VERTICAL INTEGRATION, SEPARATION AND PRICE STRATEGY IN VERTICALLY RELATED MARKETS

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Abstract

This paper analyzes the short- and long-run effects of vertical integration by a bottleneck monopolist. In the short run, relative efficiency in technologies used by an integrated and an un-integrated firm may cause product prices to rise or fall. This shows the standards against which the integration and the separation are allowed. In the long run the integrated firm may monopolize a market by some strategies. However, we show that a price strategy such as a price squeeze is not profitable for the integrated firm. The fear that deregulation causes aggravation of market efficiency is not necessarily realized.

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1 Introduction

This paper seeks to examine the short-run and the long-run effects of vertical integration by a bottleneck monopolist.[1] Vertical integration is considered as an exclusion strategy in a bottleneck monopoly game which raises rivals' costs. When the integration gives the integrated firm cost advantages and technological superiority, market competition may cause the un-integrated firms to exit a market. When the bottleneck monopolist merges with an inefficient downstream firm, it causes products prices to rise or to fall depending upon relative productivity of competing firms. It follows that splitting an integrated firm into separate firms promotes market efficiency. On the other hand, in the long run the integrated firm may try to monopolize a market by applying price strategies. Among others we focus on price squeeze which is specific to vertically related markets. Thus, there is the fear that the integrated firm will exclude other firms from a market and will thus aggravate market efficiency. However, it will be shown that a price squeeze is not a profitible strategy for vertically integrated bottleneck monopolist, called a *MVI* or a partial monopolist.

First, we consider the short-run (or simultaneous) effects. One of the effects that will be analyzed is whether competitors are *de facto* excluded. Whinston (2006) insisted that there are three types of exclusionary vertical contracts, which exclude rivals from a market and reduce competition: exclusive contracts, vertical mergers and tied sales. Our focus will be on vertical mergers. Whinston (1990) made a pioneering contribution to these problems and observed, in the analysis of tying, that a monopolist in one market has incentives to monopolize a second market. In particular, Whinston (1990) first observed that the *MVI* can make profits by supplying inputs to *efficient* rivals. Rey and Tirole (2007) observe that foreclosure arises when a *MVI* carries out maneuvers in an input market such as denying its rivals access to essential inputs, or using a tie to eliminate effective competition from the rivals in a downstream market.

The other short-run effect is what product prices prevail if rivals are not excluded from a market. Westfield (1981) showed that downstream market prices may rise or fall after the vertical integration. In pre-merger environments, an upstream monopolist supplies inputs to downstream competitive firms, while integration changes market structure into pure monopoly because all firms, including the monopolist, are integrated into a single firm. In reality, whether firms are integrated or not, they usually face oligopolistic competitors in a market. This model of vertical integration is limited in that effects of integration and/or separation are not analyzed when the resulting market structure changes into oligopolistic games. Noting the effects of the

vertical integration, Ordover, Saloner and Salop (1990) showed that it leads to foreclosure in an equilibrium market.

We will model vertically related markets as two-stage games with complete and perfect information.[2] To be more precise, a partial monopolist supplies essential inputs to an independent firm in a downstream market at the market price. In the next stage, the monopolist and the independent firm compete on outputs in a downstream market. To solve our problem, the backward induction is used. Nash equilibrium outputs are determined for a given demand for outputs in the second stage (or the downstream market), and a demand function for essential input is derived from equilibrium downstream outputs. Thus, the derived demand for essential inputs enables us to determine equilibrium price and input supplied in the first stage (or the upstream market) where it is assumed that firms act as Bertrand competitors. Equilibrium prices are determined in the vertically integrated bottleneck monopoly, abbreviated as a *VBM*.

The intuition behind our result is the following. There are two effects of the integration on product prices. One is the cost-reducing effect because the integrated firm can get access to inputs at the marginal costs. This will cause product prices to fall. The other is the technology effect; if the bottleneck monopolist firm merges with a firm with technological superiority, the technological effect leads to declines in product prices, but this effect leads to rises in product prices if the bottleneck monopolist merges with a firm with inferior technology. In the latter case, the cost-reducing effect is vitiated by the technology effect. If a bottleneck monopolist integrates with one of the downstream firms and gains technology superior to that of a rival, the un-integrated firm can not be viable because both effects work in the same direction and then product prices fall so much that the un-integrated firm can make no profits. Then, the formation of a *VBM*, which may be caused by deregulation, excludes a rival from a market. However, when a bottleneck monopolist integrates with one of the downstream firms with inefficient production technology, the cost-reducing effect is vitiated by the technology effect. It is uncertain in these oligopolistic games which effect dominates. The results depend upon how strong the technological effect is.

For example, when the monopolist becomes more productive, but still less than its rival, the technological effect that negates the cost-reducing effect is weak. Then, the integration leads to lower equilibrium prices. Finally, if the monopolist holds somewhat inefficient technologies through integration, the technological effect dominates the cost-reducing effect and product prices will rise after integration.

The *VBM* is formed from a bottleneck monopoly by vertical integration. Thus, the separation

of a partial monopolist into an upstream and a downstream firm causes the *VBM* to change into a bottleneck monopoly. Then, comparisons between pre-merger and post-merger situations enable us to get information about effects not only of vertical integration but also of separation. In view of our results on vertical integration, when the *MVI* is separated and the separated downstream firm is somewhat inefficient, separation results in decline of product prices and enhances the welfare of consumers. It is possible to get important policy implication for our results. For example, the present model will show when separation is beneficial to society and when integration enhances welfare of society.

Even if product price falls and then welfare goes up through a vertical merger, there is the fear that in the long run a *MVI* will try to exclude competitors from a market and to monopolize a market. A price squeeze is one of notable examples of strategies in the *VBM* that the monopolist seeks to perfectly control a downstream market. Following Joskow (1985), this is defined as a strategy of the partial monopolist who charges a price for the inputs supplied to its downstream competitors so high that they cannot make any profit. Joskow (1985) noted that an upstream division of an integrated firm has incentives to charge a higher price to its downstream competitor than to its downstream division.

This pricing strategy is closely related (or corresponds) to a limit price,[3] which is a strategy to block entry of new firms into a market. On the other hand, a price squeeze, which is defined in *two related markets*, enables a firm to drive rivals out of a downstream market. These pricing strategies are anti-competitive in nature. A price squeeze is an indirect method that enables a firm to control a downstream market using upstream prices,[4] while limit price is a direct method that eliminates competition in a downstream market using downstream prices.

