Mergers with Bundling

in Complementary Markets

By

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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 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. 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. 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.

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1 The case was appealed in the Court of First Instance (CFI) of the European Union. The CFI upheld the Commission’s decision to block the merger on December 14, 2005. Concerning the alleged creation of conglomerate effects due to the bundling of GE’s engine products with Honeywell’s avionics products, however, the CFI essentially held that that the Commission’s analysis was speculative and insufficiently proven, and relied on economic theories that are subject to controversy. In essence, it acknowledged that conglomerate mergers may lead to anticompetitive effects in certain circumstances, but confirmed the very high standard of proof that the Commission has to meet in order to prohibit such mergers.

2 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.

3 See Choi (forthcoming) for more details.

4 Economides (1993) considers the incentives to practice mixed bundling in duopoly competition in which firms produce complementary goods. He shows that mixed bundling is a dominant strategy for both firms, but the payoff structure has the property of prisoners’ dilemma game with both firms being worse off as a result of mixed bundling. His paper, however, is not concerned with mergers in complementary markets.
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.

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, Matutes and Regibeau (1988), Whinston (1990), Carbajo, de Meza, and Seidman (1990), Choi and Stefanadis (2001), and Nalebuff (2004)].\(^5\) 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.\(^6\)

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\(^5\) In a model of strategic market foreclosure of tying, for instance, Whinston (1990) shows that mixed bundling is not a useful strategy. In his model, mixed bundling replicates the same outcome under independent pricing without bundling. 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).

\(^6\) As will be seen later, the incentive to practice mixed bundling rather than pure bundling in the short-run is confirmed in my model.
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 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.\(^7\) 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

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\(^7\) 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.
internalize the externality arising from the complementarity of their components. 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. Consumers pay less for the merged firm’s bundle or the system comprising outside firms’ components. However, they pay more for the mix-and-match systems.

Bundling in my model thus 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 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.

The basic model is then extended to consider the effects of mergers on R&D incentives and the possibility of pure bundling as an instrument of foreclosure. 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. 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.

Dalkir et al. (2002) also develop a model of merger between complementary goods producers that allows the possibility of bundling. They demonstrate that a merger of quality
leaders in the components can result in higher profits and increased market share for the integrated firm at the expense of consumers who pay higher prices and face an effective decrease in choice. However, their model is different from mine in that they consider a model of quality differentiation in which the merging firms face the competitive fringe that constrains the monopoly power of the merging firms. More specifically, they assume that there is a single quality leader in each of the goods’ markets, with all other firms producing lower quality products. The independent firms in their model are modeled as the competitive fringe that sets a price equal to marginal cost and earns zero profit before and after the merger. As a result, there is no strategic interaction between the merging firms and the independent firms. Their model thus is not adequate to address the effect of mergers on outside firms and the possibility of potential foreclosure, a major concern of the European Commission in the GE/Honeywell case.

Nalebuff (2002) is another related paper that specifically analyzes the GE-Honeywell merger. In particular, he points out that most economic models adopt the assumption that there is one price to all customers in the market, which does not apply to the aerospace industry. According to him, customers do not pay list price for jet engines or avionics. Instead, they negotiate prices with the vendors. In addition, vendors are very well informed about their customers’ preferences. To reflect these aspects of the industry, he proposes a model of customer-specific pricing with perfect information and shows that bundling is not a profitable strategy for the merging parties. My model, however, can easily accommodate individual pricing and derive the same qualitative results by reinterpretating the demand curve as an individual demand applied to each customer rather than the aggregate demand. Thus, the real difference between my model and Nalebuff’s is in the nature and degree of uncertainty assumed.

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8 Nalebuff (2002) also makes policy recommendations concerning the evaluation of mergers between two producers of complements.

