Option Contracts and Vertical Foreclosure

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A model of vertical integration is studied. Upstream firms sell differentiated inputs; downstream firms bundle them to make final products. Downstream products are sold as option contracts, which allow consumers to choose from a set of commodities at predetermined prices. The model is illustrated by examples in telecommunication and health markets. Equilibria of the integration game must result in upstream input foreclosure and downstream monopolization. Consumers may or may not benefit from integration.

1. Introduction

Anticompetitive and welfare effects of vertical mergers have been discussed in a number of recent studies (Hart and Tirole, 1990; Krattenmaker and Salop, 1986; Ordover et al., 1990). This interest has been inspired by a set of theories that demonstrate the foreclosure possibility and the potential for higher prices and reduced consumer welfare. The leading theory is aptly explained by the general idea that a vertically integrated firm can "raise rivals' costs," or even prevent rivals from obtaining necessary upstream inputs for producing downstream products. This theory therefore concludes that firms that are vertically related have an incentive to disadvantage rivals by merging.

Clearly, any firm would like its rivals to compete at a disadvantage or be foreclosed altogether; indeed, almost all theories of oligopoly yield better equilibrium profits for monopolies than firms in any other

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market structure.[1] But when firms produce homogeneous goods under the same cost structure (without capacity constraints) and compete in a Bertrand fashion, asymmetry in market power cannot result. If two upstream firms produce intermediate inputs for the downstream market in this symmetric environment, neither one of them can gain any market power over the other. Clearly, a vertical merger between an upstream firm and a downstream firm does not change the symmetry of the environment.[2]

Nevertheless, proponents of the anticompetitive theory of vertical integration have argued that vertical merger enables the integrated firm to introduce an asymmetry in an otherwise symmetric environment. Ordover et al. (1990) were among the first to point out a basic difference between the incentives of a vertically integrated firm and those of the individual firms before the merger. When upstream and downstream firms operate independently, whenever prices are above marginal costs, it is never profit-maximizing for an upstream firm to refuse to sell to a downstream firm. But for a vertically integrated firm, the inputs the upstream division sells to a downstream rival will enable this rival to compete against the integrated firm's downstream division. Thus, the integrated firm's pricing decision to sell to the downstream rival must trade off the increase in profits from sales of upstream inputs against the adverse effect on profits from sales of final goods in a more competitive downstream market. The complete internalization of this calculus within the joint structure actually leads the integrated firm to want to raise the input price to the downstream rival—the raising-rivals'-costs strategy.

Can this strategy be implemented successfully? When the upstream division faces another upstream rival in the symmetric environment, any attempt to raise input prices above marginal costs will be reacted upon by the upstream rival's undercutting them. Thus, in the symmetric environment, the existence of the upstream rival completely constrains the merged firm's ability to raise rivals' costs. Nevertheless, Ordover et al. (1990) suggest that the pricing policy to sell inputs to the (nonintegrated) downstream rival also will be determined together with the merger decision. This makes the integrated firm a Stackelberg price leader in the upstream pricing game. By committing to a high price, the integrated firm allows the nonintegrated upstream supplier

1. One exception is the contrast between monopoly and duopoly allocations in a durable-goods model. See Ausubel and Denekere (1987), Bulow (1982), Gul (1987), and Stokey (1981).

2. A variation of this argument already has led some to make the claim that vertical integration cannot be anticompetitive; see Bork (1978).

to increase its price too. Indeed, Ordover et al. (1990) show that the integrated firm's profit-maximizing strategy is to set the price above the marginal cost, succeeding in raising rivals' costs.[3] Thus, an integrated firm can hurt a nonintegrated downstream firm when integration endows the integrated firm with an ability to commit to a price before the upstream rival decides on its own.[4]

This last point perhaps is most critical of the hypothesis that vertical integration per se can be anticompetitive, especially in an environment that includes an alternative input supply.[5] In addition, in the above analysis, the nonintegrated downstream firm is never completely foreclosed, although it must bear a higher cost to compete in the downstream market.[6] Thus, the rival's cost must not be raised too high, and the earlier analysis is inconsistent with a complete foreclosure phenomenon.

In this paper, I present a model of vertical integration that has *complete* input foreclosure and downstream monopolization in every one of its (pure strategy) equilibria. I do not assume any commitment possibility[7] and show that foreclosure is a *direct* consequence of vertical integration. My model differs from existing ones in a fundamental way: goods in the upstream market are *heterogeneous.* In other words, not only do upstream firms have different production costs, they produce different goods. The existence of an upstream rival does not prevent an integrated firm from raising input price to disadvantage its downstream rival, because the upstream rival cannot supply a perfect substitute.[8]

3. Ordover et al. (1992) contains an extensive form in which the integrated firm and the nonintegrated upstream firm engage in a descending-price auction to determine the price of the input. The equilibrium price in this extensive form turns out to be exactly the price that the integrated firm will commit to in the original model.

4. Hart and Tirole (1990) relaxes the identical costs assumption and does not allow price commitment upon integration. Then the raising-rival's-cost strategy can be implemented, but the price increase is limited to the difference between the integrated firm's and its rival's marginal costs.

5. When the benefits of vertical integration are included [such as those considered in transactions-costs economics and incentive theories (Grossman and Hart, 1986; Williamson, 1989; etc.)], it is even more questionable that vertical integration in a symmetric environment should call for special scrutiny. Furthermore, it also is well known that vertical integration (by successive monopolists) may enhance consumer welfare; the avoidance of the "double marginalization" effect generally represents a source of welfare gain for consumers (Spengler, 1950).

6. If the integrated firm sets the input price too high, the nonintegrated downstream firm will find it profitable to *integrate* with the remaining upstream firm.

7. Nor do I adopt any special interpretation for the price-setting (sub)game between upstream firms; see Ordover et al. (1992) and footnote 3 above.

8. My theory of foreclosure is quite different from the theory of contract as an entry barrier due to Aghion and Bolton (1987). Here, I do not consider penalty contracts. Neither is any firm in my model endowed with an incumbency advantage.

In my model, when a pair of upstream and downstream firms merge, the calculus of their joint-profit maximization dictates that the input price for the rival (which may or may not be vertically integrated) will be increased without limit. This results in foreclosure: the integrated firm in equilibrium refuses to sell to its rival altogether. Although foreclosure must result in the merger games, consumers may or may not benefit from the integration. When firms integrate vertically, upstream prices may rise or fall depending on whether they are strategic substitutes or complements. I show that whether consumers benefit or not from integration is related to this strategic price response by the nonintegrated upstream firm against a merger.

Downstream firms in my model bundle upstream products and sell to consumers the right to buy one from the bundle at specified prices—the *option contract.* When consumers decide to select an option contract from a downstream firm, they are uncertain about the values of consuming the goods allowed in the contract; this is the *ex ante* stage. After they have bought the option contract, they learn these values, and decide on one of the goods to consume; this is the *ex post* stage. Competition in both upstream and downstream markets is modeled in the Bertrand fashion. The distinction between the *ex ante* and *ex post* stages is important for the use of option contracts. It is also important that consumers must purchase option contracts in the *ex ante* stage in order to ensure a final purchase and consumption. These assumptions and that of heterogeneous upstream and homogeneous downstream products can be illustrated by a number of actual markets.

In the fast-growing information on-line service market, a downstream firm may be an on-line service company providing dialup and basic connection services. An upstream firm may be a company that sells information or physical products through the on-line service companies—usually called "add-on" or "premium" services. A consumer may be uncertain about her benefits from premium services at the time when she signs up for the basic connection service—the *ex ante* stage. Upon becoming a member of the network, she becomes familiar with the characteristics of premium services—the *ex post* stage—and only then decides whether to use them. The pricing by on-line service companies is almost identical to what has been described above: the regular connection charge covers the basic service, and any usage of premium services will be charged separately.

In the telecommunication market, downstream firms may be cellular telephone companies providing services to users within the local cell. Upstream firms may be cellular telephone companies in other locations. When a user travels to a location served by another cellular telephone company, she may still use her cellular telephone provided a prior arrangement has been set up by her carrier with that company. Thus, in this example, a distant cellular company (an upstream firm) sells phone services to a local cellular company (a downstream firm). The local company sells an option contract to consumers. Again, the pricing structure covers basic local charge and remote location usage charge.

The model has a strong bearing on the future of the telephone and cable industries. If entries by the telephone companies into the cable television market are allowed, cable and telephone companies will be downstream firms that sell a variety of video, information, and telecommunication products supplied by upstream firms, such as television networks, movie and video companies, and information services. Consumers will pay a basic charge for connection and additional charges for products that are requested on demand. It is possible that deregulation of the local telephone service market will happen in the near future; indeed, in a few states, entrants that mostly serve commercial users have been allowed to compete with the incumbent regional companies. Again, these local service companies will be downstream firms that deliver a variety of telecommunication products supplied by upstream firms such as long-distance carriers or cellular networks.

