Integration vs. Non-Integration, Specific Investments, and Ex-Post Resource Distribution

by

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Abstract

I adopt a non-cooperative game theoretic approach to an incomplete contracting transaction model, ala Grossman-Hart-Moore (1986, 1990) and Bolton-Whinston (1993), consisting of one upstream firm and two downstream firms. When the downstream firms need to make relation-specific investments, they can increase their ex-post bargaining position by vertically integrating ex-ante with the upstream firm with an essential asset. By introducing an explicit mechanism, bidding, which the firms can use to transfer the control right of the upstream asset, I compare the regimes of vertical integration (ex-ante) with ex-post renegotiation and non-integration, analyze equilibrium investment incentives, and show that vertical integration will evolve under certain conditions.

Keywords: Integration vs. Non-Integration, Asset Ownership, Specific Investment, Bidding, Alternating-Offer Bargaining Games with Breakdown Probability

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1. Introduction

An upstream firm often has an indivisible resource to distribute to its downstream firms. The resource can be capital, input, technology, patents or quota, more generally, an “asset”. By acquiring the essential resource, the downstream firm can increase its competitive position in the final product market.

Sometimes the downstream firms may need to make specific sunk investments during the transaction, e.g., learning/acquiring a special skill. The investments are worthless for other economic relationships. The investment costs are non-contractible, and the firms cannot write complete contracts on them. A contract is **incomplete** in the sense that it does not specify unambiguously the obligations of each party in every possible state of nature. The parties may renegotiate or bargain ex-post. Expecting that this kind of behavior will happen given the realization of the state, the ex ante sunk investments will be affected. This is called the ‘hold-up’ problem. Then, as Grossman and Hart (1986) and Hart and Moore (1990) point out, the initial allocation of the ownership of the asset (e.g., integration vs. non-integration) affects efficiency. For example, integration affects the hold-up problem because it changes the ownership of resources (assets): if the same owner gets joint payoffs of both upstream and downstream units and chooses the investments, then efficient investments will be made. This is a solution brought about just by the **internalization of externality**.

Bolton and Whinston (1993) propose the concept of quasi-stable to discuss how the initial ownership is determined. An ownership structure is quasi-stable if and only if there does not exist a trade between the firms that is guaranteed to strictly raise the payoffs of all parties to that trade. By “guaranteed”, they mean that this payoff increase occurs for each individual firm involved in the trade regardless of whether any further trades occur that do not involve that individual firm. They show that **non-integration is not quasi-stable** under the existing situation. However, they do not give any explicit economic mechanism to show how the firms can move or not from the initial non-integration to integration. That is, Bolton and Whinston (1993) pointed out that non-integration is not **quasi-stable**, in a partially cooperative-game-theoretic framework. On the other hand, this paper, in a **fully non-cooperative** set-up where the underlying extensive form game has a unique sub-game perfect Nash equilibrium, investigates a one upstream firm – two downstream firms bargaining – specific investments problem that extends the model of Bolton and Whinston (1993) where the bargaining outcome provides different incentives for the downstream firms’ (their owner-managers’) investment levels depending on the industry structure (Integration vs. Non-integration), which in turn determines the industry structure.

My model differs from that of Bolton and Whinston (1993) in two main aspects.

1. It considers a specific explicit bidding process in the ex ante merger (integration) stage.
2. It adopts a different bargaining process in the *ex post* bargaining stage.

Aspect 1 means a specific *explicit* mechanism such that the downstream firms bid for the right of integration at the beginning. Aspect 2 says that while the “outside option principle” is the only equilibrium outcome of the Bolton-Whinston model, this paper considers alternative offer bargaining games with breakdown probability, and mainly investigates the cases where outside options do *not* bind. If outside options do not always bind, the ex post bargaining payoffs must be amended because the outside option value (e.g., internal use of the input by the integrated firm) may be dominated by the option of continuing to bargain. We investigate how this setup changes the bargaining result of Bolton and Whinston (1993), and how it affects the ex ante investment incentives, as well as a boundary determination (internal vs. external supply). In this paper, I provide an *explicit mechanism*, *bidding*, which the firms can use to transfer the upstream asset. In addition, empirically, it would be natural to imagine the ‘bidding’ as representing a process of competition for integration (e.g., remember ‘take over bid’, which can imply a competition for a common targeted firm). Note that the case where the downstream firms need to make private specific investments is considered. By vertically integrating with the upstream firm, the downstream firm can increase its ex-post bargaining position, and can extract rents from the independent firm. It can increase the ex post bargaining payoff, and thus affect the ex ante specific investment incentives. With such a bidding mechanism for the asset ownership (i.e. integration) in the initial stage, it is theoretically demonstrated that vertical integration will evolve, and that this integration result depends on the fact that private investment incentives by the downstream firms are different between the two regimes of integration and non-integration, resulting in the *payoff difference*. Hence, if the downstream firms do not need to make private investments, and there are costs of integration, integration never occurs.

2. The Model

The setting of the model is based on Bolton and Whinston (1993). There are three firms in the market. One upstream firm is denoted as 0, and two downstream firms are denoted as 1 and 2. Firm

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1Bolton and Whinston (1993) mainly investigated the cases where outside options *bind*. See section 3-5 in their paper.

2It can be said to be a generalization of the Nash bargaining solution. See, Osborne and Rubinstein (1996), pp310.

3In this paper, the mechanism by which ex ante allocation of property rights is achieved is made explicit. The asset is auctioned off by the upstream firm, while in Bolton and Whinston (1993)’s paper the allocation mechanism was left unspecified. In general, the ex ante allocation mechanism is not important so long as it is *efficient*: if *efficiency is assured*, then only distribution is affected, the final allocation of property rights does not matter. However, in this paper, since the downstream firms make private specific investments, the ex ante allocation of property rights greatly affects the incentives of specific investments, and thus the overall efficiency. This is why the initial allocation mechanism of property rights is important.
0 owns or produces (at sufficiently low cost) an indivisible resource (“asset”). The resource can reduce the costs of firm 1 and 2, and increase their profits.

Next, I assume that the downstream firms need to make unobservable or unverifiable relation-specific investments, and the valuation of the final product is denoted by $V_i(I_i, s)$ for $i = 1, 2$ where $I_i \in [0, \bar{I}_i]$ is the level of the specific investment of firm $i$ and $s \in S$ is a random state of nature. Let $F(s)$ be the probability measure on the set of possible states of nature $S$.

$V_i(I_i, s)$ is assumed to be differentiable, non-decreasing, and concave in $I_i$, and $V_i(I_i, s) \geq 0$ for all $i, s$ and $I_i \in [0, \bar{I}_i]$, $V_i$ is observable but unverifiable, and can be fully extracted by firm 1 or 2 when it makes a sale. Last, the cost of the investment is given by $C_i(I_i)$ with $C_i'(I_i) \geq 0$ and $C_i''(I_i) > 0$.

Ownership in the world of incomplete contracts gives the owner of the asset complete control over the use of that asset and a full claim to its financial returns. In particular, the residual control rights include the right to exclude others from using the asset and/or to decide on how it is used (Grossman and Hart (1986) and Hart and Moore (1990)). By vertically integrating with the upstream firm, a downstream firm can “own” the asset. The firms can only write the contracts about the ownership of the asset in the first stage. Last, we suppose that after the realization of the ex-post state, they can bargain over how to use the asset.