9 Technically speaking, my linear demand model would be equivalent to assuming a particular type of uncertainty in the Nalebuff model. Which assumption is more appropriate for the industry is of course debatable, but that question is an empirical one.
Finally, Evans and Salinger (2002) chronicle the history of the proposed GE/Honeywell merger and provide a critique of the Commission’s Decision.\(^\text{10}\) In the appendix of their paper, they present a simple economic model that supports their claim.\(^\text{11}\) Despite some apparent similarities between their model and mine, there are crucial differences. Evans and Salinger consider a model in which one of the two complementary goods (component A) is provided by a monopolist and the other is provided by two firms selling differentiated products (B\(_1\) and B\(_2\)). This implies that in their model only two systems (A-B\(_1\) and A-B\(_2\)) are available, and once there is a merger between the monopolist and one of the two complementary good producers, there is no role for mixed bundling. To understand that any outcome with mixed bundling can be replicated with independent component pricing, suppose that a merger takes place between A and B\(_1\). Then, the merged entity’s price of B\(_1\) is “free” in the sense that it affects only the composite price of its own system A-B\(_1\). However, if the merged entity also faces a competitor in the component A market (say A\(_2\)), the merged entity’s price of B\(_1\) is no longer “free” since it also affects the composite price of competing system A\(_2\)-B\(_1\). With competitors in both markets, mixed bundling provides a mechanism to de-couple the composite price of the merged entity’s own system from that of other mix-and-match systems. As a result, mixed bundling allows the merged entity to raise rivals’ costs more effectively without raising its own system price. The model of Evans and Salinger lacks such a feature, and thus is not adequate to analyze the effect of mixed bundling, which was one of the main concerns held by the Commission in blocking the merger.\(^\text{12}\)

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. Welfare implications of mergers are also analyzed. Section III deals with dynamic issues in the industry by extending the model to allow for R&D

\(10\) I thank Editor Yeon-Koo Che for directing my attention to the Evans and Salinger (2002) paper.

\(11\) Their model is closely related to Salinger (1991).

\(12\) In addition, their analysis is essentially a numerical example and does not provide any general results.
opportunities and technical tying. It also considers the possibility of countermerger and implications of the policy prescription that prohibits bundling as a condition for merger. 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, \(D_{i1}\) 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

\[D_{Ai} = D_{i1}^i + D_{i2}^i\]

Similarly, the demand for component B_j is given by

\[D_{Bj} = D_{j1}^j + D_{j2}^j\]
I assume demand functions are linear and the demand system is symmetric:

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

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

\[ \text{It would be more natural to assume that system goods that share one component would be closer substitutes for each other than the ones that do not. Incorporating this property, however, requires one more parameter and would complicate the analysis without adding significant new insight.} \]
costs are zero. 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 $p_1$, $p_2$, $q_1$, and $q_2$ denote the prices set by firms A1, A2, B1, and B2, respectively. Then I can write each firm’s profit as:

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

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:

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

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

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

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

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14 If there are positive constant unit production costs, the prices in the model can be interpreted as per unit margins.
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 \((A_1B_1, A_1B_2, A_2B_1, A_2B_2)\) have the same market share of \(\frac{1}{4}\) in the systems market by substituting the equilibrium prices back into the demand function:

\[
D^{11} = D^{12} = D^{21} = D^{22} = \frac{a(b - c)}{3b - 7c}
\]

Thus, each firm has the same market share of \(\frac{1}{2}\) with demand of \(\frac{2a(b - c)}{3b - 7c}\) 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 \(A_1\) and \(B_1\) with Mixed Bundling

Now suppose that \(A_1\) and \(B_1\) merge. As a merged entity, \(A_1-B_1\) can offer three prices, \(s\) for the bundled product \((A_1B_1)\) and \(\tilde{p}_1\) and \(\tilde{q}_1\) for individual components \(A_1\) and \(B_1\), respectively.\(^{15}\) \(A_2\) and \(B_2\) remain independent and charge prices \(\tilde{p}_2\) and \(\tilde{q}_2\), respectively. Figure 2 describes the post-merger situation with mixed bundling.