It will be of some interest to know what prices in an upstream and a downstream market are like under a price squeeze and whether a firm has incentives to employ such a strategy. The present model will show that product prices under a price squeeze are equal to those under pure monopoly. As a firm can maximize profits under pure monopoly, there is a fear that the partial monopolist may have incentives to employ a price squeeze. Although a monopoly usually enables a monopolist to maximize profits, it does not necessarily hold true in vertically related markets as was shown by Whinston (1990).[5] Our analysis of vertically related markets leads us to conclude that the presence of rivals provides profits in the related markets, which are larger than additional profits earned if all markets were monopolized. It turns out that a price squeeze is not a profitible strategy for the partial monopolist because profits from sales to rivals outweigh profits lost due to the absence of rivals.[6] This means that market structures are influenced not

only by that particular market, but also by other related markets.[7]

However, if the possibility is high that foreclosure will emerge on account of the presence of the partial monopolist, the focus is mainly on how to regulate markets and to promote economic efficiency in these markets. These considerations led economists to analyze access charges.[8]

The paper is organized as follows. Section 2 sets forth the features of a bottleneck monopoly game. In Section 3, we discuss the *VBM* (or the partial monopoly) game and show some important features of this game. The prices in the upstream and the downstream markets are worked out. Thus, equilibrium prices in these games are compared, and it is shown that equilibrium prices are higher in the *VBM* game than in a bottleneck monopoly game depending upon relative efficiency of the integrated and the un-integrated firm. In Section 4, it is shown what the prices in two related markets are under a price squeeze and also that the monopolist in the *VBM* has no incentive to engage in a price-squeeze strategy. Finally, we conclude our analysis in Section 5.

2   Bottleneck Monopoly Game

Our model is formulated as a dynamic game with complete and perfect information and the concept of equilibrium is defined as the subgame perfect equilibrium. It is assumed that two firms compete on quantity in a downstream market, and that there is a sole supplier in the upstream market.

Consider first a downstream market for a consumer good which is supplied by two firms, firm 1 and firm 2. The consumer good is produced by using inputs which are provided by firm 3, an upstream monopolist. Our scenario is this: In the first stage, equilibrium outputs of downstream firms are determined as the Nash equilibrium under a given demand for products in the downstream market. Noting that the total output is a function of production costs of downstream firms, market demand for inputs is derived from the total outputs in the downstream market. In the second stage, the player in the upstream market maximizes profits under given total demand for its products. The demand for the consumer good is given by

$$P = a - x = a - (x_1 + x_2), \tag{1}$$

where P represents the price of consumer good, and x_i the quantity of output by firm i, $i = 1, 2$.

To simplify our analysis, assume that under constant returns to scale technologies, α_i units of inputs are translated into a unit of output (or a consumer good) by firm i, $i = 1, 2$. It follows that

$$x_i = \frac{1}{\alpha_i} y, \tag{2}$$

where y is the quantity of inputs. This is the production function of firms 1 and 2. To proceed with our analysis, it will be assumed that productivity of firm 2 is higher than that of firm 1. Formally, assume that

$$\alpha = \alpha_1 / \alpha_2 > 1. \tag{3}$$

This means that firms differ in their productivities. Models of other authors usually assume that one unit of inputs is transformed into one unit of outputs: α_1 and α_2 equal 1. As will be shown later, this assumption (3) is essential for our analysis which follows (See, for example, Section 3.).

As was assumed in (2), one unit of outputs are produced with α_i units of inputs. Then, the constant marginal costs of firm i are expressed as

$$c_i = \alpha_i p, \quad i = 1, 2, \tag{4}$$

where p stands for the price of inputs.

It follows that firms in the downstream market play a simultaneous-move (or a static) game, given the demand function (1), and maximize their respective profits. Together with (2) and (4), profits of firm i are given by

$$\pi_i = (P - c_i)x_i = (a - \alpha_i p - (x_1 + x_2))x_i, \quad i = 1, 2,$$

where fixed costs are assumed away because they will not play any role in the analysis to follow. The objective of each firm is to maximize π_i, which requires

$$\frac{\partial \pi_1}{\partial x_1} = a - \alpha_1 p - 2x_1 - x_2 = 0$$

and

$$\frac{\partial \pi_2}{\partial x_2} = a - \alpha_2 p - x_1 - 2x_2 = 0.$$

Solving these equations for equilibrium outputs yields

$$x_1^* = \frac{a - (2\alpha_1 - \alpha_2)p}{3},$$
$$x_2^* = \frac{a + (\alpha_1 - 2\alpha_2)p}{3},$$

where outputs of two firms are assumed positive. Total equilibrium output X^* is

$$X^* = x_1^* + x_2^* = \frac{2a - (\alpha_1 + \alpha_2)p}{3}.$$

Assume that the marginal cost MC for the upstream monopolist is a given constant such that

$$0 < MC = \beta, \tag{5}$$

and

$$a \geq 4\alpha_1 \beta. \tag{6}$$

In view of assumptions (4) and (5), $\alpha_i p$ is the production cost of downstream firms, where $p(> \beta)$ is the price of essential inputs. Assumption (6) means that demand of downstream market is high enough relative to the marginal costs of the bottleneck monopolist. A sufficient condition that outputs of downstream firms are positive is $a \geq 2\alpha_1 \beta$ because output x_1^* of firm 1 is given by $(a - (2\alpha_1 - \alpha_2)p)/3$. However, it does not necessarily guarantee that profits earned by downstream firms become positive in the subgame perfect equilibrium of this game. Downstream

price may become less than production costs $\alpha_i p$ under this condition at the subgame perfect equilibrium. For the downstream firms to make maximum positive profits in our two-stage game, a more powerful condition, assumption (6), is required.(For detail, see proof of *Lemma* 1 below.) To proceed with our analysis, assumption (6) will be made to guarantee that the downstream firms can purchase essential inputs from the bottleneck monopolist.

Now, consider a bottleneck monopoly game in which an essential input is provided by a bottleneck monopolist. The monopolist maximizes profits for a given demand for an essential input. It follows from (2) and outputs of downstream firms that the demand function of the essential input is given by

$$
\begin{aligned}
y_b &= \alpha_1 x_1^* + \alpha_2 x_2^* = \alpha_1 \frac{a + (-2\alpha_1 + \alpha_2)p_b}{3} + \alpha_2 \frac{a + (\alpha_1 - 2\alpha_2)p_b}{3} \\
&= \frac{a(\alpha_1 + \alpha_2) - 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)p_b}{3},
\end{aligned}
$$

where p_b is the price in the upstream market set by the monopolist.

Now we turn to the formal statement of our analysis in a bottleneck monopoly game:

Lemma 1. *Equilibrium prices in a bottleneck monopoly game are given by prices in the upstream market and the downstream market. They are given respectively by*

$$
p_b^* = \frac{a(\alpha_1 + \alpha_2) + 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta}{4(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} > \beta, \tag{7}
$$

and

$$
P_B = \frac{a(5\alpha_1^2 - 2\alpha_1\alpha_2 + 5\alpha_2^2) + 2(\alpha_1^3 + \alpha_2^3)\beta}{12(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} > \alpha_1 p_b^*. \tag{8}
$$

Proof. The bottleneck monopolist maximizes profits for a given demand for inputs, which are expressed as

$$
\pi_b = (p_b - \beta)y_b = (p_b - \beta)\frac{a(\alpha_1 + \alpha_2) - 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)p_b}{3}.
$$

Thus, differentiating π_b with respect to p_b and solving it for p_b, we have

$$
p_b^* = \frac{a(\alpha_1 + \alpha_2) + 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta}{4(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)}.
$$