The model can be related to the health insurance and service industry. In this framework, upstream firms are health-care providers, such as hospitals, nursing homes, and physicians, and downstream firms are insurance companies, or health maintenance and preferred provider organizations (HMOs and PPOs). Upstream firms sell health services to downstream firms, and consumers buy insurance contracts that allow them to use different providers *ex post*. Consumers are assumed to be risk-neutral here. So the model might appear to have ignored the role of risk sharing in the health market. Nevertheless, the model can be interpreted as one in which private employers or public payers (such as Medicare and Medicaid) contract on behalf of their members for prepaid health plans with insurance companies, HMOs, or PPOs. By pooling the health risks of a large group of consumers, the payer may be assumed to be risk-neutral, and the analysis will apply directly. When employers or payers contract for insurance and health services, they are uncertain about the services and providers each consumer prefers to use when she becomes ill.

Besides the examples from the telecommunication and health industries, the model also fits the general properties of ''wholesale purchase clubs,'' which charge their members subscription or entry fees for the right to purchase goods that the clubs offer either via mail or at warehouse shops. The availability of particular kinds of products may not be known when consumers join the clubs, but will be when they make purchases. Upstream firms are the common product manufacturers, and the downstream firms are the club distributors.

The following section sets up the model. A nonintegrated oligopolistic benchmark is derived in Section 3. Following that is an analysis of the vertical merger game, and the description of its equilibria in the asymmetric and symmetric integration subgames. Then I study the welfare properties of equilibrium foreclosure. I construct examples to verify that consumers may or may not benefit from equilibrium integration and foreclosure. The last section discusses some of the assumptions and extensions in the model, and draws some conclusions.

2. The Model

The model consists of two upstream firms, *U*1 and *U*2, two downstream firms, *D*1 and *D*2, and a set of countably infinite number of risk-neutral consumers, whose total mass is normalized to one. The upstream firms produce heterogeneous goods and may sell them to the downstream firms; the constant marginal costs for upstream firm *Ui* are c_i, $i = 1, 2$. A downstream firm combines a unit of an upstream firm's product with a unit of its own homogeneous input, which is produced at zero marginal cost, to make a unit of final product. Inputs from different upstream firms will yield different final products when combined with homogeneous downstream inputs; alternatively, a final, composite commodity that a downstream firm sells to consumers simply consists of one unit of homogeneous downstream product and one unit of one of the upstream products.[9] In any case, there are two final or composite products: a *U*1-*Dj* combination, and a *U*2-*Dj* combination; the former composite commodity will be called good *G*1; the latter, good *G*2.

A consumer's utility function is separable in the utility of the composite good and money. The utility of a unit of *G*1 for a consumer is u. Each consumer's utility from consuming a unit of *G*2 is uncertain initially. This uncertainty is described by identically and independently distributed random variables $\tilde{v}$, each with support $[\underline{v}, \infty)$, and distribution and density functions F and f, respectively.[10] The *ex ante* stage refers to the time periods when a consumer is uncertain about $\tilde{v}$; the *ex post* stage refers to time periods when the realization of each con-

9. Observe that consumers value only the composite products, not the upstream inputs. This rules out the upstream firms selling directly to consumers.

10. The assumption that consumers are only uncertain about the value of one of the final goods is made for convenience. If in fact consumers are uncertain about the values of both goods, then a new random variable describing the uncertainty of the *difference* between these values will be used, and the results of the current model will remain true.

sumer's $\tilde{v}$ is known. Moreover, since there are a countably infinite number of consumers, *ex post* the proportion of consumers with valuations less than or equal to v will be given by $F(v)$.

A consumer will consume one and only one of the two final or composite products, *ex post.* If a downstream firm has purchased (or has secured supplies of) upstream products from both $U1$ and $U2$, it may sell options on composite commodities, *ex ante.* A contract that a downstream firm sells to a consumer *ex ante* may specify one price if the consumer chooses composite commodity $G1$, and another price if she chooses composite commodity, $G2$, *ex post.* Such an *option contract* is represented by (A, B), where A is the price of $G1$, and B, the price of $G2$. If a downstream firm can only supply one composite good, option contracts are infeasible.

Consider an option contract (A, B). If a consumer buys this policy *ex ante,* her net utility from consuming $G1$ *ex post* is $u - A$. If the realization of her $\tilde{v}$ turns out to be v, then her net utility from consuming $G2$ *ex post* is $v - B$. Clearly the consumer chooses $G1$ if and only if $u - A \geq v - B$, or $v \leq u - A + B$. The expected utility from the option contract *ex ante* is therefore

$$\begin{aligned} \mathrm{EU}(A, B) &\equiv F(u - A + B)(u - A) + \int_{u-A+B}^{\infty} (v - B)f(v)\,dv \\ &= F(u - A + B)(u - A) \\ &\quad + \int_{u-A+B}^{\infty} vf(v)\,dv - [1 - F(u - A + B)]B. \end{aligned} \tag{1}$$

If a downstream firm cannot or has decided not to buy one of the upstream inputs, it may not offer option contracts. A simple or nonoption contract offers either $G1$ or $G2$ *ex post* (but not the choice between the two) to consumers at a certain price. A consumer's expected utility from a nonoption contract that sells $G2$ at a price B is written as $\mathrm{EU}(G2; B) \equiv E(\tilde{v}) - B$, where E is the expectation operator.[11] Likewise, a consumer's utility from a downstream firm that sells $G1$ at price A is written as $\mathrm{EU}(G1; A) \equiv u - A$.

Downstream firms compete in the Bertrand fashion. A consumer selects a policy (in the form of an option or a simple contract) from a downstream firm if and only if that policy offers a higher expected

11. The same notation is used for the expected utilities from option and nonoption contracts, but this should not create any confusion. Indeed, a nonoption contract can be regarded as an option contract with an infinite price for selecting the commodity excluded by the nonoption contract.

utility than its rival's policy. If a consumer is indifferent between policies of the two downstream firms, she may choose among these policies according to some probability distribution. Since consumers are identical *ex ante,* a downstream firm may win the entire market if it is able to offer a policy with a higher expected utility for consumers than the rival's policies.

Two industry structures will be studied in this paper. In the first, nonintegration regime, upstream and downstream firms operate independently: upstream firms simply set a price for their products and sell to downstream firms indiscriminately. In the extensive form for this regime, in stage 1, upstream firms $U1$ and $U2$ simultaneously set their respective product prices p_1 and p_2. In stage 2, downstream firms $D1$ and $D2$ simultaneously decide to purchase, or establish an agreement to purchase *ex post,* upstream products from $U1$, $U2$, or both at prices set in stage 1. In stage 3, each downstream firm sets the terms of option (or nonoption) contracts and offers them to consumers. Then, in the *ex ante* stage, each consumer buys one policy from one of the downstream firms. Finally, consumers' valuation of $G2$ becomes known in the *ex post* stage, and each of them decides to consume either $G1$ or $G2$, and pays the corresponding price set forth in her option contract with the downstream firm. Figure 1 illustrates the prices set by upstream firms to downstream firms.

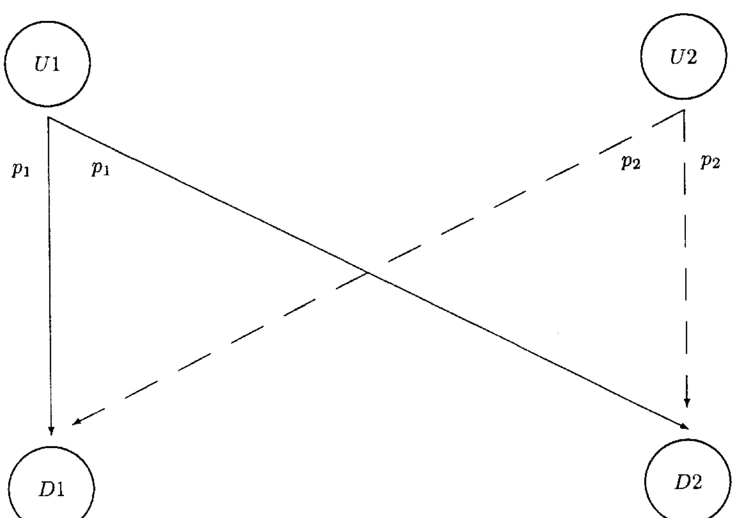

FIGURE 1. COMPETITION UNDER NONINTEGRATION.

In the second regime, an extensive form of integration is used. In stage 1, $U1$ may integrate with $D1$. In stage 2, $U2$ may integrate with $D2$ if and only if $U1$ and $D1$ have merged in the previous stage. Thus, there can be three subgames at the end of stage 2:

- *Nonintegration.* All four firms remain independent.
- *Asymmetric integration.* Only $U1$ and $D1$ have merged.
- *Symmetric integration.* Both pairs of upstream-downstream firms have merged.

