i respectively; for instance, M_d^i means that the integration of U_i and D_i has triggered exit of D_j and thus the ex ante monopolization of the downstream market (but not of the upstream market).

Step 2 (investment or exit). After choosing whether to integrate, the U and D units commit industry-specific investments: 0 or I for upstream units, 0 or J for downstream units. Investing 0 implies that the unit is not able to trade in the ex post stage and thus exits. A unit that invests is able to trade ex post. Investments are noncontractible and are thus private costs to the parties that commit them, in the tradition of the bilateral monopoly paradigms of Williamson (1975, 1985) and Grossman and Hart (1986), with the particularity that investments are industry-specific rather than firm-specific. Under integration, however, an implication of the profit-sharing assumption 1 below is that these investment costs can be internalized between the merging parties. At the end of this step, the industry structure is one of NI, PI_1, PI_2, or FI if all units have invested, or M_u^i, M_d^i, or M_{ud}^i if integration between U_i and D_i has triggered exit of U_j, D_j or both. The other configurations will be irrelevant under our assumptions.

Ex Post Stage

Step 3 (resolution of uncertainty). At the beginning of the ex post stage, all parties learn the relevant product to trade. They also learn the upstream marginal costs (c_1, c_2) to produce this product. There is no asymmetry of information (all parties know the marginal costs as well as the demand curve).

Steps 4 and 5 (contract offers and acceptances). The upstream and downstream firms contract about how much of the intermediate good to trade. Variants discussed later differ in the nature of competition between U_1 and U_2. The first variant presumes Bertrand competition, while the other two allow a more even distribution of bargaining power between the upstream and downstream firms.

Step 6 (production and payments). Outputs of intermediate good specified by contracts and internal orders are produced and delivered. Payments are made by the downstream firms to the upstream firms.

Step 7 (final product market competition). D_1 and D_2 transform the intermediate good into final product (at zero marginal cost) and sell their outputs Q_1 and Q_2 at price $P(Q_1 + Q_2)$. As noted above, it is optimal for them to do so, assuming that they learn each other's output before choosing their prices and that c_1 and c_2 are sufficiently large.

Returning to the ex ante stage, we make the following assumptions about the consequences of vertical integration, a justification for which was given in the introduction.

ASSUMPTION 1: *Integration between a U and a D results in their sharing profits ex post. This is the benefit of integration. This leads to the removal of all conflicts of interest about prices and trading policies, although conflicts over effort may remain.*[13]

13. A subtlety implicit in assumption 1 should be noted. What is actually being assumed is that under integration, profits of the parent and subsidiary are commingled in such a way that profit sharing is inevitable. In other words, the previous arrangement, whereby the manager of the subsidiary is paid according to the subsidiary's profit, is no longer feasible. Assumption 1 is, of course, extreme, but it does seem reasonable to suppose that it is harder to identify the performances of the parent and subsidiary under integration than under nonintegration. Most of our results seem likely to generalize to the case where conflicts of interest over prices and trading policies are reduced even if not eliminated under integration.

An implication of assumption 1 is that it does not matter which is the parent company and which is the subordinate company in a merger, that is, it does not matter whether the upstream firm buys the downstream firm or vice versa. This simple view of mergers suffices for the analysis presented here, but the identity of the owning party does matter under more general conditions. See Grossman and Hart (1986) or Hart and Moore (1988) for a discussion.

ASSUMPTION 2: *Integration between a U and a D involves a loss in efficiency equal to a fixed number, $E \geq 0$. This is the cost of integration.*[14]

We also make the following assumptions on the merger game.

ASSUMPTION 3: *U_i can merge with D_i only.*

This assumption is made for convenience. For example, allowing an upstream firm, say, to bargain with several downstream firms raises some thorny issues related to antitrust. What would happen under the antitrust statutes if both downstream firms agreed to merge with the same upstream firm? If we assume that an upstream firm can negotiate with a single downstream firm, assumption 3 involves no loss of generality because the downstream firms are symmetric.[15] We will further assume that U_i and D_i make the optimal merger decision for them. The distribution of the gains from merging between them depends on their relative bargaining power and will not be investigated here because it does not affect industry structure and performance.[16]

ASSUMPTION 4: *Integration is irreversible.*

Divestiture is ruled out by assumption 4. In practice, divestiture is costly because some of the integration costs are sunk and because new

14. As noted in the introduction, one component of the cost of integration is the loss caused by a subordinate manager's dulled incentives. One case consistent with our hypothesis that E is a fixed number independent of the rest of the model is that in which the subordinate's dulled incentives concern activities having to do with the reduction of fixed (as opposed to marginal) production costs and the supply of goods to third parties (firms outside the industry).

15. Assumption 3 does have one important implication, however; it rules out the possibility of extortion by the upstream firms. For instance, it might be the case that the sum of the profits of U_1 and D_1 falls if they integrate, and yet D_1 accepts a low offer from U_1 to merge because of U_1's threat to merge with D_2 and foreclose D_1 at the ex post stage.

16. As we shall see, a merger between U_i and D_i will often hurt U_j or D_j or both. One possibility we do not allow is that U_j or D_j bribes U_i or D_i not to merge. There are two justifications for this. First, such a bribe might be viewed with suspicion by the antitrust authorities. Second, there may be roundabout ways in which U_i and D_i can merge (for example, by forming a holding company that owns both U_i and D_i) so as to evade a contract committing them not to combine. Note that this position is not inconsistent with the view that the antitrust authorities can prohibit mergers. There might be enough evidence that the formation of a holding company amounted to a merger for a court to rule against such a holding company in an antitrust case, but not enough evidence for a court to make the same ruling in a breach of contract case.

costs are incurred. However, assumption 4 would be unduly restrictive in industries in which demand and cost conditions change dramatically over time. Studying the cyclical integration and disintegration decisions of firms is an important item on the research agenda, and one to which our model is amenable, but it is outside the scope of this paper.

ASSUMPTION 5: *If U_i and D_i integrate, U_j and D_j can follow suit before step 2 (immediate response).*

This assumption deserves some clarification. It states that firms can react quickly to their rivals' integration decision. Formally, it corresponds to the following "reduced-form merger game" within step 1. First, the U firms simultaneously decide whether to integrate. Second, if U_i has integrated and U_j has not, U_j gets a chance to respond (but the firms cannot integrate in this "second period of step 1" if none has integrated in the "first period").

The reduced-form merger game is not rich enough to depict some interesting situations. Suppose for instance that if one of the U merges, the unintegrated D exits; it may be the case that the reduced-form merger game has two equilibria: "U_1 integrates, U_2 does not" and "U_2 integrates, U_1 does not." To select between the two equilibria and to give a more realistic picture of merger dynamics, we also develop a continuous-time version of the merger game. Suppose that time is continuous and that at each instant there is a new trading dimension ("product" in our model) on which to contract. Contracting must be done just before trading. Similarly, investment must be committed continuously for the firms to keep abreast of industry developments (that is, to avoid exit: we suppose that once a unit has stopped investing it cannot come back). The profits mentioned in the paper are then flow profits; E is the present discounted value of the integration cost—it can be thought of as being equal to $E_0 + (E_1/r)$, where E_0 is the upfront integration cost, such as legal fees, E_1 is the flow loss of incentives, and r is the rate of interest. In this continuous-time framework, the strategic variable is the date of integration. The loss for U_i to integrating just after U_j, compared with integrating simultaneously, is negligible because the loss in flow profit is infinitesimal relative to present values of profits. We adopt the convention that the market "opens" at date 0. That is, the flow investment is incurred and the flow profits are received at each instant from date 0 on. However, we let firms incur the integration cost before date 0 if they so wish in order to allow preemption.

Besides giving an interpretation of the immediate-response postulate of assumption 5, this continuous-time model selects among multiple equilibria and yields the date at which integration occurs. In those cases in which the reduced-form game has a unique equilibrium, the continuous-time model predicts the same integration pattern, which then occurs at date 0.

Ex Post Monopolization: The Case of Perfect Certainty and No Investment

We now develop the first variant of our model in which the upstream firms compete à la Bertrand in step 4. We consider first the case in which the firms' marginal costs are certain and investment costs are zero. Later we extend the analysis to uncertain marginal costs and positive investments.

Step 4: Contract Offers under Bertrand Competition

Both upstream firms make simultaneous and secret contract offers to each unintegrated D.[17] In a vertically integrated firm, given the profit-sharing assumption, this offer is a willingness to supply any level of output at an internal marginal transfer price equal to the marginal cost, c_i, of the upstream unit.

We will not put any restriction on the contracts that can be signed between a U and a D, given the information structure.[18] A simple

17. The secrecy assumption reflects the possibility of hidden or side contracting. It allows us to abstract from the possibility of contracts committing the downstream firms to adopt certain behaviors in the final product market; see Fershtman and Judd (1986) and Katz (1987). In addition it rules out the possibility that an upstream firm can commit itself to limit its sales to some downstream firm by making an appropriate public offer to that firm.

18. Unlike most papers in this literature, our paper does not confer an exogenous advantage to the integrated firms by having the internal transfer price be equal to marginal cost while external transfer prices differ from marginal cost because two-part tariffs are ruled out. We will allow general contracts, including two-part tariffs, for external transactions.

contract between U_i and D_j specifies a transfer, t_{ij}, from D_j to U_i that depends on the quantity purchased by D_j from U_i, which is $t_{ij}\ (q_{ij})$. (For instance, a two-part tariff is an affine function of q_{ij}.) We will actually allow a finer information structure and accordingly a larger class of feasible contracts. We suppose that D_j can show to U_i any amount of the good, or exhibit receipts for the sales on the final good market, as long as it does not exceed the total amount of the good bought by D_j from U_i and U_j. Thus if $Q_j = q_{1j} + q_{2j}$ is the quantity purchased by D_j, the firm can demonstrate any $\hat{Q}_{ij} \leq Q_j$ to U_i. Accordingly we allow conditional contracts, $t_{ij}(q_{ij}, \hat{Q}_{ij})$.[19]

Step 5: Acceptance and Rejection of Contracts under Bertrand Competition

The unintegrated downstream firms simultaneously accept or reject the contracts offered in step 4. If D_j accepts U_i's offer, it selects an input level, q_{ij} and, in the case of a conditional contract, announces a quantity $\hat{Q}_{ij}$ to be exhibited later to U_i, such that $\hat{Q}_{ij} \leq Q_j \equiv q_{1j} + q_{2j}$.

Assume, without loss of generality, that $c_1 \leq c_2$. We describe an equilibrium in the four industry structures that are possible, given that no firm exits, and relegate the study of uniqueness to appendix B.

—*Nonintegration NI*. The outcome under nonintegration is given in proposition 1.

PROPOSITION 1: *Assume $c_1 \leq c_2$. Under nonintegration, D_1 and D_2 each buy $q^* = q^*(c_1)$ from U_1 and 0 from U_2, where q^* is the Cournot level corresponding to marginal cost c_1: $q^* = R_1(q^*)$. They each pay a transfer t^* to U_1 and 0 to U_2, where*

$$r(q^*, q^*) - t^* = r\,[R_2(q^*), q^*] - c_2R_2(q^*). \tag{1}$$

19. The reason for introducing conditional contracts is technical. Conditional contracts turn out to be irrelevant in six of the seven possible industry structures, and the reader might as well think in terms of simple contracts. In the seventh industry structure, partial integration in which the higher-cost upstream firm is integrated, no equilibrium exists that involves simple contracts only, unless $c_1 = c_2$ or $|\ c_2 - c_1\ |$ is large. There exists an equilibrium in conditional contract offers in which the downstream firms end up choosing simple contracts, so that conditional clauses, although offered, are not selected on the equilibrium path. Furthermore, this equilibrium yields the reasonable outcome of a richer contract-offer game in which only simple contracts are enforceable: see note 20.

Total output is $2q^*$ and profits are

$$U_1: \; U^{NI}(c_1, c_2) = 2[r(q^*, q^*) - c_1 q^*] - 2\{r[R_2(q^*), q^*] - c_2 R_2(q^*)\}$$

$$U_2: \; U^{NI}(c_2, c_1) = 0$$

$$D_j: \; D^{NI}(c_1, c_2) = r[R_2(q^*), q^*] - c_2 R_2(q^*) \quad \text{for } j = 1, 2.$$

The intuition behind proposition 1 is as follows. In equilibrium each D anticipates that its rival buys the Cournot output from the low-cost firm. Given this, it can do no better than buying q^* from the low-cost firm too. The transfer price given by equation 1 is such that each D is indifferent between accepting U_1's offer to sell q^* at t^* and buying the best reaction to q^* at a cost of c_2 per unit (from U_2). U_1's profit is equal to industry profit minus the downstream firms' profit. Note that, from Bertrand competition, $U^{NI}(c, c) = 0$ for all c.

The proof of proposition 1, as well as of other propositions in this section, is to be found in appendix A.

—*Partial integration PI_1*. Suppose now that U_1 and D_1 are integrated and U_2 and D_2 have remained independent. We index profits by PI. In particular, $D^{PI}(c, c')$ denotes the nonintegrated downstream firm's profit when the integrated supplier has cost c and the nonintegrated one has cost c'.

PROPOSITION 2: *Assume $c_1 \le c_2$. Let $(q_1^*, q_2^*) = [q_1^*(c_1, c_2), q_2^*(c_1, c_2)]$ be given by $q_1^* = R_1(q_2^*)$ and $q_2^* = R_2(q_1^*)$. Thus $q_1^* \ge q^*(c_1) \ge q_2^*$ and $q_1^* + q_2^* \le 2q^*(c_1)$. Under PI_1, U_1 produces q_1^* for the internal buyer D_1 and sells q_2^* at price t_2^* to D_2 where*

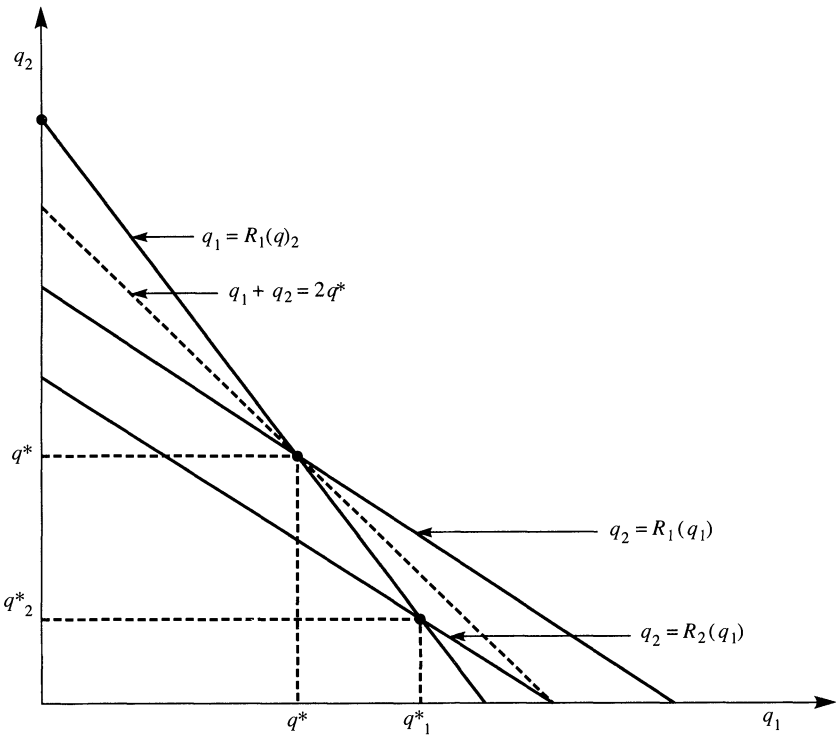
$$t_2^* = c_2 q_2^*. \tag{2}$$

U_2 does not sell. Total industry output is $(q_1^* + q_2^*)$, and profits are

$$U_1\text{-}D_1: \; V^{PI}(c_1, c_2) - E, \text{ where}$$

$$V^{PI}(c_1, c_2) = r(q_1^*, q_2^*) - c_1 q_1^* + (c_2 - c_1) q_2^* \ge U^{NI}(c_1, c_2) + D^{NI}(c_1, c_2)$$

Figure 1. The Foreclosure Effect of Vertical Integration



$$U_2\colon\ U^{PI}(c_2, c_1) = 0 = U^{NI}(c_2, c_1)$$

$$D_2\colon\ D^{PI}(c_1, c_2) = r(q_2^*, q_1^*) - c_2 q_2^* \leq D^{NI}(c_1, c_2).$$

All inequalities in this proposition are strict if and only if $c_1 < c_2$.

In words, the equilibrium is the Cournot equilibrium between two firms with marginal costs c_1 and c_2, except that production efficiency holds. The low-cost integrated upstream firm supplies q_2^* to the external buyer at profit $(c_2 - c_1)q_2^*$. The comparison with the nonintegrated case is depicted in Figure 1.

The difference from nonintegration stems from the fact that, because of profit sharing, an integrated U_1-D_1 has an incentive to restrict supplies to D_2 as much as possible. However, since it cannot stop U_2 from supplying $R_2(q_1^*)$, its best strategy is to undercut U_2 slightly and supply $R_2(q_1^*)$ itself. Firm D_2 is partially foreclosed and is hurt by vertical integration, while the profit of the integrated firm rises. Ex post monopolization ($q_1^* + q_2^* < 2q^*$ if $c_1 < c_2$) results because $-1 < dR_1/dq_2 < 0$ and (q_1^*, q_2^*) and (q^*, q^*) are both on the $q_1 = R_1(q_2)$ reaction curve. Social welfare is reduced and, gross of the integration cost E, industry profit has increased.

—*Full integration FI.* Suppose now that U_1-D_1 and U_2-D_2 are integrated.

PROPOSITION 3: *Under full integration and $c_1 \leq c_2$, the allocation is the same as under PI_1, except that the integrated firm, U_2-D_2, also incurs efficiency loss E. That is, U_1 supplies q_1^* to D_1 and q_2^* to D_2, and U_2 does not supply. The profits are thus*

$$U_1\text{-}D_1\text{: } V^{FI}(c_1, c_2) - E, \textit{ where } V^{FI}(c_1, c_2) = V^{PI}(c_1, c_2)$$

$$U_2\text{-}D_2\text{: } V^{FI}(c_2, c_1) - E, \textit{ where } V^{FI}(c_2, c_1) = D^{PI}(c_1, c_2).$$

Thus vertical integration by the high-cost supplier has no other effect than the efficiency loss. The reason is that U_2 did not supply D_1 and D_2 anyway. In particular, U_2 and D_2 do not have an incentive to integrate in the deterministic case if U_1 and D_1 have integrated. In contrast, with uncertain costs, bandwagoning may occur.

—*Partial integration PI_2:* Last, suppose that only U_2 and D_2 are integrated and that $c_1 \leq c_2$.