It follows from this and (1) that we have

$$
P_B = \frac{a(5\alpha_1^2 - 2\alpha_1\alpha_2 + 5\alpha_2^2) + 2(\alpha_1^3 + \alpha_2^3)\beta}{12(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)}.
$$

First, we will show that p_b^* is larger than β. In fact, the difference between them is

$$
p_b^* - \beta = \frac{a(\alpha_1 + \alpha_2) + 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta}{4(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} - \beta = \frac{a(\alpha_1 + \alpha_2) - 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta}{4(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)}.
$$

This difference will be positive if the numerator is positive, because the denominator is positive for $\alpha_1 > \alpha_2$. In view of (6), the numerator is written as

$$a(\alpha_1 + \alpha_2) - 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta \geq 4\alpha_1\beta(\alpha_1 + \alpha_2) - 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta = 2\beta(\alpha_1^2 + 3\alpha_1\alpha_2 - \alpha_2^2)$$
$$= 2\alpha_2^2\beta(\alpha^2 + 3\alpha - 1) > 0,$$

where the inequality is due to assumption (3), i.e., $\alpha > 1$. Thus, p_b^* is larger than β.

Next, consider whether downstream firms can make profits or not. Compare P_B and $\alpha_1 p_b^*$. The latter is the production cost for firm 1.

$$
\begin{aligned}
P_B - \alpha_1 p_b^* &= \frac{a(5\alpha_1^2 - 2\alpha_1\alpha_2 + 5\alpha_2^2) + 2(\alpha_1^3 + \alpha_2^3)\beta}{12(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} - \alpha_1 \frac{a(\alpha_1 + \alpha_2) + 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta}{4(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} \\
&= \frac{1}{12(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)}(a(2\alpha_1^2 - 5\alpha_1\alpha_2 + 5\alpha_2^2) + 2\beta(-2\alpha_1^3 + 3\alpha_1^2\alpha_2 - 3\alpha_1\alpha_2^2 + \alpha_2^3)) \\
&\geq \frac{1}{12(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)}(4\alpha_1\beta(2\alpha_1^2 - 5\alpha_1\alpha_2 + 5\alpha_2^2) + 2\beta(-2\alpha_1^3 + 3\alpha_1^2\alpha_2 - 3\alpha_1\alpha_2^2 + \alpha_2^3)) \\
&= \frac{\beta}{6(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)}(2\alpha_1^3 - 7\alpha_1^2\alpha_2 + 7\alpha_1\alpha_2^2 + \alpha_2^3) \\
&= \frac{\alpha_2\beta}{6(\alpha^2 - \alpha + 1)}(2\alpha^3 - 7\alpha^2 + 7\alpha + 1) > 0,
\end{aligned}
$$

where $\alpha = \alpha_1/\alpha_2$ and the inequality is due to assumptions (3) and (6). Then, equilibrium price P_B enables firms 1 and 2 to reap positive profits.

Note that the total outputs in the downstream market are expressed as

$$X^* = \frac{2a - (\alpha_1 + \alpha_2)p}{3} = \frac{2a - (\alpha_1 + \alpha_2)p_b^*}{3}.$$

To prove that X^* is positive, it can be rewritten as

$$\frac{2a - (\alpha_1 + \alpha_2)p_b^*}{3} > \frac{2a - 2\alpha_1 p_b^*}{3} = \frac{2}{3}(a - \alpha_1 p_b^*),$$

where the inequality comes from assumption (3). Together with (6) and (7), we have

$$
\begin{aligned}
a - \alpha_1 p_b^* &\geq 4\alpha_1\beta - \alpha_1 \frac{a(\alpha_1 + \alpha_2) + 2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)\beta}{4(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} \\
&= \frac{\alpha_1\beta(5\alpha_1^2 - 9\alpha_1\alpha_2 + 7\alpha_2^2)}{2(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} = \frac{\alpha_1\beta(5\alpha^2 - 9\alpha + 7)}{2(\alpha^2 - \alpha + 1)}.
\end{aligned}
$$

The denominator and the numerator are both positive for $\alpha > 1$. It follows that total outputs X^* are positive. It turns out that each player can earn positive profits by selling their outputs to customers in our bottleneck monopoly game. □

It is essential that all players in this game are viable at subgame perfect equilibrium. To guarantee that they can survive in this game, it is sufficient to assume that the inequality $a \geq 4\alpha_1\beta$ holds.

3   Integration and Separation in Vertically Related Market

In this section, we will examine short-run effects of a vertical integration (or separation) on a downstream market. If a bottleneck monopolist merges with one of the downstream firms, cost advantages of the integrated firm may result in driving a rival out of the market. If it does not, product prices may rise or fall. To proceed with our analysis,we first study a game in which the bottleneck monopolist integrates with a downstream firm. For example, when firms 1 and 3 are integrated, then firm 2 has to buy its essential input from its competitor, the integrated firm, called firm I. This new market structure is called a vertically integrated bottleneck monopoly VBM. The monopolist in the VBM is called a MIV or a partial monopolist because it has a competitor in the downstream market. Then, we define a VBM equilibrium as a subgame perfect equilibrium in the VBM in which the firms compete by setting outputs in the downstream market and setting prices in the upstream market.

We digress slightly to consider the general market structure. A vertical integration in our model means that an upstream monopolist integrates with a downstream firm to change the market structure into a VBM. However, if a vertically integrated firm separates into an upstream and a downstream firm, the market structure changes into a market in which an upstream monopolist faces two downstream customers. Thus, effects of a vertical integration and separation are symmetric. The effect of the integration shows what effect the separation of a vertically integrated firm will have. Note, however, that in reality firms will encounter competitors who can partially control a market even after integration and/or separation. Thus it is better to analyze the structural effects using the game-theoretic analysis. Westfield (1981) examined whether integration causes downstream market price to rise or fall. The scenario is as follows. The pre-merger situation is a market in which an upstream monopolist faces perfectly competitive firms, and all firms, including the monopolist, are integrated into one firm after merger, giving rise to pure monopoly. Thus, the analysis lacks oligopolistic elements, and it will be difficult to get information about policy implication.

Now consider the analysis of a vertical integration. The integrated firm is able to produce an essential input at the marginal cost β. On the other hand, the independent firm can purchase inputs at a market price p, which is different from the marginal cost of its rival. Then, the partial monopolist enjoys cost advantage over the independent. In the analysis to follow, we will consider whether the independent firm can be viable.

It is true that the partial monopolist has incentives to merge with a downstream firm with

9

technological superiority. Higher profits will be earned by a firm with lower costs. However, it will be demonstrated that such an integration causes an independent, downstream firm to exit the downstream market (For detail, see *Proposition* 1). Then the market structure turns into pure monopoly and we can not go into the analysis of effects of the vertical integration on an up- and down-stream market. Thus, it is assumed, in the analysis to follow, that the monopolist merges with an inefficient firm.