In each of these, the continuation game proceeds in the same way as the extensive form in the nonintegration regime, with the exception that an integrated firm's internal transfer price between the upstream and downstream divisions will be set to the marginal cost. That is, under asymmetric integration, the upstream division of the integrated firm $U1$-$D1$ may sell its product to $D2$ at price p_1 while its downstream division may use those inputs at unit cost c_1; in addition, under symmetric integration, the upstream division of $U2$-$D2$ may sell its product to the downstream division of $U1$-$D1$ at price p_2 while $U2$-$D2$'s internal transfer price is c_2. Figure 2 illustrates the pricing structure under asym-

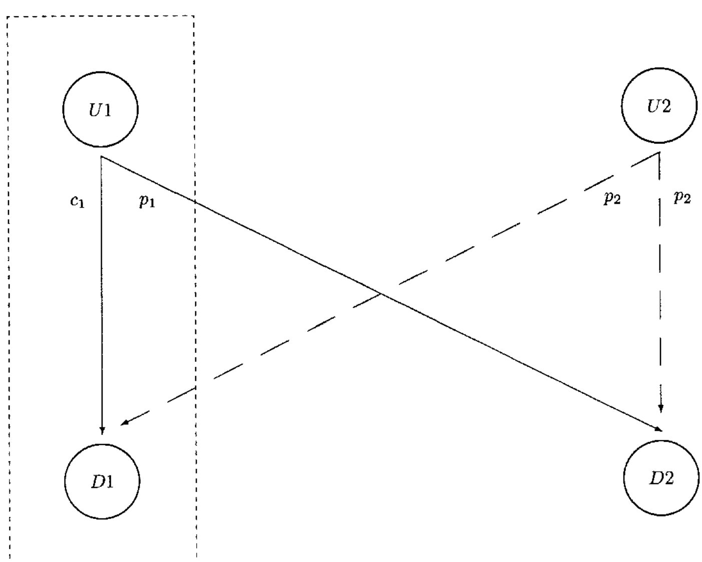

FIGURE 2. ASYMMETRIC INTEGRATION: ONLY $U1$ AND $D1$ HAVE *MERGED.*

metric integration: the dashed box represents the situation that $U1$ and $D1$ have merged. In each of these subgames, after upstream prices have been set, a downstream firm or the downstream division of an integrated firm will buy (or contract to buy) upstream inputs. Subsequently, option (or nonoption) contracts are offered to consumers, each of whom then buys one contract. Finally, consumers' valuations of $G2$ become known to them and the contracts are executed.

It is assumed that, by sharing profits, firms that have integrated can act to maximize their joint profits. Generally, the goal of maximizing the joint profits of vertically related firms may be achieved without a merger; however, information, legal, and contractual difficulties may make the goal unattainable, and a merger may be the only solution. [See Hart and Tirole (1990) for further discussions.] Results in this paper concerning the consequences of vertical integration may apply more generally: they are relevant whenever vertically related firms are able to maximize their joint profits, whether it is through a merger or through alternative contractual arrangements.

The extensive form of the merger game adopts a sequential, perfect-information structure; an alternative form would allow firms to make merger decisions simultaneously. The distinction between the sequential and simultaneous structures does not seem important: upstream and downstream prices will be set only after the merger decisions, whether they have been made sequentially or simultaneously. As a result price strategic effects of vertical integration will be contingent on all possibly merger decisions. The sequential structure does have the advantage of allowing merger as a counterstrategy against a pair of firms merging. Finally, observe that in stage 2 of the integration game, $U2$ and $D2$ are allowed to integrate only if $U1$ and $D1$ have already done so. This is without loss of generality as long as a pair of upstream and downstream firms are always granted the opportunity to react to a merger by merging themselves.[12]

3. Oligopolistic Competition under Nonintegration

In this regime, upstream and downstream firms operate independently. Each upstream firm sets its own price, and sells to both downstream firms. Let p_i be the price of Ui's products, $i = 1, 2$. To supply a unit of

12. In other words, suppose $U2$ and $D2$ may merge in stage 2 even when $U1$ and $D1$ have decided to remain independent, and suppose that $U2$ and $D2$ choose to merge in that event. Then if $U1$ and $D1$ are allowed another opportunity to merge, the original extensive form reemerges with the identities of the corresponding upstream and downstream firms interchanged.

commodity Gi, a downstream firm incurs a cost of p_i, $i = 1, 2$. Without loss of generality, option policies will be rewritten as markups over costs of delivering either $G1$ or $G2$. Thus, facing prices p_1 and p_2, Dj's option policy (A, B) will be rewritten as $(\alpha + p_1, \beta + p_2)$, where α and β represent D_j's markups when selling to consumers. Suppose that all consumers buy this policy *ex ante.* Recall that a consumer who has bought the policy $(\alpha + p_1, \beta + p_2)$ picks commodity $G1$ if and only if $u - \alpha - p_1 > v - \beta - p_2$, where v is the realization of her stochastic valuation $\tilde{v}$ of $G2$. Hence, the probability that $G2$ will be chosen is $1 - F(u - \alpha - p_1 + \beta + p_2)$, and D_j's expected profit from the policy is

$$F(u-\alpha-p_1+\beta+p_2)\alpha+[1-F(u-\alpha-p_1+\beta+p_2)]\beta. \tag{2}$$

Because consumers and firms are risk-neutral, for any set of upstream input prices p_1 and p_2 and an option contract $(\alpha + p_1, \beta + p_2)$, the available surplus between consumers and a downstream firm can be defined as the sum of the expected utilities and profits. An *efficient* option contract is one that maximizes the available surplus given the input prices. Formally, the surplus is defined by

$$\begin{aligned} S(p_1, p_2) \equiv \max_{\alpha,\beta}\, & (u - p_1)F(u - \alpha - p_1 + \beta + p_2) \\ & + \int_{u-\alpha-p_1+\beta+p_2}^{\infty} (v - p_2)f(v)\, dv. \end{aligned} \tag{3}$$

Clearly, the surplus depends only on the *difference* between α and β; their absolute levels settle the division of surplus between consumers and downstream firms. Finally, the surplus between consumers and a downstream firm that can only buy inputs from Ui for good Gi at a price p_i is simply $\mathrm{EU}(Gi; p_i)$. Because a nonoption contract, say, for good $G1$ at price p_1 is a special case of an option contract (with β set at infinity), the surplus from such a nonoption contract $[\mathrm{EU}(G1; p_1)]$ must be strictly less than the surplus from an option contract $[S(p_1, p_2)]$.

The choice between composite commodities will be efficient *ex post* when α and β are set to ensure that $G1$ is selected if and only if $u - p_1 \geq v - p_2$. But consumers decide between $G1$ and $G2$ on the basis of $u - p_1 - \alpha$ and $v - p_2 - \beta$. Thus, the difference between α and β must be set to 0 for efficient commodity selection. The following result, whose proof consists of solving the first-order conditions of (3), states this formally:

Lemma 1: *Any option contract* $(\alpha + p_1, \beta + p_2)$ *that maximizes the surplus* (3) (*equal to the sum of consumers' expected utility* (1) *and expected downstream profit* (2)) *must have* $\alpha = \beta$.

An efficient option contract must set equal markups for the two composite commodities, and acts similarly to a two-part tariff: first, it charges a markup α to a consumer—the entry fee—to sell the option to choose among composite commodities *ex post*; then, the consumer simply pays for the downstream firm's production cost for the chosen composite commodity. It is straightforward to use the envelope theorem to verify that $S(p_1, p_2)$ is continuous and decreasing in its arguments (the upstream input prices). This immediately implies that when consumers must receive a fixed expected utility level, a downstream firm's expected profit decreases with p_i, $i = 1, 2$.

Under nonintegration, both downstream firms have access to upstream products at identical terms (prices p_1 and p_2). Under Bertrand competition, each downstream firm will buy upstream products, competing to offer option policies to consumers *ex ante* at better terms than its rival's.[13] In equilibrium, downstream firms must offer the option policy with the highest expected utility for consumers, and, at the same time, make nonnegative profits. Therefore, in equilibrium a downstream firm must offer an efficient option policy with a zero entry fee: (p_1, p_2), and consumers get the entire surplus $S(p_1, p_2)$. These observations are summarized in the following:

Proposition 1: *Suppose upstream and downstream firms are nonintegrated and operate independently. For any given pair of upstream input prices p_1 and p_2 at U1 and U2 respectively, let $(\alpha^* + p_1, \beta^* + p_2)$ denote the equilibrium policy offered by D1 and D2. Then $\alpha^* = \beta^* = 0$.*

Although Bertrand competition among downstream firms ensures efficient allocations relative to the input prices p_1 and p_2, upstream firms maintain some market power. When *Ui* raises its price to downstream firms above marginal cost c_i $(i = 1, 2)$, it gains by obtaining a higher revenue from those customers who select *Gi ex post*. The cost of raising its price is the reduction of the probability that consumers will pick *Gi*. Proposition 1 implies that this fall in probability of purchase is continuous, so that *Ui* does not lose its entire demand by raising p_i. The equilibrium prices reflect the optimal tradeoff by the upstream firms, as the next proposition shows.