Then, the profit functions for the merged firm \((A_1-B_1)\) and independent firms \((A_2\) and \(B_2)\) are respectively given by

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

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

\[
D^{ij} = a - b s + c (p_1 + q_2) + c (p_2 + q_1) + c (p_2 + q_2)
\]

\(^{15}\) Variables associated with the post-merger situation are denoted with a tilde.
The merged firm’s profit, $\Pi^{A_1-B_1}$, consists of three components: the profit from selling the bundle $A_1B_1$ ($sD^{12}$), the profit from selling stand-alone product $A_1$ as part of the mix-and-match system $A_1B_2$ ($p_1D^{12}$), and the profit from selling stand-alone product $B_1$ as part of the mix-and-match system $A_2B_1$ ($q_1D^{21}$).

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

\[
\frac{\partial \Pi^{A_1-B_1}}{\partial s} = a - 2b s + 2c p_1 + 2c p_2 + 2c q_1 + 2c q_2 = 0 \\
\frac{\partial \Pi^{A_1-B_1}}{\partial p_1} = a + 2c s - 2b p_1 + 2c p_2 + 2c q_1 - (b - c) q_2 = 0 \\
\frac{\partial \Pi^{A_1-B_1}}{\partial q_1} = a + 2c s + 2c p_1 - (b - c) p_2 - 2b q_1 + 2c q_2 = 0 \\
\frac{\partial \Pi^{A_2}}{\partial p_2} = 2a + 2c s + 2c p_1 - 4(b - c) p_2 - (b - c) q_1 (b - 3c) q_2 = 0 \\
\frac{\partial \Pi^{B_2}}{\partial q_2} = 2a + 2c s - (b - c) p_1 - (b - 3c) p_2 + 2c q_1 - 4(b - c) q_2 = 0
\]

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.** Mixed bundling following the merger has the following implications for prices.

- **First,** the price of the bundle post-merger is lower than the sum of the pre-merger component prices (\(\tilde{s} = \frac{a(3b-c)}{2(3b^2 - 9bc + 4c^2)} < s'_j = p'_j + q'_j = \frac{2a}{3b-7c}\)).\(^{16}\)

- **Second,** the merged firm’s prices for individual components are higher with mixed bundling (\(\tilde{p}_1 = \tilde{q}_1 = \frac{ab}{3b^2 - 9bc + 4c^2} > p'_1 = q'_1 = \frac{a}{3b-7c}\))

- **Third,** the independent firms also cut their prices (\(\tilde{p}_2 = \tilde{q}_2 = \frac{a(b-c)}{3b^2 - 9bc + 4c^2} < p'_2 = q'_2 = \frac{a}{3b-7c}\)). However, the sum of these two prices are higher than the bundle price, i.e., \(\tilde{p}_2 + \tilde{q}_2 > \tilde{s}\). In addition, the composite prices of the mix-and-match systems increase (\(\tilde{p}_1 + \tilde{q}_2 = \tilde{p}_2 + \tilde{q}_1 = \frac{a(2b-c)}{3b^2 - 9bc + 4c^2} > p'_1 + q'_2 = p'_2 + q'_1 = \frac{2a}{3b-7c}\)).

Even though I derive the results in Proposition 1 with the assumption of a linear demand system, they are expected to hold for more general demand conditions as long as

\(^{16}\)This can be easily proved with our assumption of the gross substitutability of the demand systems, that is, \(b > 3c\).
the demand system is more or less symmetric.\textsuperscript{17} First, the reduction in the price of the bundled system comes from the well-known Cournot effect. For complementary products, any price cut for one of the products benefits the sales of complementary products. With independent ownership under which complementary products are produced by separate entities, 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 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.