2.1 The Timing of the Game

First, the downstream firms determine whether to bid for integration with the upstream firm. If one firm’s bid is both higher than the other’s and the reservation value of the upstream firm, it will integrate with the upstream firm. The other becomes an independent producer. If both firms bid less than the reservation value, there will be non-integration. Then the downstream firms determine their unobservable investment schedules $I_i, i = 1, 2$. The state $s$ is realized. The firms bargain over which firm will finally use the upstream firm’s asset and determine the transfer price. Production and final sale occur. Thus, the firm $i$ gets the revenue in a different manner, depending on integration vs. non-integration.
2.2 Ex-post Bargaining under Two Regimes: Integration and Non-Integration

Following Bolton and Whinston (1993), the ex-post bargaining follows Rubinstein (1982) alternating offer bargaining game. If vertical integration occurs in the first stage, there will be two players, an integrated firm and an independent firm in the ex-post bargaining stage. Now, consider an infinite-horizon two-person Rubinstein bargaining game. The two players, the integrated firm $i$ and the independent firm $j$, take turns to offer a division of the surplus. An important point is that the owner of the integrated firm $i$ has an “outside option” to use the asset itself, whose value is $V_i$. The timing of the bargaining game is as follows. In periods $t = 0, 2, \ldots, 2k, \ldots$, the integrated firm $i$ offers a division of the surplus. The independent firm $j$ accepts or rejects. If the independent firm $j$ accepts, the game ends and a new contract (a division of the surplus) is implemented. If he rejects, move to the next period with probability $1 - p$ where $0 \leq p \leq 1$, because there is an “exogenous risk of breakdown” of bargaining.\textsuperscript{4} In each period $t$, if the period-$t$ offer is rejected, there is probability $p$ that bargaining breaks down at the end of the period.

The integrated firm $i$ then gets $V_i$ and the independent firm $j$ gets 0. With probability $1 - p$, bargaining continues, and in next period $t + 1$, the independent firm $j$ in turn makes a counter-offer. The game continues either until one player accepts the other player’s offer, thereby they reach agreement, or bargaining breaks down, and they get their outside option values.

For the non-integration case, we have a three-player bargaining situation in the ex-post stage. The upstream firm alternates in making offers with the two downstream firms. When it is the upstream firm’s turn to receive offers, the two downstream firms simultaneously make offers. This is an extension of the Rubinstein bargaining game. That is, at dates $t = 0, 2, \cdots, 2k, \cdots$, the upstream firm offers, and at dates $t = 1, 3, \cdots, 2k + 1, \cdots$, the downstream firms make offers. The downstream firms' offers are prices at which they are willing to buy the right for integration or the residual control right of the upstream asset, among which the upstream firm can choose. If the upstream firm accepts either of the two bids, the game ends and a division of the surplus is implemented. If the upstream firm rejects, they move to the next period with probability $1 - p$ where $0 \leq p \leq 1$, because if the period-$t$ offer is rejected, there is probability $p$ that bargaining breaks down at the end of the period. The upstream firm and the two downstream firms then get 0. The outside option values for them are all 0s in this regime. With probability $1 - p$, bargaining continues, and in next period $t + 1$, the upstream firm in turn makes a counter-offer, and so on.

\textsuperscript{4} For a model of the alternating offer bargaining game in which there is an exogenous risk of breakdown, see Binmore, Rubinstein, and Wolinsky (1986), and Osborne and Rubinstein (1996).
2.3 The Results of Ex-Post Bargaining

Let $I_i^r$ denote the investment by firm $i$ with firm $r$ owning the upstream asset, $i = 1, 2$, $r = 0, 1, 2$. Then, the following proposition about the outcome of the ex-post bargaining can be asserted.

Proposition 1:
The ex-ante integration with ex-post two player bargaining (we call it Regime 1:R1) results in the following ex-post bargaining payoffs.

For the integrated firm $i$ and the independent firm $j$, where $i, j = 1, 2$, $i \neq j$

Payoff to $\{0 - i\}$: $V_i(I_i^r, s) + \frac{1}{2 - p} \max \left\{0, V_j(I_j^r, s) - V_i(I_i^r, s)\right\}$ \hspace{1cm} (1)

Payoff to $j$: $\frac{1}{2 - p} \max \left\{0, V_j(I_j^r, s) - V_i(I_i^r, s)\right\}$ \hspace{1cm} (2)

The ex-post payoffs in the non-integration with ex-post three player bargaining (Regime 2: R2) are,

Payoff to 0:
$p \max \left\{V_i(I_i^0, s), V_j(I_j^0, s)\right\}$

$(1 - p) \max \left\{\min \left\{V_i(I_i^0, s), V_j(I_j^0, s)\right\}, \frac{1}{2 - p} \max \left\{V_i(I_i^0, s), V_j(I_j^0, s)\right\}\right\}$ \hspace{1cm} (3)

Payoff to $i$: $(1 - p) \max \left\{0, V_j(I_j^0, s) - \max \left\{V_i(I_i^0, s), \frac{1-p}{2-p} V_j(I_j^0, s)\right\}\right\}$ \hspace{1cm} (4)

Payoff to $j$: $(1 - p) \max \left\{0, V_j(I_j^0, s) - \max \left\{V_i(I_i^0, s), \frac{1-p}{2-p} V_j(I_j^0, s)\right\}\right\}$ \hspace{1cm} (5)

Proof: See Appendix 1.

Note that the outcome of ex-post bargaining (3)-(5) under the ex-ante non-integration with ex-post renegotiation basically corresponds to firm 0 auctioning off its asset to downstream firms, after the valuations $(V_i, V_j)$ are realized and observed. Now, there are two corollaries regarding the non-integration regime.
**Corollary 1:**
The ex-post payoff in the non-integration case where “outside option” is binding is

Payoff to 0: \[ p \text{Max} \{ V_i(I_i^0, s), V_j(I_j^0, s) \} + (1 - p) \text{Min} \{ V_i(I_i^0, s), V_j(I_j^0, s) \} = \]

\[ \text{Min} \{ V_i(I_i^0, s), V_j(I_j^0, s) \} + p \left[ \text{Max} \{ V_i(I_i^0, s), V_j(I_j^0, s) \} - \text{Min} \{ V_i(I_i^0, s), V_j(I_j^0, s) \} \right] \]

Payoff to \( i \): \( (1 - p) \text{Max} \{0, V_i(I_i^0, s) - V_j(I_j^0, s)\} \]

Payoff to \( j \): \( (1 - p) \text{Max} \{0, V_j(I_j^0, s) - V_i(I_i^0, s)\} \)

**Corollary 2:**
The ex-post payoffs in the non-integration case when \( p = 0 \) are,

Payoff to 0: \[ \text{Max} \left\{ \text{Min} \{ V_i(I_i^0, s), V_j(I_j^0, s) \}, \frac{1}{2} \text{Max} \{ V_i(I_i^0, s), V_j(I_j^0, s) \} \right\} \]

Payoff to \( i \): \[ \text{Max} \left\{ 0, V_i(I_i^0, s) - \text{Max} \left\{ V_j(I_j^0, s), \frac{1}{2} V_i(I_i^0, s) \right\} \right\} \]

Payoff to \( j \): \[ \text{Max} \left\{ 0, V_j(I_j^0, s) - \text{Max} \left\{ V_i(I_i^0, s), \frac{1}{2} V_j(I_j^0, s) \right\} \right\} \]

This is the so-called “outside option principle”. In the non-integration regime, attention is restricted to the case where “outside option” is binding, i.e., the case of corollary 1.

Under all these ownership structures, the bargaining outcome is efficient. The firm with the highest ex-post valuation will get (use) the asset in the final production. Anticipating the above bargaining payoffs, the downstream firms choose the investment schedules in order to maximize their expected payoffs. They set the expected marginal bargaining payoff equal to the marginal cost of investments. Thus, any consequences of ownership will arise through effects on the ex-ante investment.

