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Antitrust Analysis of Mergers with Bundling in Complementary Markets:  
Implications for Pricing, Innovation, and Compatibility Choice

by

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# **Antitrust Analysis of Mergers with Bundling in Complementary Markets: Implications for Pricing, Innovation, and Compatibility Choice**

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## **Abstract**

This paper develops a simple model to analyze the effects of mergers in complementary system markets when the merged firm is able to engage in bundling. In the short-run analysis, I analyze the impact of (mixed) bundling on pricing decisions for existing generations of products. The basic model is then extended to analyze industry dynamics where the implications of mergers for innovation incentives and technical tying/compatibility decisions are explored. Welfare implications of mergers in the short- and long-run will be also analyzed.

*Keywords: merger, mixed bundling, complementary markets, compatibility, innovation, and Cournot effect.*

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## I. Introduction

On July 3, 2001, in one of its most high-profile antitrust decisions ever, the European Commission blocked the proposed merger (valued at \$43 billion) between General Electric and Honeywell. Since it is the first case in which a proposed merger between two U.S. companies that had been approved by Washington has been blocked by European regulators, the decision has been closely scrutinized.<sup>1</sup> One of the main issues raised by the proposed GE/Honeywell merger concerned the possibility of “bundling” and its likely impact on competition in the markets for jet aircraft engines and avionics.<sup>2</sup> The decision, however, has been criticized by many commentators for the alleged lack of sound economic models to support.

This paper develops a model to analyze the effects of mergers in complementary system markets when the merged firm is able to engage in bundling. The model builds on the framework developed by Economides and Salop (1992). They analyze a model of competition with complementary products in which they derive equilibrium prices for a variety of organizational and market structures that differ in their degree of competition and integration. However, they limit the strategy space of the merged entity and do not consider the possibility of *bundling* which is made possible due to the merger.

There are essentially two forms of bundling in which the merged entity could potentially engage:

- Under ‘*mixed bundling*’, the firm sells the individual components separately as well as selling the bundle (but the bundle is offered at a discount to the sum of the stand-alone prices).
- Under ‘*pure bundling*’, the firm only sells the bundle and it does not make the individual components available separately.

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<sup>1</sup> As of this writing, the case is under appeal in the Court of First Instance of the European Union.

<sup>2</sup> Another main issue that proved to be the stumbling block in the remedy negotiations between the merging parties and the Commission was the role and competitive implications of GECAS, GE’s aircraft leasing and financing arm.

The paper has two primary components – short-run and long-run analyses – since the form of bundling undertaken by the merged entity might be expected to differ over time for the following reasons:

- For *existing generations* of products, the potential for the merged firm to engage in *pure* bundling may be limited.
- For *new generations* of products with R&D, one might expect the merged firm to engage increasingly in *pure* bundling. This pure bundling could take the form of ‘technical tying’, whereby the merged firm would make its products available only as an integrated system, making them *incompatible* with the individual components offered by independent suppliers.

Much of the existing academic literature on bundling focuses on “pure bundling” [see, for instance, Whinston (1990), Carbajo, de Meza, and Seidman (1990), and Choi and Stefanadis (2001)].<sup>3</sup> In the short-run, however, the merged entity, however, is expected to engage in “mixed bundling,” continuing to sell the individual components separately but selling them more cheaply as a bundle.<sup>4</sup>

Thus, this paper develops a model of mergers that allows mixed bundling. In particular, I show that when the merging firms bundle their complementary products, the short-run effects on pricing, market shares, and profits in the industry are as follows:

1. The merged firm will reduce the price of its bundled system and expand market share relative to the situation prior to the merger. Prior to the merger, any price cut by one of the merging firms will tend to benefit the other’s sales. In the absence of the merger, neither party will take account of this benefit of a price cut on the other’s sales. Following the merger, however, the merged entity can “internalize” these “pricing externalities” arising

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<sup>3</sup> In a model of *strategic* market foreclosure of tying, for instance, Whinston (1990) shows that *mixed* bundling is not a useful strategy. Thus, the motivation for mixed bundling is often found in the monopolistic bundling literature as a price discrimination device. See Adams and Yellen (1976) and McAfee, McMillan, and Whinston (1989).

<sup>4</sup> As will be seen later, the incentive to practice mixed bundling rather than pure bundling in the short-run is confirmed in my model.

from the complementarity of their components by reducing the price of the bundle to below the level the two players would choose if acting independently.<sup>5</sup> This will expand the merged firm's sales and market share.

2. The merged firm will raise the prices of its stand-alone components, relative to their levels prior to the merger. The merged firm has less to lose from raising its stand-alone prices because a proportion of those customers that switch away from the stand-alone components as a result of the price increase will simply switch to the bundle offered by the merged firm rather than to the competing system. As such, the merged party will have an increased incentive to set high prices for its components. This raises the price of "mix-and-match" systems (i.e. systems including a component of the merged firm alongside a competitor's component) and makes them less attractive to buyers.

3. Independent rivals selling single components reduce their prices in response but fail to recapture all market shares. In response to the price cut by the merged firm for their bundled system and the price increase for the 'mix-and-match' systems, the independent rivals will cut price in order to retain some market share. However, they will not cut their prices as much as the merged firm (i.e. their system will remain more expensive than the bundled system of the merged firm) since – in the absence of counter-merger - they cannot internalize the externality arising from the complementarity of their components. As a result, they will fail to recapture all of their prior market shares. The merger would therefore reduce the profits of the merged firm's competitors. This reduction in profits follows directly from the combination of a loss of market share and the need to cut prices. Thus, there is a distinct possibility of exit by outside rival firms.

Bundling in my model entails both pro-competitive and anti-competitive effects. There is no clear-cut answer to how mixed bundling by the merging parties would affect consumer and social welfare. With heterogeneous consumer preferences, some buyers gain

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<sup>5</sup> Cournot (1838) is the first one to note that mergers among complements reduce prices. He considered the merger of two monopolists that produce complementary goods (zinc and copper) that are used as inputs for a final good (brass). My model extends his analysis to a case where both input producers face oligopolistic competition.

and others lose. For instance, those who previously purchased both products from the two merging firms would gain due to the lower bundle price. However, those who continue to purchase a mix and match system would suffer due to the increased stand-alone prices charged by the merged firm. As a result, the overall impact on consumer and social welfare is ambiguous. Numerical simulation results, however, suggest that the overall effects of such a merger would be welfare-reducing if the substitution between systems were sufficiently price-sensitive.

In the long-run analysis, I consider the effects of mergers on R&D incentives. It is shown that the merging firms' R&D incentives increase at the expense of the rival firms'. The intuition for this result is the appropriability of the innovation benefit. Mergers with bundling allow the merged entity to capture a larger market share in the systems market. This implies that any cost reduction from an innovation translates into a larger profit with merged firms. This leads to more aggressive R&D investment. For the same reason, mergers with bundling dull the R&D incentives of outside rival firms. Finally, I also consider the possibility of technical tying for new generations of products and show that it can be an effective strategy for the exclusion of rivals.