What is a novel and hitherto neglected aspect of pricing after merger in complementary markets is that the merged entity will raise the price of its stand-alone components relative to their levels prior to the merger. To see this, note that the first order conditions for individual component price, say, $A_1$ under pre-merger and post-merger situations are respectively given by:

\begin{align}
\frac{\partial \Pi^{A_1}}{\partial p_1} &= (D^{11} + D^{12}) + p_1 \left[ \frac{\partial D^{11}}{\partial p_1} + \frac{\partial D^{12}}{\partial p_1} \right] = 0 \quad (1) \\
\frac{\partial \Pi^{A_1-B_1}}{\partial p_1} &= \left[ D^{12} + p_1 \frac{\partial D^{12}}{\partial p_1} \right] + s \frac{\partial D^{11}}{\partial p_1} + q \frac{\partial D^{21}}{\partial p_1} = 0 \quad (2)
\end{align}

Let $p_1'$ and $\bar{p}_1$ be the prices that satisfy first order conditions (1) and (2), respectively. With independent ownership prior to the merger, an increase in $p_1$ implies an equal amount of increase in the system prices of $s_{11}$ and $s_{12}$. As a result, in a symmetric equilibrium we have $D^{11} + p_1 \frac{\partial D^{11}}{\partial p_1} \bigg|_{p_1=p_1'} = D^{12} + p_1 \frac{\partial D^{12}}{\partial p_1} \bigg|_{p_1=p_1'} = 0$. In contrast, in the post-merger situation with mixed bundling, an increase in $p_1$ induces a price increase only for the mixed system $A_1-B_2$, without affecting the system price of $A_1-B_1$, which implies that $\frac{\partial D^{11}}{\partial p_1} > 0$ and

\textsuperscript{17} The robustness of Proposition 1 can be further manifested by Gans and King (2006) who derive similar qualitative results in a model of “spatial competition” à la Matutes and Regibeau (1988). The focus of their paper, however, is on fixed discounts of allied brands and is not concerned with the analysis of merger.
\[ \frac{\partial D^{21}}{\partial p_1} > 0. \] As a result, when the first order condition (2) is evaluated at the price of \( p_1' \), I have

\[ \left. \frac{\partial \Pi^{11-B1}}{\partial p_1} \right|_{p_1=p_1'} = s \frac{\partial D^{11}}{\partial p_1} + q \frac{\partial D^{21}}{\partial p_1} > 0. \]

This result indicates that \( \tilde{p}_1 > p_1' \); that is, the merged firm raises the prices of its stand-alone components compared to their pre-merger levels. The reason for an increased incentive to set high prices for its components stems from the fact that mixed bundling allows the merged firm to increase the prices of the “mix-and-match” systems without increasing the price of its own system. As a result, the merged firm has less to lose from raising its stand-alone prices since a proportion of those customers that switch away from the mix-and-match system will simply switch to the bundle offered by the merged firm.\(^\text{18}\)

In response, independent rival firms reduce their prices. There are two reasons for this. First, they need to compete more aggressively to meet the price reduction of the bundled system. In addition, the higher prices of components A1 and B1 depress the demands for A2 and B2. Hence, they need to compensate the price increase for the “mix-and-match” systems to retain their market share. Nonetheless, they will not cut their prices as much as the merged firm since they cannot internalize the pricing externality arising from the complementarity of their components.

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:

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

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

\(^{18}\) The effect of merger on stand-alone component prices would be weakened if there were separate demands on individual components, such as replacement parts, since an increase in component prices induces a switch to competing components rather than to the bundled product for such demands. This implies that outsiders will also have less incentives to reduce their prices.
The profits of the merged firm and outside firms are given by:

\[
\tilde{\Pi}^{A_1-B_1} = \frac{a^2b(17b^2 - 38bc + 9c^2)}{4(3b^2 - 9bc + 4c^2)^2}
\]

\[
\tilde{\Pi}^{A_2} = \tilde{\Pi}^{B_2} = \frac{2a^2(b-c)^3}{(3b^2 - 9bc + 4c^2)^2}
\]

**Proposition 2.** Mixed bundling following the merger would have the following implications for market shares and profits.\(^{19}\)

- 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.