Let \( S_i(I_i, I_j) = \{(I_i, I_j) | V_i(I_i, s) \geq V_j(I_j, s)\} \quad i, j = 1, 2, \ i \neq j \)

denote the set of states in which it is efficient for the firm \( i \) to get the asset (upstream input) for different ownership structures. \( S = S_1 \cup S_2,^5 \) where \( S_j, i = 1, 2 \) implies the ex-post state where the downstream firm \( i \) is efficient.

\[ \int_{S_i} dF(s) + \int_{S_j^c} dF(s) = 1, \forall (I_i, I_j) \]
3 Equilibrium Incentives and Comparison of Equilibrium Payoffs

3.0 The Social Optimum (First Best Regime)

From a social point of view, it would be optimal to have only one firm, say $i$, make any investment, given $I_j = 0$, $i \neq j$. It should maximize the expected surplus

$$\int_S V_i(I_i, s) dF(s) - C_i(I_i)$$

(6)

The first order condition is

$$\int_S \frac{\partial V_i(I_i, s)}{\partial I_i} dF(s) = C_i'(I_i), \quad i = 1 \text{ or } 2$$

(7)

This condition determines the socially optimal (first best) level of investment $I_i^{FB}$.

3.1 The Ex-Ante Integration Regime with Ex-Post Two Player Bargaining (Regime 1)

The expected return for the integrated firm $i$ is given by:

$$\int_S V_i(I_i, s) dF(s) + \int_S \frac{(1-p)V_i(I_i, s) + V_j(I_j, s)}{2-p} dF(s)$$

$$= \int_S V_i(I_i, s) dF(s) + \frac{1}{2-p} \int_S [V_j(I_j, s) - V_i(I_i, s)] dF(s)$$

(8)

and the first order condition is:

$$\int_S \frac{\partial V_i(I_i, s)}{\partial I_i} dF(s) + \frac{1-p}{2-p} \int_S \frac{\partial V_i(I_i, s)}{\partial I_i} dF(s) = C_i'(I_i')$$

(9)

The implication of (9) is as follows. In this case, the integrated firm $i$ has an option to use the upstream asset internally, and it can obtain the payoff of $V_i(I_i', s)$ whether or not it actually ends up using the asset itself. It can capture the full marginal return from investment in all possible states. This is the first term. But, even when the state $S_j$ has occurred, the integrated firm $i$ can bargain
with the independent firm \( j \) and transfer the asset\(^6\) in exchange for the bargaining payoff

\[
\frac{1}{2} - p \left[ V_j(I'_j, s) - V_i(I'_i, s) \right].
\]

This generates an *ex post* additional gain from trade, but it also plays the role of ‘insurance’ for the integrated firm. Hence, it brings about the *ex ante* marginal disincentive:

\[
- \frac{1}{2} - p \int_{s_j} \frac{\partial V_i(I_i, s)}{\partial I_i} dF(s).
\]

This is the second term.

On the other hand, the expected return for the independent firm \( j \) is given by:

\[
\frac{1}{2} - p \int_{s_j} \left[ V_j(I'_j, s) - V_i(I'_i, s) \right] dF(s)
\]

and the first order condition is:

\[
\frac{1}{2} - p \int_{s_j} \frac{\partial V_j(I'_j, s)}{\partial I'_j} dF(s) = C'_j(I'_j)
\]

(11)

The solution of the equations (9) and (11) represents the Nash equilibrium in this regime.

**Remark**

Given \( I'_i > 0 \), the optimality of \( I'_j > 0 \) requires the “global condition”

\[
\frac{1}{2} - p \int_{s_j} \left[ V_j(I'_j, s) - V_i(I'_i, s) \right] dF(s) \geq C'_j(I'_j)
\]

The marginal condition (first order condition) is sufficient only when the global condition holds. In this paper, it is assumed that such conditions hold.

### 3.2 Ex-Ante Non-Integration Regime with Ex-Post Three Player Bargaining (Regime 2)

The ex-ante expected return for firm \( i,i = 1,2 \) given the investments \((I'_1, I'_2)\) is given by:

\[
(1 - p) \int_{s_i} \left[ V_i(I'_i, s) - V_j(I'_j, s) \right] dF(s)
\]

\( i = 1,2, i \neq j \)

Hence, the first order condition is

\[\text{Remark}\]

\(6\) Transferring the asset means the change of the asset ownership in the sense of Grossman and Hart (1986) and Baker, Gibbons, and Murphy (2002). So, as another more realistic interpretation, the integrated firm \( i \) preserves the ownership of the acquired asset, and employs the independent firm \( j \) as a subcontractor. This interpretation is theoretically close to “employee” in the sense of BGM (2002), but since the firm \( j \) has accumulated a valuable skill, which will lead to the potential benefit \( V_j > V_i \), we could more adequately interpret the firm \( j \) as a ‘drawing supplied’ supplier in the sense of Asanuma (1989), who is only a better processing manufacturer of the upstream asset.
The downstream firm will capture \((1 - p)\) times of its full marginal return from investment if it generates a higher ex-post value \(V_i\). But, it will receive nothing otherwise. Let \(I^*_i(I^0_j)\) denote the firm \(i\)'s best response to investment level \(I^0_j\) by firm \(j\). Firm \(i\)'s marginal return to investment is non-decreasing in its chance to get the upstream asset, which is given by the set \(S_i(I_1, I_2)\).

Increases in \(I_j\) reduce this set, so \(I^*_i(I^0_j)\) is non-increasing in \(I_j\).

### 3.3 The Incentives of the Integrated Firm and the Non-Integrated Firm under the Vertical Integration Regime

The expected bargaining payoff for the independent (unintegrated) firm under the vertical integration will shrink into \(\frac{1}{2 - p}\) of that under non-integration for any \((I_1, I_2)\). Thus, under the vertical integration regime, the investment incentive of the independent (unintegrated) firm will be decreased below the level characterized by (12). Thus, \(I^*_i \leq I^0_i\).

Next, in order to investigate the equilibrium incentives of the integrated firm under the vertical integration, we evaluate the equation (9) at \(I_i = I^*_i\), under the assumption that \(S_i \subseteq S\), \(V_i\) is concave, and \(C_i\) is convex in \(I_i\). Then, we obtain

\[
\begin{align*}
(1 - p) \int_{S_i} \frac{\partial V_i(I^*_i + s)}{\partial I_i} dF(s) & = C_i^\prime(I^0_i) \quad i = 1, 2 \\
(1 - p) \int_{S_j} \frac{\partial V_j(I^*_j + s)}{\partial I_j} dF(s) & = C_j^\prime(I^0_j) \quad j = 1, 2 \\
\end{align*}
\]

\[
\begin{align*}
(1 - p) \int_{S_i} \frac{\partial V_i(I^*_i, s)}{\partial I_i} dF(s) & + \int_{S_j} \frac{\partial V_j(I^*_j, s)}{\partial I_j} dF(s) - \frac{1}{2 - p} \int_{S_i} \left[ \frac{\partial V_i(I^*_i, s)}{\partial I_i} \right] dF(s) \\
& = \int_{S_i} \frac{\partial V_i(I^0_i, s)}{\partial I_i} dF(s) + \frac{1}{2 - p} \int_{S_i} \frac{\partial V_i(I^*_i, s)}{\partial I_i} dF(s) \\
& + \frac{1}{2 - p} \int_{S_j} \frac{\partial V_j(I^*_j, s)}{\partial I_j} dF(s)
\end{align*}
\]

The global conditions \((1 - p)\int_{S_i} \left[ V_i(I^0_i, s) - V_j(I^0_j, s) \right] dF(s) \geq C_i(I^0_i), i \neq j\) for the optimality of positive investments are supposed to hold also in this regime.
\[
\frac{C_i'(I_i^{o*})}{1-p} + \frac{1-p}{2-p} \int_{I_i^*} \frac{\partial V_i(I_i^{o*}, s)}{\partial I_i} dF(s) \geq C_i'(I_i^{o*}) \quad \text{for } 0 \leq p \leq 1. \quad \text{(The first order condition (12) was used.)}
\]

Hence, \( I_i^{o*} \geq I_i^{o*} \) in equilibrium. The equilibrium investment level for the integrated firm is (weakly) higher than under non-integration. From the analysis so far, the following proposition can be asserted.\(^8\)

**Proposition 2:** As for the marginal incentives for specific investment under each regime (R1 or R2), the following relations hold: \( I_i^{o*} \leq I_i^{o*} \leq I_i^{fB} \).\(^9\)

### 3.4 An Explicit Analysis on the Incentive Seeking for the Vertical Integration

Now the initial stage when the downstream firms bid for the ownership of the upstream firm’s asset is considered. The valuation \( \Delta_i \) for the ownership of the upstream firm’s asset is the difference between the expected profit when it gets the right of ownership and the one when the other gets that right.