The profits of the integrated firm I and the independent firm 2 are given by

$$\pi_I = \pi_d + \pi_u = (P - \alpha_1\beta)x_I + \alpha_2(p - \beta)x_2 = (a - \alpha_1\beta - (x_I + x_2))x_I + \alpha_2(p - \beta)x_2,$$

$$\pi_2 = (P - \alpha_2 p)x_2 = (a - \alpha_2 p - (x_I + x_2))x_2,$$

where π_d and π_u stand for profits of the *MVI* in the downstream and the upstream markets, and p stands for price of the essential input. In the second stage (or the downstream market), the monopolist and the independent firm compete on quantity. The first-order conditions for the maximization of profits are

$$\frac{\partial \pi_I}{\partial x_I} = \frac{\partial \pi_d}{\partial x_I} = a - \alpha_1\beta - 2x_I - x_2 = 0,$$

$$\frac{\partial \pi_2}{\partial x_2} = a - \alpha_2 p - x_I - 2x_2 = 0,$$

where x_I stands for output of the *VBM* and x_2 for that of the independent competitor. The Nash equilibrium outputs of these firms are expressed as

$$x_I^* = \frac{a - 2\alpha_1\beta + \alpha_2 p}{3}, \tag{9}$$

$$x_2^* = \frac{a + \alpha_1\beta - 2\alpha_2 p}{3}. \tag{10}$$

Firm 2 has to purchase inputs from the integrated firm and its demand is derived from its output x_2^*. Demand for inputs of firm 2 is

$$\alpha_2 x_2^* = Y = \frac{\alpha_2(a + \alpha_1\beta - 2\alpha_2 p)}{3}. \tag{11}$$

Thus, we can now summarize our analysis above as:

Lemma 2. *Equilibrium prices in the upstream and downstream markets in the integrated bottleneck monopoly are given by*

$$p_i^* = \frac{5a - \alpha_1\beta + 6\alpha_2\beta}{10\alpha_2}. \tag{12}$$

$$P_I = \frac{5a + \beta(3\alpha_1 + 2\alpha_2)}{10}, \tag{13}$$

10

where P_I is higher than $\alpha_1 p_i^*$. Finally, output of the independent firm is given by

$$x_2^* = \frac{2(\alpha_1 - \alpha_2)\beta}{5} > 0.$$

Proof. Firm I has a demand for its products derived above, which is given by (11). Thus, it follows from (9) and (11) that profits of the monopolist are given by

$$
\begin{aligned}
\pi_I &= \pi_d + \pi_u = (P - \alpha_1\beta)x_I^* + (p - \beta)Y = (a - \alpha_1\beta - x_I^* - x_2^*)x_I^* + (p - \beta)Y \\
&= \left(a - \alpha_1\beta - \frac{a - 2\alpha_1\beta + \alpha_2 p}{3} - \frac{a + \alpha_1\beta - 2\alpha_2 p}{3}\right)\frac{a - 2\alpha_1\beta + \alpha_2 p}{3} \\
&\quad + (p - \beta)\frac{\alpha_2(a + \alpha_1\beta - 2\alpha_2 p)}{3} \\
&= \left(\frac{a - 2\alpha_1\beta + \alpha_2 p}{3}\right)^2 + \frac{\alpha_2(p - \beta)(a + \alpha_1\beta - 2\alpha_2 p)}{3}.
\end{aligned}
$$

The first-order condition for maximizing profits π_I of the monopolist yields

$$\frac{d\pi_I}{dp} = 2\frac{(a - 2\alpha_1\beta + \alpha_2 p)}{3}\frac{\alpha_2}{3} + \frac{\alpha_2}{3}((a + \alpha_1\beta - 2\alpha_2 p) + (p - \beta)(-2\alpha_2)) = 0.$$

Solving this for the equilibrium price p_i^*, we have

$$p_i^* = \frac{5a - \alpha_1\beta + 6\alpha_2\beta}{10\alpha_2}.$$

Substituting p_i^* into (9) and (10), it follows from (1) that

$$P_I = a - x_I^* - x_2^* = a - \frac{a - 2\alpha_1\beta + \alpha_2 p_i^*}{3} - \frac{a + \alpha_1\beta - 2\alpha_2 p_i}{3} = \frac{5a + \beta(3\alpha_1 + 2\alpha_2)}{10}.$$

It also follows from (10) that equilibrium output of firm 2 is given by

$$x_2^* = \frac{a + \alpha_1\beta - 2\alpha_2 p_i^*}{3} = \frac{2(\alpha_1 - \alpha_2)\beta}{5} > 0,$$

where the inequality is due to (3). Next, we will check if the independent can indeed make positive profits. Using P_I and p_i^* above, we get:

$$P_I - \alpha_2 p_i^* = \frac{2\beta(\alpha_1 - \alpha_2)}{5} > 0.$$

where the inequality sign comes from (3). Then, the independent can make positive profits by supplying outputs in the downstream market.

Note also that equilibrium upstream price p_i^* is higher than β. In fact, subtracting β from p_i^*, we have

$$p_i^* - \beta = \frac{5a - \alpha_1\beta + 6\alpha_2\beta}{10\alpha_2} - \beta = \frac{5a - \alpha_1\beta - 4\alpha_2\beta}{10\alpha_2} > 0,$$

which will be positive under our assumptions (3) and (6). The monopolist can reap positive profits by supplying an essential input to its competitor. $\qquad\square$

Lemma 2 states that as the independent has cost advantages over the *MVI*, output of the independent is positive and the firm can make positive profits. In other words, the independent can be viable in the *VBM* game if it has superior technologies. It follows from these arguments that these conclusions are mainly due to assumption (3). However, if assumption (3) fails, output of the independent is not positive and the firm has to exit the downstream market. Thus, if the assumption does not hold true, the formation of the *VBM* enables the monopolist to exclude the independent from the market and then the market structure changes into pure monopoly. If the competitor can not stay in the downstream market, x_2^* must be non-positive. This implies that $\alpha \leq 1$.

Thus, we can summarize these arguments as follows:

Proposition 1. *(Whinston (1990)) An upstream monopolist maximizes profits by not selling to its downstream rival if and only if $\alpha \leq 1$.*

Proof. If α is not larger than 1, it follows from *Lemma* 2 that $x_2^* \leq 0$ for $\alpha \leq 1$. This means that the market structure changes into pure monopoly, where both markets are without competitors. On the other hand, if a competitor can not stay in the downstream market, its output must be non-positive. It follows from *Lemma* 2 that the non-positivity of outputs of the independent leads to $\alpha \leq 1$. □

It follows from *Proposition* 1 that efficiency of competitors plays an essential role in the determination of market structure. The presence of efficient competitors enables the partial monopolist to sell products to the competitors even if some of profits are lost in the downstream market. In fact, it is probable that profits lost in the downstream market are less than profits earned in an upstream market. This line of reasoning was already proposed by Whinston (1990) in his *Proposition* 3.

If $\alpha \leq 1$, then an independent is inferior in production technologies. Moreover, the firm has to purchase its inputs at a market price which is higher than the marginal costs of the inputs. However, the partial monopolist can provide its downstream division with inputs at the marginal costs. Thus, the monopolist can take advantage of productive activities and costs. Then, it follows from these advantages that the partial monopolist can maximize profits by not selling essential inputs to the independent after the vertical integration with a firm with superior technologies.