---

\(^{19}\) All results can be easily proved algebraically by simple manipulations with the assumption of \(b>3c\).
Example. Consider the case where \( a = b = 1 \) and \( c = 1/4 \). Then I can show that with the independent ownership (pre-merger) structure, \( p_1' = p_2' = q_1' = q_2' = 4/5 \). 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 \( 5 = 11/8 \) for the bundle and \( q_{1} - q_{1} = 1 \) for separate components. Thus, it offers discount for the bundle \( (11/8 < 1+1=2) \). Independent producers, \( A_2 \) and \( B_2 \), charge \( p_2 = q_2 = 3/4 \) for their component products. Thus, the prices for composite products, \( A_1B_1, A_1B_2, A_2B_1, \) and \( A_2B_2 \) are given by 11/8, 7/4, 7/4, and 3/2, respectively, where \( 7/4 > 3/2 > 11/8 \). After the merger \( A_1-B_1 \) receives the profits of 129/64 (>24/25+24/25), whereas independent producers get 27/32 (<24/25). This implies that \( A_1 \) and \( B_1 \) together increase their combined profits after merger while independent producers’ profits decrease.

II.3. Welfare Analysis

Since merger with bundling reduces the profits of non-merging firms, it can force the latter firms to exit the market. This potential foreclosure effect is important and will be discussed later, but for now 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 need to specify utility functions of consumers. Assume that there is a representative consumer (or a continuum of consumers of the same type) with a utility function separable and linear in the numeraire good so that there are no income effects and partial equilibrium analysis can be conducted. To derive the utility function that is consistent with the demand system assumed in my model, 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:

\[
\begin{align*}
D_{11}^{11}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda + \mu) a - (\lambda - 2 \mu) D^{11} - \mu D^{12} - \mu D^{21} - \mu D^{22} \\
D_{12}^{11}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda + \mu) a - (\lambda - 2 \mu) D^{12} - \mu D^{11} - \mu D^{21} - \mu D^{22} \\
D_{21}^{11}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda + \mu) a - (\lambda - 2 \mu) D^{21} - \mu D^{11} - \mu D^{12} - \mu D^{22} \\
D_{22}^{11}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda + \mu) a - (\lambda - 2 \mu) D^{22} - \mu D^{11} - \mu D^{12} - \mu D^{21} 
\end{align*}
\]
\[ s_{12}(D^{11}, D^{12}, D^{21}, D^{22}) = (\lambda + \mu) a - \mu D^{11} - (\lambda - 2\mu) D^{12} - \mu D^{21} - \mu D^{22} \]
\[ s_{21}(D^{11}, D^{12}, D^{21}, D^{22}) = (\lambda + \mu) a - \mu D^{11} - \mu D^{12} - (\lambda - 2\mu) D^{21} - \mu D^{22} \]
\[ s_{22}(D^{11}, D^{12}, D^{21}, D^{22}) = (\lambda + \mu) a - \mu D^{11} - \mu D^{12} - \mu D^{21} - (\lambda - 2\mu) D^{22}, \]

where \( \lambda = \frac{b}{(b-3c)(b+c)} \) and \( \mu = \frac{c}{(b-3c)(b+c)} \).

These inverse demand functions imply that the utility function is given by:
\[ U(D^{11}, D^{12}, D^{21}, D^{22}) = (\lambda + \mu) a [D^{11} + D^{12} + D^{21} + D^{22}] - \frac{\lambda - 2\mu}{2} [(D^{11})^2 + (D^{12})^2 + (D^{21})^2 + (D^{22})^2] - \mu [D^{11} D^{12} + D^{11} D^{21} + D^{11} D^{22} + D^{12} D^{21} + D^{12} D^{22} + D^{21} D^{22}] + m, \]

where \( m \) is the amount of the numeraire good.

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

By subtracting the firms’ profits from social welfare, I can also derive consumer surplus. I plot the changes in social welfare and consumer surplus due to the merger in Figure 3.