From (1), the ex-ante payoff for firm \( i \) if it integrates with the upstream firm is

\[
\int_{s} V_i(I_i^{o*}, s) dF(s) + \frac{1}{2-p} \int_{s} \left[ V_j(I_j^{o*}, s) - V_i(I_i^{o*}, s) \right] dF(s) - C_i(I_i^{o*})
\]

and from (2), if firm \( j \) integrates with the upstream firm, it is

\[
\frac{1-p}{2-p} \int_{s} \left[ V_i(I_i^{o*}, s) - V_j(I_j^{o*}, s) \right] dF(s) - C_i(I_i^{o*})
\]

Hence,

\[
\Delta_i = \left\{ \int_{s} V_i(I_i^{o*}, s) dF(s) + \frac{1}{2-p} \int_{s} \left[ V_j(I_j^{o*}, s) - V_i(I_i^{o*}, s) \right] dF(s) - C_i(I_i^{o*}) \right\} - \left\{ \frac{1-p}{2-p} \int_{s} \left[ V_i(I_i^{o*}, s) - V_j(I_j^{o*}, s) \right] dF(s) - C_i(I_i^{o*}) \right\}
\]

\(^8\) This result is basically consistent with the fundamental insight of the Grossman-Hart-Moore Theory, which says that the ex ante investment incentive becomes greater, through the threat point being improved, as the firm has more assets.

\(^9\) As has been explained, \( I_i^{fB} \) is defined as the maximizer of \( \int_{s} V_i(I_i, s) dF(s) - C_i(I_i) \) (given \( I_j = 0 \)).
From (3), the reservation value of the firm 0 ($\Delta_0$) obtained from the non-integration case, is

$$\Delta_0 = (1 - p) \left[ \int_{S_i} V_i(I_i^0, s) dF(s) + \int_{S_j} V_j(I_j^0, s) dF(s) \right] + p \left[ \int_{S_j} V_j(I_j^0, s) dF(s) + \int_{S_i} V_j(I_j^0, s) dF(s) \right]$$

$$= \int_{S_j} V_j(I_j^0, s) dF(s) + \int_{S_i} V_j(I_j^0, s) dF(s)$$

$$+ p \left[ \int_{S_i} \left\{ V_i(I_i^0, s) - V_j(I_j^0, s) \right\} dF(s) + \int_{S_j} \left\{ V_j(I_j^0, s) - V_i(I_i^0, s) \right\} dF(s) \right]$$

(16)

In this model, the firm 0 does not bear any investment costs of firm 1 or 2, and it is assumed that the upstream firms just flips a coin to break the tie.

The integration with firm $i$ occurs if and only if

$$\Delta_i \geq \Delta_j \quad \text{and} \quad \Delta_i \geq \Delta_0.$$  

(17)

This is because firm $i$ can win against $j$ by bidding $b_i$ weakly greater than both $j$'s and the upstream firm's reservation values, when and only when (17) holds.

Now let us investigate condition (17) in a more detailed manner.

Note that both $I_i^0$ and $I_i^*$ are determined by the first order condition (12) and

$$\frac{1 - p}{2 - p} \int_{S_i} \frac{\partial V_i(I_i^*, s)}{\partial I_i} dF(s) = C_i'(I_i^*)$$

as the first order condition for the maximization (14),

and $I_i^* \leq I_i^0$ for $0 \leq p \leq 1$. The reason is twofold. First, the integrated firm $j$ exerts the greater investment under the integration than under non-integration, i.e., $I_j^* \geq I_j^0$, bringing about

$$S_i(I_i, I_j^*) \subseteq S_i(I_i, I_j^0),$$

which is represented as $S_j^* \subseteq S_j^0$, and second, the bargaining power of the independent firm is reduced to $(1 - p)/(2 - p)$. Now, we have the following lemma.

**Lemma 1**

$$\int_{S_i} V_i(I_i^*, s) dF(s) - C_i(I_i^*) \leq \int_{S_i} V_i(I_i^0, s) dF(s) - C_i(I_i^0)$$

(18)

**Proof**

It is enough to show the following relation.

$$\int_{S_i} V_i(I_i^*, s) dF(s) - C_i(I_i^*) \leq \int_{S_i} V_i(I_i^0, s) dF(s) - C_i(I_i^0) \leq \int_{S_i} V_i(I_i^*, s) dF(s) - C_i(I_i^*)$$

By revealed preference, the second inequality comes from $I_i^0$ being optimal for the set $S_i^0$, and
the first comes from the fact that \( S_i^f \subseteq S_i^{0^*} \), given \( I_i^{f^*} \).

\[ QED \]

Also, since \( I_j^{f^*} \) is greater than \( I_j^{0^*} \),

\[
\int_S \left[ V_j \left( I_j^{f^*}, s \right) - V_j \left( I_j^{0^*}, s \right) \right] dF(s) \geq 0 \quad \text{for any } I_i \tag{19}
\]

Further, from the concavity of \( V_i \), the convexity of \( C_j \), and \( I_i^{0^*} \leq I_i^{f^*} \leq I^{FB} \), it follows that

\[
\int_S V_i \left( I_i^{0^*}, s \right) dF(s) - C_i \left( I_i^{f^*} \right) \leq \int_S V_i \left( I_i^{f^*}, s \right) dF(s) - C_i \left( I_i^{0^*} \right). \tag{20}
\]

By using (18)-(20), we have the following proposition.

**Proposition 3:**
Suppose that \( p \) is sufficiently small. If the downstream firms bid for the right of integration, the (net) ex-ante incentives for vertical integration \( \Delta_i - \Delta_0 \) tend to be non-negative. In particular, when \( p = 0 \), we exactly have \( \Delta_i - \Delta_0 \geq 0 \). Thus, vertical integration will occur.

**Proof**
See Appendix 3.

Propositions 2 and 3 have the following natural implication. ‘Integration’ raises the level of investment of the integrated firm and decreases the investment of the independent firm. Then, ex-ante vertical integration becomes beneficial and emerges in equilibrium. Furthermore, the following proposition can be asserted.

**Proposition 4:**
Suppose that \( \Delta_i \geq \Delta_j \). Then, the net surplus of the ex-ante integration \( \Delta_j \) is divided between the upstream firm, downstream firm \( i \) and \( j \) in the equilibrium of the bidding game, such that the payoff combination between them is \( \left( p \Delta_i + (1-p) \Delta_j, (1-p)(\Delta_i - \Delta_j), 0 \right) \).

Then,

\[ 10 \text{This allocation indicates that the competition for integration among the downstream firms allows the upstream firm to extract most of the surplus from the bargaining. For instance, when } p = 0 \text{ and } \Delta_i = \Delta_j = \Delta, \text{ the upstream can obtain the entire surplus } \Delta, \text{ and the payoff allocation is } \left( \Delta, 0, 0 \right). \]
the inequality \[ \Delta_j \geq \frac{(1-p)\Delta_j + \Delta_u}{2-p} \] (endogenously) holds.