On the other hand, if the independent has superior technologies and assumption (3) does hold, our discussion of *Proposition* 1 shows that the independent can be viable in the down-

stream market after the integration. Thus, if an un-integrated firm has advantageous production technology, i.e., $\alpha > 1$, the monopolist can maximize profits by supplying inputs to its downstream competitor with technological superiority over the monopolist. It follows from *Proposition* 1 that technological advantage is one of the essential means to compete in a market. Although technologies are one of the important means to cope with competitors, it will also be of some interest to know what a market is like when the integrated monopolist faces a competitor and to determine whether market prices become lower after the merger. To make such an analysis, we focus on games in which the upstream monopolist integrates with a less efficient firm.

So far two types of market structure have been analyzed, where there are two equilibrium prices in each market. This in turn enables us to explore effects of vertical integration on an up- and down-stream market. It will be of some interest to compare prices in these games and show under what condition vertical integration leads to lower market price in the downstream market. The analysis of this problem will show some of the important effects of the vertical integration on a market and on consumers' welfare in our games. In what follows, it will be shown when the integration results in an increase in consumers' surplus and when it does not.

Comparisons between P_I and P_B are much more complicated. It follows from *Lemmas* 1 and 2 that

$$
\begin{aligned}
P_I - P_B &= \frac{5a + \beta(3\alpha_1 + 2\alpha_2)}{10} - \frac{a(5\alpha_1^2 - 2\alpha_1\alpha_2 + 5\alpha_2^2) + 2(\alpha_1^3 + \alpha_2^3)\beta}{12(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} \\
&= \frac{5a(\alpha_1^2 - 4\alpha_1\alpha_2 + \alpha_2^2) + 2(4\alpha_1^3 - 3\alpha_1^2\alpha_2 + 3\alpha_1\alpha_2^2 + \alpha_2^3)\beta}{60(\alpha_1^2 - \alpha_1\alpha_2 + \alpha_2^2)} \\
&= \frac{5a(\alpha^2 - 4\alpha + 1) + 2(4\alpha^3 - 3\alpha^2 + 3\alpha + 1)\alpha_2\beta}{60(\alpha^2 - \alpha + 1)}.
\end{aligned}
$$

For notational simplicity, we now use new definitions:

$$
\begin{aligned}
f(\alpha) &= P_I - P_B, \\
g(\alpha) &= \frac{4\alpha^3 - 3\alpha^2 + 3\alpha + 1}{\alpha^2 - 4\alpha + 1}.
\end{aligned}
$$

Using these definitions, the differences in equilibrium prices are rewritten as

$$
\begin{aligned}
P_I - P_B &= f(\alpha) \\
&= \frac{2\alpha_2\beta}{60(\alpha^2 - \alpha + 1)}\{\frac{5a}{2\alpha_2\beta}(\alpha^2 - 4\alpha + 1) + (4\alpha^3 - 3\alpha^2 + 3\alpha + 1)\} \\
&= \frac{\alpha_2\beta}{30(\alpha^2 - \alpha + 1)}(\alpha^2 - 4\alpha + 1)\{\frac{5a}{2\alpha_2\beta} + \frac{4\alpha^3 - 3\alpha^2 + 3\alpha + 1}{\alpha^2 - 4\alpha + 1}\} \\
&= \frac{\alpha_2\beta}{30(\alpha^2 - \alpha + 1)}(\alpha^2 - 4\alpha + 1)\{\frac{5a}{2\alpha_2\beta} + g(\alpha)\},
\end{aligned}
$$

where $(\alpha^2 - \alpha + 1)$ is positive for any α. It then follows that $f(\alpha) = 0$ when the second and/or the last terms in equation above is equal to zero. Then, consider first the following equation:

$$\frac{5a}{2\alpha_2\beta} + g(\alpha) = 0, \tag{14}$$

which in turn implies that $f(\alpha) = 0$.

In view of equations (3) and (6),

$$\frac{5a}{2\alpha_2\beta} \geq \frac{5 \times 4\alpha_1\beta}{2\alpha_2\beta} > \frac{5 \times 4\alpha_2\beta}{2\alpha_2\beta} = 10.$$

Next, consider the following equation:

$$10 + g(\alpha) = 10 + \frac{4\alpha^3 - 3\alpha^2 + \alpha + 1}{\alpha^2 - 4\alpha + 1} = 0.$$

The approximate values of solutions to the equation are given by $\alpha = -4.217$, 0.301, and 2.166. Note also that the function $g(\alpha)$ is less than -2.5 for $\alpha > 1$ because $g(1) = -2.5$, and that $g(\alpha)$ is negative, monotonically decreasing and approaching $-\infty$ as α increases in the open interval $(1, 3.732)$. In the analysis to follow, the solution which is appropriate here is $\alpha = 2.166$ because $\alpha > 1$(assumption (3)). It follows from the properties of $g(\alpha)$ and $\frac{5a}{2\alpha_2\beta} > 10$ that the solution α^* to equation (14) is larger than 2.166, but less than 3.732.

Finally, together with *Lemmas* 1 and 2, we can formally state:

Proposition 2. *The integrated bottleneck monopoly game yields lower equilibrium prices than the bottleneck monopoly game if differences in productivity are relatively small. However, if productivity of the independent is high enough, it provides higher equilibrium price than the bottleneck monopoly game does. Formally, we have*

$$P_I \leq P_B, \quad for \quad \alpha \leq \alpha^*,$$

$$P_I > P_B, \quad for \quad \alpha > \alpha^*,$$

Proof. Comparisons between P_I and P_B are rather complicated. As shown above, the difference is given by

$$P_I - P_B = \frac{\alpha_2\beta}{30(\alpha^2 - \alpha + 1)}(\alpha^2 - 4\alpha + 1)\{\frac{5a}{2\alpha_2\beta} + g(\alpha)\}. \tag{15}$$

As was assumed before, α is larger than 1. First, consider the case in which α is less than 3.732.

14

Thus, it follows from the properties of $g(\alpha)$ that equation (14):

$$\frac{5a}{2\alpha_2\beta} + g(\alpha) = 0$$

has a unique, positive solution α^* in the open interval (2.166, 3.732).

Then, we encounter two cases depending upon whether the quadratic term $(\alpha^2 - 4\alpha + 1)$ is negative or not. It is easy to show that the quadratic term is positive and $g(\alpha) > 0$ for $\alpha > 3.732$. This means that $\frac{5a}{2\alpha_2\beta} + g(\alpha) > 0$ for $\alpha > 3.732$. Then, it follows from equation (15) that $P_I > P_B$ for $\alpha > 3.732$.