Proposition 2: *Under nonintegration, in equilibrium, upstream firms U1 and U2 set prices at p_1^* and p_2^*, respectively, where*

13. It is not an equilibrium for *Dj* to buy only one of the upstream products. Given such a strategy, its opponent downstream firm will buy both upstream products and capture the entire market.

$$p_1^* - c_1 = \frac{F(u + p_2^* - p_1^*)}{f(u + p_2^* - p_1^*)} > 0, \tag{4}$$
$$p_2^* - c_2 = \frac{1 - F(u + p_2^* - p_1^*)}{f(u + p_2^* - p_1^*)} > 0.$$

Proof. From Proposition 1, given any pair of prices p_1 and p_2 set by $U1$ and $U2$ respectively, the equilibrium policy offered by a downstream firm is (p_1, p_2). Thus, given p_2, $U1$'s expected profit from setting its price to p_1 is

$$(p_1 - c_1)F(u + p_2 - p_1), \tag{5}$$

whose first-order derivative with respect to p_1 is

$$F(u + p_2 - p_1) - (p_1 - c_1)f(u + p_2 - p_1). \tag{6}$$

In equilibrium, $U1$ chooses p_1 to maximize (5), so that the above first-order derivative will vanish. Similarly, $U2$ chooses p_2 to maximize its profit

$$(p_2 - c_2)[1 - F(u + p_2 - p_1)], \tag{7}$$

whose first-order derivative with respect to p_2 is

$$[1 - F(u + p_2 - p_1)] - (p_2 - c_2)f(u + p_2 - p_1). \tag{8}$$

In equilibrium, p_2 will be chosen to make (8) vanish. Let p_1^* and p_2^* denote the equilibrium prices set by $U1$ and $U2$ respectively. Then setting (6) and (8) to zero and simplifying yield (4). □

The equilibrium prices have the standard ''elasticity'' interpretation. Recall that the demand function facing Firm $U1$ is $F(u + p_2 - p_1)$. So the price elasticity is $pf(u + p_2 - 1_1)/F(u + p_2 - 1_1)$. So equation (4) simply says that the ratio of the markup to price is equal to the reciprocal of the elasticity. Even when remaining independent, upstream firms enjoy market power and positive profits because their products are differentiated.[14] What then are the additional incentives for upstream and downstream firms to integrate? The first incentive stems from the fact that under competition each upstream firm sells its goods (inputs for downstream production of composite goods) at a price *above* the marginal cost. If this markup is eliminated, the produc-

14. Allowing upstream firms to price-discriminate in the nonintegration regime would not change the characterization. This is because if in an equilibrium *Ui* is selling to *Dj*, which in turn is able to sell to consumers, *Ui* must use a price best response against the other upstream rival. A symmetric argument establishes that each upstream firm's equilibrium price to a particular downstream firm must be a best response.

tion of the composite good becomes efficient. Certainly, the elimination of the markup will mean a loss of upstream profits. But this will allow the downstream firm to generate a higher surplus. More important is that fact that the extra downstream surplus more than compensates for the loss of upstream profit from the markup, as the next result demonstrates.

Lemma 2: *For any* $p_1 > c_1$ *and any* p_2, $S(c_1, p_2) > (p_1 - c_1)F(u + p_2 - p_1) + S(p_1, p_2)$. *Similarly, for any* $p_2 > c_2$ *and any* p_1, $S(p_1, c_2) > (p_2 - c_2)[1 - F(u + p_2 - p_1)] + S(p_1, p_2)$.

Proof. By straightforward computation,

$$(p_1 - c_1)F(u + p_2 - p_1) + S(p_1, p_2)$$
$$= (u - c_1)F(u + p_2 - p_1) + \int_{u+p_2-p_1}^{\infty} (v - p_2)f(v)\,dv < S(c_1, p_2).$$

The inequality in the above follows from the hypothesis that $p_1 > c_1$ and Lemma 1. The second part of the lemma is proved in the same way. □

Lemma 2 already suggests an *efficiency* reason for vertical integration: the total surplus available to *Ui*, *Di*, and consumers is increased when *Ui* and *Di* merge. Of course, this does not imply that a merger must happen: Lemma 2 keeps constant a rival upstream firm's price. If $U1$ and $D1$ merge, $U2$ generally will charge $D1$ a price different from p_2^*. Indeed, a merger between $U1$ and $D1$ means that $U1$ reduces its price to $D1$ to marginal cost, and $U2$ must react to this. The analysis of this *price effect* of integration is in fact the main objective of the paper. Therefore, it will be useful to determine whether upstream prices under nonintegration are strategic substitutes or complements.

By the implicit function theorem, the derivative of each upstream firm's price reaction function against its rival can be derived:

$$\frac{dp_1}{dp_2} = \frac{g'(u + p_2 - p_1)}{1 + g'(u + p_2 - p_1)}, \tag{9}$$

$$\frac{dp_2}{dp_1} = \frac{h'(u + p_2 - p_1)}{h'(u + p_2 - p_1) - 1}, \tag{10}$$

where $g(v) \equiv F(v)/f(v)$ and $h(v) \equiv [1 - F(v)]/f(v)$ (the reciprocal of the hazard rate). The following results are immediate:

Lemma 3: *Suppose* $g'(v) > 0$ *and* $h'(v) < 0$. *Prices set by the upstream firms in the nonintegration regime are strategic complements, and the derivatives of the price reaction functions are less than one. Suppose* $-1 < g'(v)$

< 0 *and* $0 < h'(v) < 1$. *Prices set by the upstream firms in the nonintegration regime are strategic substitutes, and the derivatives of the price reaction functions are greater than negative one.*

4. Equilibria in Asymmetric and Symmetric Integration

In this section, the equilibria of the asymmetric and symmetric integration subgames will be studied. First, it is necessary to adopt a benchmark assumption:

$$\mathrm{EU}(G1; c_1) > \mathrm{EU}(G2; c_2). \tag{11}$$

Under this benchmark the composite good $G1$ generates a higher surplus than $G2$; the extensive form of the merger game allows the upstream firm that can supply inputs for the superior nonoption contract to integrate first.

As an intermediate step, results on equilibria for subgames in which downstream firms face different input prices are presented. Suppose $D1$ faces input prices p_1 and p_2 but $D2$ faces p_1' and p_2'. The surplus that $D1$ can generate is given by $S(p_1, p_2)$; for $D2$, this is $S(p_1', p_2')$.

Lemma 4: *Suppose $D1$ can generate a higher surplus with input prices p_1 and p_2 than $D2$ with p_1' and p_2': $S(p_1, p_2) \geq S(p_1', p_2')$. In an equilibrium of the subgame when downstream firms offer option contracts to consumers, $D2$ offers the option contract (p_1', p_2'), but makes zero profits. All consumers buy $D1$'s option contract to obtain an expected utility $S(p_1', p_2')$. Downstream firm $D1$ earns a positive profit of $S(p_1, p_2) - S(p_1', p_2')$ by the option contract $(\alpha + p_1, \alpha + p_2)$, where $\mathrm{EU}(\alpha + p_1, \alpha + p_2) = S(p_1', p_2')$. Finally, $D1$'s equilibrium profit is increasing in p_1' and p_2'.*

The proof of this lemma is omitted because it is straightforward. The lemma presents the familiar "limit pricing" result of asymmetric firms competing in the Bertrand fashion: in this model, when downstream firms face different sets of input prices, the firm that can offer the higher expected utility to consumers will capture the entire market by an option contract that just beats its rival's best contract. In equilibrium, the superior firm makes a profit equal to the difference between maximum surpluses it and its rival can generate. This profit takes the form of a uniform markup (α) for the composite commodities. Finally, since the function S is decreasing in its arguments, $D1$ is better off when $D2$ faces higher input prices, since it can offer consumers a lower expected utility but still dominate the market, thereby raising its profit by a higher markup.

4.1 Asymmetric Integration

In an asymmetric integration subgame, $U1$ and $D1$ have integrated but $U2$ and $D2$ decide to remain independent. Under this industry structure, the internal transfer price between the upstream and downstream divisions of $U1$-$D1$ is c_1, and $U2$ sells its products to the downstream division of $U1$-$D1$ as well as $D2$ at a price p_2. A downstream firm or an integrated firm is said to *monopolize* the downstream market if only it can sell (option) contracts to consumers. The following result describes the foreclosure and monopolization equilibrium in this subgame.