This is a characterization of the equilibrium of the ex-ante stage bidding game. The proof is not given, because its essence is almost the same as the “Non-Integration” case in appendix 1.\(^{11}\)

### 3.5 Comparison Between Ex-Post Renegotiation and Ex-Post No Renegotiation

Next, when the ex-post transfer of the right of ownership of the upstream asset is allowed, does the ex-ante incentive for integration increase, or decrease, or is it ambiguous? The ex-post renegotiation for the asset has a negative effect on the marginal investments, but generates an ex-post bargaining gain. Further, even if a downstream firm becomes an independent firm, it can secure the expected payoff:

\[
\frac{1-p}{2-p} \int_s \left[ V_j(1_i^*, s) - V_j(1_j^*, s) \right] dF(s) - C(I_i^*)
\]

Hence, the ex-ante incentive for integration when allowing the ex-post renegotiation is

\[
\int_s V_i(1_i^*, s) dF(s) + \frac{1}{2-p} \int_s \left[ V_j(1_j^*, s) - V_j(1_i^*, s) \right] dF(s) - C(I_i^*)
\]

\[\quad - \left\{ \frac{1-p}{2-p} \int_s \left[ V_j(1_j^*, s) - V_j(1_i^*, s) \right] dF(s) - C(I_i^*) \right\}.
\]

On the other hand, the ex-ante incentive for integration when the ex-post renegotiation is impossible is

\[
\Delta_i^{FB} = \int_s V_i(I_i^{FB}, s) dF(s) - C(I_i^{FB})
\]

where \(I_i^{FB}\) is the maximizer of the ex-ante expected payoff \(\int_s V_i(I_i, s) dF(s) - C(I_i)\).

Noticing the exchangeability of \(I_j^*\) and \(I_i^*\), we know that

\[
\int_s \left[ V_j(I_j^*, s) - V_j(I_i^*, s) \right] dF(s) = \int_s \left[ V_j(I_i^*, s) - V_j(I_j^*, s) \right] dF(s)
\]

Hence, we have

\[
\Delta_i^{FB} - \Delta_i^R = \left\{ \int_s V_i(I_i^{FB}, s) dF(s) - C(I_i^{FB}) \right\} - \left\{ \int_s V_i(I_j^*, s) dF(s) - C(I_j^*) \right\}
\]

\[\quad - \left\{ \frac{p}{2-p} \int_s \left[ V_j(I_j^*, s) - V_j(I_i^*, s) \right] dF(s) - C(I_i^*) \right\}.
\]
By the definition of the optimal investment $I_{FB}^{*}$ (revealed preference logic),

$$\int S V_i(I_{FB}^{*},s)dF(s) - C(I_{FB}^{*}) \geq \int S V_i(I_i^*,s)dF(s) - C(I_i^*)$$

Therefore, the following proposition can be asserted.

**Proposition 5:**

Suppose that the ex-post transfer of the right of ownership of the upstream asset is allowed. Then, the ex-ante incentive for integration does (weakly) increase (decrease) if and only if

$$\left\{ \int S V_i(I_{FB}^{*},s)dF(s) - C(I_{FB}^{*}) \right\} - \left\{ \int S V_i(I_i^*,s)dF(s) - C(I_i^*) \right\}$$

$$\leq (\geq) C(I_i^*) + \frac{p}{2-p} \int S \left[ V_j(I_i^*,s) - V_i(I_i^*,s) \right]dF(s)$$

That is, the commitment value of the ex-ante integration is increased (decreased) with the ex-post renegotiation if and only if the “Disincentive Effect” due to a kind of insurance that the ex-post renegotiation generates is smaller (greater) than the cost of investment $I_i^*$ when the rival downstream firm $j$ owns the upstream asset and the firm $i$ becomes an independent firm, which can be interpreted as a ‘rent’ that the integrated firm (‘winner’) could get in the ex-ante integration, plus, more importantly, the ex-post renegotiation gain $\frac{p}{2-p} \int S \left[ V_j - V_i \right]dF(s)$ for the integrated firm $i$ when it is defeated ex-post in that $V_i < V_j$.

4. Applications and Extensions

4.1 Competition for the Right of Integration with the Upstream Firm

Now, suppose that two downstream firms compete for integration with the upstream firm. Then, $\Delta_j - \Delta_0$ works as a prize to induce the incentive of the downstream firm, $i, i = 1, 2$.

If this incentive is also a relation specific investment, the integration regime may generate the discrete incentive through the prize. The size is $\Delta_j - \Delta_0$ under the no uncertainty case. On the other hand, the non-integration regime will induce a marginal increase in the incentive through the

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11The only formal difference is that the outside option value $\Delta_0$ of the upstream firm should be taken into consideration in deriving the equilibrium.
marginal strategic effect. It is characterized by the first order condition:

\[ \int_{s_i} \frac{\partial V_i(I_i,s)}{\partial I_i} df(s) = \psi'(I_i), \]

where \( \psi(I_i) \) with \( \psi' > 0 \) means the cost of the first period effort \( I_i, i = 1,2 \). The left-hand side implies a marginal increase in the expected revenue through marginal improvement of probability of state \( S_j \) occurring. As can be easily checked, this marginal strategic effect will be dominated by the discrete tournament effect. If the integration is interpreted as a short-term supply transaction contract between buyer and supplier, the integration regime will induce a larger relation specific incentive than the other regime. This is close in spirit to the endogenized tournament mechanism proposed by Konishi, et al. (1996).

### 4.2. R&D Application

Here, an application to the R&D context is provided. Technical analysis would be almost the same. One upstream firm (an innovator) owns an individual resource (e.g. an innovation and a patent for that innovation) and two downstream firms want to acquire that resource. At date 1, downstream firms make bids to integrate vertically with the upstream firm. Either one downstream firm integrates with the upstream firm (Regime 1) or the firms do not integrate (Regime 2). At date 2, each downstream firm (integrated or not) makes an investment \( I \) in order to be able to assimilate the resource (e.g. hiring skilled people, or bearing the cost for acquiring the know-how, or making investments for developing the innovation into a marketable product, etc). This investment affects the level of the returns that the firm will obtain if it uses the resource in the production period. These returns are also affected by the realization of a given state of nature. At date 3, once the investment has been made and the state of nature has been realized, downstream firms (again, integrated or not) bargain to allocate the asset. In this R&D application, \( V(I,s) \) is the market revenue from selling their own product, given the investment \( I \) and the state of the nature \( s \). Since here the sale of the resource through the ex-post bargaining could be interpreted as a sale of the license, the downstream firm \( i \) with the license (resource) would have an incentive to sell it to the independent (non-integrated) firm \( j \), when \( V_i(I_i,s) < V_j(I_j,s) \). Both the use of the resource (or in some cases, the transfer of patent) and the amount of transfer payment would be determined at this renegotiation stage.
4.3 A Possible Policy Implication: Spectrum Auction

Since 1993, the U.S. government has auctioned off part of the radio spectrum for personal communications services (PCS), pocket telephones, portable fax machines, and wireless computer networks. Thousands of spectrum licenses are for sale. The bidders include most U.S. telecommunications firms. There are about fifty markets called major trading areas, and two operating licenses are offered and so duopolistic competition will be generated in each area (McMillan (1994)). Also in Japan, some researchers have recently proposed that the Japanese government should auction off the spectrum resources, which are not now being utilized (Oniki and Okuno etc (2001)). The model proposed in this paper has some implications in relation to such radio spectrum policy reform. The setting is of course that the government is an upstream firm, and firms (bidders) are downstream firms. Then, by using the analysis proposed in the model, we can compare the equilibrium development incentives $I^*_i, i = 1, 2$ for utilizing the spectrum resource (‘the upstream asset’) between two auction forms (Regime 1 and Regime 2 in the model). Further, when the ex-post transfer of the spectrum resource (‘the upstream asset’) is allowed, the model analyzes which form of transfer is desirable in terms of the effect of the ex-post bargaining (where the outside option may be binding or not) on the ex-ante development incentives and the efficiency. As the results (included in appendix 2) suggest, the case where the outside option is binding would be desirable, because in this case, the first best ex-ante incentive by the winner (the integrated firm) will be induced, through the ‘threat’ such that if the own ex-post valuation $V_i(I_i^*, s)$ is lower than the potential supplier’s (the initial loser) ex-post valuation $V_j(I_j^*, s)$, then the winner must transfer the resource without exploiting any additional bargaining gain from the ex-post winner (the initial loser).\footnote{In other words, the insurance effect does not exist, which has a negative effect on the ex-ante incentive. See the section 3.1.}

4.3.1. A Consideration of the point of view of Rajan-Zingales (1998)

Rajan-Zingales (1998) adds an innovation to the Grossman-Hart-Moore paradigm, where the main source of power is the ownership of an alienable, unique asset, by introducing a role for “access” to a “critical resource”. “Access” is the ability to use, or work with, a “critical resource”, which in this context is the spectrum resource. Access to the valuable resource (the upstream asset) is important, because for specific investments to generate the surplus requires such access. Hence,
access becomes a source of power, and the possibility of a “power struggle” arises. Rajan-Zingales (1998) say that the party that is given access to a critical resource gets no new residual right of control, unlike GHM, but only the opportunity to specialize its capital to the resource and make itself valuable. Therefore, as far as this topic is concerned, the idea of power struggles for “access” to the critical resource by Rajan-Zingales (1998) might be more plausible than the terminology of ownership and integration. Nevertheless, the obtained theoretical result and policy implication would not be altered qualitatively.