PROPOSITION 4: *Under PI_2 and $c_1 \leq c_2$ the allocation is the same as under NI, except that U_2-D_2 incurs the efficiency loss E. U_1 supplies $q^* = q^*(c_1)$ to both D_1 and D_2, and U_2 does not supply. Industry output is $2q^*$ and profits are*

$$U_1\text{: } U^{PI}(c_1, c_2) = U^{NI}(c_1, c_2)$$

$$D_1\text{: } D^{PI}(c_2, c_1) = D^{NI}(c_1, c_2)$$

$$U_2\text{-}D_2\text{: } V^{PI}(c_2, c_1) - E, \textit{ where } V^{PI}(c_2, c_1) = D^{NI}(c_1, c_2).$$

As in proposition 3, vertical integration by the high-cost supplier has no other effect than the efficiency loss.[20]

Next consider the ex ante stage. This is trivial when c_1 and c_2 are deterministic and investment costs are zero. Firms U_2 and D_2 have no incentive to integrate, whether or not U_1 and D_1 have. Thus the possible equilibrium industry structures are nonintegration and partial integration by U_1 and D_1. The latter will occur if and only if U_1-D_1's profit is higher under partial integration than nonintegration, that is,

$$V^{PI}(c_1, c_2) - [U^{NI}(c_1, c_2) + D^{NI}(c_1, c_2)] - E > 0.$$

This completes the analysis of the case with deterministic marginal costs and zero investment costs. The next section considers uncertain marginal cost and positive investment cost. Because the section is more difficult than the others, the first-time reader may well wish to skip to the subsequent section, "Bargaining Effects."

Ex Post Monopolization: Uncertainty and Positive Investments

Costs c_1 and c_2 are now uncertain ex ante but are known ex post. In the certainty case with $c_1 \leq c_2$, firm U_2 had no incentive at all to remain

20. Some have questioned how our analysis would change if D_1 and D_2 competed à la Bertrand instead of à la Cournot in the downstream market. Note that this would involve a radical change in the timing of production and sales. Given our assumption that upstream firms must first ship the intermediate good to downstream firms, and that downstream firms then transform this good into final output, the downstream market game is played by firms with capacity constraints, and as noted previously, the outcome will inevitably be Cournot if c_1 and c_2 are high enough.

It is also worth giving the flavor of the argument as to why there may exist no pure strategy equilibrium in simple contracts under PI_2 (see note 19). Firm U_2 can try to reduce industry output by offering $q_{21} < q^*$ to D_1 at the money-losing price $t_{21} < c_2 q_{21}$, such that D_1 makes more profit accepting U_2's offer than U_1's. While such a strategy would be too costly in terms of production cost for U_2 if c_2 is much larger than c_1, it may become optimal for U_2 if c_2 is close to c_1. Such a strategy is unlikely to succeed in practice. Basically, U_2 bribes D_1 to purchase a low output. But D_1 would always go back to U_1 to buy more output and bring itself to the reaction curve R_1. If such recontracting is feasible, U_2's counterstrategy does not succeed in bringing industry output below $2q^*$. The possibility of D_1's getting more from U_1 is formalized in the equilibrium of our one-shot contracting game by U_1's sleeping clause, allowing D_1 to complement to q^* its purchases from U_2.

in the industry, and so with $I > 0$ it would have exited. This feature disappears once c_1 and c_2 are stochastic. Because $c_2 < c_1$ with some probability, U_2 has an incentive to stay to take advantage of realizations in which it is the more efficient firm, as long as I is small. We start by considering the case in which investment costs I and J are small enough that none of the four parties has an incentive to exit.

The Ex Ante Stage When Investment Costs Are Small

To analyze the case in which c_1 and c_2 are uncertain, we use the following corollary of propositions 1 through 4: U_i-D_i's gain from integration is independent of whether U_j and D_j merge. This is not to say they are indifferent as to U_j's and D_j's integration decision; rather, integration by U_j and D_j implies the same decrease in the aggregate profit of U_i and D_i whether U_i and D_i are integrated or not.

For $c_i \leq c_j$, define the ex post gain from integration for U_i and D_i as

$$\begin{aligned} g(c_i, c_j) &\equiv V^{PI}(c_i, c_j) - [U^{NI}(c_i, c_j) + D^{NI}(c_i, c_j)] \\ &= V^{FI}(c_i, c_j) - [U^{PI}(c_i, c_j) + D^{PI}(c_j, c_i)]. \end{aligned}$$

Note that $g(c, c) = 0$ for all c. For $c_i \geq c_j$ the ex post gain from integration is $g(c_i, c_j) = 0$. The ex ante or expected gain from integration for U_i-D_i is thus

$$G(F_i, F_j) = \mathscr{E}g(c_i, c_j) = \underset{\{c_i \leq c_j\}}{\mathscr{E}} g(c_i, c_j).$$

The deterministic case suggests that the efficient firm gains more from integration than the inefficient one, which does not gain anything. The same holds in the uncertainty case. The natural definition of efficiency refers to first-order stochastic dominance.

DEFINITION: *U_1 is more efficient than U_2 if $F_1(c) \geq F_2(c)$ for all c (with at least some strict inequality).*

PROPOSITION 5: *Suppose that U_1 is more efficient than U_2 and that*
either $[\underline{c}, \bar{c}]$ is sufficiently small where $[\underline{c}, \bar{c}]$ is the support of F_1 and F_2 (small uncertainty),

or $c_i = c$ with probability α_i and $= +\infty$ with probability $(1 - \alpha_i)$ where $\alpha_1 > \alpha_2$ (large uncertainty).

Then U_1 has more incentive to integrate than U_2:

$$G(F_1, F_2) > G(F_2, F_1).$$

The proof of Proposition 5 is in appendix D.

Next, consider the loss, $L(F_i, F_j)$, incurred by U_i and D_i when U_j and D_j merge. Propositions 1 through 4 imply that this loss is independent of whether U_i and D_i are integrated. Define, for $c_i > c_j$,

$$\ell(c_i, c_j) \equiv D^{NI}(c_i, c_j) - D^{PI}(c_j, c_i) \equiv V^{PI}(c_i, c_j) - V^{FI}(c_i, c_j);$$

and, for $c_i \leq c_j$, $\ell(c_i, c_j) \equiv 0$.

Last define

$$L(F_i, F_j) \equiv \mathscr{E}\ell(c_i, c_j) = \underset{\{c_i \geq c_j\}}{\mathscr{E}} \ell(c_i, c_j).$$

PROPOSITION 6: *Suppose that U_1 is more efficient than U_2 and that one of the two assumptions of proposition 5 (small uncertainty or large uncertainty) holds. Then U_1 and D_1 lose less from the integration of U_2 and D_2 than U_2 and D_2 lose when U_1 and D_1 integrate:*

$$L(F_1, F_2) \leq L(F_2, F_1).$$

Proposition 6 is proved in appendix D.

Under the assumptions of propositions 5 and 6, it is straightforward to solve the merger game. Let $G_i \equiv G(F_i, F_j)$ and $L_i \equiv L(F_i, F_j)$, where, by propositions 5 and 6, $G_1 \geq G_2$ and $L_1 \leq L_2$.

—*Case 1: $G_1 < E$,* which implies $G_2 < E$. In this case, U_1 and U_2 have a dominant strategy not to integrate. The industry structure is nonintegration.

—*Case 2: $G_1 - L_1 > E$.* In this case it is a dominant strategy for U_1 to integrate. There are two subcases: if $G_2 < E$, the outcome is PI_1; if $G_2 > E$, the outcome is FI. A further distinction can be made between *eager bandwagon*, which arises when U_2 and D_2 prefer a fully integrated industry to a nonintegrated industry ($G_2 - L_2 > E$), and *reluctant bandwagon*, which arises when U_2 and D_2 merge but would have preferred the industry to remain nonintegrated ($G_2 - L_2 < E$).

—*Case 3: $G_1 - L_1 < E < G_1$.* In this case, firm U_1 wants to integrate only if U_2 does not jump on the bandwagon. Thus if $G_2 < E$, firm U_1

integrates and the industry structure is PI_1, and if $G_2 > E$, firm U_1 refrains from integrating because this would trigger full integration. The industry structure is NI.

The stochastic-cost case is summarized in proposition 7.

PROPOSITION 7: *Suppose that U_l is more efficient than U_2 and that small uncertainty or large uncertainty holds. Then if $G_l < E$, or $G_l - L_l < E < G_l$ and $G_2 > E$, the industry structure is nonintegration. If $G_l - L_l > E$ and $G_2 < E$, or $G_l - L_l < E < G_l$ and $G_2 < E$, the industry structure is partial integration by U_l and D_l. If $G_l - L_l > E$ and $G_2 > E$, the industry structure is full integration.*

A welfare comparison of the different industry structures is simple in the case where I and J are sufficiently small that none of the four parties ever exits. The notion of welfare is the sum of consumer and producer surplus.

PROPOSITION 8: *In the absence of exit, any industry structure involving vertical integration (PI_l, PI_2, or FI) is socially dominated by the nonintegrated industry structure NI.*

PROOF: Vertical integration implies two welfare losses: the efficiency loss, which is E under PI_1 and PI_2 and $2E$ under FI, and output contraction—that is, $q_1^*(c_1, c_2) + q_2^*(c_1, c_2) < 2q^*(c_i)$ if $c_i < c_j$ and either regime PI_i or FI holds. See propositions 2 through 4. *Q.E.D.*

We turn now to the case where I and J may be large. Because the possibility of exit must now be allowed for, we start by solving the ex post stage when exit has occured.

The Ex Post Stage after Ex Ante Monopolization

Assume without loss of generality that U_1 and D_1 have integrated, and this causes D_2 or U_2 or both to exit, leading to ex ante monopolization. The three subcases are denoted by M_{ud} (both U_2 and D_2 have exited), M_d (only D_2 has exited), and M_u (only U_2 has exited).

—*Upstream and downstream monopolization (M_{ud}) or upstream monopolization (M_u).* If U_1 and D_1, which have integrated, are monopolists in their respective industry segments, and U_1 has marginal cost c_1, then U_1-D_1's profit is $V^{M_{ud}}(c_1)-E$, where $V^{M_{ud}}(c_1) = \pi^m(c_1)$. The same holds if U_2 only has exited because U_1 supplies only its internal unit D_1; hence $V^{M_u}(c_1) = V^{M_{ud}}(c_1)$.

—*Downstream monopolization* (M_d). Suppose that only D_2 has exited. If $c_1 \leq c_2$, then D_1 procures internally and U_1-D_1's profit is $V^{M_d}(c_1, c_2)-E$, where $V^{M_d}(c_1, c_2) = \pi^m(c_1)$, and U_2's profit, $U^{M_d}(c_2, c_1)$, is equal to zero.

If $c_1 > c_2$, then U_2 makes an offer to supply $q^m(c_2)$ to D_1 at price $t_{21} = P[q^m(c_2)]q^m(c_2)-\pi^m(c_1)$. Hence the profits for U_1-D_1 are $V^{M_d}(c_1, c_2)-E$, where $V^{M_d}(c_1, c_2) = \pi^m(c_1)$. For U_2 they are $U^{M_d}(c_2, c_1) = \pi^m(c_2)-\pi^m(c_1)$.

We return now to the ex ante stage. We consider first the case where J is large but I is small, so that only downstream firms exit.

I "Small," J "Large" (Possibility of Ex Ante Downstream Monopolization)

Assume that downstream firms' investment is large in the sense that $J > \mathscr{E}D^{PI}(c_1, c_2)$, where $\mathscr{E}$ is the expectation with respect to c_1 and c_2, while the upstream firms' investment remains small. Throughout we assume that none of the firms exits in step 2 under nonintegration.

ASSUMPTION 6: *Viability under nonintegration. For all i and j,* $\mathscr{E}U^{NI}(c_i, c_j) \geq I$ *and* $\mathscr{E}D^{NI}(c_i, c_j) \geq J$.

We first analyze when a U wants to rescue a failing D by merging with it; this may happen sometimes even though U and D would not want to merge if D were viable (we call this *forced bandwagon*).

—*When a U wants to rescue a failing D*. When U_i and D_i integrate, only D_j suffers *directly*. Its loss is equal to L_j. This may lead D_j to exit if its new expected profit falls below J and if U_j does not come to its rescue by merging with it. A merger gives D_j an incentive to invest because, given profit sharing, investment costs can be split between D_j and U_j. Firm U_j cannot come to D_j's rescue by subsidizing its investment cost because investment is not contractible. The only thing it can do is to merge at a reasonable price.

A crucial factor for knowing whether U_j and D_j merge when U_i and

D_i have merged is whether U_j is made better off by D_j's exit. To simplify the notation a bit, let $\mathcal{U}_j^{M_d} \equiv \mathcal{E}U^{M_d}(c_j, c_i)$ denote U_j's expected profit when D_j exits; $\mathcal{U}_j^{PI} \equiv \mathcal{E}U^{PI}(c_j, c_i)$ be U_j's expected profit under partial integration and no ex ante monopolization; $\mathcal{V}_j^{FI} = \mathcal{E}V^{FI}(c_j, c_i)$ be U_j-D_j's expected profit under full integration; and $\mathcal{D}_j^{PI} = \mathcal{E}D^{PI}(c_i, c_j)$ be D_j's expected profit under partial integration if it stays. These expected profits are computed assuming that U_i and D_i are integrated.

PROPOSITION 9: *Following a U_i-D_i merger, U_j would prefer D_j to exit ($\mathcal{U}_j^{M_d} > \mathcal{U}_j^{PI}$) in the case of large uncertainty. It would prefer D_j to stay ($\mathcal{U}_j^{M_d} < \mathcal{U}_j^{PI}$) in the case of small uncertainty.*

Proposition 9 (proved in appendix D) indicates when U_j would like to keep an industrial base downstream. When it has a large cost advantage over U_i, which may arise in the case of large uncertainty, U_j can obtain the monopoly profit if it deals with a single downstream firm; while it cannot commit not to supply both downstream firms if D_j stays around. We call this the commitment effect. If U_j has only a small cost advantage over U_i, Bertrand competition between the upstream firms implies that U_j's profit is approximately $2q^*(c_j)(c_i - c_j)$ when both downstream firms are around, where $q^*(c_j)$ is the symmetric Cournot output for cost c_j; and $q^m(c_j)(c_i - c_j)$ when only D_i is around, where $q^m(c_j)$ is the monopoly output at cost c_j. Because the Cournot industry output exceeds the monopoly output, U_j is then better off facing two downstream units. We call this the demand effect.

—*Forced bandwagon.* Next suppose that U_i and D_i have merged. We say that forced bandwagon by U_j and D_j occurs if the following three conditions hold: (a) D_j is no longer viable by itself ($J > \mathcal{D}_j^{PI}$); (b) U_j and D_j are better off integrating than letting D_j exit ($\mathcal{V}_j^{FI} - E - J > \mathcal{U}_j^{M_d}$); (c) U_j and D_j would not want to merge if D_j were viable ($\mathcal{U}_j^{PI} + \mathcal{D}_j^{PI} - J > \mathcal{V}_j^{FI} - E - J$).

PROPOSITION 10: *After U_i and D_i have merged: (i) a necessary condition for forced bandwagon is that U_j would prefer D_j not to exit ($\mathcal{U}_j^{PI} > \mathcal{U}_j^{M_d}$); and (ii) conversely, if $\mathcal{U}_j^{PI} > \mathcal{U}_j^{M_d}$, there exists (E, J) such that forced bandwagon occurs.*

PROOF: For (i), add (a), (b), and (c); for (ii), straightforward.

Q.E.D.

Propositions 9 and 10 together say that forced bandwagon cannot occur for large uncertainty, but may occur for small uncertainty because the nonintegrated upstream supplier is concerned about keeping an industrial base.

—*The merger game.* The merger game with large downstream investments involves many cases, including preemption and war-of-attrition games. See appendix E.

I "large," J "large" (Possibility of Ex Ante Upstream and Downstream Monopolization)

We do not treat the case of general (large) investments upstream and downstream, but instead content ourselves with the following observation. When U_i and D_i merge, U_j may suffer indirectly through the exit of D_j (see proposition 9), and may exit itself. Given that D_j exits, the exit of U_j can only hurt U_i-D_i because the integrated firm can always refuse to trade with U_j. It is therefore conceivable that U_i and D_i might refrain from integrating because this would trigger a chain of exits and reduce the industrial base upstream. In the variant of this section, however, this phenomenon does not arise because it is assumed that the upstream firms set prices. Hence, when U_j is more efficient than U_i, it makes an offer to U_i-D_i that makes the integrated firm indifferent between accepting the offer and using the internal technology. Thus U_i-D_i does not benefit from U_j's not exiting. But if the bargaining power were more evenly distributed, the phenomenon could occur. We will return to these ideas in the section "Bargaining Effects: Scarce Supplies."

Bargaining Effects

The previous sections focused on the idea that an upstream firm and a downstream firm might integrate to reduce their willingness to supply a rival downstream firm, thus enabling them to monopolize, at least partially, the downstream market. The next two sections analyze a different mechanism by which foreclosure can occur: via bargaining effects. We argue that an upstream firm and a downstream firm may merge to ensure that they trade with each other, that is that the upstream firm channels scarce supplies to its downstream partner rather than to a downstream competitor and that the downstream firm satisfies its scarce needs by purchasing from its upstream partner rather than an upstream competitor. This can benefit the merging firms in two ways. First, to the extent that rival firms were obtaining some profit from trading with the merging partners, the merger will increase the merging firms' share of total profit. Second, the profits of rival firms may fall below the critical level at which they are covering their costs, and they may exit the market. The merging firms may then succeed in monopolizing the market ex ante.

Two variants capture these ideas. The first focuses on a downstream firm with scarce needs that favors its upstream partner. The second focuses on an upstream firm with scarce supplies that favors its downstream partner. The effects are treated separately because they have somewhat different implications and because the analysis is less burdensome that way. Obviously, in many real situations one would expect to find both effects.

Bargaining Effects: Scarce Needs

Assume, as before, two upstream firms and two downstream firms. In this variant, the downstream firms are not directly hurt by vertical integration and it can be assumed without loss of generality that their investment is equal to zero. Denote the investment cost of upstream firm U_i by I_i ($i = 1, 2$), where, without loss of generality, $I_1 \leq I_2$. To abstract from the ex post monopolization issues discussed earlier, we suppose that U_1 and U_2 have the same constant marginal cost c. Earlier assumptions predicted that nonintegration would be the outcome. However, we now drop the assumption that the upstream firms make independent and simultaneous take-it-or-leave-it offers to the downstream firms, supposing instead that contracts are achieved by bargaining. To be more specific, each nonintegrated upstream firm negotiates with each downstream firm to be its supplier. Moreover, the bargaining of an independent U_i with D_1 is independent of the bargaining of U_i with D_2.[21] Finally, the competition of the upstream firms is not so fierce that

21. If U_i and D_i are integrated, bargaining between them over price is irrelevant, given our assumption that managers of U_i and D_i both get a fraction of total profit. In this case, U_i-D_i will still want to compete with U_j to supply D_j, assuming U_j has not exited.

their profits are completely eliminated; instead we suppose that a constant fraction, β, of the surplus from supplying a downstream firm accrues to each upstream firm, where $0 < \beta < 1/2$ (so the fraction of surplus accruing to the downstream firm is $1 - 2\beta$).[22] We will also sometimes need to consider the case in which there is only one upstream firm in the market. We assume that this upstream firm captures a fraction, β', of the surplus from supplying a downstream firm, where $\beta' > 2\beta$, so that a downstream firm does strictly worse bargaining with one upstream firm than with two.

REMARK: The *scarce needs* variant can be reinterpreted as applying to a situation in which the upstream firms supply a piece of machinery or a technology that allows the downstream firms to produce at marginal cost c. Each downstream firm has a unit demand for the machinery or the technology. In this reinterpretation the sense in which needs are scarce is particularly clear.

Nonintegration

Suppose for the moment that both upstream firms invest under nonintegration. Since U_1 and U_2 have the same marginal cost, the reaction curves R_1 and R_2, defined earlier, are the same: $R_1(q) = R_2(q) = R(q)$. The equilibrium under nonintegration is described in the next proposition.

