ABSTRACT: We examine a mechanism by which bundling may inefficiently deter entry into the market. The model considers an incumbent monopolist in two complementary components that faces a series of entry attempts by rivals. It is shown that the incumbent can practice bundling to buttress its monopoly position by keeping specialist innovators out of the market. Bundling prevents specialist rivals from coordinating in the dynamic entry process, reducing the probability of an eventual displacement of the incumbent. Bundling may thus lead to lower customer and total economic welfare.
1. INTRODUCTION

Recent developments in the high-technology sector have generated renewed interest in the topic of bundling. It is often alleged, for example, that Microsoft’s strategy to sell several of its products together as a bundle is an attempt to create an “applications barrier to entry,” crowding potential rivals out of the market. Similarly, across the Atlantic, the European Commission recently blocked the General Electric’s proposed acquisition of Honeywell largely to prevent the merged company from excluding rivals through bundling. Still, bundling as a barrier to entry has received relatively little attention in formal economic theory.

This paper develops a simple formal model to show how bundling can keep specialist innovators out of the market, bolstering the incumbent’s monopoly position. In particular, a monopolist in two complementary components faces rivals that make sequential attempts to enter the market. Before a rival reaches its entry decisions in each attempt, it draws its marginal costs for the two components from a random distribution. If a rival firm has low marginal costs — lower than the costs of the incumbent — in both components, it is a generalist. If, on the other hand, a rival draws a low marginal cost in only one component and a prohibitively high cost in the other, it is a specialist. Inept rivals with high marginal costs in both components are totally unable to compete.

By having a superior technology across the board, generalist firms have the opportunity to enter the market and gain access to customers independently of the actions of the incumbent. Specialists, however, can sell their product only if the other component is available separately — either from the incumbent or a low-cost entrant. As a result, bundling of the two components by the incumbent may make specialist entry in one component completely dependent upon future specialist success in the other. The innovator may be forced to stay idle, totally unable to gain access to customers, until (and unless) there is specialist entry in the other component in the future.

In this way, bundling can block the entry of specialist innovators. When the specialist innovator needs to earn immediate profits to overcome financial constraints, or when the prospect of future profits is not sufficient to outweigh the immediate fixed costs of entering the market and preserving the new technology, the specialist innovator will decide to stay out of the market. Bundling can thus effectively prevent the dynamic coordination of specialist entrants. The need for simultaneous entry in both markets —
capability that only generalist rivals have — lowers the probability of an eventual displacement of the incumbent. In this way, bundling may reduce consumer and social welfare.

In essence, the bundling decision of the incumbent entails a trade-off. If there is successful entry in only one component, the incumbent can exploit its monopoly position in the other component to practice a “price squeeze,” capturing a share in the value of the entrant’s innovation. Bundling is a profitable strategy when the incumbent’s risk of being displaced by a dynamic coordination of specialist innovators dominates the benefits of entry in a single component.

The outcome of the game is the same even if one of the incumbent’s rivals is already in the market so long as the incumbent’s marginal costs in both components are sufficiently lower than the costs of its existing competitor. Again, bundling may allow the incumbent to hinder the dynamic coordination of specialist innovators in the future. By practicing bundling, the incumbent can force specialist entrants to sell their product in conjunction with the inferior complementary component of its existing rival (until there is future specialist entry), preventing them from overcoming their financial constraints or recovering their fixed cost. As a result, the entry of specialist innovators may be blocked.

At an empirical level, the model is mainly applicable to risky and dynamic industries, where technological uncertainty makes the emergence of generalist innovators — innovators with a superior technology in all components — less likely. The primary mode of entry in such industries may be through specialist innovation.

In the software sector, for instance, practitioners often point out that Microsoft consistently practices bundling to erect barriers to entry, excluding its rivals. The new Windows XP operating system is a characteristic example. Windows XP is technologically tied to an array of diverse complementary products that reach all corners of the Internet, such as an instant messaging system, as well as digital-photography, digital-music and video conferencing software. Many of these products are not available separately. As a competitor notes, “the big play is to try to tie [all the new services] together into one gigantic universe. It makes some of the things they did in 1995 now look like child’s play.”\footnote{Buckman [2001], p. A1.} Microsoft’s rivals complain that by practicing bundling,
Microsoft may retain its monopoly profits by discouraging the entry of specialist innovators (Buckman [2001]).

Similarly, in the recent United States v. Microsoft, one of the charges brought against Microsoft was that it sold its operating system and a complementary product, the Internet Explorer, as a bundle (U.S. Department of Justice [1998]). Although Microsoft is the dominant player in both component markets, it encounters potential competition. In particular, Microsoft’s operating systems face a competitive challenge from Sun’s new programming language, Java, that is designed to permit applications written in it to run, without change, on any kind of operating system. Furthermore, the Internet Explorer has to compete with the Netscape Navigator. Both the operating system and the Internet browser market are characterized by continuous innovation. As a result, bundling may allow Microsoft to reinforce its dominant position by preventing specialist competitors, such as Sun and Netscape, from coordinating dynamically and introducing product improvements into the two markets.

Furthermore, bundling was the main issue in the European Commission’s decision on July 3rd, 2001 to block the General Electric’s proposed acquisition of Honeywell. General Electric has a dominant position in the production of aircraft engines and the provision of aircraft lease financing. Honeywell, on the other hand, is a major player in avionics equipment. As a result, the merged company would have the ability to sell a wide array of complementary components, offering one-stop shopping to airframe manufacturers. The European Commission was concerned that the merged company would bundle its products, thereby discouraging more specialized competitors, such as Pratt & Whitney and Rolls-Royce in engines or Rockwell Collins in avionics, from introducing product improvements into their markets (The Economist [2001a, b]).

