Integration between Component Producers in Markets with Differentiated Products

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This paper shows that when two systems are differentiated and not compatible to each other, it is the strictly dominant strategy not to integrate component producers if they are involved in Bertarnd competition. (*JEL* Classification: L13)

I. Introduction

As technology has been rapidly progressed, more and more brands of substitutes become available to consumers. Also, it is common that for a specific consumption behavior, a consumer is required to combine two or more complements, for instance, personal computers and software for word processing, VCRs and video tape for watching a movie, tape decks and speakers for listening to a music, ATMs and bankcards for withdrawing cash, etc.

However, it is also common that some product is compatible only with some kind of complementary product. In the home video industry, VHS video recorders cannot play video cassettes recorded by the Beta format. In the razor industry, too, some manufacturers razors are not compatible with their rivals' blades. Macintosh software often does not work on IBM PC.

We call each complementary product a component and the collection of components a system. Then, our natural question is what will happen if component producers are integrated. In this paper, we examine the incentive to integrate between compatible component producers and obtain a somewhat surprising result that it is

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strictly dominated to integrate component producers. This result may explain the phenomenon that the personal computer industry,[1] or the stereo equipment industry[2] is usually not integrated.

The organization of this paper goes as follows; In Section II, we set up model and it is analyzed in Section III. Concluding remarks and caveats follow in Section IV.

II. Model

A system usually involves a software component and several hardware components. Here, we assume that a system is constituted of a hardware component and a software component.

For the purpose, we consider a linear city model á la Hotelling (1929). Consumers are located uniformly on an interval $[0, l]$. There are two hardware firms A_1, A_2 producing X_1, X_2 respectively, located at the extremes of the interval; firm A_1 is at $x=0$ and firm A_2 is at $x=l$. Also, there are two software firms B_1, B_2 producing Y_1, Y_2 respectively, located at the extremes. Firm B_1 is at $x=0$ and firm B_2 is at $x=l$. X_1, X_2 are substitutes to each other and Y_1, Y_2 are substitutes to each other whereas X_1, Y_1 are complements and X_2, Y_2 are complements. Also, X_i and Y_j are compatible only if $i=j$. Hence, X_1Y_1 and X_2Y_2 can be considered as composite goods.

All consumers have the same reservation price r net of transportation costs. Consumers incur transportation costs t per unit of length. Each firm producing hardware has identical, constant marginal cost c and each firm producing software also has identical marginal cost which is, without loss of generality, assumed to be 0.

We consider the following multi-stage game. In the first stage, compatible component producers A_i, B_i collectively decide whether to integrate each other. In the second stage, independent firms choose their prices in a non-cooperative way. Then, in the last stage, consumers decide which composite goods to purchase, X_1Y_1 or X_2Y_2.

Some notation will follow. We will denote by p_i, q_i the price charged by firm A_i, B_i respectively, by $\pi_{\tau,i}$ the profit of the firm τ_i, $\tau=A, B$, $i=1, 2$ and by π_i the joint profit from producing com-

[1]Most of the major software firms, for instance, Microsoft, Borland, Adobe, are not owned by hardware firms such as IBM, Apple.

[2]Sony is an exception.

patible components i.e., $\pi_i = \pi_{A,i} + \pi_{B,i}$. Also, throughout the paper, we will assume that the demand is inelastic i.e., the market is always covered.

III. Analysis

The natural solution concept of this model will be the subgame perfect equilibrium. There are three kinds of subgames in this game where neither side is integrated, both sides are integrated and only one side is integrated.

First, consider the subgame where neither side is integrated. Then, all of four firms will choose their prices independently. Consumers will decide whether to purchase system 1 or system 2 by comparing their net valuations from purchasing them. Given p_1, p_2, q_1, q_2, the demand for system 1 is determined by x^N satisfying $tx^N + p_1 + q_1 = t(l - x^N) + p_2 + q_2$. This yields $x^N = (tl + p_2 + q_2 - p_1 - q_1)/2t$. Thus, the optimization problems firm A_1, B_1 face are given by

$$\max_{p_1} \pi_{A,1}(p_1\,;\ q_1,\ p_2,\ q_2) = (p_1 - c)\,\frac{tl + p_2 + q_2 - p_1 - q_1}{2t}, \tag{1}$$

$$\max_{q_1} \pi_{B,1}(q_1\,;\ p_1,\ p_2,\ q_2) = q_1\,\frac{tl + p_2 + q_2 - p_1 - q_1}{2t}, \tag{2}$$

respectively. Therefore, the best response functions of firm A_1 and B_1 are $p_1 = (1/2)(p_2 + q_2 - q_1 + c + tl)$, $q_1 = (1/2)(p_2 + q_2 - p_1 + tl)$, respectively. Similarly, the best response functions of firm A_2 and B_2 are derived as $p_2 = (1/2)(p_1 + q_1 - q_2 + c + tl)$, $q_2 = (1/2)(p_1 + q_1 - p_2 + tl)$. Solving four equations given by best response functions, we get equilibrium prices $P_1^N = p_2^N = c + tl$, $q_1^N = q_2^N = tl$ and, as a result, the equilibrium profits are $\pi_{\tau,1}^N = \pi_{\tau,2}^N = tl^2/2$, $\tau = A, B$.