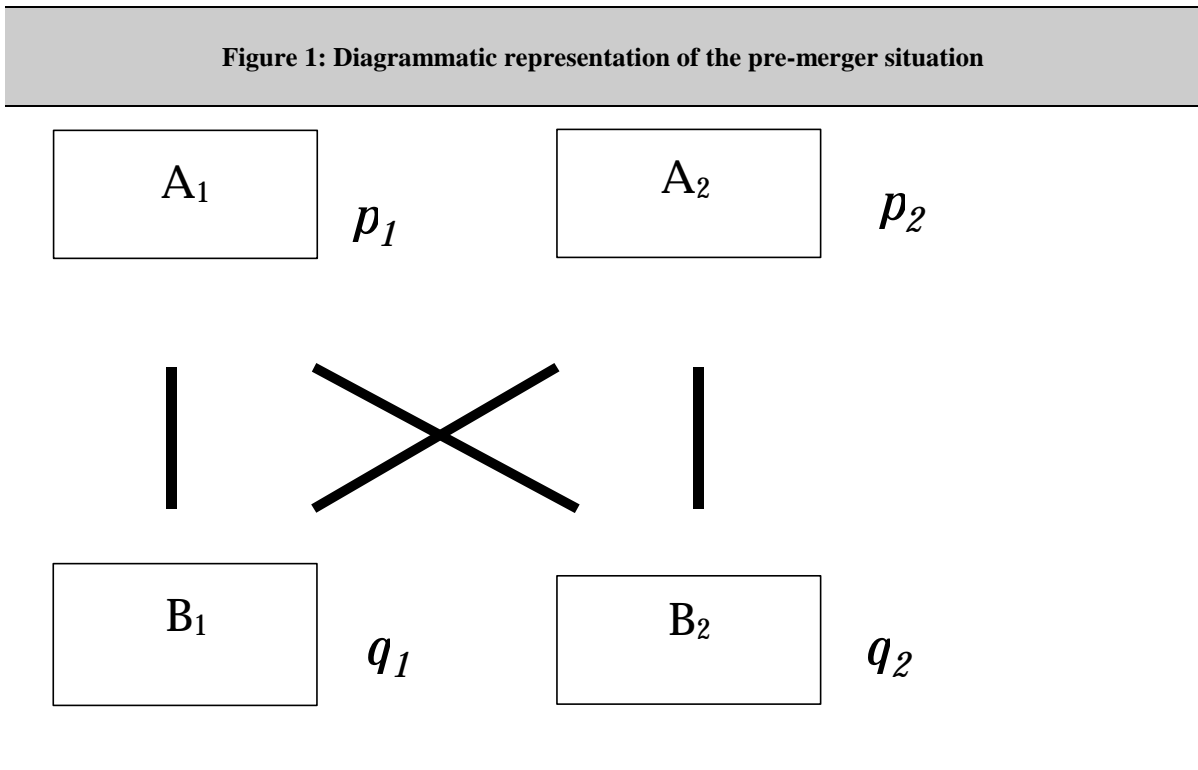
The rest of the paper is organized in the following way. Section II sets up the basic model and conducts a short-run analysis investigating the effects of mergers with mixed bundling on pricing decisions. Section III deals with dynamic issues in the industry by extending the model to allow for R&D opportunities and technical tying. Welfare implications of mergers in the short- and long-run will be also analysed in sections 2 and 3, respectively. Section IV concludes.

## **II. A Model of Mergers with Mixed Bundling**

Consider two *complementary* components, A and B, which are valuable only when used together. Customers combine A and B in fixed proportions on a one-to-one basis to form a final product. For instance, I can consider A and B as operating systems and application software, respectively, for computer, or cable/satellite service and content providers, respectively, to provide entertainment. In the case of the proposed

GE/Honeywell merger, they correspond to engines and avionics, respectively, to form an aircraft.

There are two differentiated brands of each of the two components A ( $A_1$  and  $A_2$ ) and B ( $B_1$  and  $B_2$ ). Consequently, there are four ways to form a composite product,  $A_1B_1$ ,  $A_1B_2$ ,  $A_2B_1$ ,  $A_2B_2$ . Let the price of brand  $A_i$  be  $p_i$  and the price of brand  $B_j$  be  $q_j$ , where  $i=1,2$  and  $j=1,2$ . Then, the composite product  $A_iB_j$  is available at the total *system* price of  $s_{ij} = p_i + q_j$ . Let  $D^{ij}$  denote demand for the composite product  $A_iB_j$ . The combinations of products and suppliers in this stylized model result in four possible systems, as shown in Figure 1.



As in Economides and Salop (1992), I assume that the four potential composite goods are substitutes for one another:  $D^{ij}$  is decreasing in its own price and increasing in the prices of the three substitute composite goods. For instance,  $D^{11}$  is decreasing in  $s_{11}$ , and increasing in  $s_{12}$ ,  $s_{21}$ , and  $s_{22}$ . I can derive the demand functions for the components from

the demand functions for the composite goods. For instance, component  $A_i$  is sold as a part of composite goods  $A_iB_1$  and  $A_iB_2$ . Thus, the demand for component  $A_i$  is given by

$$D^{A_i} = D^{i1} + D^{i2}$$

Similarly, the demand for component  $B_j$  is given by

$$D^{B_j} = D^{j1} + D^{j2}$$

I assume demand functions are linear and the demand system is symmetric:

$$D^{11}(s_{11}, s_{12}, s_{21}, s_{22}) = a - b s_{11} + c s_{12} + d s_{21} + e s_{22}$$

$$D^{12}(s_{12}, s_{11}, s_{22}, s_{21}) = a - b s_{12} + c s_{11} + d s_{22} + e s_{21}$$

$$D^{21}(s_{21}, s_{22}, s_{11}, s_{12}) = a - b s_{21} + c s_{22} + d s_{11} + e s_{12}$$

$$D^{22}(s_{22}, s_{21}, s_{12}, s_{11}) = a - b s_{22} + c s_{21} + d s_{12} + e s_{11}, \text{ where } a, b, c, d, e > 0.$$

I also assume that  $b > c + d + e$  to ensure that composite goods are gross substitutes, i.e., an equal increase in the prices of all composite goods reduces the demand of each composite good. To illustrate the effects of the merger, I further simplify the analysis by assuming that all four composite products are equally substitutable, that is,  $c = d = e$  with the parameter restriction of  $b > 3c$ . Without loss of generality, I assume that constant unit production costs are zero.<sup>6</sup> The “ $a$ ” parameter then represents the basic level of demand that would exist for each system if the per unit margins on each system were zero. The “ $b$ ” parameter describes how demand for a given system falls as its own price increases (i.e. it reflects the own-price elasticity of demand for that system). The “ $c$ ” parameter describes how demand for a given system rises as the prices of its competitors increase (i.e. it reflects the cross-price elasticity of demand across systems). I now analyze how the market equilibrium changes depending on the market structure.

## II.1. Pre-merger situation

As a benchmark, I consider the case where all component brands  $A_i$  and  $B_j$  are independently owned implying there are four separate firms. This case is analyzed in Economides and Salop (1992) and describes the situation before a merger. Let  $p_1, p_2, q_1,$

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<sup>6</sup> If there are positive constant unit production costs, the prices in the model can be interpreted as per unit margins.



and  $q_2$  denote the prices set by firms A1, A2, B1, and B2, respectively. Then I can write each firm's profit as:

$$\Pi^{A1} = p_1 (D^{11} + D^{12}); \Pi^{A2} = p_2 (D^{21} + D^{22}); \Pi^{B1} = q_1 (D^{11} + D^{21}); \Pi^{B2} = q_2 (D^{12} + D^{22})$$

where:

$$D^{11} = a - b(p_1 + q_1) + c(p_1 + q_2) + c(p_2 + q_1) + c(p_2 + q_2)$$

$$D^{12} = a - b(p_1 + q_2) + c(p_1 + q_1) + c(p_2 + q_2) + c(p_2 + q_1)$$

$$D^{21} = a - b(p_2 + q_1) + c(p_2 + q_2) + c(p_1 + q_1) + c(p_1 + q_2)$$

$$D^{22} = a - b(p_2 + q_2) + c(p_2 + q_1) + c(p_1 + q_2) + c(p_1 + q_1)$$

The market equilibrium (Nash equilibrium prices) is characterized by the following first-order conditions:

$$\partial \Pi^{A1} / \partial p_1 = 2a - 4(b - c)p_1 + 4c p_2 - (b - 3c)q_1 - (b - 3c)q_2 = 0$$

$$\partial \Pi^{B1} / \partial q_1 = 2a - (b - 3c)p_1 - (b - 3c)p_2 - 4(b - c)q_1 + 4c q_2 = 0$$

$$\partial \Pi^{A2} / \partial p_2 = 2a + 4c p_1 - 4(b - c)p_2 - (b - 3c)q_1 - (b - 3c)q_2 = 0$$

$$\partial \Pi^{B2} / \partial q_2 = 2a - (b - 3c)p_1 - (b - 3c)p_2 + 4c q_1 - 4(b - c)q_2 = 0$$