Proposition 3: *In an asymmetric integration subgame, the integrated firm $U1$-$D1$ does not sell to $D2$. As a result, the downstream firm $D2$ cannot offer option contracts; neither can it sell its (nonoption) contract for commodity $G2$ to consumers in equilibrium. Consequently, in equilibrium the integrated firm $U1$-$D1$ monopolizes the downstream market.*

Proof. Suppose that $U1$-$D1$ does sell to $D2$ at a price $p_1 \geq c_1$, and that $U2$ sets its price at p_2. Now $D2$ faces input prices p_1 and p_2; the corresponding input prices for the integrated firm $U1$-$D1$ are c_1 and p_2. Because $c_1 \leq p_1$, we have $S(c_1, p_2) \geq S(p_1, p_2)$: $U1$-$D1$ can generate a higher surplus than $D2$. Lemma 4 applies; in particular, $U1$-$D1$'s profits must increase with p_1. Because of this, the price p_1 must increase without bound, and in equilibrium, $U1$-$D1$ does not sell to $D2$ at all.

As a result of $U1$-$D1$ refusing to sell to $D2$, the latter only offers a nonoption contract for $G2$. But because $S(c_1, p_2) > \mathrm{EU}(G2; p_2)$, downstream firm $D2$ cannot sell any nonoption contract for $G2$ to consumers in equilibrium, and $U1$-$D1$ monopolizes the downstream market. □

It remains to characterize the upstream equilibrium prices under asymmetric integration. Since $U1$-$D1$'s internal transfer price is c_1, $U2$'s price must be a best response against this. Thus, $U2$'s equilibrium price $p_2^\dagger$ must be

$$p_2^\dagger = \arg\max_{p_2} (p_2 - c_2)[1 - F(u + p_2 - c_1)]. \tag{12}$$

The following characterization is straightforward to verify:

Proposition 4: *In an asymmetric integration subgame, the equilibrium option contract $U1$-$D1$ offers to consumers is $(\alpha_1 + c_1, \alpha_1 + p_2^\dagger)$, where $\mathrm{EU}(\alpha_1 + c_1, \alpha_1 + p_2^\dagger) = \mathrm{EU}(G2; p_2^\dagger)$. Firm $U1$-$D1$'s equilibrium profit is $\alpha_1 = S(c_1, p_2^\dagger) - \mathrm{EU}(G2; p_2^\dagger)$, and $U2$'s profit is $(p_2^\dagger - c_2)[1 - F(u + p_2^\dagger - c_1)]$. Consumers' equilibrium expected utility is $\mathrm{EU}(G2; p_2^\dagger)$.*

4.2 Symmetric Integration

Under symmetric integration, the internal transfer price within each pair of integrated firms is equal to its marginal cost. The next result shows that in the symmetric integration subgame, the equilibrium downstream market must result in monopolization—consumers will buy option contracts from one and only one of the integrated firms.

Lemma 5: *In an equilibrium of a symmetric integration subgame, either $U1$-$D1$ or $U2$-$D2$ monopolizes the downstream market.*

Proof. It is clear from (11) that $U1$-$D1$ must make strictly positive profits in an equilibrium. Indeed, a feasible strategy for $U1$-$D1$ is to refuse to sell to $U2$-$D2$; in this case, the best contract $U2$-$D2$ can offer consumers is a nonoption contract for $G2$ at its marginal cost c_2. By (11), $U1$-$D1$ can beat $U2$-$D2$'s best offer by selling $G1$ at a price $\alpha + c_1$, where $\mathrm{EU}(G1; \alpha + c_1) = \mathrm{EU}(G2; c_2)$ and $\alpha > 0$, guaranteeing itself strictly positive profits α.

Suppose the lemma is false. Then there is an equilibrium in which $U1$-$D1$ shares the downstream market with $U2$-$D2$. Suppose in this equilibrium $U1$-$D1$ sells its upstream product to $U2$-$D2$ at price p_1, while $U2$-$D2$ sells its product to $U1$-$D1$ at p_2. Since in equilibrium firms share the downstream market, each downstream division must compete away its profits by offering to consumers equilibrium option contracts without any positive markup; moreover, it must offer the same level of expected utilities to consumers: $S(c_1, p_2) = S(p_1, c_2)$. But because $U1$-$D1$ must earn a strictly positive profit, in equilibrium its upstream division must sell the input for $G1$ to $U2$-$D2$ at a price $p_1 > c_1$. Now, consider a deviation of reducing the price p_1 to $p_1 - \varepsilon$. Then the downstream market will be monopolized by $U2$-$D2$—by applying Lemma 4 to $S(c_1, p_2) < S(p_1 - \varepsilon, c_2)$. For a sufficiently small ε, this reduction in p_1 allows $U1$-$D1$ to double its profit approximately, since all consumers now will buy $U2$-$D2$'s option contract. This contradicts the assumption that in equilibrium $U1$-$D1$ shares the downstream market with $U2$-$D2$. □

Lemma 5 says that in a symmetric integration subgame, one of the integrated firms must monopolize the downstream market in equilibrium. Thus, consider such an equilibrium, and suppose that $U1$-$D1$ monopolizes the downstream market. The surplus that $D1$ generates must be higher than $D2$. According to Lemma 4, $U2$-$D2$ will be unable to sell its equilibrium option contract to consumers, implying that $U1$-$D1$ derives its entire profit from the markup of its equilibrium option contracts. From Lemma 4, this profit is equal to the difference between the surpluses generated by the two integrated firms, and therefore is increasing in $U1$-$D1$'s price to sell its upstream inputs to $U2$-$D2$. Thus, in equilibrium, $U1$-$D1$ does not sell inputs to $U2$-$D2$, which then only manages to offer a nonoption contract for good $G2$ at marginal cost c_2. The characterization of the equilibrium is similar to Proposition 4, with the change that $U2$-$D2$ offers an expected utility of $\mathrm{EU}(G2; c_2)$ to consumers, and $U1$-$D1$'s profit is $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; c_2)$. The characterization for the other equilibrium when $U2$-$D2$ monopolizes the downstream market proceeds in the same way. This discussion will be summarized by the next proposition, which uses the price $p_1^\dagger$, defined by

$$p_1^\dagger = \arg\max_{p_1} (p_1 - c_1)F(u + c_2 - p_1). \tag{13}$$

Proposition 5: *Consider a symmetric integration subgame. In an equilibrium, for i, $j = 1, 2$ and $i \neq j$, firm Ui-Di does not sell inputs for Gi to Uj-Dj and monopolizes the downstream market, while Uj-Dj sells its inputs for Gj to Ui-Di at a price $p_j^\dagger$, and offers to consumers the nonoption contract for Gj at a price c_j but sells none of these contracts.*

1. *For $i = 1$, the option contract $U1$-$D1$ offers to consumers is $(\alpha + c_1, \alpha + p_2^\dagger)$, where $\mathrm{EU}(\alpha + c_1, \alpha + p_2^\dagger) = \mathrm{EU}(G2; c_2)$. Firm $U1$-$D1$ makes a profit of $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; c_2)$, and firm $U2$-$D2$ makes a profit of $(p_2^\dagger - c_2)[1 - F(u + p_2^\dagger - c_1)]$. Consumers' equilibrium expected utility is $\mathrm{EU}(G2; c_2)$.*
2. *For $i = 2$, the option contract $U2$-$D2$ offers to consumers is $(\alpha + p_1^\dagger, \alpha + c_2)$, where $\mathrm{EU}(\alpha + p_1^\dagger, \alpha + c_2) = \mathrm{EU}(G1; c_1)$. Firm $U1$-$D1$ makes a profit of $(p_1^\dagger - c_1)F(u + c_2 - p_1^\dagger)$, and firm $U2$-$D2$ makes a profit of $S(p_1^\dagger, c_2) - \mathrm{EU}(G1; c_1)$. Consumers' equilibrium expected utility is $\mathrm{EU}(G1; c_1)$.*

Because of Bertrand competition in the downstream market, an integrated firm's (expected) profit function may be discontinuous in the price it sets to sell its inputs to the rival; the proof of Lemma 5 in fact uses this property. For this reason, there may not always exist a pure-strategy equilibrium in a symmetric integration subgame. My purpose in this article is not to derive all the (mixed-strategy) equilibria in this subgame. The following two propositions (as well as the one following them) present conditions for the (pure-strategy) equilibria in Proposition 5. It must be noted that these are *sufficient* conditions. Also, they are not mutually exclusive: multiple (pure strategy) equilibria may exist in a symmetric integration subgame.