Next, consider a case in which the quadratic term is negative, or equivalently $1 < \alpha < 3.732$. Noting that $g(\alpha)$ is negative and is monotonically decreasing to $-\infty$ as α goes from 1 up to 3.732, we have a unique solution to equation (14) in the open interval (1, 3.732)

Finally, it follows from the properties of function $g(\alpha)$ and equation (14) that we have

$$g(\alpha) + \frac{5a}{2\alpha_2\beta} \geq 0, \quad for \quad \alpha \leq \alpha^*,$$
$$g(\alpha) + \frac{5a}{2\alpha_2\beta} < 0, \quad for \quad \alpha > \alpha^*.$$

Noting that $(\alpha^2 - 4\alpha + 1) < 0$ for α in the open interval $(1, 3.732)$, it follows from equation (15) that

$$P_I \leq P_B, \quad for \quad \alpha \leq \alpha^*,$$
$$P_I > P_B, \quad for \quad \alpha > \alpha^*.$$

This completes the proof. □

This proposition clearly shows one of the essential features of vertically related markets . The vertical integration generally causes equilibrium prices to decline.[9] However, our proposition shows that this is not necessarily true when the integration occurs in a bottleneck monopoly. The integration has two distinct effects on equilibrium prices in the downstream market: cost effects and technological effect. The integrated firm can get access to inputs at lower costs (the marginal costs), while an un-integrated, independent firm is supplied inputs at market price. Decreases in production costs result in lower equilibrium price and *vice versa*. Then, the effect of the integrated monopolist may be called a cost-reducing effect. Considering the technological effect, productivity of the integrated firm either strengthens or weakens the cost-reducing effect. For example, when productivity of the integrated is high, it strengthens the cost-reducing effect. However, that effect is weakened when productivity is low.

In view of *Proposition* 2, we can be more precise than this. When the integrated firm is so efficient that $\alpha \leq 1$, the cost-reducing effect of the integrated firm becomes stronger due to its productivity. Then, equilibrium price in the downstream market will fall too much for the independent to make any profits. Thus, the integrated firm has advantages not only in costs but also in technology. This in turn means that the independent can not be viable. This is the case in which *Proposition* 1 holds true. However, when the integrated firm is inefficient in that $\alpha \leq \alpha^*$, the cost-reducing effect of the integrated firm is weakened by its technological inefficiency. Thus, equilibrium price in the downstream market falls but by a lesser amount after the integration. However, when the integrated firm has technologies so inefficient that $\alpha > \alpha^*$, technological inefficiency weakens the cost-reducing effect so much that production costs become higher. Then, product prices will rise after integration. Thus, depending upon the relative efficiency of production of the two firms, the integration by the bottleneck monopolist causes equilibrium prices to go up in some cases and go down in others.

In reality, however, there is the fear that the vertical integration by the bottleneck monopolist is sure to eliminate competition in the downstream market because the integration confers more controlling power on the the monopolist in the downstream market. It immediately follows that the integration is expected to cause equilibrium prices in the downstream market to go up. According to *Proposition* 2, if the integrated monopolist is rather inefficient, that is, $\alpha = \alpha_1/\alpha_2 > \alpha^*$ to be precise, it does stand to reason that the fear will be realized. The integration would thus aggravate economic efficiency in the integrated market structures. However, if the integrated firm is not highly inefficient in that $\alpha \leq \alpha^*$, the integration promotes market efficiency. Then, the fear that the integration results in inefficiency in the downstream market will not generally be realized when the integrated monopolist is not highly inefficient.

On the other hand, the fear of monopoly sometimes leads to forced separation of vertically related firms. It is not certain whether such separation results in enhancement of market efficiency. However, *Proposition* 2 shows when the separation of integrated firms into an upstream and a downstream division promotes market efficiency. When a separated downstream division is superior in productivity in that the difference in marginal costs is small, $\alpha \leq \alpha^*$ to be precise, the resulting market price will go up. When the difference is so large that $\alpha > \alpha^*$, the separation causes market efficiency to be enhanced. Thus, our results can shed some light on the effects of regulation policy.

We now turn to the formal statement of these arguments concerned with regulation of firms.

Proposition 3. *Separation of a vertically integrated monopolist should not be prohibited if pro-*

ductivity of the downstream division of the monopolist is high, i.e., $\alpha^* < \alpha$ to be precise.

If the vertically integrated monopolistic firm is separated into an upstream and a downstream firm, the market structure is turned into a bottleneck monopoly. The downstream firm has to buy essential inputs at higher costs and an independent firm may get inputs at lower costs. Thus, the former effect results in a higher product price, while the latter effect by the independent causes market price to fall. It is not clear which effect dominates. However, when productivity of the independent is high enough so that $\alpha > \alpha^*$, price-decreasing effect by the independent dominates. Thus, market price of products will fall after separation. Finally, the separation causes market efficiency to be enhanced and hence it should not be banned by regulation. On the other hand, when productivity of the independent is not so high that $\alpha < \alpha^*$, the price-decreasing effect is not dominant. Then, product price rises due to the separation of a vertically integrated monopolistic firm. The separation should not be promoted in these situations.

Finally, it is not clear whether the vertically integrated monopolist has incentives to supply an essential input to the independent competitor even if $\alpha > 1$. For example, there is a possibility that the monopolist employs strategies that exclude a rival from a market; such as refusing to supply inputs to the independent or by applying price squeeze. However, our analysis in the next section will show that the monopolist does not have incentives to follow such a strategy.

4   Price Strategy by the Partial Monopolist

The second, long-run effect which will be examined in this section is a price squeeze by the partial monopolist (or *MVI*), which is a price strategy in the *VBM*. When the monopolist faces competitors, there is the fear that hostile activity toward the competitors will be undertaken by the monopolist. For example, the main concern about formation of a vertically integrated bottleneck monopoly is that the *MVI* sets the price for the input so high that the downstream competitors can not compete with the *MVI*. After competitors exit the market, it will set higher (or monopoly) prices for the output to maximize its profits. Put another way, the fear is that the monopolist will engage in a price-squeeze strategy.

It will be of some interest to examine whether the price set by the bottleneck supplier in the *VIB* causes the independent firm to exit the downstream market. If costs of essential inputs for the independent firm are low, the independent will stay in the market and compete with the monopolist. However, if these costs are too high, the independent cannot make any profits and will leave the market. This has been the fear when integration results in an integrated bottleneck monopoly. In this section, our focus is on the long-run effect of vertical integration. The *MVI* has incentives to monopolize the up- and the down-stream market. If the monopolist has such incentives, prices set by the monopolist are too high for the independent firm to stay in the market. Then, if a high price is set for inputs the monopolist is said to engage in a price-squeeze strategy.

In what follows, consider a price-squeeze strategy by a *MVI* and its long-run influence on market outcomes. Following Joskow (1985), this is defined as a strategy of the *MVI* who charges so high a price for the inputs supplied to its downstream competitors that they cannot make any profit.

We proceed with our analysis as follows. In the first stage, the *MVI* adopts a price squeeze strategy and makes profits π_{sq}. In the second stage, the monopolist reaps the monopoly profits π_m. Then, total profits under this strategy are given by $(\pi_{sq}+\pi_m)$.[10] Note that π_{sq} and π_m are not necessarily the same. If the monopolist does not employ such a strategy, it can make the same profits π_I in two stages. Then, the total profits will sum up to $2\pi_I$. If the monopolist can make larger profits using the price squeeze strategy, it is sure to have incentives to apply that strategy. To examine this further, we will calculate profits under a price squeeze strategy.