The equilibrium prices under this regime ( $p_1^I, p_2^I, q_1^I, q_2^I$ ), where superscript  $I$  denotes Independent Ownership (i.e. the pre-merger situation)) are given as follows:

$$p_1^I = p_2^I = q_1^I = q_2^I = \frac{a}{(3b - 7c)}$$

Thus, the total system price of each composite good is given by:

$$s_{ij} = p_i^I + q_j^I = \frac{2a}{(3b - 7c)}, \text{ where } i, j = 1, 2.$$

With the symmetry of the model, all four systems (A<sub>1</sub>B<sub>1</sub>, A<sub>1</sub>B<sub>2</sub>, A<sub>2</sub>B<sub>1</sub>, A<sub>2</sub>B<sub>2</sub>) have the same market share of 1/4 in the systems market by substituting the equilibrium prices back into the demand function:

$$D^{11} = D^{12} = D^{21} = D^{22} = \frac{a(b - c)^2}{3b^2 - 9bc + 4c^2}$$

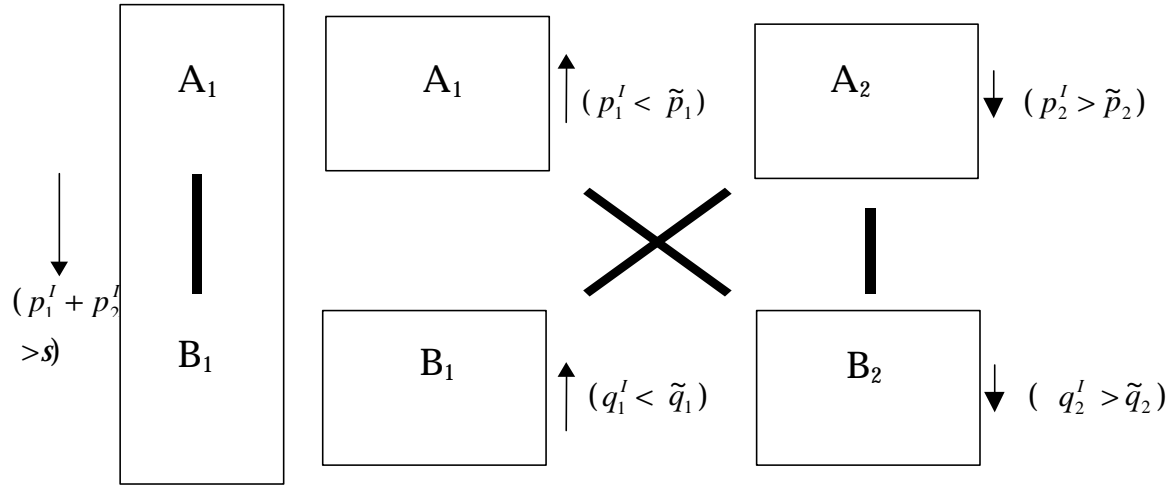
Thus, each firm has the same market share of 1/2 with demand of  $\frac{2a(b - c)^2}{3b^2 - 9bc + 4c^2}$  in the relevant stand-alone markets. Each firm's profit in turn can be derived as:

$$\Pi^{A1} = \Pi^{A2} = \Pi^{B1} = \Pi^{B2} = \frac{2a^2(b-c)}{(3b-7c)^2}$$

## II.2. Merger between A<sub>1</sub> and B<sub>1</sub> with Mixed Bundling

Now suppose that A<sub>1</sub> and B<sub>1</sub> merge. As a merged entity, A<sub>1</sub>-B<sub>1</sub> can offer three prices,  $s$  for the bundled product (A<sub>1</sub>B<sub>1</sub>) and  $\tilde{p}_1$  and  $\tilde{q}_1$  for individual components A<sub>1</sub> and B<sub>1</sub>, respectively. A<sub>2</sub> and B<sub>2</sub> remain independent and charge prices  $\tilde{p}_2$  and  $\tilde{q}_2$ , respectively. Figure 2 describes the post-merger situation with mixed bundling.

Figure 2: Diagrammatic representation of post-merger with mixed bundling



Then, the profit functions for the merged firm (A<sub>1</sub>-B<sub>1</sub>) and independent firms (A<sub>2</sub> and B<sub>2</sub>) are respectively given by

$$\Pi^{A1-B1} = sD^{11} + p_1 D^{12} + q_1 D^{21}$$

$$\Pi^{A2} = p_2 (D^{21} + D^{22}) \text{ and } \Pi^{B2} = q_2 (D^{12} + D^{22}), \text{ where}$$

$$D^{11} = a - b s + c (p_1 + q_2) + c (p_2 + q_1) + c (p_2 + q_2)$$

$$D^{12} = a - b (p_1 + q_2) + c s + c (p_2 + q_2) + c (p_2 + q_1)$$

$$D^{21} = a - b (p_2 + q_1) + c (p_2 + q_2) + c s + c (p_1 + q_2)$$

$$D^{22} = a - b (p_2 + q_2) + c (p_2 + q_1) + c (p_1 + q_2) + c s$$

The merged firm's profit,  $\Pi^{A^1-B^1}$ , consists of three components: the profit from selling the bundle  $A_1B_1$  ( $sD^{11}$ ), the profit from selling stand-alone product  $A_1$  as part of the mix-and-match system  $A_1B_2$  ( $p_1 D^{12}$ ), and the profit from selling stand-alone product  $B_1$  as part of the mix-and-match system  $A_2B_1$  ( $q_1 D^{21}$ ).

The market equilibrium (Nash equilibrium prices) is characterized by the following first-order conditions:

$$\partial \Pi^{A^1-B^1} / \partial s = a - 2bs + 2cp_1 + 2cp_2 + 2cq_1 + 2cq_2 = 0$$

$$\partial \Pi^{A^1-B^1} / \partial p_1 = a + 2cs - 2bp_1 + 2cp_2 + 2cq_1 - (b-c)q_2 = 0$$

$$\partial \Pi^{A^1-B^1} / \partial q_1 = a + 2cs + 2cp_1 - (b-c)p_2 - 2bq_1 + 2cq_2 = 0$$

$$\partial \Pi^{A^2} / \partial p_2 = 2a + 2cs + 2cp_1 - 4(b-c)p_2 - (b-c)q_1 - (b-3c)q_2 = 0$$

$$\partial \Pi^{B^2} / \partial q_2 = 2a + 2cs - (b-c)p_1 - (b-3c)p_2 + 2cq_1 - 4(b-c)q_2 = 0$$

By taking advantage of the symmetry of the model, I can derive the equilibrium market

prices as  $\tilde{p}_1 = \tilde{q}_1 = x$ , and  $\tilde{p}_2 = \tilde{q}_2 = y$ , where  $x$  and  $y$  satisfy

$$a - 2bs + 4c(x+y) = 0$$

$$a + 2cs - 2(b-c)x - (b-3c)y = 0$$

$$2a + 2cs - (b-3c)x - (5b-7c)y = 0$$

Solving the equations above simultaneously yields:

$$\tilde{s} = \frac{a(3b-c)}{2(3b^2-9bc+4c^2)} \quad (\text{the bundle price})$$

$$\tilde{p}_1 = \tilde{q}_1 = \frac{ab}{3b^2-9bc+4c^2} \quad (\text{stand-alone product price by the merged firm})$$

$$\tilde{p}_2 = \tilde{q}_2 = \frac{a(b-c)}{3b^2-9bc+4c^2} \quad (\text{independent firms' component price})$$

With the parameter restriction  $b > 3c$ , I have the following result.

**Proposition 1.** The model shows that mixed bundling following the merger would have the following implications for prices.

- First, the price of the bundle post-merger is lower than the sum of the pre-merger component prices ( $\tilde{s} = \frac{a(3b-c)}{2(3b^2-9bc+4c^2)} < s_{ij}^I = p_i^I + q_j^I = \frac{2a}{3b-7c}$ ).<sup>7</sup>
- Second, the merged firm's prices for individual components are higher with mixed bundling ( $\tilde{p}_1 = \tilde{q}_1 = \frac{ab}{3b^2-9bc+4c^2} > p_1^I = q_1^I = \frac{a}{3b-7c}$ )
- Third, the independent firms also cut their prices ( $\tilde{p}_2 = \tilde{q}_2 = \frac{a(b-c)}{3b^2-9bc+4c^2} < p_2^I = q_2^I = \frac{a}{3b-7c}$ ).

With the equilibrium prices derived for mixed bundling, I can calculate the changes in market shares and profits after the merger. The demand for each system after the merger is given by:

$$\tilde{D}^{11} = \frac{ab(3b-5c)}{2(3b^2-9bc+4c^2)}$$

$$\tilde{D}^{12} = \tilde{D}^{21} = \frac{a(2b^2-5bc+c^2)}{2(3b^2-9bc+4c^2)}$$

$$\tilde{D}^{22} = \frac{a(2b^2-3bc+3c^2)}{2(3b^2-9bc+4c^2)}$$

The profits of the merged firm and outside firms are given by:

$$\tilde{\Pi}^{A1-B1} = \frac{a^2b(17b^2-38bc+9c^2)}{4(3b^2-9bc+4c^2)^2}$$

$$\tilde{\Pi}^{A2} = \tilde{\Pi}^{B2} = \frac{2a^2(b-c)^3}{(3b^2-9bc+4c^2)^2}$$

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<sup>7</sup> This can be easily proved with our assumption of the gross substitutability of the demand systems, that is,  $b > 3c$ .

**Proposition 2.** Mixed bundling following the merger would have the following implications for market shares and profits.