PROPOSITION 11: *Under nonintegration, D_1 and D_2 each buy q^* from the upstream firms, where q^* is the Cournot level corresponding to marginal cost c: $q^* = R(q^*)$. The surplus to be shared among each downstream firm and U_1 and U_2, given that the rival downstream firm chooses q^*, is $P(2q^*)q^* - cq^* \equiv \pi^d$, and this is divided in the proportions $(1 - 2\beta)$, β, and β respectively. Total output is $2q^*$ and profits are*

$$U_i\colon\ U^{NI} = \beta\pi^d + \beta\pi^d = 2\beta\pi^d$$

$$D_i\colon\ D^{NI} = (1 - 2\beta)\,\pi^d.$$

22. Here, β can be understood as the expected share of the surplus that U_i obtains rather than the actual share. For example, one interpretation is that each upstream firm wins the competition to supply a particular downstream firm with probability 1/2; the winner receives a share, 2β, of profit and the loser receives nothing.

The proof of this proposition is straightforward. Let q_1 and q_2 be the amounts that D_1 and D_2 are expected to purchase in equilibrium. Then D_1 in combination with either U_1 or U_2, or both, can, taking q_2 as given, achieve a total surplus of $\max_q [P(q + q_2)q - cq]$. The solution to this maximization problem is $q_1 = R(q_2)$. By a similar argument, $q_2 = R(q_1)$. It follows that $q_1 = q_2 = q^*$. The remainder of proposition 11 follows from the assumptions about bargaining and the division of surplus.

Full Integration

Consider next full integration, maintaining for the moment the assumption that U_1 and U_2 both invest. The only change caused by full integration is that D_1 will obtain all its supplies from its partner U_1, and D_2 will obtain all its supplies from U_2. There is no reason to buy externally because internal production is as cheap. This does not change equilibrium output levels because the best reaction for U_i-D_i to an expected purchase of q_j by D_j is $R(q_j)$. Hence $q_1 = R(q_2)$ and $q_2 = R(q_1)$, that is, $q_1 = q_2 = q^*$. Firms U_1 and D_1 will together share the profit π^d, and similarly so will U_2 and D_2. From these profits must be subtracted the integration costs E. The outcome is summarized in proposition 12.

PROPOSITION 12: *Under full integration, D_i buys q^* from upstream firm U_i ($i = 1, 2$), where $q^* = R(q^*)$. Total output is $2q^*$ and profits are*

$$U_1\text{-}D_1\text{: } V^{FI} = \pi^d - E$$

$$U_2\text{-}D_2\text{: } V^{FI} = \pi^d - E.$$

Note that the profits of U_i-D_i are the same under full integration as under nonintegration, except for the integration cost.

Partial Integration

Suppose next that U_i and D_i integrate, U_j and D_j remain separate, and U_i and U_j both continue to invest. U_i will now supply all of D_i's needs, putting D_i on its reaction curve $R(q_j)$; but, as in the case of nonintegration, U_i and U_j will compete for D_j's custom. The latter conclusion follows from the fact that, because U_i and U_j have the same marginal costs, U_i cannot gain ex post from refusing to deal with D_j or restricting its supplies to D_j. U_j alone will agree to put D_j on its reaction curve $R(q_i)$, which is the same outcome that occurs if U_i and U_j are both willing to supply D_j.

This argument shows that $q_i = R(q_j)$ and $q_j = R(q_i)$, that is, $q_i = q_j = q^*$. Although partial integration does not change output levels, it does affect the division of surplus. U_j will lose the $\beta\ \pi^d$ it earned from supplying D_i under nonintegration (that is, U_i and D_i will now divide π^d between them); while the gains from trade that D_j can realize in combination with U_i or U_j or both will be shared in the proportions $1 - 2\beta$, β, and β respectively.

PROPOSITION 13: *Under partial integration, D_i buys q^* from U_i and D_j buys q^* from U_i or U_j or both, where $q^* = R(q^*)$. Total output is $2q^*$ and profits are*

$$U_i\text{-}D_i\text{: } V^{PI} = (1 + \beta)\ \pi^d - E$$

$$U_j\text{: } U^{PI} = \beta\ \pi^d$$

$$D_j\text{: } D^{PI} = (1 - 2\beta)\ \pi^d.$$

The combined profits of U_i and D_i are higher by $\beta\ \pi^d - E$ under partial integration than under nonintegration. On the other hand, the profits of U_j and D_j are lower by $\beta\ \pi^d$.

Ex Ante Monopolization

So far we have supposed that U_1 and U_2 invest under both integration and nonintegration. The final structure we consider is one in which the integration of U_1 and D_1 causes U_2 to exit (the mirror image case in which U_2, the firm with higher investment costs, merges with D_2 and U_1 exits will turn out to be irrelevant). This case leaves the single supplier, U_1, facing D_1 and D_2, one of which is its partner. We can apply proposition 1 to learn the outcome: U_1 will supply only D_1 and will monopolize the market; that is U_1-D_1 will choose the output level q^m that maximizes $P(q)q - cq$.

Denote monopoly profit, $P(q^m)q^m - cq^m$ by π^m.

PROPOSITION 14: *Under ex ante monopolization (integration by U_1 and D_1 and exit by U_2), D_1 buys q^m from U_1, where q^m maximizes $P(q)q - cq$, and D_2 buys nothing. Total output is q^m and profits are*

$$U_1\text{-}D_1\text{: } V^{M_u} = \pi^m - E$$

$$U_2\text{: zero}$$

$$D_2\text{: zero.}$$

We will assume in what follows that the profits of U_1 and D_1 are higher under ex ante upstream monopolization than under nonintegration. That is:

$$V^{M_u} = \pi^m - E > \pi^d. \tag{3}$$

If this were not the case, integration would not be profitable under any conditions in the model of this section.[23]

The Investment Decision

Let us reconsider the assumption that upstream firms invest. Under nonintegration, U_1 and U_2 cover their costs and invest as long as

$$2\beta\ \pi^d > I_2. \tag{4}$$

We assume condition 4 in what follows.

Consider full integration. Here investment is less an issue. Full integration plus exit by U_i, say, could never be a correctly anticipated equilibrium outcome because, given that D_i will not be supplied by U_j and will make zero profits, U_i and D_i could do better by staying separate and saving their merger costs E.

Consider next partial integration, in particular the case in which U_1 and D_1 merge but U_2 and D_2 stay separate (the logic in the reverse case is similar). Under these conditions U_2 may or may not invest. It is easily seen, however, that U_1 invests. In particular, suppose the contrary: U_1 does not invest, but U_2 does. (If U_2 does not invest, U_1-D_1's profits are automatically zero if U_1 does not invest; hence it is better for U_1 to invest.) Then ex post a single nonintegrated firm, U_2, will face two downstream firms, D_1 and D_2. Applying the same logic

23. In particular, $V^{M_u} \leq \pi^d \Rightarrow \beta\ \pi^d < E$, because $\pi^m > 2\pi^d$. That is, the net gain to U_i and D_i from integrating when U_j and D_j stay separate is negative.

as in proposition 1, we see that U_2 will supply q^* to both D_1 and D_2. Moreover, given the assumption about one-on-one bargaining, D_1 and D_2 will obtain a share $(1 - \beta')$ of the surplus π^d, and U_2 will obtain the remainder. Thus U_1-D_1's profits will be $(1 - \beta')\pi^d - E$. But because $I_1 \leq I_2$ and $\beta' > \beta$ and because of condition 4, $(1 - \beta')\, \pi^d < (1 + \beta)\pi^d - I_1$, which ensures that U_1-D_1 can do better by investing (see proposition 13). Thus it is never profitable for U_1 and D_1 to merge if U_1 does not invest.

The Merger Game

We treat the merger game as in the ex post monopolization variant. In particular, we suppose that the merger is irreversible and that if U_i and D_i merge, U_j and D_j can respond instantaneously by merging too. Under these assumptions full integration will never be an equilibrium outcome in the present variant. Neither U_1 and D_1 nor U_2 and D_2 will merge if the other pair follows suit because, by propositions 11 and 12, the final profit of each pair, U_i-D_i, will be less than the combined profits of U_i and D_i under nonintegration.

Partial integration without exit is also not possible. As in the ex post monopolization variant, the gain from the merger of U_j and D_j is the same whether U_i and D_i are integrated or not. This is given by $\beta\, \pi^d - E$. If this gain is positive, then U_j and D_j will follow suit if U_i and D_i merge. If it is negative, then U_j and D_j will not follow suit, and U_i and D_i will prefer nonintegration to partial integration.

Thus the only reason for U_i and D_i to merge is if the response of U_j is to exit. In other words, the final outcome of the merger game will be either nonintegration or ex ante monopolization.

Proposition 15 shows which of these outcomes will occur. In the formal statement of the proposition we suppose that U_1 and D_1 merge if any merger occurs at all. It turns out that in case 2 of the proposition, there can be another equilibrium in which U_2 and D_2 merge and U_1 exits. This equilibrium is not compelling, however, because in the continuous-time model described earlier, U_1 and D_1 would preempt U_2 and D_2 by merging before date 0.

PROPOSITION 15: *Assume conditions 3 and 4. Suppose also that U_1 and D_1 decide first whether to merge, and if, and only if, they merge, U_2 and D_2 can respond by merging too. Then:*

1. *The merger game will result in nonintegration if*
   (a) $\beta\ \pi^d > E$ *and* $\pi^d - E > I_2$; *or*
   (b) $\beta\ \pi^d < E$, *and* $\pi^d - E > I_2$; *or*
   (c) $\beta\ \pi^d < E$, $\beta\ \pi^d > I_2$.
2. *The merger game will result in a merger of* U_1 *and* D_1 *and exit of* U_2 *if*
   (a) $\beta\ \pi^d > E$, $\pi^d - E < I_2$; *or*
   (b) $\beta\ \pi^d < E$, $\pi^d - E < I_2$ *and* $\beta\ \pi^d < I_2$.

As long as "probability zero" cases of equality ($\beta\ \pi^d = E$ and so forth) are ruled out, these cases are exhaustive.

The proof of proposition 15 is straightforward. In case 1(a), $\beta\ \pi^d > E$ implies that U_2 and D_2 will find it profitable to bandwagon if U_1 and D_1 merge, unless U_2 exits. Because full integration is unprofitable for U_1 and D_1, they will merge only if U_2 exits (that is, only if $\pi^d - E < I_2$). In 1(b), U_2-D_2's profits are positive under full integration ($\pi^d - E > I_2$), and hence U_1-D_1 cannot force exit by U_2. Therefore U_1 and D_1 prefer not to integrate. In 1(c), U_1-D_1 again cannot force exit by U_2 because U_2 can cover its investment costs by staying independent. Again U_1 and D_1 choose not to integrate.

Case 2 consists of the complementary region in parameter space to case 1; that is, it consists of those subcases in which the merger of U_1 and D_1 will cause U_2 to exit. Under these conditions, integration is profitable for U_1 and D_1 (by condition 3).

In case 2 the model may be consistent with another outcome: U_2 and D_2 merge and U_1 exits. In the continuous-time version of the model described earlier, however, this would lead to a preemption game that U_1 and D_1 would win by merging at date $-T$, where T satisfies

$$- E + e^{-rT}\left[\frac{\pi^m - I_2}{r}\right] = 0.$$

Note that the discounted profit of U_1-D_1 at date 0 in this equilibrium is $(I_2 - I_1)/r$. For this reason the possibility that U_2 and D_2 merge and force exit of U_1 is ignored.

REMARK: In this scarce needs variant, partial integration (without exit) and bandwagon (full integration) are not possible outcomes. However, there is another version of the scarce needs variant in which these outcomes can occur. Suppose that there are limits on how much D_1 and

D_2 can purchase from the upstream firms, perhaps because they have limited storage. If D_1 has more storage space than D_2, U_1 may merge with D_1 to cut U_2 out of the gains from trading with D_1. Moreover, this can be profitable even if U_2 and D_2 respond by merging to cut U_1 out of the gains from trading with D_2.

Rather than analyze a model of this type, we analyze shortly a symmetric version of it in which the upstream firms have scarce capacities. See the section called "Bargaining Effects: Scarce Supplies."

Welfare

The welfare effects of merger are straightforward in this variant. Merger followed by exit leads to lower output (q^m vs. $2q^*$) and higher prices for consumers. So consumer surplus falls. Producer surplus, however, rises, and in some cases total surplus may also rise because of the saving in the exiting firm's investment cost.[24]

Bargaining Effects: Scarce Supplies

The second bargaining effect is scarce supplies, the situation in which the upstream firms are capacity-constrained and integration occurs to ensure that an upstream firm channels its scarce supplies to its downstream partner. Suppose that the two upstream firms, U_1 and U_2, have exogenously given capacities $\bar{q}_1$ and $\bar{q}_2$, respectively. Assume that U_1 is bigger than U_2 and thus $\bar{q}_1 > \bar{q}_2$. To simplify, suppose that U_i's marginal cost of production is zero up to its capacity constraint $\bar{q}_i$ (i = 1, 2) and that

$$\bar{Q} = \bar{q}_1 + \bar{q}_2 \leq q^m = \arg\max P(q)q. \tag{5}$$

Condition 5 ensures that there is no motive to monopolize the market ex post by restricting output. Given the condition, even if there were

24. For example, let $p = a - bQ$, $\beta = \frac{1}{2}$. Then $q^m = (a - c)/2b$ and $q^* = (a - c)/3b$. Total surplus if U_1 and D_1 merge and U_2 exits is $W_m = \frac{3}{8}[(a - c)^2/b] - I_1 - E$. Total surplus under duopoly is $W_d = \frac{4}{9}[(a - c)^2/b] - I_1 - I_2$. If E is small and $\pi^d - E < I_2$, it is easy to check that U_1 and D_1 will merge and U_2 will exit; and $W_m > W_d$. These conditions are also consistent with $2\beta\pi^d > I_2$, that is, with both firms investing under nonintegration.

only one downstream firm, it would wish to purchase and sell on the downstream market all the output that U_1 and U_2 have available.

Condition 5 is a simplifying assumption that will fail to be satisfied in many markets.[25] In the absence of the condition, aspects of both previous variants come into play ($\overline{q}_i = \infty$ and $\overline{q}_j = 0$ arises in the large-uncertainty case of the ex post monopolization variant and $\overline{q}_i = \overline{q}_j = \infty$ in the scarce needs variant). A new possibility must also be dealt with: a downstream firm may try to purchase more supplies than it needs and destroy some of them to keep them out of the hands of a rival (in principle, each firm would like to destroy $\overline{Q} - q^m$ if it could buy all the supplies). If condition 5 holds, such a strategy is never optimal. We should also stress that we are confident that our results will continue to be relevant when condition 5 does not hold.

Although D_1 and D_2 compete for supplies, they do not really compete on the product market. As long as no upstream firm exits, each unit of the intermediate good has a fixed value, $P(\overline{Q})$, for the downstream firms. Thus, if upstream investment costs are small enough and ex ante monopolization is not an issue, the scarce supplies model applies to industries in which the downstream firms are in separate product markets.

Because only the nonintegrated downstream firms are hurt by integration in this variant, it is natural to assume that only D_i has to invest to operate (but see the remark after proposition 20, which discusses upstream investments). We denote D_i's investment cost by J (assumed to be independent of i).

Bargaining is modeled in a way similar to that for the case of scarce needs. The roles of the upstream and downstream firms are reversed. The downstream firms are assumed to negotiate with each independent upstream firm to purchase supplies, and the bargaining of D_i with U_1 is independent of the bargaining of D_i with U_2. We suppose that a fraction, β, of the surplus from U_i's supplying D_1 or D_2 accrues to each of D_1 and D_2, and the remaining fraction $(1 - 2\beta)$ accrues to U_i. We will also sometimes want to consider the case where a single downstream firm bargains with U_i. Under these conditions, again by analogy to the discussion of scarce needs, the downstream firm receives a fraction, β', of the surplus, and U_i receives $1 - \beta'$, where $\beta' > 2\beta$.

25. We expect the condition to hold if the cost of building capacity is large.

Nonintegration

Suppose for the moment that both downstream firms invest under nonintegration. The proposition that characterizes equilibrium in this case is immediate.

PROPOSITION 16: *Under nonintegration, the downstream firms buy the total available capacity, $\overline{Q}$, from the upstream firms. The surplus to be shared between each upstream firm and D_1 and D_2 is $P(\overline{Q})\overline{q}_i$. This is divided in the proportions $(1 - 2\beta)$, β, and β, respectively. Profits are*

$$U_i\colon U_i^{NI} = (1 - 2\beta)\, P(\overline{Q})\overline{q}_i$$

$$D_i\colon D^{NI} = \beta\, P(\overline{Q})(\overline{q}_1 + \overline{q}_2) = \beta\, P(\overline{Q})\overline{Q}.$$

Full Integration and Partial Integration

Next consider full integration and partial integration, maintaining for the moment the assumption that D_1 and D_2 invest. If U_i and D_i and U_j and D_j both merge, U_i will sell all its supplies to D_i and U_j all its supplies to D_j. If U_i and D_i merge and U_j and D_j do not, U_i will sell all its supplies to D_i, and D_i and D_j will compete for U_j's supplies.

The outcomes in these cases are summarized in propositions 17 and 18.

PROPOSITION 17: *Under full integration, D_i buys $\overline{q}_i$ from U_i $(i = 1, 2)$ and profits are*

$$U_i\text{-}D_i\colon V_i^{FI} = P(\overline{Q})\overline{q}_i - E(i = 1, 2).$$

PROPOSITION 18: *Under partial integration (U_i and D_i merge, U_j and D_j do not), D_i buys $\overline{q}_i$ from U_i, and D_i and D_j compete to buy U_j's supplies, $\overline{q}_j$, sharing the surplus from this transaction in the proportions β, β, and $1 - 2\beta$, respectively. Profits are*

$$U_i\text{-}D_i\colon V_i^{FI} = P(\overline{Q})(\overline{q}_i + \beta\overline{q}_j) - E$$

$$U_j\colon U_j^{PI} = (1 - 2\beta)\, P(\overline{Q})\overline{q}_j$$

$$D_j\colon D_j^{PI} = \beta\, P(\overline{Q})\overline{q}_j.$$

Propositions 16 through 18 show that the gain to U_1 and D_1 from integrating while U_2 and D_2 do not is $\beta P(\overline{Q})\overline{q}_1 - E$, which is the share of surplus that D_2 used to get from buying U_1's supplies, but which is now divided between U_1 and D_1. The gain to U_2 and D_2 of jumping on the bandwagon is $\beta P(\overline{Q})\overline{q}_2 - E$. In other words, as in the previous two variants, the benefits to U_i and D_i of integrating are independent of whether U_j and D_j integrate (this ignores the possibility that integration by U_i and D_i causes D_j to exit). In contrast to the scarce needs case, however, U_1 and D_1 may gain from integrating even if U_2 and D_2 follow suit because $V_i^{FI} - (U_i^{NI} + D^{NI}) = \beta P(\overline{Q})(\overline{q}_i - \overline{q}_j) - E$, which may be positive if $\overline{q}_1$ is sufficiently larger than $\overline{q}_2$ (however, the same formula shows that U_2 and D_2 cannot gain from integrating if U_1 and D_1 follow suit, given $\overline{q}_2 < \overline{q}_1$).