Proposition 6: *In a symmetric integration subgame, if $S(p_1^\dagger, p_2^\dagger) >$*

EU($G2$; c_2), *there is an equilibrium in which* $U1$-$D1$ *monopolizes the downstream market, and it is described by Proposition 5 (for the case of* $i = 1$ *in that proposition).*

Proof. Suppose $U2$-$D2$ sells inputs for $G2$ to $U1$-$D1$ at price $p_2^\dagger$. The integrated firm $U1$-$D1$ can always monopolize the downstream market by setting a sufficiently high price of the input for $G1$, say p_1, to integrated firm $U2$-$D2$, because (11) implies that $S(c_1, p_2^\dagger) > \mathrm{EU}(G1; c_1) > S(p_1, c_2)$ for a sufficiently high p_1. Furthermore, Lemma 4 implies that $U1$-$D1$'s profit increases in p_1. Thus, if $U1$-$D1$ chooses to monopolize the downstream market, its maximum profit is $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; c_2)$.

It must be shown that $U1$-$D1$ has no other profitable deviation. But the only other possibly profitable deviation is to let $U2$-$D2$ monopolize the downstream market. In this case, $U1$-$D1$ derives all its profit from selling inputs for $G1$ to $U2$-$D2$; hence, its best price must be $p_1^\dagger$ for $U2$-$D2$, obtaining profit $(p_1^\dagger - c_1)F(u + c_2 - p_1^\dagger)$. Therefore, it has to be shown that this is less than $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; c_2)$.

By Lemma 2, $S(c_1, p_2^\dagger) > (p_1^\dagger - c_1)F(u + p_2^\dagger - p_1^\dagger) + S(p_1^\dagger, p_2^\dagger)$. Because $p_2^\dagger > c_2$, it follows that

$$S(c_1, p_2^\dagger) - \mathrm{EU}(G2; c_2) > (p_1^\dagger - c_1)F(u + c_2 - p_1^\dagger) + S(p_1^\dagger, p_2^\dagger) - \mathrm{EU}(G2; c_2).$$

By the hypothesis of the proposition, the last two terms on the right-hand side of the above inequality must combine into a positive number. Hence, $S(c_1, p_2^\dagger) - EU(G2; c_2) > (p_1^\dagger - c_1)F(u + c_2 - p_1^\dagger)$. Therefore, it does not pay $U1$-$D1$ to deviate.

Finally, it is straightforward to verify that given $U1$-$D1$'s strategy of not selling to $U2$-$D2$, it is profit-maximizing for $U2$-$D2$ to sell inputs for $G2$ at price $p_2^\dagger$. □

Proposition 7: *In a symmetric integration subgame, if* $S(p_1^\dagger, p_2^\dagger) > \mathrm{EU}(G1; c_1)$ *and* $\mathrm{EU}(G1; c_1)$ *is sufficiently close to* $\mathrm{EU}(G2; c_2)$, *there is an equilibrium in which* $U2$-$D2$ *monopolizes the downstream market, and the outcome is described by Proposition 5 (for the case of* $i = 2$ *in that proposition).*

Proof. The proof that it is a best response for $U2$-$D2$ to refuse to sell upstream inputs to $U1$-$D1$ given that $U1$-$D1$ sells its upstream product to $U2$-$D2$ at price $p_1^\dagger$ follows the same line as the proof of Proposition 6. It only remains to verify that it is a best response for $U1$-$D1$ to sell upstream inputs at price $p_1^\dagger$.

Clearly, given $U2$-$D2$'s strategy, $U1$-$D1$'s only possibly profitable deviation from selling upstream inputs at price $p_1^\dagger$ is to refuse to sell to $U2$-$D2$. This strategy yields a profit of $\mathrm{EU}(G1; c_1) - \mathrm{EU}(G2; c_2)$. But under the hypothesis of the proposition, the payoff from the deviation must be less than $(p_1^\dagger - c_1)F(u + c_2 - p_1^\dagger)$. $\square$

Remark: The hypothesis that $S(p_1^\dagger, p_2^\dagger)$ is greater than EU($G1$; c_1) or EU($G2$; c_2) used in the last two propositions will be satisfied whenever the markups in the competitive regime are sufficiently low and when upstream prices are strategic complements. Indeed, if consumers prefer having the competitive option contracts to obtaining one of the composite goods at marginal cost, namely $S(p_1^*, p_2^*) > \mathrm{EU}(G1; c_1)$, then the hypothesis will hold whenever upstream prices are strategic complements. I should add that the hypothesis is not necessary for the propositions. The examples in the next section do not satisfy it.

5. Equilibrium Foreclosure and Welfare

Consider those equilibria of the symmetric integration subgame in which $U1$-$D1$ monopolizes the downstream market. The integrated firm $U2$-$D2$ earns the same amount of profit as does the upstream firm $U2$ in the equilibrium of the asymmetric integration subgame.[15] If $U2$ and $D2$ anticipate that the continuation equilibrium in the symmetric integration subgame is such an equilibrium, they will not have any incentive to integrate. Their integration decision does not affect their joint equilibrium profit, although $U1$-$D1$ prefers them to remain independent. The prices of inputs for $G2$ to $U1$-$D1$ set by the upstream division of $U2$-$D2$ (if they are integrated) or $U2$ (if they remain independent) will always be $p_2^\dagger$. Can $U1$ integrating with $D1$ be an equilibrium? That is, if $U1$ can implement the equilibrium in the nonintegration regime, will it have an incentive to integrate with $D1$? The following proposition lays out a set of conditions for an affirmative answer. But first, the following requirements, for which Lemma 3 gives sufficient conditions, will be stated:

Condition A: Price best response of upstream firms in the nonintegration regime are strategic complements, and the derivatives of the price reaction functions are less than one.

Condition B: Price best responses of upstream firms in the nonintegration regime are strategic substitutes.

Proposition 8: *Suppose the hypotheses of Proposition 6 hold. Suppose*

15. In the asymmetric integration subgame, $D2$ earns zero profits.

$S(p_1^*, p_2^*) - EU(G2; p_2^*) > (p_1^* - c_1)F(u + p_2^* - p_1^*)$. *When either Condition A or Condition B holds, the integration game admits an equilibrium in which U*1 *integrates with D*1*, while U*2 *and D*2 *respond by remaining independent.*

Proof. By Proposition 6, in the symmetric integration subgame there is a continuation equilibrium in which *U*1-*D*1 monopolizes the downstream market. Hence, it is an equilibrium for *U*2 and *D*2 to remain independent when *U*1 and *D*1 integrate. Thus, if *U*1 and *D*1 integrate, let the continuation be the monopolization equilibrium of the asymmetric integration subgame in Proposition 4.

In the asymmetric integration subgame, the integrated firm's profit is given by $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; p_2^\dagger)$. It will now be shown that this is bigger than *U*1's profit under nonintegration, $(p_1^* - c)F(u + p_2^* - p_1^*)$. First, observe that for any p_1 and p_2, the definition of $S(p_1, p_2)$ can be rewritten as

$$S(p_1,p_2) - \mathrm{EU}(G2; p_2) = \int_{\underline{v}}^{u+\ p_2-\ p_1} [(u - p_1) - (v - p_2)] f(v)dv. \tag{14}$$

Clearly, the left-hand side of (14) is decreasing in p_1. Moreover, for any number Δ,

$$S(p_1 + \Delta, p_2 + \Delta) - \mathrm{EU}(G2; p_2 + \Delta) = S(p_1, p_2) - \mathrm{EU}(G2; p_2). \tag{15}$$

Hence, setting p_1 and p_2 in (15) equal to p_1^* and p_2^* (respectively, the equilibrium prices under nonintegration) and Δ equal to $p_2^\dagger - p_2^*$ yields

$$S(p_1^*, p_2^*) - \mathrm{EU}(G2; p_2^*) = S(p_1^* + p_2^\dagger - p_2^*, p_2^\dagger) - \mathrm{EU}(G2; p_2^\dagger). \tag{16}$$

Under Condition A, upstream price best responses are strategic complements, and have derivatives less than one. Since p_2^* is *U*2's best response against p_1^*, and $p_2^\dagger$ against c_1, it must be true that $p_2^* - p_2^\dagger < p_1^* - c_1$. This inequality and (16), together with the fact that the left-hand side of (14) is decreasing in p_1, imply

$$S(p_1^*, p_2^*) - \mathrm{EU}(G2; p_2^*) < S(c_1, p_2^\dagger) - \mathrm{EU}(G2; p_2^\dagger). \tag{17}$$

The left-hand side of the above inequality is bigger than *U*1's profit under nonintegration by assumption. Therefore, it is an equilibrium for *U*1 to integrate with *D*1.