- *First, the demands for the bundle ( $A_1B_1$ ) and the system comprised of outside firms' components ( $A_2B_2$ ) increase at the expense of mix-and-match systems ( $A_1B_2$  and  $A_2B_1$ ). Since the bundle price is lower than the sum of the outside firms' component prices, the increase in the demand for the bundle is larger than that for the outside system, that is,  $\tilde{D}^{11} > \tilde{D}^{22} > (D^{ij}) > \tilde{D}^{12} = \tilde{D}^{21}$ .*
- *Second, the derived demand for the components increases for the merging firms at the expense of the derived demand for outside firms ( $\tilde{D}^{11} + \tilde{D}^{12} = \tilde{D}^{11} + \tilde{D}^{21} > D^{11} + D^{12} = D^{11} + D^{21}$ ,  $\tilde{D}^{21} + \tilde{D}^{22} = \tilde{D}^{12} + \tilde{D}^{22} < D^{21} + D^{22} = D^{12} + D^{22}$ ).*
- *Third, the merging firms' profits increase at the expense of independent firms' profits ( $\tilde{\Pi}^{A_1-B_1} > \Pi^{A_1} + \Pi^{B_2}$ ,  $\tilde{\Pi}^{A_2} = \tilde{\Pi}^{B_2} < \Pi^{A_2} = \Pi^{B_2}$ ). The merger would therefore reduce the profits of the merged firm's competitors. This reduction in profits follows directly from the combination of a loss of market share and the need to cut prices.<sup>8</sup>*

**Example.** Consider the case where  $a=b=1$  and  $c=1/4$ . Then I can show that with the independent ownership (pre-merger) structure,  $p_1^I = p_2^I = q_1^I = q_2^I = 4/5$ . The total price of each composite good is  $8/5$  and each firm gets the profits of  $24/25$ .

After the merger between  $A_1$  and  $B_1$ , the merged entity ( $A_1-B_1$ ) charges  $\tilde{s}=11/8$  for the bundle and  $\tilde{p}_1 = \tilde{q}_1 = 1$  for separate components. Thus, it offers discount for the bundle ( $11/8 < 1+1=2$ ). Independent producers,  $A_2$  and  $B_2$ , charge  $\tilde{p}_2 = \tilde{q}_2 = 3/4$  for their component products. Thus, the prices for composite products,  $A_1B_1$ ,  $A_1B_2$ ,  $A_2B_1$ , and  $A_2B_2$

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<sup>8</sup> All results can be easily proved algebraically by simple manipulations with the assumption of  $b>3c$ , except the merging firms' profit changes. The Mathematica program, however, shows that the merging firms' profits increase after the merger.

are given by 11/8, 7/4, 7/4, and 3/2, respectively, where  $7/4 > 3/2 > 11/8$ . After the merger A<sub>1</sub>-B<sub>1</sub> receives the profits of 129/64 ( $> 24/25 + 24/25$ ), whereas independent producers get 27/32 ( $< 24/25$ ). This implies that A<sub>1</sub> and B<sub>1</sub> together increase their combined profits after merger while independent producers' profits decrease.

### II.3. Welfare Analysis

I perform a welfare analysis of the effects of a merger in the *absence* of foreclosure. I take the sum of consumer and producer surplus as a measure of social welfare. To derive the consumer surplus, I first invert the demand system to obtain inverse demand functions (that is, demand functions in which the price of a system is given as a function of sales volumes for all systems). The inverse demand system can be written as:

$$s_{11}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a - (\beta - 2\gamma)D^{11} - \gamma D^{12} - \gamma D^{21} - \gamma D^{22}$$

$$s_{12}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a - \gamma D^{11} - (\beta - 2\gamma)D^{12} - \gamma D^{21} - \gamma D^{22}$$

$$s_{21}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a - \gamma D^{11} - \gamma D^{12} - (\beta - 2\gamma) D^{21} - \gamma D^{22}$$

$$s_{22}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a - \gamma D^{11} - \gamma D^{12} - \gamma D^{21} - (\beta - 2\gamma)D^{22},$$

where  $\beta = \frac{b}{(b-3c)(b+c)}$  and  $\gamma = \frac{c}{(b-3c)(b+c)}$ .

These inverse demand functions imply that the utility function is given by:

$$U(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a [D^{11} + D^{12} + D^{21} + D^{22}] - \frac{\beta - 2\gamma}{2} [(D^{11})^2 + (D^{12})^2 + (D^{21})^2 + (D^{22})^2] - \gamma [D^{11} D^{12} + D^{11} D^{21} + D^{11} D^{22} + D^{12} D^{21} + D^{12} D^{22} + D^{21} D^{22}]$$

Having calculated this utility function, it is possible to calculate total consumer valuations of the products purchased.

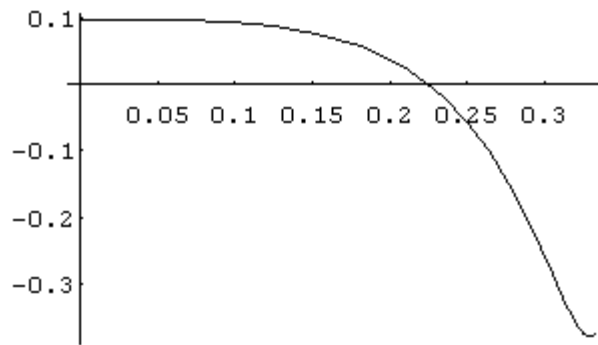
In my linear model, the level of the demand intercept “a” has no effect on the relative prices. Similarly, the parameters *b* and *c* only affect the results through the ratio of *b/c*. I

thus normalize  $a = b = 1$  and analyze the effects of a merger on social welfare as I change the  $c$  parameter. With the assumption of the gross substitutability of composite goods, the normalization of  $b=1$  implies that  $c \in (0, 1/3)$ . With these restrictions, I can calculate pre-merger social welfare,  $W$ , and post-merger social welfare,  $\tilde{W}$ , as follows:

$$W = \frac{2(5 - 18c + 13c^2)}{(3 - 7c)^2(1 - 3c)}, \quad \tilde{W} = \frac{87 - 455c + 741c^2 - 421c^3 + 88c^4}{8(1 - 3c)(3 - 9c + 4c^2)^2}$$

I plot the changes in social welfare due to the merger in Figure 3.

$$\tilde{W} - W = \frac{63 - 648c + 2274c^2 - 3152c^3 + 1471c^4 - 328c^5}{8(7c - 3)^2(3 - 9c + 4c^2)^2}$$



$$\frac{\tilde{W}}{W} = \frac{(3 - 7c)^2(87 - 455c + 741c^2 - 421c^3 + 88c^4)}{16(3 - 9c + 4c^2)^2(5 - 18c + 13c^2)}$$

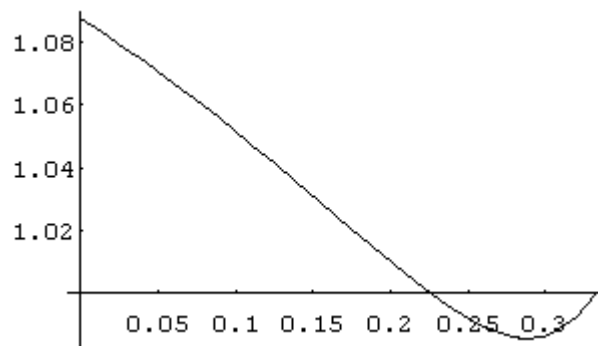


Figure 3. Absolute Changes and the Ratio of Social Welfare due to a Merger

I emphasize that the above calculations assume there is no foreclosure due to the merger and the merging firm does not behave strategically with anticompetitive intent. Otherwise, the effects of a merger on social welfare would be decidedly negative. For instance, suppose that there is a fixed cost of operation  $F$  that can be avoided by exiting the industry. If I have a situation such that  $\tilde{\Pi}^{A2} = \tilde{\Pi}^{B2} < F < \Pi^{A2} = \Pi^{B2}$ , a merger between  $A_1$  and  $B_1$  will induce exit by the outsiders, and social welfare will be unambiguously affected in a negative way.

Even in the *absence* of such foreclosure effects, there could be significant welfare loss when  $c$  (cross-substitutability parameter) is sufficiently large. When  $c$  is close to zero, each system is essentially a separate product, and there is little direct competition between systems. In this case, the structure of each system market is equivalent to the one considered by Cournot and mergers are welfare enhancing. In cases with high degrees of substitutability and intense competition among systems (i.e., high  $c$ ), however, the model suggests that the effects of mergers on social welfare are negative.