Propositions 16 through 18 also tell us that a merger by U_1 and D_1 reduces D_2's profits, but does not have a direct effect on U_2's profits (compare U_2^{PI} and U_2^{NI}). The reduction in D_2's profit may cause D_2 to exit, a case we consider next.

Ex Ante Monopolization (Exit by D_2)

With D_2 exiting, D_1 receives U_1's supplies automatically (since they are merged) and negotiates to buy U_2's supplies too. An important difference between this case and previous ones is that if D_1 declines to buy U_2's supplies, they disappear from the market. Hence the gains that D_1 can achieve from trading with U_2 are $P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1$, rather than $P(\overline{Q})(\overline{Q} - \overline{q}_1) = P(\overline{Q})\overline{q}_2$. Given one-on-one bargaining, a fraction, β', of these gains goes to D_1 and a fraction $(1 - \beta')$ to U_2.

PROPOSITION 19: *Under the integration of U_1 and D_1 and exit by D_2, D_1 buys $\overline{q}_1$ from U_1 and $\overline{q}_2$ from U_2. Profits are*

$$U_1\text{-}D_1\text{: } V_1^{M_d} = P(\overline{q}_1)\overline{q}_1 + \beta'[P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1] - E$$

$$U_2\text{: } U_2^{M_d} = (1 - \beta')\,[P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1]$$

D_2: Zero.

As in the case of scarce needs we suppose that U_1-D_1's profits are higher under ex ante monopolization than under nonintegration. That is:

$$(6) \quad V_1^{M_d} = P(\bar{q}_1)\bar{q}_1 + \beta'[P(\bar{Q})\bar{Q} - P(\bar{q}_1)\bar{q}_1] - E$$
$$> (1 - 2\beta)P(\bar{Q})\bar{q}_1 + \beta P(\bar{Q})\bar{Q}.$$

The right side of the equation is decreasing in β because $\bar{Q} < 2\bar{q}_1$ and so reaches a maximum $P(\bar{Q})\bar{q}_1$ when $\beta = 0$. Hence the condition certainly holds if E is small enough. If the condition fails to hold, neither U_1 and D_1 nor U_2 and D_2 will ever have an incentive to integrate in the present model.

The Investment Decision

Let us reconsider the assumption that downstream firms invest. Under nonintegration, D_1 and D_2 cover their costs and invest as long as

$$(7) \quad \beta P(\bar{Q})\bar{Q} > J.$$

We assume condition 7 in what follows.

Under full integration, it is not difficult to show that it will never pay D_i to exit for some i. (Obviously, it would not pay D_1 and D_2 both to exit since then there would be no market.) In particular, U_i and D_i would do better not to merge at all if merger leads to D_i's exit. The result of D_i's exit would be that U_i would sell $\bar{q}_i$ to D_j, receiving a fraction $(1 - \beta')$ of the surplus. U_i-D_i's total profits would be $(1 - \beta')\,[P(\bar{Q})\bar{Q} - P(\bar{q}_j)\bar{q}_j] - E$, as opposed to $P(\bar{Q})\bar{q}_i - E - J$ if D_i invests. Because $P(\bar{q}_j) \leq P(\bar{Q})$, D_i's exit increases U_i-D_i's profit only if $J > \beta' P(\bar{Q})\bar{q}_i$. But in the latter case, D_i would exit if U_i and D_i were not integrated, given that U_j-D_j are integrated; and thus U_i would enjoy profit $(1 - \beta')\,[P(\bar{Q})\bar{Q} - P(\bar{q}_j)\bar{q}_j] > (1 - \beta')\,[P(\bar{Q})\bar{Q} - P(\bar{q}_j)\bar{q}_j] - E$ by *not* merging with D_i. Thus U_i would be better off refusing to merge with D_i.

Consider finally partial integration, in particular where U_1 and D_1 merge but U_2 and D_2 stay separate (the logic in the reverse case is the same). Under these conditions D_2 may or may not invest. It is easily seen, however, that D_1 invests (if the U_1-D_1 merger is worthwhile at all). In particular, note that, by the same argument as in the full integration case, if D_1 exits, U_1-D_1's profit equals $(1 - \beta')\,[P(\bar{Q})\bar{Q} - P(\bar{q}_2)\bar{q}_2] - E$. But this is smaller than U_1's profit in the worst possible scenario if U_1 and D_1 do not integrate, $(1 - \beta')\,[P(\bar{Q})\bar{Q} - P(\bar{q}_2)\bar{q}_2]$, which occurs if U_2 and D_2 integrate and D_1 exits.

The Merger Game

Again suppose that a merger is irreversible and that if U_i and D_i merge, U_j and D_j can respond instantaneously by merging too. As in proposition 15, we suppose first that U_1 and D_1 merge if any merger occurs at all; we then check that U_2-D_2 will not preempt U_1-D_1. It is clear that the worst outcome for U_1-D_1 is if U_2 and D_2 decide to merge. The reason is that in this case U_2's supplies are denied to D_1 but at the same time they are sold on the market and so depress output price. Hence if U_1-D_1's profits rise because of the merger even in this case, U_1 and D_1 will certainly merge: doing so is a dominant strategy. From propositions 16 and 17, we conclude that if

$$\beta P(\overline{Q})\,(\overline{q}_1 - \overline{q}_2) > E, \tag{8}$$

U_1 and D_1 certainly merge. On the other hand, if

$$\beta P(\overline{Q})\,(\overline{q}_1 - \overline{q}_2) < E, \tag{9}$$

the U_1-D_1 merger will depend on the response of U_2 and D_2. Proposition 20, which is proved in appendix F, provides a full characterization of the different cases. Let $X \equiv P(\overline{Q})\overline{q}_2 - J - E$ and $Y \equiv (1 - \beta')[P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1]$.

PROPOSITION 20: *Suppose U_1 and D_1 decide first whether to merge, and if and only if they merge, U_2 and D_2 can respond by merging too. Then:*

1. *If $\beta P(\overline{Q})\,(\overline{q}_1 - \overline{q}_2) > E$ and $\beta P(\overline{Q})\overline{q}_2 > E$, then U_1 and D_1 will merge and*
   (a) *U_2 and D_2 will also merge if $X > Y$ (reluctant bandwagon).*
   (b) *D_2 will exit if $X < Y$.*
2. *If $\beta P(\overline{Q})\,(\overline{q}_1 - \overline{q}_2) > E$ and $\beta P(\overline{Q})\overline{q}_2 < E$, then U_1 and D_1 will merge and*
   (a) *U_2 and D_2 will stay independent, with D_2 investing if $\beta P(\overline{Q})\overline{q}_2 > J$.*
   (b) *D_2 will exit if $\beta P(\overline{Q})\overline{q}_2 < J$ and $X < Y$.*
   (c) *U_2 and D_2 will merge if $\beta P(\overline{Q})\overline{q}_2 < J$ and $X > Y$ (forced bandwagon).*
3. *If $\beta P(Q)\,(\overline{q}_1 - \overline{q}_2) < E$,*
   (a) *U_1 and D_1 will merge and D_2 will exit if $\beta P(\overline{Q})\overline{q}_2 < J$ and $X < Y$.*

(b) *U_1 and D_1 will merge, U_2 and D_2 will stay separate, and D_2 will not exit if $\beta P(\overline{Q})\overline{q}_2 > J$, $\beta P(\overline{Q})\overline{q}_2 < E$, and $\beta P(\overline{Q})\overline{q}_1 > E$.*

(c) *No merger will occur if $\beta P(\overline{Q})\overline{q}_2 < J$ and $X > Y$, or $\beta P(\overline{Q})\overline{q}_2 > J$ and $\beta P(\overline{Q})\overline{q}_2 > E$, or $\beta P(\overline{Q})\overline{q}_2 > J$, $\beta P(\overline{Q})\overline{q}_2 < E$, and $\beta P(\overline{Q})\overline{q}_1 < E$.*

Note that a U_1-D_1 merger will certainly occur if $\overline{q}_1$ is very large relative to $\overline{q}_2$, that is, if $q_1 \simeq \overline{Q}$, $\overline{q}_2 \simeq 0$. This is because condition 6 implies that $\beta P(\overline{Q})\overline{Q} \simeq \beta P(\overline{Q})\ (\overline{q}_1 - \overline{q}_2) > E$. However, a U_1-D_1 merger can also occur even if $\overline{q}_1$ and $\overline{q}_2$ are quite close if the shift in surplus away from D_2 is just enough to cause D_2's profits to fall below J and lead to D_2's exit—for example, consider 3(a) in proposition 20 and suppose $\beta P(\overline{Q})\overline{q}_2 \simeq J$, $P(\overline{Q}) \simeq P(\overline{q}_1)$, and β' is very small.

Eager bandwagon is never an outcome in this model. U_2 and D_2 are never better off under full integration than under nonintegration; this follows because condition 8 cannot hold when $\overline{q}_1$ and $\overline{q}_2$ are interchanged. However, reluctant bandwagon occurs in 1(a) and the forced bandwagon in 2(c) of proposition 20. (The characterization of the different types of bandwagon is not contained in the proof of proposition 20 but is left to the reader.)

So far we have assumed that U_1 and D_1 move to merge first. Might U_2 and D_2 want to preempt a U_1-D_1 merger? Clearly there is no advantage to preemption if U_1 and D_1 decide to merge anyway; U_2 and D_2 would do better to let U_1 and D_1 merge first and then select a best response. This means that preemption is useless in cases 1 and 2 of proposition 20 because a U_1-D_1 merger is a dominant strategy. In case 3(c) preemption is unnecessary because no merger occurs anyway. This leaves 3(a) and 3(b). Case 3(b) implies that $\beta P(\overline{Q})\overline{q}_1 > J$, that is, D_1 does not exit if U_2 and D_2 merge; moreover, $\beta P(\overline{Q})\overline{q}_1 > E$, so U_1 and D_1 will jump on the bandwagon. Hence preemption does not prevent merger here. This leaves case 3(a). It is easy to check that in the continuous-time preemption game described in the discussion of the model, U_1 and D_1 have more incentive to integrate, and their merger preempts U_2-D_2, except possibly in the following subcase: if $\beta P(\overline{Q})\overline{q}_1 < J$ (D_1 exits if U_2 and D_2 merge and U_1 does not rescue D_1), and $P(\overline{Q})\overline{q}_1 - J - E < (1 - \beta')\ [P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1]$ (U_1 does not rescue D_1), the incentives for U_1-D_1 to preempt U_2-D_2 and for U_2-D_2 to preempt U_1-D_1 are equal. Whoever preempts the other, the nonintegrated downstream firm exits, and preemption is a zero-sum game—what one gains, the other loses. Preemption then occurs at the date at which each is indifferent between preempting or not preempting.[26]

Finally, in contrast to the earlier ex post monopolization scenario, there are no "public good" aspects to mergers here: the nonmerging downstream firm suffers from lack of supplies, and the nonmerging upstream firm may suffer from the exit of its downstream partner. Neither pair, U_1 and D_1 nor U_2 and D_2, ever *wants* the other pair to move first, and there cannot be a war of attrition.

REMARK. To keep the variant relatively simple, we have ignored upstream investments. An implication of this is that vertical mergers have no effect on consumers: in all the subcases of proposition 20, $\overline{Q}$ units are supplied to consumers and price is $P(\overline{Q})$. Allowing upstream investments would not alter the first-round effects of a U_1-D_1 merger because it has no effect on U_2's profits. However, if D_2 exits as a result of the merger, this *will* reduce U_2's profits and might cause U_2 to exit. In other words, a sequence of exits is a possible outcome when upstream and downstream firms both invest. Under these conditions, supplies will disappear from the market and consumer prices will rise.

There is another new possibility that arises when upstream firms invest. Whereas U_1-D_1 always benefits from D_2's exit (this increases D_1's monopsony power), U_1-D_1 may suffer from U_2's exit because scarce supplies disappear from the market. Hence in some cases U_1 and D_1 may refrain from merging in order to keep U_2 alive.[27]

Welfare

The welfare effects of a merger are straightforward in the scarce supplies variant. Since, in the absence of upstream investments, total

26. U_1-D_1 and U_2-D_2 then have equal probabilities of preempting: see Fudenberg and Tirole (1985) for the formalization of the continuous-time preemption strategies. The date $(-T)$ at which preemption occurs is given by $E = e^{-rT}\{P(\overline{q}_1)\overline{q}_1 + \beta'[P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1] - (1 - \beta')[P(\overline{Q})\overline{Q} - P(\overline{q}_2)\overline{q}_2]\}$, where E is now taken to be a stock rather than a flow.

27. One case in which U_1-D_1 will barely be hurt by U_2's exit is when $P(\overline{q}_1)\overline{q}_1 \simeq P(\overline{Q})\overline{Q}$. This is because even if D_2 and U_2 exit, U_1-D_1 achieves $P(\overline{q}_1)\overline{q}_1 - E$, and this is almost as much as is received if only D_1 exits (V^{M_d}). Hence for this case the presence of upstream investments will not change the analysis at all. Moreover, if $\beta P(\overline{Q})\overline{q}_2 < J$ and $(1 - \beta')[P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1] < I$, that is if D_2 and U_2 both exit, there will be a clear effect on consumers from the U_1-D_1 merger: output will fall from $\overline{Q}$ to $\overline{q}_1$, and price will rise from $P(\overline{Q})$ to $P(\overline{q}_1)$.

output is always $\overline{Q}$, consumers neither gain nor lose from mergers. Firms lose in the aggregate to the extent that merger costs are incurred, but gain to the extent that investment costs J are saved (for example, if U_1 and D_1 merge and D_2 exits, the net gain is $J - E$). Since, under partial or full integration, merger costs are incurred without investment costs being saved, these cases are always dominated by nonintegration.

Once upstream investments are allowed, consumers will generally be affected by mergers. In particular, under the maintained hypothesis that all firms invest under nonintegration, a U_1-D_1 merger that leads to the exit of both D_2 and U_2 will cause a fall in total supply from $\overline{Q}$ to $\overline{q}_1$, and a corresponding price rise from $P(\overline{Q})$ to $P(\overline{q}_1)$.

Extensions

We mention two brief possible extensions of the model. First, our analysis is couched in terms of integration between a supplier and a buyer. However, the ex post monopolization variant seems likely to extend to integration between two manufacturers of complementary products. Suppose manufacturer A_1 merges with B_1. By doing this, A_1 makes it credible that it will give information about developments of its products only to B_1, thus allowing B_1 an early start in the design of compatible complements.

Suppose first that A_1 is a monopolist in the X market (this situation is analogous to the essential facility case). Two firms, B_1 and B_2, produce goods Y_1 and Y_2 that are complements to X. An unintegrated A_1 has an incentive to provide both Y manufacturers with information about its product developments in order to create low costs and competition in the Y market and consequently to be able to charge a high price for good X. But total industry profit (from goods X and Y) can often be raised by raising prices in the Y market. For instance, if Y_1 and Y_2 are good substitutes, the prices in the Y market under Bertrand competition are close to marginal cost. However, if consumers are heterogeneous and have different demands in the Y market, optimal second-degree price discrimination requires prices well above marginal cost.[28] Another reason why higher prices in the Y market might increase

28. See, for example, Tirole (1988, pp. 145–47).

industry profits is that some consumers may want to consume the Y good only. In either case, integration of A_1 and B_1 credibly commits A_1 not to give early information to B_2 if Y_1 and Y_2 are good substitutes. This enables B_1 to raise its price.

Second, assume that A_1, which produces X_1, faces competition by A_2, which produces X_2. The rival A_2 will be indirectly hurt by A_1-B_1's integration even though it may not need any information from B_1. On the one hand, the increase in the price of Y_1 reduces the number of consumers who want to mix and match X_2 and Y_1. On the other hand, if B_2 exits, there are no more consumers who want to mix and match X_2 and Y_2. Several outcomes may result. A_2 may exit; or it may be forced to bandwagon by coming to B_2's rescue.

As very tentative illustrations (tentative because we have not studied the industries in detail), consider IBM's limiting early announcements of its developments in computer technology to its disk drive subsidiary or airlines' that offer complementary flights and merge to gain market power by facilitating exclusive coordination of schedules at hubs.

We have also assumed that the upstream firms are subject either to constant returns to scale (first two variants) or to decreasing returns to scale (third variant). An interesting extension of the model would allow for upstream increasing returns to scale over some range, as in the case of a U-shaped cost curve. A (possibly hypothetical) illustration is the following: by buying supercomputers exclusively from Japanese manufacturers (as a result of vertical integration, for example) Japanese owners of supercomputers reduce the size of the market for U.S. supercomputer manufacturers, whose unit production costs therefore rise. As a consequence, U.S. consumers of supercomputers forgo some use of them and hence are at a disadvantage relative to their Japanese competitors in the product market. This illustration is similar to our ex post monopolization variant, except that vertical integration not only enables the most efficient supplier, which is ex post the Japanese manufacturers of supercomputers, to commit to restrict supplies to U.S. consumers of supercomputers, but also creates the upstream cost differential that was assumed exogenous in the discussion of ex post monopolization. The illustration also possesses some features of our scarce needs variant.[29]

29. In that variant a merger between an upstream and a downstream firm could disadvantage the rival downstream firm by causing exit of the rival upstream firm. This is an extreme example of an increase in the upstream firm's unit production costs.

Applications

This section applies the model to three industries. The discussion is only meant to suggest how one might analyze these industries using the framework just presented. Of course, the evidence on vertical integration in these industries was not collected with this kind of model in mind.

Case 1: The Cement and Ready-Mixed Concrete Industries

The cement industry consists of kilns and mills that convert limestone, clay, and gypsum into cement. The ready-mixed concrete industry combines cement, sand, aggregates, and water to make concrete. In the early 1960s a great deal of vertical integration occurred between the cement and the ready-mixed industries. In particular, a large number of cement companies integrated forward by acquiring ready-mixed concrete companies. This heightened merger activity attracted the attention of the Federal Trade Commission, and it conducted an inquiry resulting in the *Economic Report on Mergers and Vertical Integration in the Cement Industry* in 1966.

CHARACTERISTICS OF THE CEMENT AND CONCRETE INDUSTRIES. Cement is a very homogeneous commodity; it is manufactured to strict specifications, there are no problems of customer-specific investment, and any ready-mixed concrete manufacturer can easily turn to an alternative supplier.

Because of large minimum efficient scale, concentration in the cement industry was very high in the 1960s. Since cement is bulky and costly to transport, 90 percent of it was shipped 160 miles or less.[30] And even at the state level, which may be larger than actual market areas, in only 6 percent of the states did the four largest suppliers account for less than 50 percent of cement shipments.

Concentration in the ready-mixed concrete industry was apparently lower; however, the industry consisted of a few large firms handling large contracting jobs such as highways and bridges and many small firms handling smaller jobs. As a result, in 17 of 22 metropolitan areas for which the FTC had data, the 4 leading ready-mixed companies accounted for 50 percent or more of ready-mixed sales. In eight of

30. Federal Trade Commission, *Economic Report on Mergers and Vertical Integration in the Cement Industry* (1966, p. 7), henceforth referred to as FTC *Report*.

these markets the four largest companies accounted for 75 percent or more.[31]

The period immediately after World War II saw a steady growth in demand for cement with no corresponding increase in capacity. As a result, by 1955 cement mills were operating at 94 percent of capacity.[32] In response, existing cement mills were expanded and new mills constructed so that by 1960 the capacity utilization rate was down to 74 percent.