Even in the absence of such foreclosure effects, there could be significant welfare loss when \( c \) (cross-substitutability parameter) is sufficiently large. The welfare result can be understood by the interplay between the “vertical” externality among complements and the
“horizontal” externality among competing systems. The merger is beneficial from the viewpoint of “vertical” externality in that it internalizes the pricing externality for complementary products and induces a reduction in the price of the bundled system. However, the merger can be harmful from the perspective of “horizontal” externality in that it increases the prices of the “mix-and-match” systems. 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. There exists only “vertical” externality and mergers are welfare enhancing. In cases with high degrees of substitutability and intense competition among systems (i.e., $c \leq 0.225$), however, the model suggests that the effects of mergers on social welfare are negative. As $c$ (the cross elasticity of competing systems) increases, the “horizontal” externality becomes more important. The effect on consumer surplus is also negative if $c \leq 0.278$.\(^{20}\)

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 and consumer surplus turn out to be decidedly negative in this model. For instance, suppose there is a fixed cost of operation $F$ that can be avoided by exiting the industry. If I have a situation such that $\Pi_A^2 < F < \Pi_B^2 + F$, a merger between $A_1$ and $B_1$ will induce an exit by the outsiders. In such a case, the merged entity becomes a monopolist and charges a system price of $\frac{1}{2(1-3c)}$ (with the normalization of $a = b = 1$). Consumers are obviously worse off with the exit of outsiders. A social welfare analysis with foreclosure requires weighing the saving of the fixed costs against the loss of consumer surplus. The cost saving, however, is limited by $(\Pi_A^2 + \Pi_B^2)$; otherwise, outsiders would not operate even before the merger. Even with the maximum

\(^{20}\)My model assumes that A and B are perfect complements in that consumers demand a system that is composed of one unit of A and one unit of B. If they are imperfect complements, both “vertical” and “horizontal” externalities would be weakened and there would be less concern for the so-called “portfolio effects.” See Nalebuff (2004) for an analysis of how the competitive effects of bundling depend on the degree of complementarity.
cost saving of \((\Pi^A + \Pi^B)\), social welfare is unambiguously affected in a negative way with foreclosure of outsiders as shown in Figure 4.\textsuperscript{21}

Figure 3. Changes in Social Welfare and Consumer Surplus due to a Merger

\textsuperscript{21} My welfare analysis assumes symmetric firms. In the GE/Honeywell case, GE’s dominant position in jet engines was an essential part of the case. To the extent that the merging firms’ dominant position reflects efficiency, the merger can be less likely to lower welfare since the output mix after the merger would be more efficient with the merged entity producing more in the absence of foreclosure. However, when the merging firms have dominant positions, the merger will also enhance the possibility of foreclosure with detrimental effects on consumer and social welfare.
Proposition 3. Let us normalize $a = b = 1$ and $c \in (0, 1/3)$. In the absence of foreclosure, the effect of the merger with mixed bundling on social welfare is negative if $ct < 0.225$. The effect on consumer surplus is negative if $c < 0.278$. If foreclosure takes place with the merger, the impacts on social welfare and consumer surplus are unambiguously negative.

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.

The analysis of this paper thus suggests that for antitrust evaluations of mergers in complementary markets it is crucial to assess the likelihood of exit by rival firms and estimate the degree of substitutability between systems.

III. Extensions and Policy Implications

In this section, I discuss several extensions of the basic model and their policy implications.
The Effects of Mergers (with Mixed Bundling) on R&D Incentives

In the previous section, I have analyzed the effects of mergers on pricing assuming that the product characteristics and cost structures are given. The basic framework laid out in section II, however, can be extended to analyze the impact of mergers on R&D incentives. To this end, consider a two-stage game in which price competition is preceded by R&D competition.

If I consider cost-reducing R&D investments, the R&D incentives for each firm can be represented by the marginal benefit from decreasing its production cost. There are two channels through which cost-reducing R&D affects the firm’s profit: the direct effects of innovation through cost saving and the indirect effects of innovation through price competition.

In terms of the direct effects, the basic model indicates that a merger with mixed bundling reduces the future market available to independent rivals \((\bar{D}^{21} + \bar{D}^{22} = \bar{D}^{12} + \bar{D}^{22} < D^{21} + D^{22} = D^{12} + D^{22}, \text{see Proposition 2})\) 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, 2004). Any reduction in the future market available will thus reduce expected future profits and current R&D spending. In contrast, the same type of analysis reveals that the merged entity will have higher incentives to engage in R&D since \(\bar{D}^{11} + \bar{D}^{12} = \bar{D}^{11} + \bar{D}^{21} > D^{11} + D^{12} = D^{11} + D^{21} \text{ (see Proposition 2)}\).