### **III. The Effects of Mergers on the R&D Incentives Compatibility Decision**

In the previous section, I have analyzed the effects of mergers on pricing assuming that the product characteristics and cost structures are given. I now extend the basic framework laid out in section II to analyze the impact of mergers on R&D incentives and incentives to engage in pure bundling when technical tying is feasible as a result of the merger. To this end, I consider a two-stage game in which price competition is preceded by R&D competition/ compatibility decision. The basic model indicates that bundling (or incompatible product design) on the part of the merged firm reduces the future market available to independent rivals and consequently reduces their incentives to invest in cost reducing R&D. The main intuition is that firms' incentives to engage in R&D activities are proportional to their outputs in the product market since R&D costs are largely sunk (Choi, forthcoming). Any reduction in the future market available will thus reduce expected future profits and current R&D spending. The analysis of the incentives to bundle can also be



applied to the compatibility decision for the merged firm with the rest of the suppliers since pure bundling is the same as the choice of incompatibility in its economic effects.

### III.1. The Effects of Mergers (with Mixed Bundling) on R&D Incentives

This subsection describes how the reduced output by independent firms due to the A<sub>1</sub>-B<sub>1</sub> merger will adversely affect independent firms' R&D incentives.

Let me denote A<sub>1</sub>, A<sub>2</sub>, B<sub>1</sub>, and B<sub>2</sub>'s marginal costs as  $\alpha_1$ ,  $\alpha_2$ ,  $\beta_1$ , and  $\beta_2$ , respectively. Let  $\boldsymbol{\gamma} = (\alpha_1, \alpha_2, \beta_1, \beta_2)$  be the vector of marginal costs. Then I can represent each firm's equilibrium profits in the pre-merger situation as:

$$\Pi^{A1}(p_1(\boldsymbol{\gamma}), p_2(\boldsymbol{\gamma}), q_1(\boldsymbol{\gamma}), q_2(\boldsymbol{\gamma}); \boldsymbol{\gamma})$$

$$\Pi^{A2}(p_1(\boldsymbol{\gamma}), p_2(\boldsymbol{\gamma}), q_1(\boldsymbol{\gamma}), q_2(\boldsymbol{\gamma}); \boldsymbol{\gamma})$$

$$\Pi^{B1}(p_1(\boldsymbol{\gamma}), p_2(\boldsymbol{\gamma}), q_1(\boldsymbol{\gamma}), q_2(\boldsymbol{\gamma}); \boldsymbol{\gamma})$$

$$\Pi^{B2}(p_1(\boldsymbol{\gamma}), p_2(\boldsymbol{\gamma}), q_1(\boldsymbol{\gamma}), q_2(\boldsymbol{\gamma}); \boldsymbol{\gamma}),$$

where  $p_1(\boldsymbol{\gamma})$ ,  $p_2(\boldsymbol{\gamma})$ ,  $q_1(\boldsymbol{\gamma})$ , and  $q_2(\boldsymbol{\gamma})$  are equilibrium prices for A<sub>1</sub>, A<sub>2</sub>, B<sub>1</sub>, and B<sub>2</sub> when  $\boldsymbol{\gamma}$  is the industry cost structure.

Prior to the merger between A<sub>1</sub> and B<sub>1</sub>, the R&D incentives for A<sub>2</sub> can be represented by:

$$-\frac{d\Pi^{A2}}{d\alpha_2} = -\left[ \frac{\partial \Pi^{A2}}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial p_1} \frac{\partial p_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial p_2} \frac{\partial p_2}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_1} \frac{\partial q_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_2} \frac{\partial q_2}{\partial \alpha_2} \right]$$

The expression above yields the marginal benefit to A<sub>2</sub> from decreasing its production cost and thus represents the R&D incentives for A<sub>2</sub>. By the envelope theorem:

$$\frac{\partial \Pi^{A2}}{\partial \alpha_2} = -(D^{21} + D^{22})$$

which is the equilibrium output level for A<sub>2</sub> prior to innovation, and

$$\frac{\partial \Pi^{A2}}{\partial p_2} = 0.$$

Therefore, I can rewrite the expression for A<sub>2</sub>'s R&D incentives as:

$$-\frac{d\Pi^{A2}}{d\alpha_2} = (D^{21} + D^{22}) - \left[ \frac{\partial \Pi^{A2}}{\partial p_1} \frac{\partial p_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_1} \frac{\partial q_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_2} \frac{\partial q_2}{\partial \alpha_2} \right]$$

I can interpret the term  $(D^{21} + D^{22})$  as the direct effects of innovation through cost saving and the second term:

$$-\left[ \frac{\partial \Pi^{A2}}{\partial p_1} \frac{\partial p_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_1} \frac{\partial q_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_2} \frac{\partial q_2}{\partial \alpha_2} \right]$$

as the indirect effects of innovation through price competition.

After the A<sub>1</sub>-B<sub>1</sub> merger, I can represent each firm's equilibrium profits in the pre-merger situation as:

$$\tilde{\Pi}^{A1-B1}(\tilde{s}(\gamma), \tilde{p}_1(\gamma), \tilde{p}_2(\gamma), \tilde{q}_1(\gamma), \tilde{q}_2(\gamma); \gamma)$$

$$\tilde{\Pi}^{B1}(\tilde{s}(\gamma), \tilde{p}_1(\gamma), \tilde{p}_2(\gamma), \tilde{q}_1(\gamma), \tilde{q}_2(\gamma); \gamma)$$

$$\tilde{\Pi}^{B2}(\tilde{s}(\gamma), \tilde{p}_1(\gamma), \tilde{p}_2(\gamma), \tilde{q}_1(\gamma), \tilde{q}_2(\gamma); \gamma),$$

where  $\tilde{s}(\gamma)$  is the bundle price, and other variables corresponding with the post merger situation are denoted with a tilde. Then the post-merger expression for A<sub>2</sub>'s R&D incentives can be written as:

$$-\frac{d\tilde{\Pi}^{A2}}{d\alpha_2} = -\left[ \frac{\partial \tilde{\Pi}^{A2}}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{s}} \frac{\partial \tilde{s}}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{p}_1} \frac{\partial \tilde{p}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{p}_2} \frac{\partial \tilde{p}_2}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_1} \frac{\partial \tilde{q}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_2} \frac{\partial \tilde{q}_2}{\partial \alpha_2} \right]$$

Once again, by the envelope theorem,

$$\frac{d\tilde{\Pi}^{A2}}{d\alpha_2} = -(\tilde{D}^{21} + \tilde{D}^{22}),$$

which is the post-merger equilibrium output level for  $A_2$  prior to innovation, and

$$\frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{p}_2} = 0.$$

Therefore, I can rewrite the expression for  $A_2$ 's R&D incentives as:

$$-\frac{d\tilde{\Pi}^{A2}}{d\alpha_2} = (\tilde{D}^{21} + \tilde{D}^{22}) - \left[ \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{s}} \frac{\partial \tilde{s}}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{p}_1} \frac{\partial \tilde{p}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_1} \frac{\partial \tilde{q}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_2} \frac{\partial \tilde{q}_2}{\partial \alpha_2} \right]$$

Once again, I can interpret the first term  $-(\tilde{D}^{21} + \tilde{D}^{22})$  as the direct effects and the second term

$$-\left[ \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{s}} \frac{\partial \tilde{s}}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{p}_1} \frac{\partial \tilde{p}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_1} \frac{\partial \tilde{q}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_2} \frac{\partial \tilde{q}_2}{\partial \alpha_2} \right]$$

as the indirect effects.

If I compare the direct effects of innovation,  $A_2$  will unambiguously reduce R&D expenditures since its market output contracts after the  $A_1$ - $B_1$  merger;  $(D^{21} + D^{22}) > (\tilde{D}^{21} + \tilde{D}^{22})$ .

In general, the indirect effects of innovation through price competition before and after the merger are not directly comparable. However, if the merged firm responds more aggressively to other firms' price cuts after the merger, I expect that:

$$-\left[ \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{s}} \frac{\partial \tilde{s}}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{p}_1} \frac{\partial \tilde{p}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_1} \frac{\partial \tilde{q}_1}{\partial \alpha_2} + \frac{\partial \tilde{\Pi}^{A2}}{\partial \tilde{q}_2} \frac{\partial \tilde{q}_2}{\partial \alpha_2} \right]$$

is smaller than

$$-\left[ \frac{\partial \Pi^{A2}}{\partial p_1} \frac{\partial p_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_1} \frac{\partial q_1}{\partial \alpha_2} + \frac{\partial \Pi^{A2}}{\partial q_2} \frac{\partial q_2}{\partial \alpha_2} \right].$$

Then  $A_2$  will unambiguously reduce its R&D. Even if the last inequality is reversed, if the direct effects of innovation are sufficiently large compared to the indirect effects,  $A_2$  will still reduce its R&D.