The merger wave seems to have been triggered by significant excess capacity among cement mills. From 1955 to 1965 the cement industry expanded capacity by 60 percent—twice as fast as actual shipments of cement grew during the decade.[33] This burst in cement mill construction and expansion was a response to high-capacity utilization levels in the early 1950s, which resulted in spot shortages of cement. Demand continued to grow throughout the 1960s, but because so much new capacity was brought on line, cement manufacturers saw their excess capacity cut into industry profits. Eighty percent of the vertical acquisitions occurred when market conditions were weak, and 37 of 55 took place in markets with above-average excess capacity.[34] The overcapacity was also aided by technological change that made newer cement mills cheaper to operate and made it feasible to build larger plants. By modernizing to cut costs, cement makers contributed to the industrywide overcapacity. Neither demand conditions nor innovations in the concrete market seem to have played an important role in triggering mergers.

PATTERN OF INTEGRATION. The 1960s witnessed a wave of acquisitions of concrete manufacturers by cement producers. The acquired ready-mixed companies made between 19 percent and 45 percent of total sales in their respective market areas.[35]

It is generally agreed that each acquiring cement producer hoped to assure itself of guaranteed outlets.[36] Efficiency reasons do not seem to have been an important factor.[37]

31. FTC *Report* (1966, p. 3).
32. FTC *Report* (1966, table III-3).
33. *Wall Street Journal*, March 29, 1965, p. 1.
34. FTC *Report* (1966, p. 100); and Allen (1971, p. 263).
35. FTC *Report* (1966, p. 14).
36. FTC *Report* (1966, p. 14); Allen (1971, p. 254).
37. Allen (1971, p. 253); Wilk (1968, pp. 633–36); and FTC *Report* (1966, p. 3).

Bandwagoning occurred in many markets. All the executives' comments point to the fact that many companies had been driven to purchase their customers because their competitors were doing likewise. For example, in its *Annual Report* of 1963, the Alpha Portland Cement Company stated, "Vertical integration within our industry has been on the increase in recent years. Alpha is presently not inclined to integrate vertically. However, if our position in the industry is put in jeopardy as a result of such corporate arrangements, there will be no alternative but to make similar moves."[38]

Wilk (1968) also cites evidence that many cement firms dropped out of a market after a large customer had been bought out by competing cement manufacturers.

LINK WITH ANALYSIS. The pattern of integration in the industry suggests that the relevant variant is the scarce needs one (see in particular the extension of the scarce needs model in which downstream firms have limited capacity). Upstream firms were eager to assure themselves of a downstream outlet. The bottleneck seems to have been the downstream industry.

Also consistent with the scarce needs variant are that the complaining firms were cement producers and that the mergers affected the largest ready-mixed concrete firms.[39]

One prediction of the scarce needs model is not borne out by the facts. Although the ready-mixed companies that had been acquired increased from 37 percent to 69 percent the fraction of their supply obtained from the acquiring cement companies after the mergers, as the theory would predict, they still purchased from other cement suppliers.[40] The scarce needs variant has all supplies produced by the internal manufacturer. This particular prediction, however, relies on constant returns to scale upstream; and although there was excess capacity in the cement industry, there may have been capacity constraints

38. FTC *Report* (1966, p. 2).

39. Although the scarce supplies variant is clearly ruled out by the existence of excess capacity in the cement industry, the evidence against ex post monopolization is more circumstantial and consists mainly of the fact that upstream firms were the ones that complained. To get more factual evidence against ex post monopolization, one would have to show that there were only small differences in marginal costs among the upstream firms, or at least that the upstream firms that first merged were not the most efficient ones.

40. FTC *Report* (1966, p. 14).

for some individual cement producers. The theory of scarce needs could be modified by increasing the number of upstream firms and allowing for individual but not industry capacity constraints to account for the possibility of outside supplies.

Based on the executives' interviews and annual reports, the relevant bandwagoning behavior seems to have been reluctant.[41]

Why did integration take place in the 1960s and not earlier? A primary determinant of the merger activity was the excess capacity in the cement industry that appeared then. Before this wave of forward integration, there were some instances of backward integration into cement manufacture by concrete makers. Typically, a large concrete maker would build a modern cement mill from scratch and use most of the cement to meet its own needs. These backward moves were initiated during the late 1950s, when cement was very profitable because of the limited capacity in the industry. Concrete makers' profits were squeezed by the high price of cement and the highly competitive nature of the concrete business, which held prices down. That is, the relevant model for the late 1950s may have been the scarce supplies variant. However, the gains from foreclosure seem to have been smaller than in the 1960s.

Finally, it would be interesting to know whether the Federal Trade Commission and the various commentators, in dismissing efficiency reasons for mergers, recognized the possibility of holdup problems in the cement industry. It is possible that at a time of excess capacity, a number of cement producers were no longer viable; they would have exited if they could not have combined with a concrete firm. This would provide an efficiency motive for mergers, which might offset the foreclosure effects emphasized here. More information is required to tell whether this efficiency effect could have been large. As noted in the introduction, however, the fact that the mergers involved large cement and concrete firms provides some support for foreclosure as the relevant effect.

Case 2: Computer Reservation Systems

Computer reservation systems (CRS) book airline seats electronically. The CRS industry was vertically integrated with airlines from its inception, and the two largest systems are Sabre, owned by American

41. FTC *Report* (1966, pp. 2–3); Allen (1971, pp. 267–70).

Airlines, and Apollo, controlled by United Airlines. TWA, Texas Air, and Delta have competing CRS. Although the systems typically listed flights of airlines other than the ones that controlled them, by 1984 there were widespread complaints that they were biased in favor of the host airlines, neutral vis à vis the airlines that did not compete with the hosts, and biased against airlines that did compete with the hosts. The bias was partly monetary. In 1981–82 American charged Eastern Airlines \$0.24 for each booking on Sabre, Delta Airlines \$1.32, and New York Air \$2.00.[42] Eastern was a large carrier that did not compete fiercely with American. It was charged a low rate to give Sabre wider coverage, making the CRS more attractive to travel agents. Delta competed with American at its Dallas hub, and there is evidence that American wanted to drive Delta out of Dallas–Fort Worth. New York Air was a price cutter. Another important element of discrimination concerned the order the flights were displayed on the travel agent's screen. This order is crucial because agents have little time or willingness to screen through several displays. Being listed near the top provides a major competitive advantage for an airline.

In 1984 eleven airlines that were not integrated into the systems filed an antitrust suit against American and United, charging them with monopolization of CRS. In November 1984 the Civil Aeronautics Board established regulations to guarantee more equal access.

ANALYSIS. One way of looking at the industry is to regard the CRS as an upstream firm with, possibly, scarce supplies. The system supplies an input (flight booking) to downstream firms, the airlines, which set prices for flights. For simplicity, we will use the paradigm of an upstream monopolist (an essential facility) serving several downstream competitors. Clearly there is competition among computer reservation systems, but this competition is imperfect. Furthermore, a travel agent usually consults a single CRS when serving a customer.

What are the efficiency gains of vertical integration? They do not seem substantial, but they may exist, and further research is needed to see whether this is the case.[43] The integrated CRS and airline can derive

42. Commerce Clearing House. 1989. *Trade Regulation Reports*. ¶68,316.

43. It is sometimes argued that computer interconnections between the CRS and the airlines can be improved through vertical integration; it is unclear, however, why the same coordination could not be achieved under nonintegration via a contract.

three other types of benefits. First, the host airline may favor its own flights by biasing display in their favor; this gives rise to an ex post monopolization effect. Second, the host airline may acquire real-time access to all prices and seat availability and thus get an edge over its competitors. The implications of this effect are less clear than those of the first, but they relate to an ex post competitive advantage as well. Third, the integrated CRS will give priority to the host airline and thus does not leave bargaining rents to other airlines.

How do the first and third gains fit in the model? To take an extreme example, suppose there is a single CRS and two airlines. Assume first that there are two priority lines on the screen allowing the CRS to display two flights (other lines require another display for the travel agent and do not sell in this extreme case). Assume also that priority is not contractible. A customer's preferred departing time to go from city A to city B is noon, and the two airlines each have such a flight. A nonintegrated CRS will list the two flights. (The CRS is actually indifferent between doing this and listing two flights of the same airline because it does not receive compensation for priority, but it is reasonable to assume that it displays the noon flights of the two airlines if it receives some small benefit from pleasing travel agents or helping both airlines stay alive.) Knowing this, the two airlines will compete fiercely in the price of their noon flight. But if the first airline and the CRS merge, the CRS will show this airline's noon and 2:00 p.m. flights and will relegate the other airline's noon flight to a lower, nonselling ranking. Facing less competition, the first airline can raise its price on the noon flight, and the customers as well as the rival airline are hurt.

This is an example of ex post monopolization. Take now another extreme case in which there is a single priority line on the screen (all other lines are not conspicuous enough to sell), and priority can be contracted between an airline and the CRS. The situation in which the unintegrated CRS is unable to commit to give priority to a single airline disappears. This then is the scarce supplies variant. An unintegrated CRS leaves some bargaining gains to each airline when selling the scarce supply; one airline's gain can be recaptured if the CRS vertically integrates with the other airline.

The assumptions underlying ex post monopolization and scarce supplies here seem inconsistent. However, reality is a mixture of the two situations. First, priority was partly contractible before 1984. The ordering of display was computed through a complex system of penalties, one for not being the host airline, another depending on the difference between the actual flight departure time and a customer's desired departure time, a third for stops and connecting flights, and so forth. Airlines could reduce the level of nonhost penalty by becoming cohosts. However they could not fully contract on priority because the CRS could often make minor adjustments to its algorithm to decide which connections were listed, change the algorithm when introducing new flights, issue boarding passes only for the host airline, shave schedule times, break ties in favor of airlines who have certain flight numbers, and so forth. Thus priority had both contractible and noncontractible elements. Second, whether the supply of screen space for relevant flights is scarce depends on the route, the time of day, the season, and so forth. Thus one would expect space on the screen sometimes to be scarce, as in the one-line example, and sometimes not, as in the two-line example.[44]

Case 3: Terminal Railroad Case

Terminal Railroad is the quintessential example of an essential facility:

> The Terminal Company controlled a bridge across the Mississippi River, and the approaches and terminal at St. Louis, a very significant junction point for competing railroads. That company had every incentive to serve equally all railroads entering or leaving St. Louis, charging whatever the market or regulatory agencies would bear. However, once the Terminal Company was acquired by several of those railroads, the new owners might use their control over it to exclude or prejudice their rivals. Rather than order dissolution of the combination, with restoration of the Ter-

44. The contracting difficulties may also offer clues as to why the vertically integrated outcome could not have been achieved through an exclusive-dealing contract between the CRS and the airline. After all, discriminatory rates and penalties resemble partial exclusive dealing. One issue with exclusive dealing is that ideally an independent CRS would have liked to give a low penalty level to an airline *together* with the commitment to impose high penalty levels to rival airlines. Such an exclusionary practice, like other forms of exclusive-dealing contracts, would probably have been frowned on by the courts. Another issue is that display bias is only partially contractible, so that some of the private gains to exclusionary behavior are best realized through vertical integration. And indeed, only one short-lived attempt to compete was made by a CRS not owned by an airline, which suggests that integrated CRS yielded more profits.

minal Company's independence, the Supreme Court required the members to admit their railroad competitors to their consortium. Although the Court did not use the word, we might describe the Terminal Company's bridge, tracks, and terminals as "essential facilities" that had to be shared with competitors.[45]

One can view the Terminal Company as an upstream monopolist and the competing railroads as downstream rivals. Note that strategic vertical integration by an upstream essential facility cannot be driven by scarce needs downstream. Because there is a single supplier, integration of a U and a D appropriates no bargaining surplus from other suppliers. Thus, absent efficiency gains, forward integration by an upstream monopolist may be driven either by the ex post monopolization effect or by the scarce supplies effect.

Scarce supplies seemed to play no role in this case. According to Areeda and Hovenkamp (1987, ¶736.1b), the Terminal Company's "minimum efficient scale could accommodate all the traffic." Although there is little evidence, efficiency considerations also seemed secondary. Furthermore, if there had been efficiency gains from vertical integration, one would have to explain why these gains would not also have applied to the excluded railroads, in which case joint ownership of the Terminal Company by all the railroads would have been optimal.[46] Thus a first look at the Terminal Railroad case suggests that the motive for integration was to monopolize the rail market around St. Louis.

Review of the Literature

This section compares our analysis with those in the literature on vertical integration and foreclosure, in particular the contributions of Ordover, Saloner, and Salop (1990); Salinger (1988); and Bolton and Whinston (1989).

The model presented by Ordover, Saloner, and Salop is, in effect, a special case of our first variant in which $c_1 = c_2$. In contrast to our analysis, they find that vertical integration can be profitable under these

45. Areeda and Hovenkamp (1987, pp. 565–66, ¶736.1b). The case can be found at 224 U.S. 383 (1912).

46. See the discussion in Hart and Moore (1988, section 4.4).

conditions. The authors argue that, under nonintegration, price competition in the intermediate and output markets leads to the standard Bertrand product-market outcome. If upstream firm U_1 and downstream firm D_1 merge, U_2 can raise its input price to D_2 because U_1 will no longer be as anxious to supply the rival downstream firm D_2 as before. This gives D_2 a disadvantage as a competitor in the product market and allows U_1-D_1 to increase market share and make positive profit.[47] In other words, vertical integration forecloses product-market competition by "raising rivals' costs."[48]

The authors' analysis makes implicit assumptions about commitment and contracting possibilities that are questionable. They assume that when U_1 and D_1 merge they can commit not to supply rival D_2 at a price below $\overline{p}$, where $\overline{p}$ is a choice variable for U_1 and D_1. Then U_2 and D_2 decide whether to merge. The authors show that U_1 and D_1 commit to a price $\overline{p}$ above marginal cost c. In equilibrium, U_2 slightly undercuts $\overline{p}$ to $\overline{p} - \epsilon$ and supplies D_2. Thus U_1-D_1 has succeeded in raising D_2's marginal cost. However, $\overline{p}$ cannot be too large because the shrinking of D_2's market share would induce U_2 and D_2 to merge as well.

There are two problems with this reasoning. First, if two-part tariffs are allowed, as in our analysis, U_2 and D_2 always have an incentive to transfer the intermediate good at marginal cost and bargain over a fixed fee. Thus in the presence of two-part tariffs, U_1-D_1 cannot affect D_2's marginal cost and hence market competition. Second, the commitment of U_1-D_1 is unlikely to be believable. Why would U_1-D_1 not undercut U_2 by ϵ in turn? The effect on D_2's reaction curve is negligible (of the order of ϵ), while U_1-D_1's increased profit from supplying D_2 is significant (it is approximately $(\overline{p}-c)q$, where q is the quantity U_2 sells to D_2). Thus U_1-D_1 can gain from such a deviation ex post, and any commitment ex ante not to make such a deviation lacks credibility. This is in spite of the fact that competitive undercutting of this type leads inexorably to the Bertrand outcome and thus eliminates all the benefits from the integration of U_1 and D_1.

We are not suggesting that it is *never* feasible for an upstream firm to commit to charge high prices to a downstream firm. One way this

47. In fact, because competition between U_1 and U_2 becomes less fierce, the nonintegrated upstream firm U_2 also benefits from the merger (makes a profit) in equilibrium.

48. Salop and Scheffman (1983).

could be achieved is via a form of exclusive-dealing contract (see appendix C); another is through reputation. What is unclear from Ordover, Saloner, and Salop, however, is the mechanism for enforcing commitments and why U_1 and D_1 need to merge to take advantage of this mechanism. That is, if exclusive-dealing contracts are feasible, why cannot U_1 write such a contract with D_1 to restrict supplies to D_2 while remaining independent?[49]

The authors also obtain different conclusions from ours. Our model explains why firms sometimes respond to a merger by themselves merging, how it can be profitable for an integrated upstream firm to sell to a rival downstream firm, and why an upstream firm and downstream firm may merge to drive a rival out of the market. In contrast, bandwagoning never occurs in their model (at most one pair of firms is integrated). Integrated and nonintegrated firms never trade with each other and, because a nonintegrated upstream firm benefits from its rival's integration, an upstream firm might refrain from integration in order to monopolize the market ex ante (in the presence of investment costs). Finally our model yields predictions on which firms are more likely to integrate (those with lower marginal costs, lower investment costs, or higher capacities), whereas Ordover, Saloner, and Salop are silent on this because they consider identical firms.[50]

49. Several papers have in fact studied the use of exclusive-dealing contracts to foreclose markets. See Comanor and Frech (1985), Mathewson and Winter (1986), and Schwartz (1987). These papers, however, put restrictions on the types of nonexclusive-dealing contracts that can be offered. Also see Krattenmaker and Salop (1986) for a very good discussion of the law and economics of exclusive dealing.

50. Salinger's (1988) model is similar to that of Ordover, Saloner, and Salop in several respects. He makes the same technological assumptions they do but assumes that a large number of upstream and downstream firms interact in an anonymous market. The downstream firms take the price of the intermediate good as given in their input decisions, but act as Cournot oligopolists in the consumer-good market. The upstream firms in turn act as Cournot oligopolists in the intermediate-good market. Salinger argues that, if U and D merge, U no longer supplies the intermediate good to the anonymous market, preferring instead to channel it to D. Similarly, D no longer purchases input in the anonymous market, preferring instead to be supplied by U. A strategy that Salinger's upstream Cournot assumption does not permit is for an integrated supplier to undercut its nonintegrated rivals slightly, so that nonintegrated purchasers buy the same total amount as before but now buy from the integrated supplier. Yet a price-cutting strategy seems natural, particularly in the context of many trading relationships between upstream and downstream firms that are personalized rather than anonymous, and where price setting, possibly in conjunction with quantity setting, seems more plausible than pure quantity setting.

A recent paper by Bolton and Whinston (1989), written independently of ours, studies the motives for vertical integration from the perspective of incomplete contracting, but mainly in a situation in which downstream firms operate in different product markets. The authors' basic model consists of two downstream firms, D_1 and D_2, and one upstream firm, U. The downstream firms make variable investments specific to the upstream firm, but the upstream firm does not invest. Each downstream firm requires one unit of intermediate good from the upstream firm ex post; the upstream firm can satisfy both downstream firms in some states of the world, but in others it has only one unit of intermediate good available. Long-term contracts cannot be written, and ex post bargaining is modeled as an extensive-form game in which the ability of the upstream firm to sell to D_j plays the role of an outside option in the bargaining between it and D_i. In contrast to our model, investment costs are not shared under integration and the returns to investment are completely appropriated by a firm's owner.

When the upstream firm has only one unit of intermediate good available, the authors' model is close to our scarce supplies variant. The motive for integration is different, however. If D_1 buys U, this has no direct effect on D_2's investment decision because, assuming the outside option binds, if D_2 values the intermediate good more than D_1 does, D_2 will continue to buy it at a price equal to that D_1 is willing to pay. However, there is an indirect effect because D_1 now appropriates all the returns from U's bargaining with D_2 and so has an incentive to invest more to increase these returns. This in turn causes D_2 to invest less.[51]

Given that the motive for integration is different in their model, it is not surprising that Bolton and Whinston also reach different conclusions. They find that when outside options are binding in the bargaining process, nonintegration is socially optimal. The reason is that because each downstream firm pays an input price determined by the other downstream firm's willingness to pay, it receives at the margin the full increase in the marginal product of its investment. (In contrast, in the discussion of scarce supplies we find that either nonintegration or vertical integration and exit can be socially optimal.) However, when

51. Bolton and Whinston also consider a form of bandwagoning, whereby a merger of U and D_1 causes D_2 to build upstream capacity so as to supply its internal needs.

outside options are binding, nonintegration is not privately optimal in their model: by integrating, U and one of the downstream firms can make themselves better off at the expense of the other downstream firm. In fact, Bolton and Whinston find that the only privately optimal arrangements involve vertical integration by U and one of the D's, or complete integration of U, D_1, and D_2. In contrast, we do not allow complete integration, and find that when $\overline{q}_2 = 0$ (that is, when there is only one upstream firm), either nonintegration or integration between U and D_i, with or without exit of D_j, can be privately optimal.