Under Condition B, $p_2^\dagger > p_2^*$, so that $c_1 < p_1^* + p_2^\dagger - p_2^*$. It follows from (16) that (17) holds. Again it is an equilibrium for *U*1 to integrate with *D*1. □

The inequality $S(p_1^*, p_2^*) - \mathrm{EU}(G2; p_2^*) > (p_1^* - c_1)F(u + p_2^* - p_1^*)$ in Proposition 8 can be interpreted easily. Imagine that in the nonintegration regime, $U1$ supplies $D1$ at p_1^*, but refuses to sell to $D2$. Then the downstream firm $D1$ will make a profit $S(p_1^*, p_2^*) - \mathrm{EU}(G2; p_2^*)$. The inequality simply states that if $U1$ can appropriate this downstream profit (say, by a lump-sum fee from $D1$), then it will make a higher profit than continuing to supply $D2$ at p_1^*. The inequality will hold whenever the equilibrium markups in the nonintegration regime are low.

Proposition 8 makes clear the way integration may obtain in equilibrium. First, in equilibrium, integration by $U2$ and $D2$ as a reaction to a previous merger may not be profitable: integration by $U2$ and $D2$ may not prevent $U1$-$D1$ from monopolizing the downstream market. Second, upon integration, $U1$ will set its (transfer) price to $D1$ at marginal cost c_1. This move alone eliminates the markup between a pair of upstream and downstream firms. In addition, the merger leads to a strategic response from the upstream rival $U2$. Clearly, if integration results in $U2$ raising its price, the integrated firm will benefit. Nevertheless, if upstream prices are strategic complements, $U2$ responds to the integration by $U1$ and $D1$ by a price reduction. This effect alone tends to depress the integrated firm's profit. For integration to be an equilibrium, this profit reduction must not be too much, as required by one of the hypotheses of Proposition 8 (Condition A).

Generally, a merger between $U1$ and $D1$ may be unprofitable. This may be because $U2$ and $D2$ react by their own merger, resulting in their ability to offer consumers a higher expected utility $\mathrm{EU}(G2; c_2)$, depressing $U1$-$D1$'s profit. Alternatively, this may be because after $U2$ and $D2$ merge, the continuation equilibrium in the symmetric integration subgame has $U2$-$D2$ monopolizing the downstream market. The existence of multiple equilibria in the symmetric integration subgame allow different classes of equilibria to be supported in the merger game. Thus, it may be an equlibrium for $U1$ and $D1$ to stay independent (although a set of conditions for this class of equilibria will not be presented here).

Now I consider the welfare properties of those equilibria in Proposition 8. When upstream prices are strategic substitutes (Condition B), $p_2^\dagger > p_2^*$. Consumers' expected utility in the nonintegration regime is $S(p_1^*, p_2^*)$, which must be larger than $\mathrm{EU}(G2; p_2^\dagger)$ when $p_2^\dagger > p_2^*$. In this class of equilibria, consumers are hurt by the merger. On the other hand, when upstream prices are strategic complements, $p_2^\dagger < p_2^*$. If $\mathrm{EU}(G2; p_2^\dagger) > S(p_1^*, p_2^*)$, consumers benefit from vertical integration even though it leads to foreclosure. The comparison between $\mathrm{EU}(G2; p_2^\dagger)$ and $S(p_1^*, p_2^*)$ will depend on the distribution function F and other parameters, and is ambiguous in general. But the following example clearly illustrates the possibility that $\mathrm{EU}(G2;\, p_2^\dagger)$ can be the greater quantity.

Consider an example in which $\tilde{v}$ is uniformly distributed on [0, 1]. Straightforward computation yields

$$p_1^* = (1 + 2c_1 + c_2 + u)/3,$$

$$p_2^* = (2 + c_1 + 2c_2 - u)/3,$$

$$p_1^\dagger = (u + c_1 + c_2)/2,$$

$$p_2^\dagger = (1 - u + c_1 + c_2)/2.$$

For $u = 0.75$, $c_1 = 0.2$, and $c_2 = 0.2$, the following results obtain:

p_1^*	p_2^*	$p_1^\dagger$	$p_2^\dagger$	$S(p_1^*, p_2^*)$	$\mathrm{EU}(G2; p_2^\dagger)$
0.7833	0.6167	0.5750	0.3250	0.0535	0.1750

Furthermore, $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; c_2) = 0.2578 > 0.1406 = (p_1^\dagger - c_1)F(u + c_2 - p_1^\dagger)$, which implies that $U1$-$D1$ monopolizing the downstream market is a continuation equilibrium in the symmetric integration subgame (see the proof of Proposition 6). Hence, it is an equilibrium for $U2$ and $D2$ to remain independent when $U1$ and $D1$ merge. Given this continuation equilibrium, it is optimal for $U1$ to integrate with $D1$: $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; p_2^\dagger) = 0.3828 > 0.3403 = (p_1^* - c_1)F(u + p_2^* - p_1^*)$. Finally, consumers' expected utility increases when $U1$ and $D1$ merge: $\mathrm{EU}(G2; p_2^\dagger) = 0.1750 > 0.0535 = S(p_1^*, p_2^*)$. Notice that the assumptions used in Propositions 6 and 8 are not satisfied by the example.

It also is straightforward to construct an example of an equilibrium with vertical integration and foreclosure but with consumers becoming worse off as a result. Suppose $\tilde{v}$ follows an exponential distribution with parameter λ; that is, $f(v) = \lambda \exp(-\lambda v)$. Suppose $\lambda = 2$, so that $E(\tilde{v}) = 0.5$ (the same value as the expectation of $\tilde{v}$ in the previous example). Then again for $u = 0.75$, $c_1 = 0.2$, and $c_2 = 0.2$, the following results[16] obtain:

p_1^*	p_2^*	$p_1^\dagger$	$p_2^\dagger$	$S(p_1^*, p_2^*)$	$\mathrm{EU}(G2; p_2^\dagger)$
0.9800	0.7	0.6363	0.7	0.0302	−0.2

Furthermore, $S(c_1, p_2^\dagger) - \mathrm{EU}(G2; c_2) = 0.4166 > 0.2033 = (p_1^\dagger - c_1)F(u + c_2 - p_1^\dagger)$, which implies that $U1$-$D1$ monopolizing the downstream market is a continuation equilibrium in the symmetric integration sub-

16. Unlike the uniform distribution, analytical expressions for such variables as p_i^* and $p_i^\dagger$ cannot be obtained explicitly.

game. Hence, it is an equilibrium for $U2$ and $D2$ to remain independent when $U1$ and $D1$ merge. Given this continuation equilibrium, it is optimal for $U1$ to integrate with $D1$: $S(c_1, p_2^\dagger) - \text{EU}(G2; p_2^\dagger) = 0.9166 > 0.4753 = (p_1^* - c_1)F(u + p_2^* - p_1^*)$. Finally, consumers' expected utility *decreases* when $U1$ and $D1$ merge: $\text{EU}(G2; p_2^\dagger) = -0.2 < 0.0302 = S(p_1^*, p_2^*)$. It should be pointed out that for this example, $p_2^* = p_2^\dagger$, since for the exponential distribution $[1 - F(v)]/f(v)$ is equal to $1/\lambda$, a constant. This implies that when $U1$ and $D1$ integrate, $U2$'s best response does not change. Because of this, consumers must become worse off whenever integration by $U1$ and $D1$ can be supported as an equilibrium.[17]

It should be emphasized that in many examples, integration by $U1$ and $D1$ is *not* an equilibrium (although consumers may prefer that outcome). Again, this may be either because the continuation equilibrium after $U1$ and $D1$ have merged has $U2$-$D2$ monopolizing, or because it does not pay $U1$ to merge with $D1$ even if $U2$ does not respond by integrating with $D2$. Nevertheless, I emphasize that all the continuation equilibria after the merger of a pair of upstream and downstream firms must result in monopolization.

6. Concluding Remarks and Extensions

I have presented a model of vertical integration in which upstream firms sell differentiated inputs and downstream firms bundle and sell them to consumers as option contracts. The characterization of equilibria in the merger game is simple: either firms remain completely independent, or a merger results and the downstream market is monopolized. In each of the merger equilibria, vertical foreclosure obtains: a downstream firm or division competes unsuccessfully because the rival upstream firm refuses the sale of inputs altogether. As a consequence, the disadvantaged downstream firm or division can only offer an inferior bundle (nonoption contract) to consumers.

The extensive form of the game does not allow any price commitment possibility.[18] In my model, foreclosure *is* a direct consequence of vertical integration and a vertically integrated firm's objective to maximize its joint (upstream and downstream) profits. The welfare effects of vertical integration, however, are ambiguous. Because up-

17. The Mathematica programs for performing these simulations are available from the author.

18. Nor does it impose any special interpretation of the price setting or bidding mechanism.

stream inputs are differentiated, upstream firms have market power. Upon integration, the transfer price between the upstream and downstream divisions will be set equal to the marginal cost of the input. From the rival upstream firm or division's point of view, this represents a price *decrease* by the opponent, and it must respond by altering its own price. If this results in a price increase (the case of upstream prices being strategic substitutes), then consumer welfare must fall. The rival, however, may respond by cutting its price, too (the case of strategic complements). If this decrease is sufficiently big, then consumers may benefit.