In the Appendix, I conduct a simulation analysis in which I confirm that the merged firm increases its R&D level whereas outside rival firms reduce their R&D levels in a linear demand model with quadratic R&D cost functions. I also perform a dynamic welfare analysis and show that the effects of mergers can be especially harmful in industries with more R&D opportunities.

### III.2. Pure Bundling/Compatibility Choice and Foreclosure

Until now, I have analyzed only the possibility of *mixed bundling* after a merger between complementary producers in which the merged firm sells the individual components separately as well as selling the bundle (but the bundle is offered at a discount to the sum of the stand-alone prices). In this subsection, I consider another type of practice known as *pure bundling*, under which the firm only sells the bundle and does not make the individual components available individually. For *existing generations* of products, it is a reasonable assumption that the merged firm's ability to engage in pure bundling is limited since pure bundling is typically not an *ex post* optimal strategy for the merged firm, and thus it requires a commitment device.<sup>9</sup>

In the long run, however, the merged firm can commit to pure bundling in the form of technical tying, especially for *new generations* of products, by making its products available only as an integrated system, incompatible with the individual components offered by outside suppliers. In such a case, the only available systems in the market are  $A_1$ - $B_1$  and

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<sup>9</sup> See Whinston (1990) for a classical analysis of pure bundling in which he shows the importance of commitment ability for bundling to have any impact on competition.

A<sub>2</sub>-B<sub>2</sub> since A<sub>1</sub> and B<sub>1</sub> will only function effectively as part of the bundled system and cannot be used alongside components from other suppliers. By inverting the inverse demand system in section II.3 with the constraint  $D^{I2} = D^{2I} = 0$ , I can derive the following demand system:

$$D^{I1}(s, p_2, q_2) = \frac{(b+c)}{(b-c)} [a - (b-2c)(p_2 + q_2) + cs]$$

$$D^{22}(s, p_2, q_2) = \frac{(b+c)}{(b-c)} [a - (b-2c)(p_2 + q_2) + cs],$$

where  $s$  = the merged firm's price for system A<sub>1</sub>-B<sub>1</sub>,  $p_2$  = the price of A<sub>2</sub> and  $q_2$  = the price of B<sub>2</sub>.

Then the profit functions for the merged firm (A<sub>1</sub>-B<sub>1</sub>) and independent firms (A<sub>2</sub> and B<sub>2</sub>) with pure bundling are respectively given by

$$\Pi^{A1-B1} = sD^{I1}, \Pi^{A2} = p_2 D^{22} \text{ and } \Pi^{B2} = q_2 D^{22}$$

The market equilibrium (Nash equilibrium prices) is characterized by the following first-order conditions:  $\partial \Pi^{A1-B1} / \partial s = 0$ ,  $\partial \Pi^{A2} / \partial p_2 = 0$ , and  $\partial \Pi^{B2} / \partial q_2 = 0$ . Solving the conditions simultaneously yields:

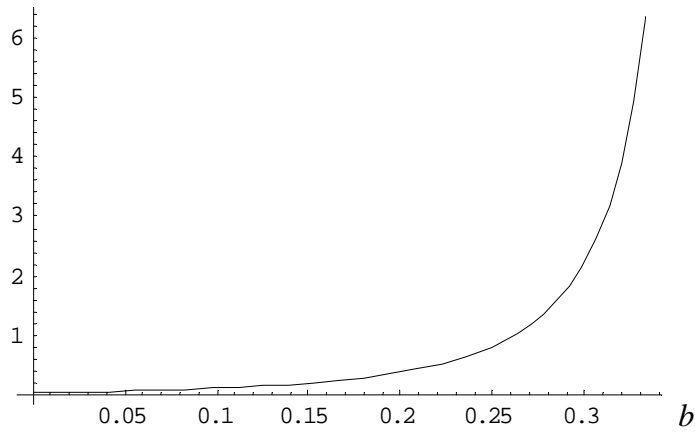
$$\bar{s} = \frac{a(3b-4c)}{2(3b^2-12bc+11c^2)} \quad (\text{the bundle price})$$

$$\bar{p}_2 = \bar{q}_2 = \frac{a(2b-3c)}{2(3b^2-12bc+11c^2)} \quad (\text{independent firms' component price})$$

As in the case of mixed bundling, the bundle price offered by the merged firm is lower than the sum of independent firms' component prices. As a result, the merged firm dominates the outside firms in terms of market share.

I conduct a numerical analysis to investigate the profitability of merging with pure bundling. Once again, I normalize parameters with  $a=b=1$ . With this normalization, the effects of a merger with pure bundling on the merging and outside firms' profits are plotted in Figures 4 and 5.

$$\bar{\Pi}^{A1-B1} - (\Pi^{A1} + \Pi^{B1})$$



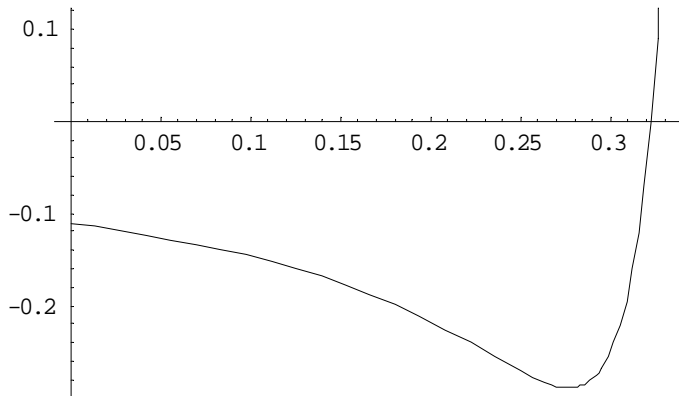
$\bar{\Pi}^{A1-B1}$  = merged entity's profit with pure bundling

$\Pi^{A1}$  = pre-merger profit for firm A<sub>1</sub>

$\Pi^{B1}$  = pre-merger profit for firm B<sub>1</sub>

Figure 4. Changes in Profits for the Merging Firms with Pure Bundling

$$\bar{\Pi}^{A2} - \Pi^{A2} \text{ and } \bar{\Pi}^{B2} - \Pi^{B2}$$



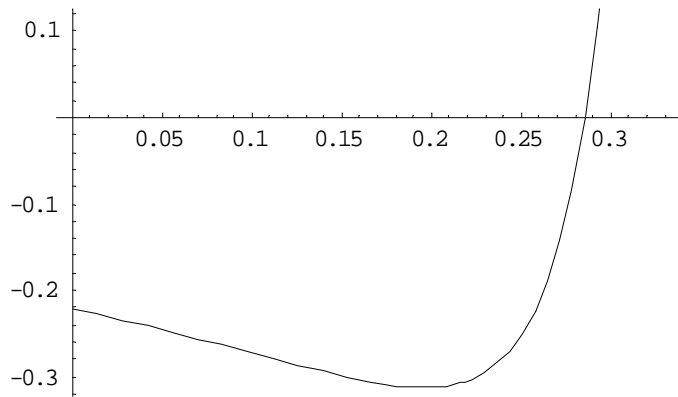
$\bar{\Pi}^{A2}$ ,  $\bar{\Pi}^{B2}$  = post-merger profits for outsiders with pure bundling

$\Pi^{A2}$ ,  $\Pi^{B2}$  = pre-merger profits for firms A<sub>2</sub> and B<sub>2</sub>, respectively

Figure 5. Changes in Profits for the Outsiders with Pure Bundling

Thus, the merger with pure bundling is profitable for merging firms  $A_1$  and  $B_1$ . However, pure bundling is less profitable than mixed bundling for the merged entity as shown in Figure 6.

$$\overline{\Pi}^{A1-B1} - \widetilde{\Pi}^{A1-B1}$$



$\overline{\Pi}^{A1-B1}$  = merged entity's profit with pure bundling

$\widetilde{\Pi}^{A1-B1}$  = merged entity's profit with mixed bundling

**Figure 6. Mergers with Pure Bundling vs. Mixed Bundling**

I can thus conclude that the merged firm will not practice pure bundling since mixed bundling yields higher profits as an accommodation strategy. However, as in Whinston (1990), pure bundling can be still profitable if the exclusion of rivals through predation is possible with pure bundling, but not with mixed bundling. This may occur because outsiders' profits are affected more adversely with pure bundling. To see this, I plot the differences in outsiders' profits with pure bundling and mixed bundling in Figure 7.<sup>10</sup>

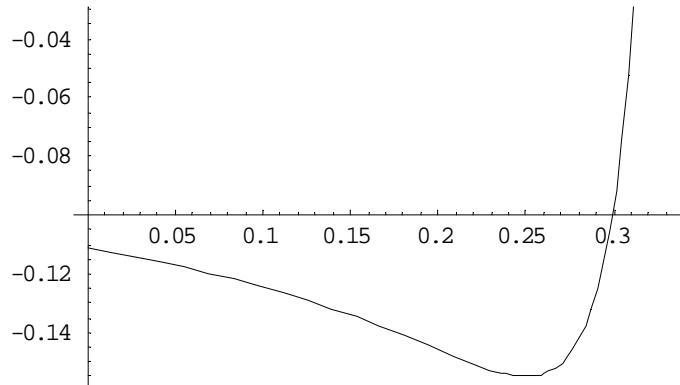
Thus, I can imagine a situation where there is a fixed cost of operation and rival firms can recoup fixed costs with mixed bundling but not with pure bundling, that is,

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<sup>10</sup> For the sake of brevity, I report only the effects of pure bundling with price competition. However, similar results can be derived when we introduce the possibility of R&D competition in the model.