Now, consider the case where both sides are integrated. Then, the integrated firm A_1B_1, A_2B_2 will choose their prices simultaneously. Let the price of the composite goods produced by firm A_iB_i be v_i, where $v_i = p_i + q_i$. Then, the optimization problem for each integrated firm will be

$$\max_{v_i} \pi_i(v_i\,;\ v_j) = (v_i - c)\,\frac{tl + v_j - v_i}{2t},\quad i = 1,\ 2,\ \ j \neq i. \tag{3}$$

Then, the best response function of firm A_iB_i is given by $v_i = (1/2)(v_j + c + tl)$. Therefore, the equilibrium prices of composite goods are

TABLE 1
EQUILIBRIUM PAYOFFS

		II: integrate	II: not integrate
I	integrate	$\left(\frac{1}{2}tl^2,\ \frac{1}{2}tl^2\right)$	$\left(\frac{25}{32}tl^2,\ \frac{18}{32}tl^2\right)$
	not integrate	$\left(\frac{18}{32}tl^2,\ \frac{25}{32}tl^2\right)$	$(tl^2,\ tl^2)$

$v_1{}^I = v_2{}^I = c+tl$. Hence, the equilibrium profits are $\pi_1{}^I = \pi_2{}^I = tl^2/2$.

Finally, consider the intermediate case where only one side, say, A_2B_2, is integrated. The optimization problem for the unintegrated firms A_1, B_1 and the integrated firm A_2B_2 each are given by

$$\max_{p_1} \pi_{A,1}(p_1\,;\ q_1,\ p_2,\ q_2) = (p_1 - c)\,\frac{tl+p_2+q_2-p_1-q_1}{2t}\,, \tag{4}$$

$$\max_{q_1} \pi_{B,1}(q_1\,;\ p_1,\ p_2,\ q_2) = q_1\,\frac{tl+p_2+q_2-p_1-q_1}{2t}\,, \tag{5}$$

$$\max_{p_2,\,q_2} \pi_2(p_2,\ q_2\,;\ p_1,\ q_1) = (p_2+q_2-c)\left(l - \frac{tl+p_2+q_2-p_1-q_1}{2t}\right), \tag{6}$$

respectively. Then, we have $p_1 = (1/2)(p_2+q_2-q_1+c+tl)$, $q_1 = (1/2)(p_2+q_2-p_1+tl)$, $v_2 = p_2+q_2 = (1/2)(p_1+q_1+c+tl)$. Therefore, the equilibrium prices are $p_1{}^M = c+(3/4)tl$, $q_1{}^M = (3/4)tl$, $v_2{}^M = p_2{}^M + q_2{}^M = c+(5/4)tl$. Also, the market shares for the unintegrated firms and the integrated firm are $x^M = (3/8)l$, $l - x^M = (5/8)l$, respectively. Hence, the equilibrium profits are $\pi^M_{A,1} = \pi^M_{B,1} = (9/32)tl^2$, $\pi_2{}^M = (25/32)tl^2$.

Now, consider the integration decision. The equilibrium profits of firms in each subgame are summarized in Table 1. By comparing the equilibrium profits, we can easily see that firms will be better off by not integrating its counterpart producing complementary goods, whether the other side is integrated or not, that is, it is strictly dominated to integrate between component producers.

The following theorem summarizes the above results.

***Theorem* 1**

(i) Prices of composite goods are lowest when both sides are integrated and highest when neither side is integrated, more concretely, $v^I < v_2{}^M < v_1{}^M < v^N$.

(ii) In equilibrium, neither side will be integrated.

The reason that the integration lowers the prices of composite goods whether or not the other side is integrated is that with integration a firm can internalize the negative externality a marginal increase in its price can incur on the demand of its complement that it would not take into account without integration. As a result, lowered prices increase consumer surplus, but instead reduce profits of firms. That is, integration transfers welfare from producers to consumers.

Before we close this section, special attention deserves to be paid to the outcome (integrate, not integrate). In this outcome, the integrated firm enjoys profits higher than the sum of the profits of the unintegrated firms! However, we should stress it does not imply that firms prefer integrating to not integrating, since it can be much better off by choosing not to integrate.

IV. Conclusion

We have shown that when two systems are differentiated, it never pays to integrate component producers if they are involved in Bertarnd competition, more accurately, that it is strictly dominated to integrate component producers.

There are several related works. Church and Gandal (1992) examines the incentives to integrate when the hardware industry is oligopolistic and the software industry is monopolistically competitive. Economides and Solop (1992) considers a model of full compatibility among components i.e., that any of hardware components can be matched to any of software components, and show that the prices are lowered if both sides are integrated. Our paper takes a step further in the sense that it endogenizes the firms' decision whether to integrate.

However, we admit that the result obtained in this paper is far from robust to the form of the demand function and cost function. It would be the next step to consider a general form of the demand function and derive the condition under which the above result remains valid.

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