A final difference between the two models is that in Bolton and Whinston consumer surplus is independent of ownership structure (for example, if downstream firms make take-it-or-leave-it offers to consumers, consumer surplus equals zero). In our scarce supplies variant, exit by a downstream firm can lead to exit by an upstream firm, and thereby to a decrease in total supplies and a decrease in consumer surplus.

Appendix A: Proofs of Propositions 1–4

Proof of Proposition 1. The strategies are: U_1 offers to sell q^* units at price t^* to each D_j (formally: $t_{1j}(q_{1j}) = t^*$ if $q_{1j} = q^*$, $= +\infty$ if $q_{ij} \neq q^*$). U_2 offers to supply each D_j at marginal cost, that is, $t_{2j}(q_{2j}) = c_2 q_{2j}$ for $j = 1, 2$. Each downstream firm accepts (t^*, q^*) in equilibrium. If one of the upstream firms offers another contract to D, this D continues to anticipate output q^* by its rival and maximizes its profit: that is, it maximizes $r(q_{1j} + q_{2j}, q^*) - t_{1j}(q_{1j}, \hat{Q}_{1j}) - t_{2j}(q_{2j}, \hat{Q}_{2j})$ subject to $q_{1j} + q_{2j} \geq \max(\hat{Q}_{1j}, \hat{Q}_{2j})$. A downstream firm's behavior is obviously optimal given the offers it faces and given that it expects its rival to purchase q^*.

Can U_2 deviate and make a positive profit? For instance, can it sell q_{22} at price $t_{22} > c_2 q_{22}$ to D_2? Note that D_2 can guarantee itself $D^{NI}(c_1, c_2) = r[R_2(q^*), q^*] - c_2 R_2(q^*)$ by refusing U_2's offer and purchasing q^* at price t^*. Because $R_2(q^*)$ is the best response to q^* for marginal cost c_2, firm D_2 would get strictly less than $D^{NI}(c_1, c_2)$ by buying q_{22} at price $t_{22} > c_2 q_{22}$ and rejecting offer (q^*, t^*) from U_1. Similarly, because $R_2(q^*) \leq q^*$ (as $c_2 \geq c_1$), $q_{22} = 0$ maximizes $r(q^* + q_{22},$

$q^*) - c_2 q_{22}$, and thus D_2 makes strictly less than $D^{NI}(c_1, c_2)$ if it buys from U_1 and furthermore buys q_{22} at price $t_{22} > c_2 q_{22}$ from U_2.

Last, can U_1 increase its profits? No, because it is already maximizing $t_{1j} - c_1 q_{1j}$, subject to the constraint $r(q_{1j}, q^*) - t_{1j} \geq r[R_2(q^*), q^*] - c_2 R_2(q^*)$ over pairs (q_{1j}, t_{1j}). Thus it extracts the maximum feasible surplus from each D_j, given that the latter can buy at marginal cost c_2 and expects its rival to buy q^*. *Q.E.D.*

PROOF OF PROPOSITION 2. The strategies are: U_1 offers q_2^* at price t_2^* to D_2. U_2 offers to supply at marginal cost: $t_{2j}(q_{2j}) = c_2 q_{2j}$ for all j and q_{2j}. In equilibrium, D_2 buys q_2^* from U_1 and 0 from U_2. Again, it is clear that D_2 acts optimally given the contract offers and the anticipation that D_1 procures q_1^* internally.

Can U_2 make a strictly positive profit? Suppose that U_2 makes a different offer and D_2 buys q_{22} at price $t_{22} > c_2 q_{22}$ from U_2. Then D_2's profit is $\max[r(q_2^* + q_{22}, q_1^*) - c_2 q_2^* - t_{22}, r(q_{22}, q_1^*) - t_{22}]$. Because $q_2^* = R_2(q_1^*)$ and $t_{22} > c_2 q_{22}$, this profit is strictly lower than $D^{PI}(c_1, c_2)$, and D_2 is better off rejecting U_2's contract after all.

Can U_1-D_1 make more than $V^{PI}(c_1, c_2)$? Suppose that U_1 offers a different contract to D_2. Let (Q_1, Q_2) denote the resulting outputs for D_1 and D_2, which we for the moment assume deterministic. First, note that $Q_1 = R_1(Q_2)$, because U_1-D_1 can procure internally at marginal cost c_1 and externally at marginal cost c_2. Furthermore, $Q_2 \geq R_2(Q_1)$ because D_2 can buy any amount from U_2 at marginal cost c_2. We thus have $Q_1 \leq q_1^*$, $Q_2 \geq q_2^*$ and $Q_1 + Q_2 \geq q_1^* + q_2^*$ from $|dR_1/dq_2| < 1$ (see figure 1). Thus industry profits are lower than in our presumed equilibrium. Yet D_2 can guarantee itself $D^{PI}(c_1, c_2)$ because by turning down U_1's offer it obtains

$$\max_{q_{22}}[r(q_{22}, Q_1) - c_2 q_{22}] \geq \max_{q_{22}}[r(q_{22}, q_1^*) - c_2 q_{22}] = D^{PI}(c_1, c_2).$$

Hence industry profits have fallen, while U_2 and D_2 are at least as well off. Hence U_1-D_1 cannot increase its profit. This reasoning extends straightforwardly to random outcomes $(\tilde{Q}_1, \tilde{Q}_2)$. First note that $\tilde{Q}_1$ is necessarily deterministic (equal to some Q_1) as it maximizes the strictly concave function

$$\mathop{\mathscr{E}}_{\tilde{Q}_2}[r(Q_1, \tilde{Q}_2) - c_1 Q_1],$$

where $\mathscr{E}$ denotes the expectation operator. Furthermore, any realization Q_2 of $\tilde{Q}_2$ exceeds $R_2(Q_1)$. Let $\underline{Q}_2$ be the infimum in the support of $\tilde{Q}_2$. Then $\underline{Q}_2 \geq R_2(Q_1)$ and $Q_1 \leq R_1(\underline{Q}_2)$ (recall that reaction curves are downward sloping). This implies that $\underline{Q}_2 \geq q_2^*$ and $Q_1 \leq q_1^*$ (see figure 1). Hence, D_2 can guarantee itself $D^{PI}(c_1, c_2)$. Let $Q_2^e = \mathscr{E}\tilde{Q}_2 \geq \underline{Q}_2 \geq q_2^*$ denote the expectation of $\tilde{Q}_2$. Our assumption that a firm's marginal revenue is convex in the other firm's output and the fact that marginal revenue is decreasing in Q_1 imply that $Q_1 \geq R_1(Q_2^e)$. This inequality, together with $Q_2^e \geq R_2(Q_1)$, implies that $Q_1 + Q_2^e \geq q_1^* + q_2^*$ (see figure 1). Last, because the industry profit function is concave in total output, the upper bound on industry profit, which presumes production efficiency, satisfies $\mathscr{E}[P(Q_1 + \tilde{Q}_2)(Q_1 + \tilde{Q}_2) - c_1(Q_1 + \tilde{Q}_2)] \leq P(Q_1 + Q_2^e)(Q_1 + Q_2^e) - c_1(Q_1 + Q_2^e) \leq P(q_1^* + q_2^*)(q_1^* + q_2^*) - c_1(q_1^* + q_2^*)$. Hence, industry profit is smaller, and so is the profit of U_1-D_1. *Q.E.D.*

Proof of Proposition 3. In equilibrium U_1 produces internally q_1^* and offers to supply q_2^* to D_2 at price $t_2^* = c_2 q_2^*$. U_2 does not supply. The proof is essentially that of proposition 2. The only possible point of departure comes from the fact that U_2 "supplies" D_2 internally instead of externally. But this makes no difference for the proof that U_1-D_1 cannot raise its profit because D_2 can already buy at marginal cost c_2 from U_2 under PI_1. We only have to check that U_2-D_2 cannot raise its profit by making an alternative offer to D_1. Suppose it does so. Because D_1 and D_2 can purchase internally at marginal cost, we have $Q_1 \geq R_1(Q_2)$ and $Q_2 \geq R_2(Q_1)$ (the case of random $\tilde{Q}_1$ and $\tilde{Q}_2$ is solved as in proposition 2). Thus industry profit can only be lower than the one obtained in proposition 3. It thus suffices to check that even if U_2 changes its contract offer to D_1, which was to supply at marginal cost c_2, still U_1-D_1 can guarantee itself $V^{FI}(c_1, c_2)$ (gross of the efficiency loss). To see this, note that if $Q_2 > R_2(Q_1)$, it is unprofitable for U_2 to supply D_2 any positive amount internally, and so $Q_2 = q_2^*$; but then U_1-D_1 can get $V^{FI}(c_1, c_2)$ by not buying from U_2 and producing q_1^* internally. On the other hand, if $Q_2 = R_2(Q_1)$, $Q_2 \leq q_2^*$ because $Q_1 \geq R_1(Q_2)$ (see figure 1) and again U_1-D_1 can get $V^{FI}(c_1, c_2)$. Hence, U_2-D_2 cannot gain by offering a different contract to D_1. *Q.E.D.*

Proof of Proposition 4. Consider the following strategies: U_2 offers to sell at marginal cost c_2 to D_1 up to q^*. Thus $t_{21}(q_{21}) = c_2 q_{21}$ for

$q_{21} \leq q^*$, $= +\infty$ for $q_{21} > q^*$. U_1 offers to sell q^* at price t^* to D_2 (where q^* and t^* are as in proposition 1). U_1 offers to sell either q^* at price t^* or q_{11} at price $t_{11}(q_{11}, q^*) = r(q^*, q^*) - r(q^* - q_{11}, q^*)$ to D_1 if D_1 can exhibit total output $\hat{Q}_1 \geq q^*$. In equilibrium D_1 buys q^* at price t^* from U_1.

Note that U_1 simply offers to make up the difference to q^* if D_1 does not buy q^* from U_2. First, we show that D_1 cannot increase its profit. From the definition of t_{11}, if D_1 buys $q_{21} \leq q^*$ from U_2, then D_1 has the same profit whether it buys the complement to q^* from U_1 or not. Its profit is thus $r(q_{21}, q^*) - c_2 q_{21} \leq r[R_2(q^*), q^*] - c_2 q^* = D^{NI}(c_1, c_2)$ (by definition of R_2). Second, the proof that U_1 cannot make more than $U^{NI}(c_1, c_2)$ is the same as that in proposition 1: U_2 and D_2 are now integrated, but U_2 continues to supply D_2 at marginal cost c_2.

The third and most difficult part of the proof consists of showing that U_2-D_2 cannot make more than $D^{NI}(c_1, c_2)$. Suppose that U_2 makes a different contract offer to D_1. Suppose first that there exists no (q_{21}, t_{21}) in the new contract, such that $r(q_{21}, q^*) - t_{21} > D^{NI}(c_1, c_2)$. Then specify that D_1 turns down U_2's contract offer and buys q^* from U_1, and that D_2 also buys q^* from U_1 and does not produce internally. This is clearly a continuation equilibrium, and it gives the same profit to U_2-D_2 as before. Thus assume that there exists (q_{21}, t_{21}) such that $r(q_{21}, q^*) - t_{21} > D^{NI}(c_1, c_2)$. The definition of $D^{NI}(c_1, c_2)$ implies that U_2-D_2 does not make money on the trade because $t_{21} \leq c_2 q_{21}$. Suppose $q_{21} \leq q^*$ and then specify that D_1 buys q_{21} at price t_{21} from U_2 and buys $q^* - q_{21}$ at price $t_{11}(q^* - q_{21}, q^*)$ from U_1, and that D_2 buys q^* at price t^* from U_1 and does not produce internally. Again, this continuation equilibrium yields at most $D^{NI}(c_1, c_2)$ to U_2-D_2. Or suppose $q_{21} > q^*$, and assume that in equilibrium D_1 buys q_{21} from U_2 (the case of a random strategy for D_1 is treated as in proposition 2). Then D_1's total output $Q_1 \geq q_{21}$ and the profit of U_2-D_2 is at most $\max_{Q_2}[r(Q_2, q_{21}) - c_2 Q_2] \leq r[R_2(q^*), q^*] - c_2 R_2(q^*) = D^{NI}(c_1, c_2)$. Buying q^* from U_1 is not a best response to Q_1 as it yields $r(q^*, Q_1) - t^* = r(q^*, Q_1) - r(q^*, q^*) + D^{NI}(c_1, c_2) < D^{NI}(c_1, c_2)$. We thus conclude that U_2-D_2 cannot increase its profit beyond $D^{NI}(c_1, c_2)$.

Q.E.D.

Appendix B: Uniqueness in the Ex Post Monopolization Variant

We look at (perfect Bayesian) equilibria in the following class:

Restriction 1. The equilibrium is in pure strategies.

Restriction 2. Market-by-market bargaining: when a downstream firm, D_k, receives an out-of-equilibrium offer from an unintegrated upstream firm, U_i, it does not change its beliefs about U_i's offer to $D_\ell (\ell \neq k)$.

Restriction 3. No-money-losing offers: an unintegrated firm does not make an offer at a price below marginal cost—that is, one that would lose money if accepted; $t_{ij}(q_{ij}, \hat{Q}_{ij}) \geq c_i q_{ij}$ for all i, j, q_{ij}, and $\hat{Q}_{ij}$.

Let us comment on restrictions 2 and 3. Restriction 2, although not implied by perfect Bayesian equilibrium, is a natural one. An unintegrated U makes secret and independent offers to two downstream firms and tries to extract the best deal from each of them. Because there is no information leakage from one customer to the other, the unintegrated U has no incentive to change the offer to D_ℓ when it changes its offer to D_k (and indeed equilibrium behavior requires that it does not do so if its offer to D_ℓ is uniquely optimal). No such restriction can be imposed for an integrated U. When it changes its offer to its subsidiary's rival, it also wants to change its supply to its subsidary, with whom it shares profit.

Given restriction 2, restriction 3 is in the spirit of trembling-hand perfection of not allowing a player to play a weakly dominated strategy.[52] An offer that contains a money-losing pair is worse for U than the same offer without it if there is a small probability that the downstream firm chooses this money-losing pair.[53]

The equilibria described in the discussion of the ex post monopolization variant satisfy restrictions 1 through 3.

PROPOSITION A: *Under NI, FI, PI_1, M_u, M_d, and M_{ud} there exists a single perfect Bayesian equilibrium satisfying restrictions 1 through 3.*

Under PI_2 the equilibrium described in proposition 4 is undominated in the set of perfect Bayesian equilibria satisfying 1 through 3. Fur-

52. Selten (1975).

53. One might think that including the money-losing pair could act as a "sunspot" and induce the downstream firm to choose from among the non-money-losing pairs the one that U prefers. However, this selection can also be made directly by U by offering a single best pair to the downstream firm.

thermore, any other equilibrium satisfying 1 through 3, if one exists, has U_2 supplying at a loss to D_1, and D_1 producing more than q^*, and the integrated firm U_2-D_2 making less profit than in the equilibrium of proposition 4.

We have been unable to prove or disprove uniqueness in the class considered under PI_2. But if other equilibria exist, they are somewhat pathological: U_2 supplies at a loss its subsidiary's rival. Such behavior might be plausible if D_1 bought from U_2 a quantity less than q^* and bought nothing from U_1. However, D_1 ends up buying more than q^*, the amount it buys from U_1 in the equilibrium of proposition 4.

PROOF OF PROPOSITION A. Let q_1 and q_2 denote the final outputs of D_1 and D_2, and let q_{ij} be U_i's supply to $D_j(q_j \equiv q_{1j} + q_{2j})$.

NONINTEGRATION. Under market-by-market bargaining (restriction 2), U_1 and U_2 are competing à la Bertrand for each D_j separately. For instance, D_1's beliefs about q_2 are fixed in a given equilibrium and do not depend on U_1's and U_2's offers to D_1. U_1's best offer is then trivially the best reaction $R_1(q_2)$ to q_2, at the highest price such that D_1 does not want to buy from U_2. And symmetrically for D_2. Hence the equilibrium outputs are $q_1 = q_2 = q^*$ and the transfers to U_1 equal t^*, where q^* and t^* are given in proposition 1.

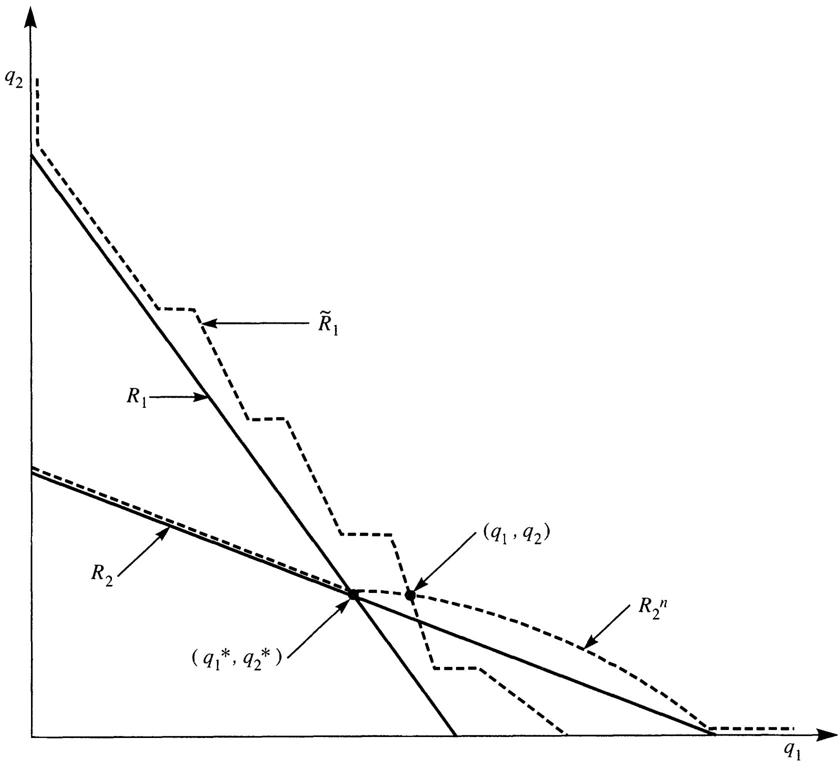
FULL INTEGRATION. Because integrated downstream firms can procure internally at marginal cost, $q_i \geq R_i(q_j)$, aggregate profit, gross of integration cost, $\pi_1 + \pi_2$, satisfies $\pi_1 + \pi_2 \leq r(q_1^*, q_2^*) + r(q_2^*, q_1^*) - c_1(q_1^* + q_2^*)$, with equality only if $q_1 = q_1^*$ and $q_2 = q_2^*$; that is only if $q_1 = R_1(q_2)$ and $q_2 = R_2(q_1)$. It thus suffices to show that U_1-D_1 can guarantee itself $\pi_1^* \equiv r(q_1^*, q_2^*) - c_1q_1^* + (c_2 - c_1)q_2^*$, and that U_2-D_2 can guarantee itself $\pi_2^* \equiv r(q_2^*, q_1^*) - c_2q_2^*$. If this is so, the equilibrium outputs and profits are as in proposition 4.