5. Concluding Remarks

In this paper, I discussed the problem of whether the downstream firms can increase their own payoffs by vertical integration with a monopoly upstream firm with an indivisible resource. Under the situations of incomplete contracts and relation specific investments, the various ownership structures and their effects on ex-ante investment incentives and efficiency were examined. When the investment costs and the valuation of the final product cannot be contractible, the firms may bargain ex-post. When adding these considerations, vertical integration (ex-ante vertical integration as regime 1 in this paper) increases the payoffs for the downstream firms, and so they compete for integration with the upstream firm.

Bolton and Whinston (1993) pointed out that non-integration is not quasi-stable, in a partially cooperative-game-theoretic framework. On the other hand, this paper investigated a one upstream firm – two downstream firms bargaining – specific investments problem that extends the model of Bolton and Whinston (1993) in a fully non-cooperative set-up. The model proposed in this paper differs from that of Bolton and Whinston (1993) in two main aspects. First, it adopts a different bargaining process in the ex post bargaining stage. While the “outside option principle” is the only equilibrium outcome of the Bolton-Whinston model, this paper considers alternative offer bargaining games with breakdown probability, and mainly investigates the cases where outside options do not bind. We investigated how this setup changes the bargaining result of Bolton and Whinston (1993), and how it affects the ex ante investment incentives, as well as a boundary determination (internal vs. external supply). Second, it considers an explicit mechanism, bidding, such that the downstream firms bid for the right of integration at the beginning, and examines the equilibrium determination of the ownership structure. The analysis shows that vertical integration will evolve, if the cost of integration is sufficiently small\textsuperscript{13}, and that its result depends on the fact that private investment

\textsuperscript{13} If considered more carefully, the owner/manager of the upstream firm may feel a private benefit such as job satisfaction or pride from working with his own asset, i.e., having an own asset as an independent firm. (As for the original idea of private benefits, see Aghion-Bolton (1982).) If the upstream firm is integrated with either downstream firm ex ante, its private benefit will disappear, since the owner of the asset is changed and the new owner will neglect the private benefit (job satisfaction or pride) of the original owner, who is an employee after the integration. This is definitely a cost against integration, as modeled in Hart-Holmstrom (2002). If the cost of lost
incentives by the downstream firms are different between the two regimes of integration and non-integration (the two ownership structures), resulting in the payoff difference.

There are two final remarks that need to be made. First, modeling the downstream market (and competition there) explicitly would be interesting, because it enables us to analyze more clearly the effect of the downstream market ‘structure’ on the level of investment in the two regimes and the ex-ante incentives to integrate as well as the problem regarding the sale of the license and its resale in the R&D application. Second, in the paper the resource is assumed to be indivisible. However, if the resource is divisible and the monopoly upstream firm is committed to a bidding mechanism such that a divided unit of resources is sold to the highest bidder, and the remaining unit is sold to the second highest bidder, it would be interesting to investigate whether the upstream firm could exploit its monopoly power. However, it is the author’s view that it would reduce the monopoly power, because it reduces the payoff difference between the integrated firm and the non-integrated firm, and so the division of the surplus that the upstream firm gets in equilibrium would be smaller. Hence, given this model, the indivisibility assumption of the resource could be endogenously derived, and thus justified as a solution to the optimization problem.

Appendix 1 (Proof of Proposition 1)

1. The Case of Ex-post Two-Player Bargaining after Ex-ante Integration

Proof

In the ex-post bargaining stage, there are two players, an integrated firm \(i\) and an independent firm \(j\), whose ex-post valuations are \(V_i\) and \(V_j\), respectively.

First, suppose that \(V_i \geq V_j\). Then, the integrated firm \(i\), the owner of the upstream asset, does not have an incentive to renegotiate with the independent firm \(j\), but exercises his “outside option” to use the asset itself.

Next, suppose that \(V_j > V_i\). We are analyzing an infinite-horizon alternating offer game, but, first consider any three periods, \(t-1, t, t+1\). In period \(t\), suppose that the independent firm \(j\) offers the surplus for the integrated firm \(i\). The integrated firm \(i\) must accept or reject the proposed offer. If the integrated firm \(i\) rejects the offer, then bargaining continues with probability \(1-p\),

private benefit is sufficiently large, vertical integration will not occur, even though the (monetary) condition (17) holds. This direction needs to be examined in future research.
and in next period \( t+1 \), the integrated firm \( i \) in turn makes a counter-offer, and can get a *continuation payoff* \( z \). With probability \( p \), bargaining breaks down, and the integrated firm \( i \) then gets \( V_i \). Thus, the expected payoff from choosing “reject” in period \( t \) for the integrated firm \( i \) is \( pV_i + (1-p)z \). Hence, in order for the integrated firm \( i \) to accept the offer in period \( t \), the independent firm \( j \) (the “proposer” in period \( t \)) must offer at least as much surplus as \( pV_i + (1-p)z \) for the integrated firm \( i \). The optimal transfer price is thus \( pV_i + (1-p)z \), and the independent firm \( j \) gets the residual surplus \( V_j - [pV_i + (1-p)z] \). In period \( t-1 \), the integrated firm \( i \) offers the surplus for the independent firm \( j \). If the independent firm \( j \) rejects the offer, then bargaining continues with probability \( 1-p \), and in next period \( t \), the independent firm \( j \) in turn makes a counter-offer, and can get \( V_j - [pV_i + (1-p)z] \). With probability \( p \), bargaining breaks down, and the independent firm \( j \) then gets 0, which is the outside option value for the independent firm. Thus, the expected payoff from choosing “reject” in period \( t-1 \) for the independent firm \( j \) is \( (1-p)[V_j - [pV_i + (1-p)z]] \). Hence, in order for the independent firm \( j \) to accept the offer in period \( t-1 \), the integrated firm \( i \) (the “proposer” in period \( t-1 \)) must offer at least as much surplus as \( (1-p)[V_j - [pV_i + (1-p)z]] \) for the independent firm \( j \). The integrated firm \( i \) gets the residual surplus \( V_j - (1-p)[V_j - [pV_i + (1-p)z]] \).

Due to the *stationarity* of this game, conditional on the game’s not being ended (no offer has been accepted), the game “looks the same” at periods \( t-2 \) and \( t \). Thus, in looking for “stationary strategies”, it should satisfy the equality

\[
z = V_j - (1-p)[V_j - [pV_i + (1-p)z]] \iff z = \frac{(1-p)V_i + V_j}{2-p} = \frac{1}{2-p}(V_i + \frac{1}{2-p}(V_j - V_i)).
\]

As this result shows, the outside option is *not binding*. In particular, the following observation can be made.

\[
z = \frac{V_i + V_j}{2} = V_j - \frac{V_i - V_j}{2} \quad \text{when} \quad p = 0 \quad \text{(Nash bargaining solution), and}
\]

\[
z = V_j \quad \text{when} \quad p = 1 \quad \text{(The case where the integrated firm can make a "TIOLI" offer)}.
\]

We completed the proof. \quad \text{Q.E.D.}
2. The Case of “Non-integration”

Proof

Without loss of generality, suppose that \( V_i \geq V_j \). We are analyzing an infinite-horizon alternating offer game, but, first consider any three periods, \( t-1, t, \) and \( t+1 \). In period \( t \), suppose that the two downstream firms simultaneously bid the transfer prices \( P_i', P_j' \). Because the downstream firm \( j \) offers \( P_j' = V_j \), the downstream firm \( i \) must offer the transfer price \( P_i' \) such that \( P_i' \geq V_j \). If the upstream firm rejects their offers, with probability \( 1 - p \), bargaining continues, and in the next period \( t+1 \), the upstream firm in turn makes a counter-offer, and can get a continuation payoff \( z \). Thus, the expected payoff for the upstream firm by choosing “reject” in period \( t \) is \( (1 - p)z \).