I must emphasize that the possibility of firms exiting the market is *not* considered in the paper. In particular, in a foreclosure equilibrium, one of the downstream firms is unable to sell to consumers, and yet its role in the market is important, since it prevents the other firm from becoming a monopolist. In a more general model, if the number of firms may fall after vertical integration (and complete or partial foreclosure), then the welfare comparison must consider the effect of a vertically integrated firm possibly becoming a monopoly. This will generally make vertical integration less favorable to consumers.

This paper provides a different perspective on antitrust policies towards vertical mergers. While the earlier literature has focused on the case of homogeneous upstream inputs and illustrated the potential anticompetitive effects of the raising-rivals'-costs strategy, this model has examined the price interaction between upstream firms producing heterogeneous inputs. One implication of my model is that an attempt by one upstream supplier to foreclose a market does not necessarily raise the *total* costs of production downstream. This is because upstream firms will react against a foreclosure strategy by changing their prices, too. In particular, upstream firms may reduce prices upon a merger, allowing a downstream firm to supply more cheaply. Thus, to ascertain whether or not a vertical merger is harmful to consumers, it is as important to consider upstream firms' price reactions to the merger as whether foreclosure is a consequence of integration.

In this paper, I focus on a vertically integrated firm's incentive to maximize its total of upstream and downstream profits. Clearly, equilibrium allocations of vertical integration also may be achieved through contracts. For example, for a lump-sum fee, an upstream firm may promise to sell its inputs to one of the downstream firms at marginal cost, and commit never to sell to the remaining downstream firm. This *exclusive* contract actually may implement the foreclosure outcome if contract enforcements are credible. To the extent that contracts allow vertically related firms to achieve joint-profit maximization, they will implement those allocations due to vertical integration. In this sense, contracts that allow the internalization of the joint-profit maximization calculus actually should be identified with integration.[19]

The assumption that all consumers face uncertainty about the values of the goods allows the most severe form of Bertrand competition in the downstream market, since consumers are identical *ex ante.* More important, this assumption helps support the complete foreclosure result. For the moment, consider the other extreme in which each consumer already knows her valuation of good $G2$ before firms set prices. Then the issue of vertical integration becomes unimportant in this version of the model. Consider an asymmetric integration subgame in which $U1$ has integrated with $D1$. But since consumers already know their valuations, an option contract is not a valuable strategy. Indeed, ordinary sales contracts for the composite goods are sufficient. If $U2$ sells its input to downstream firms at a price p_2, then it knows that whether consumers eventually buy good $G2$ through the downstream division of $U1$-$D1$ or firm $D2$, its profit is given by $(p_2 - c_2)[1 - F(u + p_2 - p_1)]$, where p_i is the upstream input price for good Gi. When consumers know their valuation before prices are set, the model can be analyzed as a standard oligopoly with only $U1$ and $U2$.

The same argument will apply if consumers can delay their purchase decisions until they learn their valuations and prices. In this case, the *ex ante* stage of the model is irrelevant. If downstream firms are allowed to offer *spot* contracts on goods $G1$ and $G2$ at the *ex post* stage, then vertical integration is inconsequential: the model, again, can be analyzed as a standard oligopoly with just $U1$ and $U2$. I have assumed that such spot contracts in the *ex post* stage are impossible. Although this assumption cannot be justified *a priori,* it is actually realistic, and satisfied in markets where the downstream firms supply long-term services involving fixed costs.

In markets mentioned in the introduction, spot markets seldom exist, or imply significantly higher costs or prices to consumers. This is almost obvious in the health-care market: without insurance (that determines coinsurance, deductible, or both) and previously negotiated contracts with health-care providers by insurance companies, consumers must pay significantly higher prices. The "spot" market of health services, in which a consumer walks into a hospital or a physician's office without any insurance, and pays cash right after the deliv-

19. Neither will I dispute the fact that contracts may implement allocations due to *horizontal* integration. For example, if in my model both upstream firms sell exclusively to only one of the downstream firms at marginal costs in return for lump-sum fees, then the other downstream firm is unable to sell any product. This multilateral exclusive contract in fact allows the upstream firms to behave as if they had integrated.

ery of health care, is rare in the US. In the telecommunication and information industries, the fixed costs associated with installation and initial configurations have yet to drop to a negligible level. Thus, in the on-line service market, it remains true that different Internet service providers supply different packages of products; a user must first join a service provider before actually making choices on these products. If the deregulation of cable television continues, a typical community in the US may have more than one cable carrier. Again, it seems plausible that these companies will have different upstream program suppliers. But because of installation and "basic service" charges, it seems unlikely that the majority of households will have spot-market access to all the programs: such a scenario would require households to be connected to each and every cable provider in their locality, an unlikely event in the near future. In these examples, consumers must sign options contracts when their preferences on the final goods are uncertain.

Nevertheless, it may be interesting to consider the spot-contract possibility. To do this, one can use the assumption that a fraction of the consumers are aware of their valuations before they buy contracts from the downstream firms. I argue that the foreclosure result will be essentially unaffected.

Suppose that a downstream firm (or a division) faces input prices p_1 and p_2 to produce the composite goods $G1$ and $G2$, respectively. In this environment, downstream firms may need to consider offering option and nonoption contracts simultaneously. There is no loss of generality to assume that a downstream firm offers *three* contracts: two nonoption contracts (one for each composite good) and a single option contract. Let these be written as $(\alpha_1 + p_1, G1)$, $(\alpha_2 + p_2, G_2)$ and $(\beta_1 + p_1, \beta_2 + p_2)$. These denote the nonoption contract for good Gi at price $\alpha_i + p_i$, $i = 1, 2$, and the option contract for $G1$ or $G2$ at prices $\beta_1 + p_1$ or $\beta_2 + p_2$ respectively. This is without loss of generality because of the usual *incentive compatibility* reason—informed and uninformed consumers (respectively those who know their valuations before selecting a contract and those who do not) must self-select into these contracts.[20] Let $\mathrm{EU}(Gi; \alpha_i + p_i)$ be the expected utility from the nonoption contract $(\alpha_i + p_i)$ for composite good Gi, $i = 1, 2$, and $\mathrm{EU}(\beta_1 + p_1, \beta_2 + p_2)$ the expected utility for the option contract (see Section 2 for definitions): they represent what these contracts are worth to those

20. If consumers choose less than three contracts, then simply replicate some of them for analytical convenience.

consumers who are uncertain about their valuations. Incentive compatibility requires

$$\alpha_1 \leq \beta_1, \qquad \alpha_2 \leq \beta_2, \tag{18}$$

$$\mathrm{EU}(\beta_1+p_1,\beta_2+p_2) \geq \max\{\mathrm{EU}(G1;\alpha_1+p_1),\mathrm{EU}(Gi;\alpha_2+p_2)\}. \tag{19}$$

The conditions in (18) guarantee that informed consumers will prefer a nonoption contract, while (19) says that uninformed consumers will select the option contract.

Consider a nonintegration regime, in which upstream firms sell indiscriminately to downstream firms. Here, the downstream firms face identical input prices. Therefore, they must sell option and nonoption contracts without any markup. The equilibrium upstream prices will be given by Proposition 2 again.

Next, consider an asymmetric integration regime. Let p_2 be $U2$'s price of its goods, and p_1 be $U1$-$D1$'s price for its goods for $D2$. Then the input prices for the downstream division of $U1$-$D1$ and $D2$ are respectively (c_1, p_2), and (p_1, p_2). Under these sets of input prices, $U1$-$D1$ can offer to consumers superior (nondegenerate) option contracts as well as a nonoption contract for $G1$. But $U1$-$D1$ faces the same cost as $D2$ when selling a nonoption contract for $G2$. It seems clear that $U1$-$D1$ has an incentive to raise without limit the price of its input, p_1, to $D2$, because it will compete at an advantage in selling the option contract and nonoption contract for $G1$. Both firms, however, will sell nonoption contracts of $G2$ to consumers. Therefore, the nonintegrated downstream firm will be foreclosed only in the uninformed consumers' market segment. It seems likely that equilibrium prices will be different from those in Proposition 4 because, depending on the ratio between informed and uninformed consumers, some of the incentive constraints in (18) and (19) may bind. It seems that a similar argument will apply for the symmetric integration regime, and I conjecture that in a continuation equilibrium in this regime, one firm will foreclose the other in the uninformed consumer market segment, but both firms may continue to offer and sell nonoption contracts.

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