Noting, by assumption (2), that α_2 units of an essential input are required by firm 2 (the

independent) to produce one unit of outputs, we can define a price squeeze as,

$$P_{SQ} = \alpha_2\, p_{sq}. \tag{16}$$

Note that individual equilibrium outputs of firms I and 2 are given by (9) and (10). Total output is the sum of the individual outputs. Therefore, we have

$$x_I^* + x_2^* = \frac{a - 2\alpha_1\beta + \alpha_2 p}{3} + \frac{a + \alpha_1\beta - 2\alpha_2 p}{3} = \frac{2a - \alpha_1\beta - \alpha_2 p}{3}.$$

Taking this, (1) and (16) into account, the price P_{SQ} set under the price squeeze strategy is expressed as

$$P_{SQ} = a - x_I^* - x_2^* = a - \frac{2a - \alpha_1\beta - \alpha_2 p_{sq}}{3} = \frac{a + \alpha_1\beta + \alpha_2 p_{sq}}{3} = \frac{a + \alpha_1\beta + P_{SQ}}{3}.$$

This gives us price P_{SQ} as

$$P_{SQ} = \frac{a + \alpha_1\beta}{2}. \tag{17}$$

Together with (16), the price of input, which is derived from the price squeeze strategy by the partial monopolist, is reduced to

$$p_{sq}^* = \frac{a + \alpha_1\beta}{2\alpha_2}. \tag{18}$$

Note that if the partial monopolist sets input price equal to p_{sq}^* given above, output of firm 2 is equal to zero. Indeed, substituting (18) into (10) reveals that x_2^* equals zero.

On the other hand, if the bottleneck supplier of inputs is a monopolist in the downstream market too, it faces demand (1) and its constant average cost is β. This game will be called pure monopoly. It is straightforward to show that monopoly price P_M is given by

$$P_M = \frac{a + \alpha_1\beta}{2}. \tag{19}$$

Monopoly output x_m is given by

$$x_m = a - \frac{a + \alpha_1\beta}{2} = \frac{a - \alpha_1\beta}{2}.$$

Now we turn to the formal statement and proof of our proposition.

Proposition 4. *The downstream price set under a price squeeze strategy by the MVI is the same as equilibrium price in pure monopoly. Moreover, this price under the price squeeze strategy is higher than the equilibrium price in the integrated bottleneck monopoly game. Thus,*

$$P_I < P_{SQ} = P_M.$$

Moreover, input price under this strategy is given by

$$p_{sq}^* = \frac{a + \alpha_1\beta}{2\alpha_2}.$$

Proof. Note that the prices set under the price squeeze strategy are given by (17) and (18), while a monopolist in pure monopoly game charges a price equal to (19). These are the same.

Next, it is easy to see that

$$P_{SQ} - P_I = \frac{a + \alpha_1\beta}{2} - \frac{5a + (3\alpha_1 + 2\alpha_2)\beta}{10} = \frac{(\alpha_1 - \alpha_2)\beta}{5} > 0.$$

where the inequality comes from (3). Input price under a price squeeze is given by (18).

This completes the proof. □

This proposition shows what prices are fixed in an up- and down-stream market under a price squeeze. A price squeeze is a maneuver of a *MVI* to drive the *efficient* competitor out of a downstream market.[11] When a rival is efficient in technologies, a price squeeze is used as an exclusion strategy by the partial monopolist in vertically related markets. If the monopolist sets higher input prices, the competitor, who is the customer in a downstream market, can not make positive profits. Although limit price is employed in the downstream market, a price squeeze works in the two related markets. Thus, it is closely related to limit price. Both the exclusion strategies cause a competitor to exit a market and help the remaining firms reap the maximum profits. These strategies are anti-competitive in nature, and enable the monopolist to make the maximum profits. Then, a price squeeze is rather complicated in that the monopolist has to fix not only product prices but also input prices.

It is interesting to note that monopoly price equals downstream price set under a price squeeze. Monopoly is a market in which a monopolist has the maximum control over the market and hence can reap the highest profits by setting higher prices. In fact, monopoly price is higher than the price in the *VBM*. On the other hand, prices set under a price squeeze are constrained by assumption (16). Thus, a monopoly price and prices under a price squeeze are set under quite different conditions. It is natural that a monopoly price is higher than a price under constraint (16) because a monopolist can perfectly control a market and then can set the price under fewer constraints than a partial monopolist. However, it follows from *Proposition* 4 that these prices are the same. Then, there is the fear that the partial monopolist will try to exclude a rival from a market and thereby to monopolize two related markets.

The partial monopolist under a price squeeze loses a customer of products in the upstream market, and then this strategy has negative effects on its profits. On the other hand, the partial

monopolist can be a true monopolist even in the downstream market under this strategy and this has a positive effect on its profits. Thus, a price squeeze has two opposite effects on profits; one is negative and the other positive. It is not clear which effect is dominant. This point reveals one of the important features of vertically related markets.

It will be interesting to examine if the partial monopolist has incentives to manage the integrated bottleneck monopoly. If it does, the market structure will turn into pure monopoly and will aggravate economic efficiency. Deregulation will then result in inefficiency in the integrated market structure. Thus, it is necessary to compare profits under a price squeeze and under a *VBM*. In view of *Proposition* 4 the partial monopolist can earn the same profits under a price squeeze strategy and under a pure monopoly. The profits are given by $\pi_{sq} = \pi_m$. Total profits in two stages under this strategy are expressed as $2\pi_{sq}$.

This is summarized in a formal statement and proof as follows.

Proposition 5. *The monopolist in the VBM would prefer to keep the market structure unchanged in this two-stage game (or an integrated bottleneck monopoly) game.*

Proof. The *MVI* can make profits not only in the downstream market, but also in the upstream market. If the monopolist succeeds in driving competitors out of the downstream market, the resulting increase in profits earned in that market using perfect control may be greater or smaller than the profits lost in the upstream market. It is not clear which is larger. Therefore, a precise comparison of profits earned by pure monopolist with those earned by the *MVI* is necessary.