In general, the indirect effects of innovation through price competition before and after the merger are not directly comparable. However, if the direct effects of innovation are sufficiently large compared to the indirect effects, the merged firm increases its R&D level whereas outside rival firms reduce their R&D levels. In the Appendix, I conduct a simulation analysis in which I confirm the discussion above 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.

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22 This result comes from an application of the envelope theorem.
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). 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.\(^{23}\)

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 A\(_2\)-B\(_2\) since A\(_1\) and B\(_1\) will only function effectively as part of the bundled system and cannot be used alongside components from other suppliers.

I conduct a numerical analysis to investigate the profitability of merging with pure bundling.\(^{24}\) The numerical analysis indicates that for most parameter values, pure bundling is less profitable than mixed bundling for the merged entity. I can thus conclude that the merged firm will not practice pure bundling since mixed bundling yields higher profits as an accommodation strategy unless \(c\) is sufficiently large (\(c \geq 0.28546\)).\(^{25}\) However, as in

\(^{23}\) 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.

\(^{24}\) The numerical analysis is available upon request from the author.

\(^{25}\) Pure bundling can be profitable if \(c\) is sufficiently high and the systems are relatively undifferentiated. In such a case, the effect of pure bundling is an increase in the extent of differentiation and make the system demands less elastic since the two mix-and-match systems \(D^{12}\) and \(D^{21}\) are no longer available. In addition, the merged entity no longer internalizes losses on components associated with the mix-and-match systems. These two effects provide the merged entity with an incentive to raise the price of its system. When the systems are
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.

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, 
\[ \Pi^A < F < \Pi^A \] or 
\[ \Pi^B < F < \Pi^B. \] In such a case, the merged firm can foreclose rival firms by committing to pure bundling with technical tying as in Whinston (1990). One way to accomplish such a commitment is by designing new generations of products that are incompatible with those of rival firms.

**Prohibition of Mixed Bundling as Policy Prescription**

Given that bundling was a major roadblock for the GE/Honeywell merger, we can consider a policy prescription in which the merged entity is prohibited from engaging in mixed bundling and allowed only to sell individual components as a condition for merger. Indeed, it can be shown that consumer surplus is always higher with such a prohibition in my model. The reason for this is that restriction of bundling deprives the merged entity of a mechanism to de-couple the composite price of the merged entity’s own system from that of other mix-and-match systems; it is not possible to raise the mix-and-match systems’ prices without raising its own system price with individual pricing. As a result, the raising rivals’ cost effect is mitigated without bundling as in Evans and Salinger (2002). The restriction of bundling thus seems to be an appealing condition to impose for merger.26

**Counter-merger**

less differentiated, the negative demand effect from the sales loss of the mix-and-match systems is also mitigated since the mix-and-match consumers simply switch to the “pure” systems \( D^1 \) and \( D^2 \). I thank Jeffrey Church for this interpretation of the result. See also Church (2004).

26 In reality, however, the effectiveness of such restriction as a policy instrument depends crucially on the enforceability of the policy. In mass consumer markets where every consumer pays list price, it is easy to monitor the merged firm’s adherence to the policy. If prices are customer-specific as in the aerospace industry (Nalebuff, 2002), it may be difficult to monitor discounting for consumers who purchase the bundle.
We can also analyze incentives to counter-merge for outside firms. In my model, outsiders have incentives to counter-merge. In case counter-merge takes place, it can be shown that social welfare decreases in my model if \( c < 0.236 \).

With the possibility of counter-merge explicitly considered, it is possible that the rational response of counter-merge by outside firms keeps the initial merger from taking place in the first place. However, there is a parameter space (that is, \( c < 0.120354 \) or \( c > 0.226677 \)) in which the profit increase from the initial merger is greater than that from the counter-merge. If there are internal “governance” costs associated with merger, then we may have a situation in which the profit increase from the initial merger is sufficiently large to outweigh the governance costs of the merger whereas the profit increase from the counter-merge is not. In such a case, counter-merge does not materialize.