First, we investigate the case \( V_j \geq (1 - p)z \). In this case, the downstream firm \( i \) bids \( P_i' = V_j \) for winning, and then the upstream firm chooses the downstream firm \( i \), and the firm \( i \) obtains the payoff \( V_i - V_j \).

In period \( t-1 \), the upstream firm offers a transfer price \( P_{i-1}' \) that a winning downstream firm should pay, which satisfies the downstream firm \( i \)'s incentive constraint:

\[
V_i - P_{i-1}' \geq (1 - p)(V_i - V_j) \iff P_{i-1}' \leq V_i - (1 - p)(V_i - V_j).
\]

Hence, the optimal offer is \( P_{i-1}' = V_i - (1 - p)(V_i - V_j) \). Only the downstream firm \( i \) accepts the offer, and the upstream firm selects him and obtains the payoff:

\[
V_j - (1 - p)(V_i - V_j) = pV_i + (1 - p)V_j. \tag{14}
\]

Due to the stationarity of this game, conditional on the game’s not being ended (no offer has been accepted), the game “looks the same” at periods \( t-2 \) and \( t \). Thus, in looking for “stationary strategies”, it should satisfy the equality \( z = pV_i + (1 - p)V_j \).

Substituting this value into the initial condition \( V_j \geq (1 - p)z \), we endogenously get

\[p \max \{V_i, V_j\} + (1 - p) \min \{V_i, V_j\} = pV_i + (1 - p)V_j \] if \( V_i \geq V_j \).

\[p \max \{V_i, V_j\} + (1 - p) \min \{V_i, V_j\} = pV_i + (1 - p)V_j \] if \( V_i \geq V_j \).

\[p \max \{V_i, V_j\} + (1 - p) \min \{V_i, V_j\} = pV_i + (1 - p)V_j \] if \( V_i \geq V_j \).
\[ V_j \geq (1-p)z = (1-p)[pV_j + (1-p)V_j] \iff V_j \geq (1-p)(V_j - V_i) \iff \frac{1-p}{2-p}V_i \leq V_j \]

The winning firm \( i \) obtains the expected value (payoff) \( V_j - z = (1-p)(V_j - V_i) \). Especially, when \( p = 0 \), the result is the same as the standard “outside option principle”, with the outside option binding.\(^{15}\) But this result generalizes it a bit more.

Next, we investigate the case \( V_j \leq (1-p)z \). In this case, the downstream firm \( i \) bids

\[ P_i^t = (1-p)z, \] in order for the upstream firm to accept the offer. The upstream firm accepts the offer \( P_i^t = (1-p)z \), and the firm \( i \) obtains the payoff \( V_j - (1-p)z \).

In period \( t-1 \), the upstream firm offers a transfer price \( P^{t-1} \) that the winning downstream firm should pay, which satisfies the downstream firm \( i \)'s incentive constraint:

\[ V_j - P^{t-1} \geq (1-p)[V_j - (1-p)z] \iff P^{t-1} \leq V_j - (1-p)[V_j - (1-p)z] \]

So, the optimal offer is \( P^{t-1} = V_j - (1-p)[V_j - (1-p)z] \). Only the downstream firm \( i \) accepts the offer, and the upstream firm selects him and obtains the payoff \( V_j - (1-p)[V_j - (1-p)z] \).

Similarly, due to the stationarity of this game, conditional on the game’s not being ended (no offer has been accepted), the game “looks the same” at periods \( t-2 \) and \( t \). Thus in looking for “stationary strategies”, it should satisfy the equality \( z = P^{t-1} \).

\[ z = P^{t-1} = V_j - (1-p)[V_j - (1-p)z] \iff z = \frac{V_j}{2-p} \]

Substituting this value into the condition \( V_j \leq (1-p)z \), we endogenously get

\[ V_j \leq (1-p)z \iff V_j \leq \frac{1-p}{2-p}V_i \]

This result is also the parallel to the standard “outside option principle”, with outside option non-binding. In particular, the following observation can be made.

\[ z = \begin{cases} \frac{V_j}{2} & \text{when } p = 0 \text{ (Nash bargaining solution)} \\ V_j & \text{when } p = 1 \text{ (The case where the upstream firm can make a "TIOLI"offer)} \end{cases} \]

\(^{15}\) That is, \( V_j \geq \frac{V_i}{2} \), even when \( V_i \geq V_j \).
We completed the proof. \textbf{Q.E.D.}

\textbf{Appendix 2 When the Outside Option is Binding at the Ex-Post Two Player Bargaining in the Ex-Ante Integration Regime: The case of the “Outside Option Principle”}

Here, the case where the outside option is binding at the ex-post two player bargaining in the ex-ante integration regime is analyzed. In order to do this, we assume that $V_i > V_j / 2$, even when $V_i < V_j$.

Then, the ex-post bargaining outcome will change drastically, since the outside option to use the asset itself is binding. The integrated firm $i$ would obtain $V_i$ by always extracting $V_i$ from the independent firm $j$. Hence, the ex-post bargaining payoffs for the integrated firm $i$ and the independent firm $j$, $i \neq j$ are, respectively,

Payoff to $\{0-i\}$: $V_i(\{I'_i, s\})$

Payoff to $j$: $\text{Max}\{V_i(\{I'_i, s\}), V_j(\{I'_j, s\})\} - V_i(\{I'_i, s\})$

Anticipating these bargaining payoffs, the downstream firms will choose the ex-ante investment schedules in order to maximize their ex-ante expected payoffs. At the optimum, they set the marginal bargaining payoffs equal to the marginal cost of investments, $C'_i(I_i), i = 1, 2$

We can check the equilibrium incentives and equilibrium payoffs in a similar way.

The expected return for the integrated firm $i$ is given by:

$$\int_s V_i(I'_i, s)dF(s) = \int_s V_i(I'_i, s)dF(s) + \int_s V_i(I'_i, s)dF(s)$$

and the first order condition is:

$$\int_s \frac{\partial V_i(I'_i, s)}{\partial I'_i}dF(s) = \int_s \frac{\partial V_i(I'_i, s)}{\partial I'_i}dF(s) + \int_s \frac{\partial V_i(I'_i, s)}{\partial I'_i}dF(s) = C'_i(I'_i)$$

The implication of FOC is as follows. The integrated firm $i$ has an option to use the upstream asset internally, and can obtain the payoff of $V_i(I'_i, s)$ \textit{whether or not it actually ends up using the asset itself.} Hence, it can capture a 100% marginal return from investment in all possible states. This is the same first order condition that generates the socially optimal (first best) investment

$$\int_s \frac{\partial V_i(I'_i, s)}{\partial I'_i}dF(s) = C'_i(I'_i), \quad i = 1 \text{ or } 2.$$
On the other hand, the expected return for the independent firm $j$ in this regime is given by:

$$\int_{s_j} \left[ V_j(I_j', s) - V_i(I_i', s) \right] dF(s), i \neq j$$

and the first order condition is

$$\int_{s_j} \frac{\partial V_j(I_j', s)}{\partial I_j'} dF(s) = C'(I_j')$$

The expected payoff formulation for the independent firm $j$ is $$(2 - p)/(1 - p)$$ times that under the integration regime (R1) for any $(I_i, I_j)$, as equation (10) shows. Hence, the investment schedules given $I_i'$, i.e., the best response function $I_j^{**}(I_i')$ for the independent firm $j$ is the same in its shape, and is decreasing in $I_i^1$ but shifts outward by $(2 - p)/(1 - p)$ times.