If the monopolist can perfectly control the downstream market, its profit is

$$\pi_m = (P_M - \alpha_1\beta)x_m = \left(\frac{a + \alpha_1\beta}{2} - \alpha_1\beta\right)\left(\frac{a - \alpha_1\beta}{2}\right) = \left(\frac{a - \alpha_1\beta}{2}\right)^2.$$

On the other hand, the *MVI* can make a profit of π_I, which consists of profits π_d in the downstream market and π_u in the upstream market. In view of *Lemma* 2 and its proof, the profit in the downstream market is

$$\pi_d = (P_I - \alpha_1\beta)x_I^* = \left(\frac{5a + \beta(3\alpha_1 + 2\alpha_2)}{10} - \alpha_1\beta\right)x_I^* = \frac{(5a - 7\alpha_1\beta + 2\alpha_2\beta)^2}{100}.$$

Similarly, the profit earned in the upstream market is

$$\pi_u = (p_i^* - \beta)\alpha_2 x_2^* = \frac{\beta(\alpha_1 - \alpha_2)(5a - (\alpha_1 + 4\alpha_2)\beta)}{25}.$$

Total profits of the *MVI* are given by

$$
\begin{aligned}
\pi_I &= \pi_d + \pi_u = \frac{(5a - 7\alpha_1\beta + 2\alpha_2\beta)^2}{100} + \frac{\beta(\alpha_1 - \alpha_2)(5a - (\alpha_1 + 4\alpha_2)\beta)}{25} \\
&= \frac{5a^2 - 10a\alpha_1\beta + (9\alpha_1^2 - 8\alpha_1\alpha_2 + 4\alpha_2^2)\beta^2}{20}.
\end{aligned}
$$

21

It follows from *Proposition* 4 that $\pi_{sq} = \pi_m$. Thus, comparisons of profits in two stages can be made. In fact, the difference between total profits $(\pi_m + \pi_{sq})$ earned under a price squeeze and total profits $2\pi_I$ earned by the partial monopolist is reduced to that between π_{sq} and π_I. It is given by

$$\pi_{sq} - \pi_I = \left(\frac{a - \alpha_1\beta}{2}\right)^2 - \frac{5a^2 - 10a\alpha_1\beta + (9\alpha_1^2 - 8\alpha_1\alpha_2 + 4\alpha_2^2)\beta^2}{20} = -\frac{(\alpha_1 - \alpha_2)^2\beta^2}{5} < 0.$$

As profits are lower in pure monopoly than in the *VBM* , a price squeeze strategy results in lower profits for the *MVI*. This means that the *MVI* can make higher profits when it does not change the integrated market structure. $\qquad\qquad\square$

It follows from these arguments that our results differ from those obtained by Joskow (1985). The fear that the *MVI* will try to monopolize a downstream market and raise market price is unfounded. On the contrary, our *Proposition* 5 shows that it is not economically rational for the *MVI* to monopolize a downstream market.

5 Conclusions

We have examined the short-run and the long-run effects of a vertical integration. The short-run scenario examined in this paper gives the integrated firm technological disadvantage and lower-cost inputs, which in turn gives cost advantage to the integrated firm and a disadvantage to the un-integrated firm. Relative efficiency of the integrated and the un-integrated firm is an essential factor that characterizes the effects of vertical integration. If relative efficiency of the integrated firm is high in that it has technological superiority, it can maximize profits by not supplying inputs to the un-integrated firm. If relative efficiency of the integrated becomes lower because the un-integrated has only a modest advantage in technological efficiency, cost advantages of the integrated are vitiated by technological disadvantage. Downstream prices fall after the vertical integration, but product prices are sufficiently high for the un-integrated to be viable. Finally, if the integrated has large disadvantage in technology, it is not overcome by cost advantage, and hence the integration causes product prices to rise. Thus, technological efficiency of firms participating in the vertical integration can make a difference in post-merger situations. These are direct or simultaneous effects of vertical integration. Then, the fear that deregulation may help the bottleneck monopolist to merge with other firms and thus to aggravate market efficiency is not necessarily well founded.

If the un-integrated firm is viable after merger, there is the fear that the integrated firm will drive a rival out of a market by some strategies. This is the long-run effect of the vertical merger. As an example of such strategies, we consider a price squeeze by the integrated firm. It was shown that the fear of exclusion of a rival is not justified on the basis of the model used in this paper. This result shows one of the essential features in the vertically related markets. When the integrated firm has a downstream rival who is a customer of the firm, the firm can make some profits by supplying inputs to the rival. However, if the rival exits a downstream market and the integrated becomes a monopolist, the integrated can make additional profits in a downstream market. However, the integrated has to sacrifice profits in an upstream market. It was shown that profits lost in the upstream are larger than additional profits which would be earned in the downstream market. Thus, a price squeeze is not a profitible strategy for the integrated bottleneck monopolist.

This seems counter-intuitive because a firm can reap the maximum profits by perfectly controlling a market. This is true when we consider a single market. However, it is not true when we extend the analysis to vertically related markets. In fact, the presence of a downstream com-

petitor enables extra profits in the upstream market to outweigh profits lost in the downstream market. Thus, it follows that further deregulation, which is supposed to aggravate the welfare of consumers, does not necessarily result in the monopolization in the downstream market. This means that deregulation does not necessarily lead to the monopolization of a downstream market by some maneuvers of the partial monopolist. In other words, the formation of vertically integrated bottleneck monopoly can not only give the partial monopolist higher profits but also provide higher consumer welfare than a bottleneck monopoly game. These results are the key characteristics of the integrated market structures. The present model has shown the effects of separation of the *VBM* into an upstream and a downstream firm. The model has revealed the standard against which such a separation may be allowed. If the separated downstream firm is somewhat inefficient, the resulting product prices fall. This is a case in which the separation is beneficial to consumers.

However, there are several limitations to our model. Crucially, it has been assumed that the demand and production functions are linear. These enable us to simplify our analysis and to derive interesting results. When we try to extend our model to include non-linearity of important functions, different results may be obtained. For example, if the production functions are concave, the derivation of demand functions of essential inputs is complicated. This, in turn, makes it difficult to determine equilibrium prices in the upstream market. Although these extensions will be of interest, the analysis of these problems will form the basis of our future research.

Endnotes

[1] Avenel (2008) tries to explain why there are industries with some vertical integration even if it does not have effects of foreclosure.

[2] Using a model similar to ours, Salinger (1988) showed when the increased number of vertical mergers will result in an improvement of welfare in the vertically integrated bottleneck monopoly (hereafter, *VBM*). In contrast with these results, DeGraba (2003) observed that the formation of the *VBM* results in an enhancement of welfare.

[3] For a pioneering analysis of this problem, see Modigliani (1958). Kawashima (1983) showed when limit prices prevail.

[4] There are other types of exclusionary strategies. A notable example is sabotage, which is defined as an indirect method such as quality degradation that raises costs of non-integrated rivals in a downstream market. Beard, Kaserman and Mayo (2001), Chen (2001), and Economides (1998) observed that firms have incentives to employ sabotage, while Weisman (1995) showed that firms do not necessarily engage in sabotage.

[5] Sappington (2006) draws similar inferences from Weisman (1995), Sibley and Weisman (1998) and Mandy (2000).

[6] Biglaiser and DeGraba (2001) observed that under a given input price the monopolist does not have incentives to monopolize a downstream market.

[7] Industrial organization has focused mainly on the structure of a single market; for example, see Scherer and Ross (1990), Tirole (1988), and Vives (1999).

[8] Vickers (1995), and Engel, Fischer and Galetovic (2004) examined a bottleneck monopoly from the viewpoint of regulation of markets. There, prices of essential inputs are given parameters. For comprehensive treatment of access charges, see Armstrong (2002).

[9] See, for example, Spengler (1950).

[10] To simplify our analysis, discount rate is assumed away.

[11] If the competitor is not efficient, it can not be viable because it is disadvantaged both in costs and technologies. In such a case, vertical integration results in the exclusion of a rival from a downstream market.

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