$\bar{\Pi}^{A2} < F < \tilde{\Pi}^{A2}$  or  $\bar{\Pi}^{B2} < F < \tilde{\Pi}^{B2}$ . In such a case, the merged firm can foreclose rival firms by committing to pure bundling with technical tying. One way to accomplish such a commitment is by designing new generations of products that are incompatible with those of rival firms.

$$\bar{\Pi}^{A2} - \tilde{\Pi}^{A2} \text{ and } \bar{\Pi}^{B2} - \tilde{\Pi}^{B2}$$



$\bar{\Pi}^{A2}$ ,  $\bar{\Pi}^{B2}$  = post-merger profits for outsiders with pure bundling

$\tilde{\Pi}^{A2}$ ,  $\tilde{\Pi}^{B2}$  = post-merger profits for outsiders with mixed bundling

Figure 7. Pure Bundling vs. Mixed Bundling for Outsiders' Profits

I considered only the case of duopolistic competition in each component market. When there are many outside independent firms, the possibility of full foreclosure of all independent suppliers seems to be remote. However, if one of the smaller firms chooses not to compete in certain segments of the complementary market, it could potentially have a *ripple effect* in terms of threatening the viability of other independent firms in the complementary segments.

#### IV. Concluding Remarks

In this paper, I provided a framework to analyze the effects of a merger in systems markets when the merger enables the merging parties to engage in mixed bundling. As



such, it can shed some light on merger/divestiture issues in network industries such as “portfolio effects” or “range effects.” The model, for instance, can be applied to the recent proposed merger between GE and Honeywell. When the European Commission blocked the proposed merger, the decision was heavily, and in my opinion unfairly, criticized in the popular press and by the U.S. antitrust agencies and senior administration officials, raising fears of escalating trade disputes between the US and EU.<sup>11</sup> In particular, there have been some unfortunate suggestions in the newspapers that the decision was made without any theoretical support.<sup>12</sup> This paper, in contrast, shows that the effects of bundling can be analyzed with sound economic modeling.

My model suggests that mergers with bundling in systems markets could entail both pro-competitive and anti-competitive effects. In the event of any foreclosure of competitors, however, conglomerate mergers with mixed bundling would be predominantly anti-competitive. Even in the absence of such foreclosure effects, there is no clear-cut answer to how mixed bundling by the merging parties would affect consumer and social welfare. With heterogeneous consumer preferences, some buyers gain and others lose. For instance, those who previously purchased both products from the two merging firms would gain due to the lower bundle price. However, those who continue to purchase a mix-and-match system would suffer due to the increased stand-alone prices charged by the merged firm. As a result, the overall impact on consumer and social welfare is ambiguous. In general, conglomerate mergers would have different implications for competition depending on specific market conditions such as market shares of the merging parties in their individual markets, economies of scale due to avoidable fixed costs, ease of entry, etc. To sort out pro-competitive effects and anti-competitive effects of each conglomerate merger case, the relative magnitudes of these countervailing effects and the likelihood of the foreclosure of

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<sup>11</sup> See, for instance, the address by William J. Kolasky (2001), Deputy Assistant Attorney General for International Affairs in the Antitrust Division of the U.S. Department of Justice.

<sup>12</sup> Interestingly enough, the EC’s bundling theory was described as “19<sup>th</sup>-century thinking” in the *New York Times* whereas it was described as “novel” in the *Wall Street Journal*. See Hal R. Varian, *Economic Scene; In Europe, GE and Honeywell ran afoul of 19<sup>th</sup>-century thinking.*, N.Y. Times, June 28, 2001 and Editorial, *Europe to GE: Go Home*, Wall Street J., June 15, 2001.

one or more competitors need to be assessed. Blanket approvals of conglomerate mergers with the presumption that bundling is either pro-competitive or competitively neutral are certainly not warranted.

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## Appendix. The Effects of Merger with Mixed Bundling on R&D Incentives

In this appendix, I conduct a simulation analysis on the effects of mergers on R&D incentives and welfare implications in a linear demand model with a quadratic R&D cost function. For the sake of presentation, I consider R&D that improves the quality of components and shifts the system demand curves outward. More precisely, let  $(\Delta_1, \Delta_2, \delta_1, \delta_2)$  denote quality improvements of components  $A_1, A_2, B_1, B_2$ , respectively, which represent consumers' willingness to pay for the systems that contain them. For instance, consumers' willingness to pay for the system  $A_i B_j$  increases by  $\Delta_i + \delta_j$ . Let me assume that the cost of improving the quality of each component is given by  $k\Delta^2/2$ , where  $\Delta$  is the amount of quality improvement and  $k$  is an R&D cost parameter.

The inverse demand system can be written as:

$$s_{11}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a + (\Delta_1 + \delta_1) - (\beta - 2\gamma)D^{11} - \gamma D^{12} - \gamma D^{21} - \gamma D^{22}$$

$$s_{12}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a + (\Delta_1 + \delta_2) - \gamma D^{11} - (\beta - 2\gamma)D^{12} - \gamma D^{21} - \gamma D^{22}$$

$$s_{21}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a + (\Delta_2 + \delta_1) - \gamma D^{11} - \gamma D^{12} - (\beta - 2\gamma)D^{21} - \gamma D^{22}$$

$$s_{22}(D^{11}, D^{12}, D^{21}, D^{22}) = (\beta + \gamma) a + (\Delta_2 + \delta_2) - \gamma D^{11} - \gamma D^{12} - \gamma D^{21} - (\beta - 2\gamma)D^{22},$$

where  $\beta = \frac{b}{(b-3c)(b+c)}$  and  $\gamma = \frac{c}{(b-3c)(b+c)}$ .

Then, the inverse demand system implies the following system demand functions given  $(\Delta_1, \Delta_2, \delta_1, \delta_2)$ :

$$D^{11} = a + (b-c)(\Delta_1 + \delta_1) - 2c(\Delta_2 + \delta_2) - b(p_1 + q_1) + c(p_1 + q_2) + c(p_2 + q_1) + c(p_2 + q_2)$$

$$D^{12} = a + (b-c)(\Delta_1 + \delta_2) - 2c(\Delta_2 + \delta_1) - b(p_1 + q_2) + c(p_1 + q_1) + c(p_2 + q_2) + c(p_2 + q_1)$$

$$D^{21} = a + (b-c)(\Delta_2 + \delta_1) - 2c(\Delta_1 + \delta_2) - b(p_2 + q_1) + c(p_2 + q_2) + c(p_1 + q_1) + c(p_1 + q_2)$$

$$D^{22} = a + (b-c) (\Delta_2 + \delta_2) - 2c(\Delta_1 + \delta_1) - b(p_2 + q_2) + c(p_2 + q_1) + c(p_1 + q_2) + c(p_1 + q_1)$$

For a simulation analysis, let me normalize the parameters to  $a=b=1$ . Then, Figures A-1 and A-2 show the changes in profits due to the A1-B1 merger for the merging firms ( $A_1$  and  $B_1$ ) and outsider firms ( $A_2$  and  $B_2$ ) for parameter values  $k \in [20,100]$  and  $c \in [0,1/3]$ .