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 criticized in the popular press and by the U.S.

\[ \text{since every bundle price can be } \text{ex post} \text{ broken down as a sum of individual component prices to circumvent the restriction on bundling.} \]

\[ \text{27 The simulation result is available upon request.} \]

\[ \text{28 In my model, the initial merger is not profitable if the merging firms expect a countermerger by outsiders for } c \in (0.102225, 0.320927). \]

\[ \text{29 Governance costs of merger due to misaligned managerial incentives have been extensively discusses in the economics literature. See, for instance, Williamson (1989) for extensive treatments, and Cremer (1996) and Hart and Moore (1990) for formal models.} \]

\[ \text{30 The “portfolio effects” or “range effects” refer to mechanisms through which competitive harm can arise in markets where there is no direct horizontal overlap between the merging parties. The terms are used to describe a variety of ways in which a merger may create or strengthen a dominant position in non-overlapping markets such as bundling/tying.} \]
antitrust agencies and senior administration officials, raising fears of escalating trade disputes between the US and EU. There have been even allegations in the newspapers that the decision was made without any theoretical support. This paper provides an analytical framework that could be used to evaluate the pros and cons, both in the short and long-run, of such a merger.

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 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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31 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.

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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 \(A_iB_j\) 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:

\[
\begin{align*}
\bar{s}_{11}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda+\mu) a + (\Delta_1+\delta_1) - (\lambda-2\mu)D^{11} - \mu D^{12} - \mu D^{21} - \mu D^{22} \\
\bar{s}_{12}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda+\mu) a + (\Delta_1+\delta_2) - \mu D^{11} - (\lambda-2\mu)D^{12} - \mu D^{21} - \mu D^{22} \\
\bar{s}_{21}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda+\mu) a + (\Delta_2+\delta_1) - \mu D^{11} - \mu D^{12} - (\lambda-2\mu)D^{21} - \mu D^{22} \\
\bar{s}_{22}(D^{11}, D^{12}, D^{21}, D^{22}) &= (\lambda+\mu) a + (\Delta_2+\delta_2) - \mu D^{11} - \mu D^{12} - \mu D^{21} - (\lambda-2\mu)D^{22},
\end{align*}
\]

where \(\lambda = \frac{b}{(b-3c)(b+c)}\) and \(\mu = \frac{c}{(b-3c)(b+c)}\).

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

\[
\begin{align*}
D^{11} &= a + (b-c) (\Delta_1+\delta_1) - 2c(\Delta_2+\delta_2) - b (p_1 + q_2) + c (p_1 + q_2) + c (p_2 + q_1) + c (p_2 + q_2) \\
D^{12} &= a + (b-c) (\Delta_2+\delta_2) - 2c(\Delta_2+\delta_1) - b (p_1 + q_2) + c (p_1 + q_1) + c (p_2 + q_2) + c (p_2 + q_1) \\
D^{21} &= a + (b-c) (\Delta_2+\delta_1) - 2c(\Delta_1+\delta_2) - b (p_2 + q_1) + c (p_2 + q_2) + c (p_1 + q_2) + c (p_1 + q_1) \\
D^{22} &= a + (b-c) (\Delta_2+\delta_2) - 2c(\Delta_2+\delta_1) - b (p_2 + q_2) + c (p_2 + q_2) + c (p_1 + q_2) + c (p_1 + q_1)
\end{align*}
\]

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 (A₁ and B₁) and outsider firms (A₂ and B₂) for parameter values k ∈ [20, 100] and c ∈ [0, 1/3].

![Figure A-1. Changes in Profits for the Merging Firms with R&D](image1)

![Figure A-2. Changes in Profits for the Outsider Firms with R&D](image2)

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-3. 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-4. 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-4. The Effects of R&D Opportunities on Changes in Welfare due to Mergers