Suppose that firm U_1 offers to supply D_2 up to q_2^* at price $t_{12}^n(q_{12})$, where

$$t_{12}^n(q_2^*), = c_2q_2^*,\ t_{12}^n(q_{12}) < c_2q_{12} \text{ and } \lim_{n\to\infty} t_{12}^n(q_{12}) = c_2q_{12}$$

for $0 < q_{12} < q_2^*$. That is, U_1 offers to undercut U_2 slightly up to q_2^*. Figure 2 exhibits D_2's reaction curve, $R_2^n(q_1)$, coming from the maximization of $r(q_2, q_1) - c_2q_{22} - t_{12}^n(q_{12})$, subject to $q_{12} + q_{22} = q_2$. R_2^n coincides with R_2 for $q_1 \leq q_1^*$ and, for n sufficiently large, is close

Figure 2. Uniqueness under full Integration



to R_2 for $q_1 \geq q_1^*$. Note that $t_{12}^n(\cdot)$ can be chosen so that R_2^n is continuous, which we will assume.

Because U_2 may make an offer to D_1, the reaction curve $\tilde{R}_1(q_2)$ of D_1 is obtained by solving

$$\max[r(q_1, q_2) - c_1 q_{11} - t_{21}(q_{21}, \hat{Q}_{21})],$$

$$\text{subject to} \begin{cases} q_{11} + q_{21} = q_1 \\ q_1 \geq \hat{Q}_{21} \end{cases}$$

where we adopt the convention that $t_{21}(0, \cdot) = 0$. ($\hat{Q}_{21}$ denotes the quantity exhibited to U_2 by D_1.) By the standard revealed preference argument, $\tilde{R}_1(q_2)$, which need not be single-valued, is monotonic (non-increasing). Furthermore $\tilde{R}_1(q_2) \geq R_1(q_2)$ because D_1 can always refrain from buying from U_2. The crucial feature of $\tilde{R}_1$ is that it admits only horizontal jumps. Therefore $\tilde{R}_1$ and R_2^η intersect for some $q_2 \leq q_2^*$ (there may exist several such intersections, but they all share this property); see figure 2. This implies that by buying $q_{21} = 0$, the merged U_1-D_1 can guarantee itself at least π_1^* by offering the above contract to D_2. The reasoning for why U_2-D_2 can guarantee itself π_2^* is symmetrical. It suffices that U_2 offer no contract to D_1.

PARTIAL INTEGRATION PI_1. First note that the no-money-losing-offer assumption implies that in equilibrium $q_1 = R_1(q_2)$. Because the unintegrated U_2 does not supply under marginal cost c_2, and D_1 can procure internally at marginal cost $c_1 < c_2$, firm D_1 only purchases internally and has reaction curve R_1. Next we claim that $q_2 \geq R_2(q_1)$, for if $q_2 < R_2(q_1)$, then U_2 could increase its profit by offering to put D_2 on its reaction curve. More precisely, if q_{12}, q_{22}, $\hat{Q}_{12}$, and $\hat{Q}_{22}$ maximize $r(q_2, q_1) - t_{12}(q_{12}, \hat{Q}_{12}) - t_{22}(q_{22}, \hat{Q}_{22})$, such that $q_{12} + q_{22} = q_2$ and $q_2 \geq \hat{Q}_{12}, \hat{Q}_{22}$, then the contract "$R_2(q_1) - q_{12}$ at price $t_{22}(q_{22}, \hat{Q}_2) + r[R_2(q_1), q_1] - r(q_2, q_1) - \epsilon$" offered by U_2, where ϵ is positive and small, is strictly preferred by D_2 to rejecting the contract and buying from U_1 only, and yields a strictly higher profit to U_2, as is easily checked.

Because $q_1 = R_1(q_2)$ and $q_2 \geq R_2(q_1)$, $q_1 \leq q_1^*$ and $q_2 \geq q_2^*$ and $\pi_1 \leq \pi_1^*$ with equalities if, and only if, $\pi_1 = \pi_1^*$. To show that U_1-D_1 can guarantee itself π_1^*, note that if it offers the schedule $t_{12}^\epsilon(q_{12}) = (c_2 - \epsilon)q_{12}$ for all q_{12} to D_2, where ϵ is small, D_2 will never buy from U_2, which makes no money-losing offer, and has reaction curve $R_2^\epsilon(\cdot)$ converging uniformly to $R_2(\cdot)$ when ϵ tends to 0. Thus as ϵ tends to 0, the Nash equilibrium when $t_{12}^\epsilon(\cdot)$ is offered to D_2 by U_1 converges to (q_1^*, q_2^*). We thus conclude that the unique equilibrium satisfying our restrictions is the one exhibited in proposition 2.

PARTIAL INTEGRATION PI_2. Note first that market-by-market bargaining for U_1 implies that U_1 sells $q_2 = R_1(q_1)$ at price $c_2 q_2$ to D_2. Second, we claim that $q_1 \geq R_1(q_2)$. Otherwise, U_1 would put D_1 on its reaction curve $R_1(q_2)$—again, we invoke market-by-market bargaining. Furthermore, $q_1 = R_1(q_2)$ if $q_{21} = 0$. We thus conclude that either $q_1 = q_2 = q^*$ and U_1 supplies q^* at price $c_2 q^*$ to both D_1 and D_2, or $q_1 > q^* > q_2$ and $q_{21} > 0$. Uniqueness under M_u, M_d, and M_{ud} is straightforward. *Q.E.D.*

Appendix C: Exclusive Dealing

We analyze exclusive dealing in the context of the model of ex post monopolization. We solve the ex ante stage with deterministic costs under exclusive dealing (ED) to point to the essential difference between ED and vertical integration as means of foreclosing markets. In our model, an exclusive-dealing contract between U_1 and D_1 allows U_1 to commit not to supply D_2.

In a nutshell, ED has two drawbacks and one advantage relative to vertical integration. It dominates vertical integration in that it allows firms to remain independent and avoids the incentive loss E. The first drawback, which we will not study but could be represented by a constant loss, K, given our constant-returns-to-scale assumption, is associated with the loss of gains from trade between the upstream firm U_1 and third parties (firms outside the industry). Such a loss occurs either if shipments by U_1 cannot be monitored by D_1 or if arbitrage between third parties and D_2 cannot be prevented. Then the only credible way for U_1 to cease trading with D_2 is if U_1 promises not to trade with anybody but D_1. Second, and more important from the point of view of our model, ED implies production inefficiency. Precisely when U_1-D_1 gain by foreclosing the market ($c_1 < c_2$), ED forces D_2 to buy from the high-cost supplier. Hence under ED, U_1-D_1 loses the profit $(c_2\text{-}c_1)q_2^*$ obtained by selling q_2^* to D_2. Thus, ignoring the cost K of not trading with third parties (for example, if no third party exists), the total profit of U_1 plus D_1 when $c_1 \leq c_2$ is

$$V^{ED}(c_1, c_2) = r(q_1^*, q_2^*) - c_1 q_1^*$$

under ED, and

$$\begin{aligned} V^{PI}(c_1, c_2) - E &= V^{FI}(c_1, c_2) - E \\ &= r(q_1^*, q_2^*) - c_1 q_1^* + (c_2 - c_1)q_2^* - E \end{aligned}$$

under vertical integration.

Now, suppose that costs are deterministic and that $c_1 \leq c_2$. Propositions 3 and 4 imply that U_2 and D_2 have no incentive to integrate whether U_1 and D_1 are integrated or not. It is easy to see that U_2 and D_2 have no incentive to sign an ED contract either. Assuming no exit occurs, the only possible industry structures are NI, PI_1, and ED_1 (ED

contract between U_1 and D_1). The optimal choice for U_1-D_1 between these three structures is given by proposition B.

PROPOSITION B: *Consider the deterministic case in which there are no investments and thus exit does not occur. Assuming $c_I < c_2$, either of the three possible industry structures—NI, PI_I, and ED_I—may be optimal for U_I-D_I, and thus arise. In particular:*

(i) If c_2 is close to c_I, NI is preferred to ED_I by U_I-D_I if the demand function is linear.
(ii) If c_2 is much larger than c_I, ED_I is preferred to NI.
(iii) If E is small, PI_I dominates both NI and ED_I.
(iv) If E is large, PI_I is dominated by both NI and ED_I.

PROOF: (i) Note that $V^{ED}(c_1, c_1) = U^{NI}(c_1, c_1) + D^{NI}(c_1, c_1)$, so U_1-D_1 is indifferent between *NI* and ED_1 in the symmetric case. Raising c_2 above c_1, we obtain from the envelope theorem:

$$\frac{\partial V^{ED}}{\partial c_2} = \frac{\partial r}{\partial q_2} \frac{\partial q_2^*}{\partial c_2} = P'(q_1^* + q_2^*)\, q_1^* \frac{\partial q_2^*}{\partial c_2},$$

while

$$\frac{\partial (U^{NI} + D^{NI})}{\partial c_2} = R_2[q^*(c_1)].$$

Because at $c_2 = c_1$, $q^*(c_1) = R_1(q_2^*) = R_2[q^*(c_1)]$, for linear demand one has

$$\left.\frac{\partial V^{ED}}{\partial c_2}\right|_{c_2=c_1} < \left.\frac{\partial (U^{NI} + D^{NI})}{\partial c_2}\right|_{c_2=c_1}.$$

(ii) Fixing c_1, define $\bar{c}_2$ as the lowest value of c_2, such that $q_2^*(c_2, c_1) = 0$. For $c_2 \geq \bar{c}_2$, ED_1 allows U_1-D_1 to obtain the monopoly profit $\pi^m(c_2)$, while $U^{NI}(c_1, c_2) + D^{NI}(c_1, c_2)$ is bounded away from this monopoly profit (see proposition 1).

(iii) It suffices to show that U_1-D_1 strictly prefers vertical integration for $E = 0$ (by continuity, this will also hold for E = small). That PI_1 strictly dominates *NI* for U_1-D_1 when $E = 0$ results from proposition 2. And $V^{PI}(c_1, c_2) = V^{ED}(c_1, c_2) + (c_2 - c_1)q_2^*$ implies that PI_1 dominates ED_1 when $E = 0$ (for $c_2 < \bar{c}_2$; for $c_2 \geq \bar{c}_2$, ED_1 and PI_1 are equivalent if $E = 0$).

(iv) Trivial (E is incurred only under vertical integration).

Q.E.D.

Appendix D: Proofs of Propositions 5, 6, and 9

Proof of Proposition 5

Proposition 5 is trivial in case ii. From propositions 1 through 4, the gain from integration occurs when $c_i = c$ and $c_j = +\infty$, which has a higher probability for $i = 1$ than for $i = 2$.

To prove the proposition for small uncertainty (case i) we first show that $g(c_i, c_j)$ is decreasing in c_i and increasing in c_j. Using the definition of $g(c_i, c_j)$ and the envelope theorem, we have (for $c_i < c_j$):

$$\frac{\partial g(c_i, c_j)}{\partial c_j} = P'(q_i^* + q_j^*)q_i^* \frac{\partial q_j^*}{\partial c_j} + q_j^* + (c_j - c_i) \frac{\partial q_j^*}{\partial c_j} - R_j[q^*(c_i)].$$

In particular, because $q_j^*(c, c) = R_j[q^*(c)]$,

$$\left.\frac{\partial g(c_i, c_j)}{\partial c_j}\right|_{c_j = c_i} = P'[2q^*(c_i)]q^*(c_i) \frac{\partial q_j^*}{\partial c_j} > 0.$$

Hence, $g(c_i, c_j)$ is increasing in c_j for small uncertainty. Next, we have

$$\frac{\partial g(c_i, c_j)}{\partial c_i} = -q_i^* - q_j^* + [P'(q_i^* + q_j^*)q_i^* + (c_j - c_i)] \frac{\partial q_j^*}{\partial c_i}$$
$$- \left(2P'[2q^*(c_i)]q^*(c_i) \frac{dq^*}{dc_i} - 2q^*(c_i) - P' \{q^*(c_i)\right.$$
$$\left. + R_2[q^*(c_i)]\}R_2(q^*) \frac{dq^*}{dc_i}\right).$$

In particular,

$$\left.\frac{\partial g(c_i, c_j)}{\partial c_i}\right|_{c_i = c_j} = P'[2q^*(c_i)]q^*(c_i) \left[\frac{\partial q_j^*}{\partial c_i} - \frac{dq^*(c_i)}{dc_i}\right] < 0,$$

because $\partial q_j^*/\partial c_i - dq^*(c_i)/dc_i > 0$.

Last, if $\partial g/\partial c_i < 0$ and $\partial g/\partial c_j > 0$, then $G(F_i, F_j) > G(F_j, F_i)$ if F_i first-order stochastically dominates F_j. Because $\partial g/\partial c_j > 0$, then $G(F_i, F_j) > G(F_i, F_i)$. And because $\partial g/\partial c_i < 0$, then $G(F_i, F_i) > G(F_j, F_i)$. *Q.E.D.*

Proof of Proposition 6

The inequality in proposition 6 is an equality in the large uncertainty case. U_i and D_i might suffer from integration by U_j and D_j only if $c_i = +\infty$ and $c_j = c$ (see propositions 1 through 4). But in this case $D_i^{NI}(+\infty, c) = 0$ anyway.

Consider next small uncertainty: as in proposition 5, our strategy is to show that $\ell(c_i, c_j)$ is decreasing in c_j and increasing in c_i for $c_i > c_j$. We have

$$\frac{\partial \ell(c_i, c_j)}{\partial c_j} = P'\{R_i[q^*(c_j)] + q^*(c_j)\}R_i[q^*(c_j)]\,\frac{dq^*(c_j)}{dc_j} - P'(q_i^* + q_j^*)q_i^*\,\frac{\partial q_j^*}{\partial c_j}\,.$$

At $c_j = c_i$,

$$\left.\frac{\partial \ell(c_i, c_j)}{\partial c_j}\right|_{c_i=c_j} = P'[2q^*(c_j)]q^*(c_j)\left(\frac{dq^*(c_j)}{dc_j} - \frac{\partial q_j^*}{\partial c_j}\right) < 0,$$

because $dq^*/dc_j - \partial q_j^*/\partial c_j > 0$, as is easily seen on a diagram. Hence, in the small uncertainty case, $\ell(c_i, c_j)$ is decreasing in c_j. Next,

$$\left.\frac{\partial \ell(c_i, c_j)}{\partial c_i}\right|_{c_i=c_j} = -R_i[q^*(c_j)] + q_i^* - P'(q_i^* + q_j^*)q_i^*\,\frac{\partial q_j^*}{\partial c_i}\,.$$

In particular,

$$\left.\frac{\partial \ell(c_i, c_j)}{\partial c_i}\right|_{c_i=c_j} = -P'[2q^*(c_j)]q^*(c_j)\,\frac{\partial q_j^*}{\partial c_i} > 0.$$

Hence, $\ell(c_i, c_j)$ is increasing in c_i in the case of small uncertainty.

Last, if $\partial \ell/\partial c_j < 0$, then $L(F_1, F_2) < L(F_1, F_1)$. And because $\partial \ell/\partial c_i > 0$, then $L(F_1, F_1) < L(F_2, F_1)$. *Q.E.D.*

Proof of Proposition 9

In the case of large uncertainty,

$$\mathcal{U}_j^{M_d} = \alpha_j(1 - \alpha_i)\pi^m(c) > \mathcal{U}_j^{PI} = \alpha_j(1 - \alpha_i)[2\pi^d(c)],$$

where $\pi^d(c) \equiv r[q^*(c), q^*(c)] - cq^*(c)$ and $\pi^m(c) \equiv \max [r(q, 0) - cq]$.

Suppose that $c_j \leq c_i$. Then

$$\begin{aligned} U^{PI}(c_j, c_i) - U^{M_d}(c_j, c_i) = {} & 2\{r[q^*(c_j), q^*(c_j)] - c_j q^*(c_j)\} \\ & - 2\{r[R_i q^*(c_j)], q^*(c_j)\} - c_i R_i[q^*(c_j)] \\ & - [\pi^m(c_j) - \pi^m(c_i)]. \end{aligned}$$

Keeping c_j constant, let us take the derivative of this expression with respect to c_i at $c_i = c_j$:

$$\left.\frac{\partial[U^{PI}(c_j, c_i) - U^{M_d}(c_j, c_i)]}{\partial c_i}\right|_{c_i = c_j} = 2q^*(c_j) - q^m(c_j) > 0,$$

where we use the fact that in a symmetric Cournot equilibrium, total output exceeds the monopoly output. But $U^{PI}(c_j, c_i) = U^{M_d}(c_j, c_i) = 0$ for $c_j \geq c_i$. Hence, $U^{PI}(c_j, c_i) > U^{M_d}(c_j, c_i)$ for $c_j < c_i$ and $(c_i - c_j)$ small, which proves the result in the case of small uncertainty.

Q.E.D.

Appendix E: War of Attrition and Preemption in the Ex Post Monopolization Variant Merger Game

We assume large downstream investments ($\mathcal{D}_2^{PI} < J$), and small upstream investments so as to focus on downstream monopolization, and show that two polar cases of merger dynamics, *war of attrition* and *preemption*, may arise. If uncertainty is large, a low-cost upstream firm is a monopolist when its rival's cost is high. The low-cost firm's problem is then to commit not to supply both downstream firms. One possibility for commitment is that the low-cost supplier is integrated. Another is that one of the downstream firms has exited. The upstream firm then benefits from downstream monopolization and does not want to rescue a failing downstream firm (proposition 9). In this respect ex ante monopolization by vertical integration resembles a public good. Both upstream firms benefit from it, and each firm prefers the other to trigger downstream exit and incur the integration cost. This suggests the possibility of a war of attrition between the upstream firms. There is a second consideration, however. When both upstream firms' costs are low, the remaining buyer after ex ante monopolization enjoys a monopoly profit on the product market. Obviously, each downstream firm would like to be the one that enjoys this monopoly profit, which suggests that the merger game might resemble a game of preemption. We show by means of symmetric examples that there is indeed a conflict between these two effects. In the relevant range for the integration cost, firms will wage a war of attrition if the integration cost is high, and will try to preempt each other if the integration cost is low, resulting in late and early vertical integration respectively.