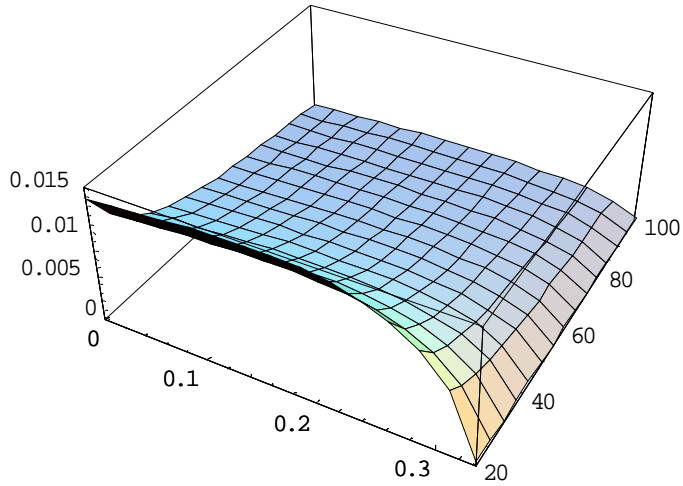


Figure A-1. Changes in Profits for the Merging Firms with R&D

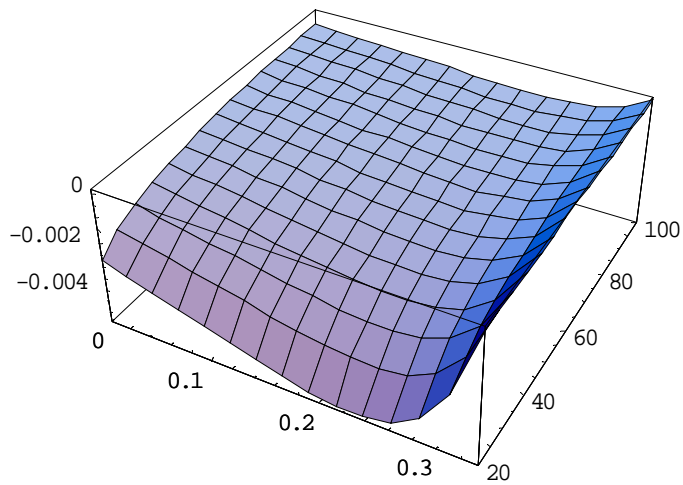


Figure A-2. Changes in Profits for the Outsider Firms with R&D

Our simulation results suggest that for wide ranges of parameter spaces, the merger is profitable for  $A_1$  and  $B_1$  whereas it reduces the outsider firms' profits. Welfare implications of the merger in the presence of R&D are represented in Figure A-3.

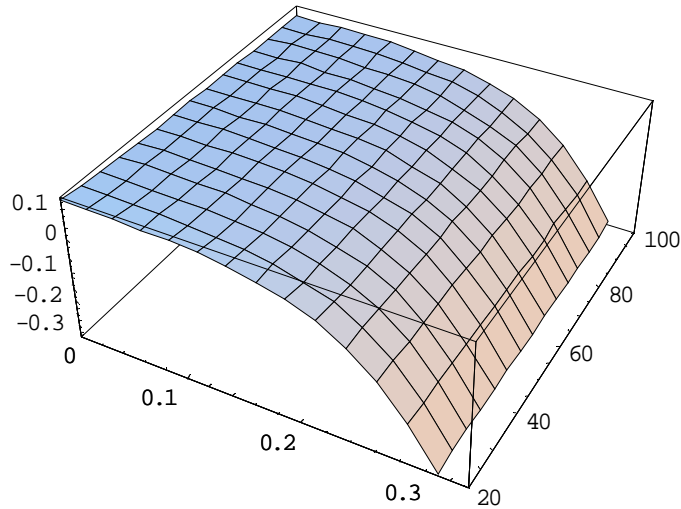


Figure A-2. Changes in Welfare due to Mergers in the Presence of R&D

As in the case without R&D, simulation results suggest that welfare results are ambiguous and depend crucially on  $c$  (cross-substitutability parameter). Once again, when  $c$  is close to zero, each system is essentially a separate product and there is little direct competition between systems. In this case, the structure of each system market is equivalent to the one considered by Cournot and the merger is welfare enhancing. In cases with high degrees of substitutability and intense competition among systems, the effects of mergers on social welfare are negative.

To investigate the effects of the R&D cost parameter, I also plot the changes in welfare due to mergers with three different values of  $k$  in Figure A-3. The results suggest that mergers are more likely to reduce welfare when there are more opportunities for cost reduction through R&D, that is, when  $k$  is lower.

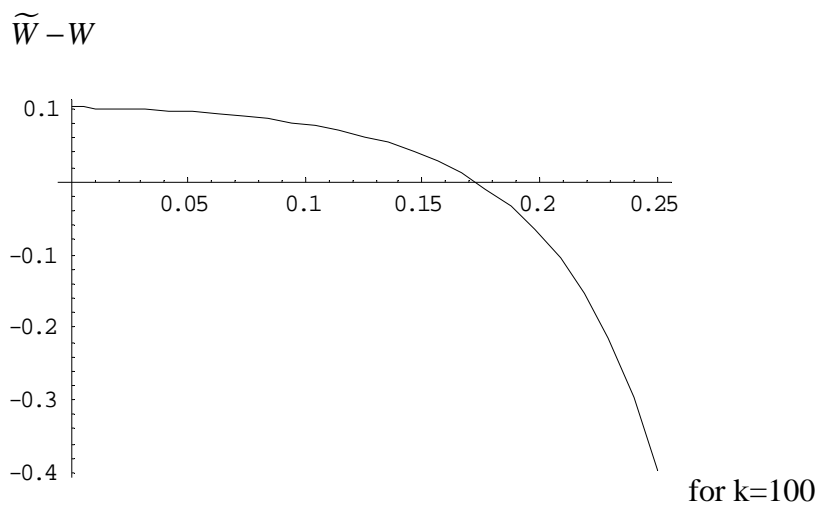
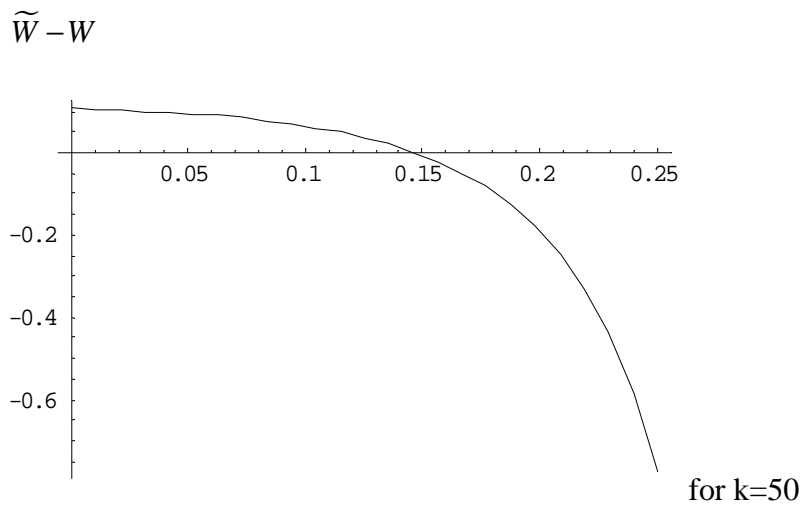
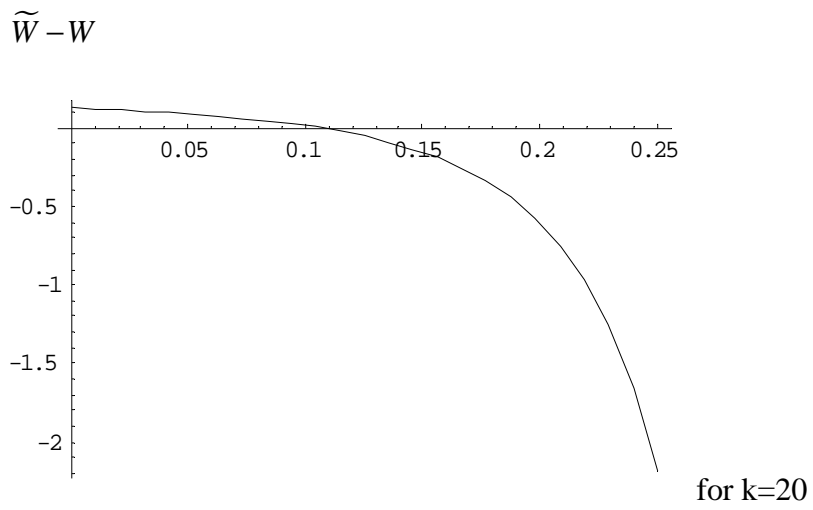


Figure A-3. The Effects of R&D Opportunities on Changes in Welfare due to Mergers