Hence, the equilibrium investment level $I_i^{FB}$ in this “outside-option-binding” regime is not only unambiguously greater$^{17}$ than the equilibrium investment level $I_i^{**}$ in the “outside-option-non-binding” regime, but also the best response by the independent firm $j$ is unambiguously bigger than the equilibrium investment level $I_j^{**}$ in the integration regime (R1).

Next, the expected payoff formulation for the independent firm $j$ is $1/(1 - p)$ times that under non-integration regime for any $(I_i, I_j)$. Hence, the investment schedules given $I_i'$, i.e., the best response function $I_j^{**}(I_i')$ for the independent firm $j$ is the same in its shape, and is decreasing in $I_i'$ but shifts outward by $1/(1 - p)$ times. Though the equilibrium investment level $I_i^{FB}$ in this “outside-option-binding” regime is unambiguously greater than the equilibrium

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$^{16}$See also the Bolton and Whinston (1993)’s explanation on pp 133.

$^{17}$As Bolton and Whinston (1993) shows on pp 133, the best response function for the integrated firm is a vertical line at $I_j = I_j^{FB}$ in this regime.
investment level \( I^*_j \) in the “outside-option-non-binding” regime, it is ambiguous whether the best response by the independent firm \( j \) is smaller or bigger than the equilibrium investment level \( I^*_j \), because unlike Bolton-Whinston (1993), the model proposed in this paper has an effect by the breakdown probability \( p \) on the best response function. When \( p \) is sufficiently small, the equilibrium investment level by the independent firm \( j \) when outside option is binding will be smaller than the equilibrium level \( I^*_j \) under non-integration regime.

**Appendix 3 (Proof of Proposition 3)**

From (15) and (16), the following can be computed.

\[
\Delta_j - \Delta_0 = \left\{ \int_{S_j} V_j(I^*_j,s)dF(s) - C_j(I^*_j) \right\} + \frac{1}{2 - p} \int_S \left[ V_j(I^*_j,s) - V_s(I^*_j,s) \right] dF(s)
\]

- \[\int S_j V_j(I^*_j,s)dF(s) + \int S_j V_s(I^*_j,s)dF(s)\]

- \[\int S_j V_j(I^*_j,s)dF(s) - p \left[ \int S_j \left[ V_j(I^*_j,s) - V_s(I^*_j,s) \right] dF(s) \right] \]

\[
= \left\{ \int_{S_j} V_j(I^*_j,s)dF(s) - C_j(I^*_j) \right\} - \left\{ \int S_j V_j(I^*_j,s)dF(s) - C_j(I^*_j) \right\} - \int S_j V_s(I^*_j,s)dF(s) \\
+ \frac{1}{2 - p} \int S_j V_j(I^*_j,s)dF(s) + \frac{1}{2 - p} \int S_j V_j(I^*_j,s)dF(s) + \frac{p}{2 - p} \int S_j \left[ V_j(I^*_j,s) - V_s(I^*_j,s) \right] dF(s)
\]

\[
\Delta_j - \Delta_0 \geq \left\{ \int S_j V_j(I^*_j,s)dF(s) - C_j(I^*_j) \right\} - \left\{ \int S_j V_s(I^*_j,s)dF(s) - C_j(I^*_j) \right\} - \int S_j V_s(I^*_j,s)dF(s) \\
+ \frac{1}{2 - p} \int S_j V_j(I^*_j,s)dF(s) + \frac{1}{2 - p} \int S_j V_j(I^*_j,s)dF(s) + \frac{p}{2 - p} \int S_j \left[ V_j(I^*_j,s) - V_s(I^*_j,s) \right] dF(s)
\]

- \[\int S_j V_j(I^*_j,s)dF(s) - p \left[ \int S_j \left[ V_j(I^*_j,s) - V_s(I^*_j,s) \right] dF(s) \right] \]

\[
= \int S_j V_j(I^*_j,s)dF(s) - C_j(I^*_j) - \int S_j V_s(I^*_j,s)dF(s) + \frac{1}{2 - p} \int S_j V_j(I^*_j,s)dF(s) + \frac{p}{2 - p} \int S_j \left[ V_j(I^*_j,s) - V_s(I^*_j,s) \right] dF(s) \\
- \int S_j V_j(I^*_j,s)dF(s) - p \left[ \int S_j \left[ V_j(I^*_j,s) - V_s(I^*_j,s) \right] dF(s) \right] \]

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\[
\begin{align*}
&= \left[ \int_S V_i (I^s_i, s) dF (s) - C_i (I^s_i) \right] - \left[ \int_S V_i (I^o_i, s) dF (s) - C_i (I^o_i) \right] \\
&+ \frac{1}{2 - p} \int_S \left[ V_i (I^s_i, s) - V_i (I^o_i, s) \right] dF (s) + \int_S V_j (I^s_j, s) dF (s) + \frac{p}{2 - p} \int_S \left[ V_j (I^o_j, s) - V_j (I^s_j, s) \right] dF (s) \\
&- \int_S V_j (I^o_j, s) dF (s) - p \left[ \int_S \left[ V_j (I^o_j, s) - V_j (I^s_j, s) \right] dF (s) \right] + \int_S \left[ V_j (I^o_j, s) - V_j (I^s_j, s) \right] dF (s) \\
&= \left[ \int_S V_i (I^s_i, s) dF (s) - C_i (I^s_i) \right] - \left[ \int_S V_i (I^o_i, s) dF (s) - C_i (I^o_i) \right] \\
&+ \frac{1}{2 - p} \int_S \left[ V_i (I^s_i, s) - V_j (I^s_j, s) \right] dF (s) + \int_S V_j (I^s_j, s) dF (s) - \int_S V_j (I^o_j, s) dF (s) \\
&- 2p \int_S \left[ V_j (I^o_j, s) - V_j (I^s_j, s) \right] dF (s) \\
&\geq \left[ \int_S V_i (I^s_i, s) dF (s) - C_i (I^s_i) \right] - \left[ \int_S V_i (I^o_i, s) dF (s) - C_i (I^o_i) \right] \\
&+ \frac{1}{2 - p} \int_S \left[ V_i (I^s_i, s) - V_j (I^s_j, s) \right] dF (s) - 2p \int_S \left[ V_i (I^s_i, s) - V_j (I^o_j, s) \right] dF (s) \\
&\quad \because \int_S V_j (I^s_j, s) dF (s) - \int_S V_j (I^o_j, s) dF (s) \geq \int_S V_j (I^o_j, s) dF (s) - \int_S V_j (I^o_j, s) dF (s) = 0
\end{align*}
\]

Because \( \left\{ \int_S V_i (I^s_i, s) dF (s) - C_i (I^s_i) \right\} - \left\{ \int_S V_i (I^o_i, s) dF (s) - C_i (I^o_i) \right\} \geq 0 \) and

\[
\frac{1}{2 - p} \int_S \left[ V_i (I^s_i, s) - V_j (I^s_j, s) \right] dF (s) \geq 0 \quad \text{for} \ 0 \leq p \leq 1,
\]

we tend to obtain \( \Delta_i - \Delta_0 \geq 0 \), when \( p \) goes to 0. In the limiting case of \( p = 0 \), we exactly obtain \( \Delta_i - \Delta_0 \geq 0 \).

\( \Delta_i \geq \Delta_0 \) implies that the net benefit of the ex-ante integration, which will be the bid in the ex-ante stage, is larger than the reservation value which corresponds to the expected equilibrium value of the firm 0 obtained under the non-integration regime.

Q.E.D.
REFERENCES