Consider, in the ex post monopolization variant, a slight modification of the symmetric, large uncertainty case. Let $c_i = c$ with probability α, and c' with probability $(1 - \alpha)$. Before, we assumed that $c' = +\infty$. Let us assume that c' is slightly smaller than $\bar{c}$, where $\bar{c}$ is the smallest marginal cost, such that the Cournot output of a firm with cost $\bar{c}$ facing a firm with cost c is equal to zero. The purpose of having c' lower than $\bar{c}$ is to allow downstream firms to suffer from integration. Let $q^*(c)$ denote the Cournot output when both firms have cost c. Let

$$\pi^d(c) \equiv r[q^*(c), q^*(c)] - cq^*(c)$$

denote the Cournot profit. And let

$$\pi^m(c) \equiv \max_q \, [r(q, 0) - cq]$$

denote the monopoly profit. In this symmetric example, we drop the subscripts under the expected profit functions. The reader will easily check that the expected profits are:

$$NI\colon\ \mathcal{U}^{NI} = \alpha(1 - \alpha)2[\pi^d(c) - D^{NI}(c, c')]$$

$$\mathcal{D}^{NI} = \alpha^2\pi^d(c) + (1 - \alpha)^2\pi^d(c') + 2\alpha(1 - \alpha)D^{NI}(c, c')$$

$$M_d\colon\ \mathcal{V}^{M_d} = \alpha\pi^m(c) + (1 - \alpha)\pi^m(c')$$

$$\mathcal{U}^{M_d} = \alpha(1 - \alpha)[\pi^m(c) - \pi^m(c')] < \mathcal{V}^{M_d}.$$

(Partial integration is not feasible if, as we will assume, J is sufficiently big. Also, full integration will not occur if c' is close to $\bar{c}$, from propositions 9 and 10.) Because $D^{PI}(c, c') < D^{NI}(c, c')$ (from proposition 2), for any α, there exists J such that $\mathcal{D}^{NI} > J > \mathcal{D}^{PI} = \alpha^2\pi^d(c) + (1 - \alpha)^2\pi^d(c') + \alpha(1 - \alpha)D^{NI}(c, c') + \alpha(1 - \alpha)D^{PI}(c, c')$. Furthermore, a merger implies exit of the unmerged downstream firm. Knowing that $\mathcal{V}^{M_d} > \mathcal{U}^{NI} + \mathcal{D}^{NI}$, let us choose E such that

$$\mathcal{V}^{M_d} - E > \mathcal{U}^{NI} + \mathcal{D}^{NI},$$

so that nonintegration cannot be an equilibrium of the merger game. We must further distinguish two cases.

Case 1: $\mathcal{V}^{M_d} - E - J < \mathcal{U}^{M_d}$. In this case, every firm likes ex ante monopolization, but each would like the other to merge because the integration cost is high. Ex ante monopolization is a "public good." Although our reduced form for the merger game yields two pure-strategy equilibria (U_1 and D_1 merge and U_2 and D_2 merge), in this case the reduced-form representation of the game is inadequate. In real time we would expect a war of attrition. To be more precise, suppose that all payoffs are flow payoffs (as discussed in the description of the merger game), and let e denote the flow equivalent of the integration cost at rate r: $e = rE$. Case 1 can then be described by $\mathcal{V}^{M_d} - e - J < \mathcal{U}^{M_d}$.

In the symmetric equilibrium of the war of attrition, each U_i-D_i randomizes between integrating and not integrating at each instant, conditionally on no one having merged yet. That is, if the game takes place on $[0, +\infty)$, the probability of integration by U_i and D_i between t and $t + dt$ conditional on no merger having yet occurred is xdt, where x is given by

$$x\left[\frac{\mathcal{U}^{M_d} - (\mathcal{V}^{M_d} - e - J)}{r}\right] = (\mathcal{V}^{M_d} - e) - (\mathcal{U}^{NI} + D^{NI}).$$

The left-hand side represents the benefits of not integrating times the per-unit-of-time probability that the rival integrates, and the right-hand side denotes the gain from monopolizing the industry. The war of attrition is shorter (x is larger) when the integration cost is larger.

Case 2: $\mathcal{V}^{M_d} - E - J > \mathcal{U}^{M_d}$. In this case, each firm prefers to be the one that triggers ex ante monopolization. Again, the reduced-form representation of the merger game is not adequate. In real time the game would resemble a preemption game, and rent dissipation would occur. To see this, suppose that the game is played in continuous time, with the payoffs standing for flow payoffs; thus case 2 corresponds to $(\mathcal{V}^{M_d} - J - \mathcal{U}^{M_d})/r > E$. Assume that the market opens at date 0, but mergers can occur before date 0. We claim that some U_i-D_i merges at date $-T$ (triggering D_j's exit), where T is such that U_j and D_j are indifferent between preempting U_i-D_i by merging at $-(T + \epsilon)$ and letting U_i-D_i preempt:

$$-E + e^{-rT}\left(\frac{\mathcal{V}^{M_d} - \mathrm{J} - \mathcal{U}^{M_d}}{r}\right) = 0.$$ [54]

In equilibrium, the firms' profits from ex ante monopolization are dissipated through wasteful early integration.

Appendix F: Proof of Proposition 20

We argued in the text that, if $\beta P(\overline{Q})(\overline{q}_1 - \overline{q}_2) > E$, it is a dominant strategy for U_1 and D_1 to merge. What is the response of U_2 and D_2? If $\beta P(\overline{Q})\overline{q}_2 > E$, then propositions 16 and 18 tell us that, given that D_2 invests, U_2 and D_2 will prefer to merge. Hence either U_2 and D_2 will integrate or D_2 will exit, depending on whether $P(\overline{Q})\overline{q}_2 - J - E \gtrless (1 - \beta')\,[P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1]$. The left-hand side of this inequality represents the profits of U_2 and D_2 if they merge, while the right-hand side represents U_2's profits if D_2 exits; it is easy to see that if the left side is less than the right, D_2 will choose to exit.

On the other hand, if $\beta P(\overline{Q})\overline{q}_2 < E$, and if partial integration is viable, that is, $\beta P(\overline{Q})\overline{q}_2 > J$, then U_2 and D_2 will not merge. However, if $\beta P(\overline{Q})\overline{q}_2 < J$, then U_2 can either let D_2 exit and make profit $(1 - \beta')\,[P(\overline{Q})\overline{Q} - P(\overline{q}_1)\overline{q}_1]$ or rescue D_2 by a merger and make profit $P(\overline{Q})\overline{q}_2 - J - E$. U_2 will choose whichever strategy is more profitable.

Consider next the case $\beta P(\overline{Q})(\overline{q}_1 - \overline{q}_2) < E$. Now the decision of U_1 and D_1 to merge will depend on the response of U_2 and D_2. A

54. See Fudenberg and Tirole (1985) for a similar treatment in the context of the adoption of a new technology and for a full description of the equilibrium strategies.

comparison of V_1^{FI} and $U_1^{NI} + D_1^{NI}$ shows that, given condition 9, U_1 and D_1 will only merge if U_2 and D_2 remain separate, with D_2 possibly exiting. In fact we know from condition 6 that D_2's exiting is a sufficient condition for U_1 and D_1 to merge. On the other hand, if D_2 remains independent and continues to invest, U_1 and D_1 will merge if, and only if, $\beta P(\overline{Q})\overline{q}_1 > E$, because this guarantees that U_1-D_1's profits are higher under partial integration than under nonintegration. This yields case C.

Q.E.D.

Comments and Discussion

Comment by Dennis W. Carlton: Hart and Tirole have written a very clever paper to show how vertical integration can be privately desirable yet socially undesirable. Even though the paper is difficult, it is certainly valuable because vertical foreclosure is an important issue in antitrust enforcement. The authors use a very general model and make a lot of assumptions (or avoid making assumptions) and that means it is difficult for them to get their results simply. In some sense, they may make more work for themselves than they have to.

I discuss three main topics. First, I discuss how to formulate the game that the firms play and suggest ways that vertical integration can influence that formulation. Some of these ways are not analyzed directly by Hart and Tirole, but they could be especially important and have direct effects for the problem analyzed.

Second, I discuss some standard motives for vertical integration that are specifically abstracted from in the paper. These motives have a tremendous effect on how one interprets the results of the paper—in particular, the authors' suggestions about when the anticompetitive effects of vertical integration would be most severe.

Finally, I conclude with comments on the authors' empirical examples of vertical integration.

Model Formulation

In the model there is duopoly at the upstream and downstream stages. Therefore to make any progress, one must specify the game played at each stage in both the integrated and nonintegrated cases. I am always uncomfortable when the strategy space is specified because it is often not obvious. Is it Bertrand in prices? Is it Cournot in quantities? If the point of a paper is to show that something is theoretically possible—for example, that socially undesirable vertical foreclosure could occur—then the paper is interesting only as long as the strategy space is not too outlandish. If the point of a paper is to show that foreclosure is not only theoretically possible but actually occurs and if the paper will be used for policy recommendations, then it matters very much what the strategy space is. I am especially wary when I know that the results may change significantly if there are changes in the strategy space.

To illustrate my point regarding sensitivity of results, I will use a paper by Ordover, Salop, and Saloner to which Hart and Tirole refer. In that paper foreclosure occurs if there is Bertrand competition but not if there is Cournot competition. Hart and Tirole criticize the authors for assuming that firms can make certain binding commitments, and Hart and Tirole obtain their results in a more general strategy space than Ordover, Salop, and Saloner. But commitments may possibly be made in more complicated ways than the models of Hart and Tirole allow. Their results would change dramatically if such commitments were allowed and, as in the paper by Ordover, Salop, and Saloner, would depend on whether the game is Bertrand or Cournot.

The theoretical results on vertical foreclosure depend critically on assumptions about strategies and commitments that I find hard to validate empirically. I am left in the undesirable situation of understanding the theoretical possibility of socially undesirable vertical foreclosure, but not being able to identify it when I see it.

Hart and Tirole emphasize that their approach, in contrast to that of others, relies on commitments that are credible. This is a virtue of their paper. However, vertical integration can enable a firm to make many more commitments than the ones Hart and Tirole analyze. The ability to make such commitments will influence outcomes and thereby influence the incentive to engage in vertical integration.

Let me explain how vertical integration can affect the credibility of a commitment. Vertical integration can eliminate opportunism and thereby allow greater specialization of assets to occur. When specialization occurs, products can be more idiosyncratic and can be more differentiated. If products become more differentiated, the force of Bertrand competition can be lessened. Therefore, vertical integration can be a way for firms to commit not to produce identical products, which would be beneficial to them because it would lessen competition.

A second commitment from vertical integration is also related to specialization. If the upstream product produced by the vertically integrated firm becomes more specialized, it may not be as useful to an unintegrated firm. In fact, if the integrated firm chose to, it could make the input useless to the unintegrated firm. Therefore, vertical integration is a way in which the integrated firm can create a credible commitment that it will not supply an unintegrated firm.

Finally, there are situations in which a rival will not rely on a competitor to supply its product. Customers interested in obtaining a second source often want to make sure that it has a supply completely separate from that of the first source. This is another way in which vertical integration could result in a commitment not to supply.

When Anticompetitive Foreclosure Is Likely to Occur

There are two standard reasons, not discussed in the paper, for vertical integration. One has to do with variable proportions and the other with double markup. Hart and Tirole eliminate these reasons by assuming the possibility of two-part tariffs. It is proper for them to ignore the standard reasons because they focus on the incentive to integrate vertically that arises solely from strategic considerations related to foreclosure. In terms of logic, what they are doing is perfectly reasonable.

But if the relevance of their results for policymaking is to be considered, these standard reasons must be taken into account because two-part tariffs may not be in use, and price may exceed marginal cost. Any time an input supplier is charging a downstream firm a price different from marginal cost, there are incentives for vertical integration to eliminate the double markup or, if there are variable proportions, to induce efficient input ratios of capital and labor. Hart and Tirole suggest that policymakers should be especially alert to anticompetitive foreclosure when vertical integration occurs and one of the firms is especially efficient. But this is precisely the situation in which efficiency gains from vertical integration are greatest because price exceeds marginal cost and there are variable proportions or a double markup.

Therefore, I would take exception to their recommendation that the burden of justifying a vertical merger should be borne by the merging firms if one of the merging firms is especially efficient. First, as I have explained, it is not clear that the anticompetitive harm, compared with the efficiency gains, is greatest when one of the integrating firms is very efficient. Second, shifting the burden of justifying a merger onto the merging parties may be counterproductive. Suppose a vertical merger will create efficiencies. I have little faith that economists can always convince a government enforcement agency ex ante of efficiencies. Enforcement agencies are thus appropriately skeptical when they see such demonstrations. Shifting the burden, as Hart and Tirole suggest, could result in fewer efficient vertical mergers.

Empirical Examples

Most theoretical models stress asymmetries of cost and information among firms. Yet these asymmetries appear to play no role in the empirical discussion of this paper. Moreover, all the theoretical models assume that two-part tariffs are used. Were two-part tariffs used in any of the empirical cases studied here?

Comment by Oliver E. Williamson: This paper works out of an incomplete contracting setup, broadly in the spirit of Grossman and Hart (1986). Because the modeling of incomplete contracting is a formidable task, simplification is greatly needed. Simplification is accomplished by focusing on competition and exchange between two successive stages of production, both of which are organized as duopolies.

That the analysis of even a successive duopoly is complicated is borne out by the length of the paper. Indeed, keeping the three variants of the authors' model straight puts a real burden on the reader. That, however, is in the nature of the problem. They have done all that can be reasonably expected to relieve these burdens by their meticulous procedure. Their comparison and contrast of their treatment with the recent literature reveals, I think, the advantage of addressing the issues on their terms.

Nevertheless, I have two reservations. First, and most important, the public policy tone of the paper seems wrong. Second, the way the authors characterize the benefits and costs of integration (effects of market power aside) are restrictive.

Antitrust analysis and enforcement have come a long way from the 1960s. Then, possible economies associated with new forms of organization (vertical, horizontal, and conglomerate mergers and nonstandard forms of contracting) were held in low regard, and monopoly power was ascribed to market shares, even small shares, in what were often contrived definitions of relevant markets. Although some would contend that the pendulum has swung too far, the excesses of the 1990s are to be preferred to those of the 1960s. One of the reasons for the improvement is that antitrust enforcement in the 1990s is much more informed by the relevant economic theories.

Hart and Tirole inform and refine our understanding of the tradeoffs posed by vertical integration. I would urge, however, that applications of their results be restricted to circumstances that closely approximate those of the model. Their use of the model to interpret the reorganization of the cement industry in the 1960s suggests wider scope for the model and a more elastic approach to public policy than I believe is appropriate.

Their model examines consequences for market power and efficiency arising from vertical mergers between successive duopolists. Although the qualitative effects the authors display arguably apply outside these very special circumstances, concerns about monopoly power are nonetheless attenuated as the number of firms increases or as entry becomes easier. If nontrivial market power indicia need to be exceeded before antitrust enforcement resources are properly mobilized, which is surely judicious, then the first question is whether the cement industry crossed the threshold. That the conditions of concentration and entry at both the cement and ready-mixed stages in relevant geographic markets exceeded the threshold is not demonstrated and is, I think, doubtful.

Hart and Tirole propose that the scarce needs variant of their model is the one applicable to cement. They aver in this connection that the "bottleneck seems to have been the downstream industry." A striking feature of the cement industry in the 1960s, however, is that there was significant excess capacity.[1] Possibly that excess was less in the ready-

1. Allen (1971).

mixed stage than in the manufacture of cement. There is no indication whatsoever, however, that the bottleneck was constraining. Furthermore, temporary bottlenecks that are easily relieved by low-cost entry—possibly financed by efficient upstream cement suppliers who are the intended victims of ready-mixed firm foreclosures—are scarcely constraints at all.

But so what? The hazard is that the elastic use of the model by the authors encourages the even more expansive use of it by others, especially those directly involved in enforcing antitrust laws. If such uses are not what Hart and Tirole intend, then they should restrict their applications to circumstances that more closely approximate the conditions of the model, as is arguably the case for the other two examples that they discuss.

My second concern is that the paper by Grossman and Hart (1986) out of which Hart and Tirole work characterizes the efficiency gains and losses from vertical integration in a very special way. Specifically, Grossman and Hart (and Hart and Tirole) assume that managers of firms and of divisions are compensated very similarly—namely, that they appropriate the net receipts of the stage of production to which they are assigned. Thus these managers face high-powered incentives. The source of the efficiency gains and losses of vertical integration under this setup turn entirely on the different ex ante investment distortions that alternative forms of ownership induce.

That is an important result. As I have argued elsewhere, however, the managers of internal divisions do not face the same high-powered incentives as the owners of independent firms: these internal incentives are more easily corrupted, internal organization has access to control instruments that are superior to the market, the deliberate attenuation of incentives promotes easier and better ex post bilateral adaptation.[2] An important contributing factor to these differences between market and hierarchy is that each mode faces a different system of contract law. The courts treat disputes over prices, quality, delays, and so forth that arise between firms differently than they do identical disputes that arise within firms. They will routinely hear the former, but they refuse to give standing to the latter. In effect, the rule of law that applies to internal disputes (of an instrumental kind) is that of forbearance.[3] That

2. Williamson (1985, chap. 6); and Williamson (1988).
3. Williamson (1990).

is why fiat is an important instrument for dealing with internal disputes and distinguishes internal from market organization, earlier claims to the contrary notwithstanding.[4]

The upshot is that the efficiency gains and losses of vertical integration are different from those that Hart and Tirole address. Specifically, the main efficiency trade-off with which vertical integration needs to be concerned is between incentive intensity (where market procurement enjoys the advantage) and bilateral adaptability (where the advantage accrues to internal organization as a condition of bilateral dependency builds up). Possibly these efficiency features will play out very similarly to those of concern to Hart and Tirole when examined in a combined market power–efficiency framework. That, however, is conjectural.

In any event, it has long since been conceded that the die-hard branch of the Chicago School erred on the pure logic of vertical integration and vertical market restrictions: there really can be anticompetitive effects.[5] Although new demonstrations of the die-hard error may add to our understanding, the instinct that antitrust should proceed in the vertical area with great caution is not upset. In the degree to which an elastic application of new models encourages an expansive antitrust enforcement program, errors of excess are certain to result. That is easily avoidable by applying the lessons of the new models in carefully delimited ways.

General Discussion: Many of the participants commented on the assumptions underlying the authors' models. Daniel Spulber emphasized the important contribution made by the Hart-Tirole model. He noted that the model assumes barriers to entry and exit and said that in the absence of such barriers, there is the possibility of entry of efficient competitors who will supply the downstream firm that is left out after

4. Alchian and Demsetz (1972).

5. The term die-hard Chicagoan is that of Richard Posner, who defines such a person as one "who has not accepted any of the suggested refinements of or modifications in Director's original ideas" (Posner, 1979, p. 932). Posner is somewhat reluctant to grant that vertical integration could disadvantage rivals but concedes in a footnote that capital costs would be adversely affected (p. 936) and subsequently elevates this admission to the text (p. 945). For a more expansive discussion of this and other possible costs of vertical integration, see Williamson (1974, pp. 1456–63).

a vertical merger occurs. The model also assumes that the strategies of downstream firms are exogenous. Spulber commented that after a vertical merger, the manner in which downstream firms compete might change, which would affect any evaluation of vertical mergers. Spulber also noted that the model used constant returns to scale, and he speculated that if economies of scale existed, monopoly gains from vertical mergers might be even greater.

Michael Salinger praised the model because it allowed two-part tariffs and relaxed assumptions about contracts. He noted, however, that the perfect two-part tariffs that result from the model could not exist under any reasonable set of assumptions. According to Salinger, allowing for perfect two-part tariffs eliminates the success of markup as an issue in vertical integration.

Steven Salop believed that the model was much better than the traditional one of the Chicago School. The Chicago School critique of vertical integration—that no monopoly power could be gained through a vertical merger—was based, he said, on an overly simple model (with fixed proportions, constant returns, and so forth). Salop also noted that Hart and Tirole built a model in which the players are psychologically, legally, and informationally unable to make commitments. Though he believed that contract law made it possible to make and enforce commitments, he was pleased that the authors were working out the implications.

Michael Whinston said that once it is acknowledged that vertical structures involve multilateral supply relations and that there are incomplete contracts, there will be ex post externalities. There will be a difference between what is privately optimal and what is socially optimal, which means that the parties left out of a vertical merger—the other competitors and the consumers—might be hurt by it.

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