The general idea that is more difficult for entrants to supplant an incumbent engaging in an array of interlocked activities, rather than in an individual activity, is discussed informally in the management literature (Porter [1996]). As Porter notes,

2 United States v. Microsoft, Civil Case No. 98-1232 [1998].

3 At present, Java does not have the capabilities to seriously challenge Microsoft’s operating systems. Java, however, has the potential to become a superior technology if it is sufficiently refined and improved (Banks [1999]).
“positions built on systems of activities are far more sustainable than those built on individual activities.”

Our paper formalizes and extends this general idea to bundling.

The notion that incompatibility prevents “narrow specialists” from mixing and matching their components is discussed in Farrell, Monroe and Saloner (1998). This paper draws out the implications of this general idea for bundling, showing how incompatibility decisions can arise endogenously (rather than exogenously, as in Farrell, Monroe and Saloner). In a sense, our model is a dynamic version of Farrell, Monroe and Saloner and demonstrates that bundling may allow an incumbent to defend its position against a series of potential entrants.

In the law literature, the old leverage theory of bundling states that a monopolist in one product can increase its profits by expanding into complementary markets. The incumbent, the argument runs, can leverage its dominant position from one component to another, excluding competitors and extracting higher rents from customers. Formal economic theory, however, has seriously questioned the soundness of the leverage doctrine. As the Chicago School (Director and Levi [1956], Bowman [1957], Posner [1976], Bork [1978]) points out, a firm can extract the entire monopoly rent even if it has a monopoly position in only one complementary component. Since the remaining components are part of the same final product, they cannot generate additional monopoly rents. As a result, when bundling takes place, it can be attributed to efficiency factors or other relatively benign reasons (e.g., price discrimination), rather than leverage.

The Chicago School argument is applicable to numerous situations as bundling is often justified by efficiency conditions. Nevertheless, the assumptions of the Chicago benchmark model are not entirely appropriate for risky and dynamic industries. In this paper, we show that when the assumptions of the model are altered to better describe the structure of such industries, the relevance of the leverage theory can be reestablished.

---

4 Porter [1996], p. 73.

5 Williamson [1979] informally suggests that bundling may discourage entry if the rival is experienced in the production of only one component. By also forcing the rival to introduce the other complementary component in which it has no production experience, bundling may raise the rival’s cost of capital. Furthermore, Comanor [1967] shows that vertical integration by the incumbent may lead to higher capital requirements for entrants.

6 In a different vein, several articles in the literature show that bundling may serve as a vehicle for price discrimination. See, for example, Stigler [1963], Adams and Yellen [1976], Schmalensee [1982], McAfee, McMillan and Whinston [1989] and Mathewson and Winter [1997].
There are three main differences between the Chicago School argument and this model. First, in our model, the incumbent does not have a guaranteed monopoly position in one component, but rather faces the threat of potential entry in all components. As a result, if it fails to take proper protective measures, it may be totally displaced from the market. Second, the incumbent in our model has market power in both components. In the Chicago School analysis, on the other hand, a monopolist in one product expands into a competitive complementary market. The third difference is our focus on the role of cost uncertainty and different entrant types, i.e., generalist and specialist entrants. These assumptions allow us to derive a new, more dynamic version of the old leverage theory.

In the leverage theory literature, Whinston [1990], Choi and Stefanadis [2001] and Carlton and Waldman [2002] also demonstrate that bundling may be used as an entry deterrence strategy. Specifically, Whinston [1990] shows that selling a monopolized primary product and an unrelated differentiated product together as a bundle may allow the monopolist to commit to a more aggressive pricing strategy, preventing entry in the differentiated market. Whinston primarily examines the bundling of unrelated, rather than complementary products. In the case of complementary products, on the other hand, he concludes that bundling does not occur, except in the rather special setting where there is either an unrelated use of one component, or an inferior, competitive alternative. Unlike Whinston, we focus on the bundling of complementary components and show that bundling can strengthen the incumbent’s position in both the primary and the complementary market by excluding superior (rather than inferior) rivals.

---

7 In Carbajo, De Meza, and Seidman [1990] and Chen [1997], on the other hand, bundling is used as a strategy to segment the market and relax price competition.
8 Our results are consistent with Whinston’s [1990] conclusion that a monopolist does not need to tie two complementary components to extract the full monopoly rent when it has an undisputed monopoly position in one component. In our model, however, the monopolist faces the threat of entry in both complementary components.
9 Nalebuff [1999] also examines the implications of bundling when an incumbent monopolist in two independent (or, in a special case, partly complementary) components faces potential entry in one component. An important assumption in Nalebuff is the presence of customer heterogeneity in the valuations of one component. Then, bundling is an effective tool of price discrimination, raising the profits of the incumbent and reducing the profits of the entrant (a la McAfee, McMillan and Whinston [1989]). When the entrant’s profits are sufficiently reduced, the entrant is forced to stay out of the market because it is unable to recover its fixed cost. In this paper, we have a different focus from Nalebuff since we examine the mechanics of bundling when the incumbent faces the threat of entry in both components. Furthermore, the two components are complementary. As a result, the main issues in our analysis — such as the importance of dynamic coordination and the interplay of specialist and generalist technologies — do not arise in Nalebuff.
Choi and Stefanadis [2001] examine the effects of bundling on R&D investment. In Choi and Stefanadis, the probability of successful entry depends on the level of R&D expenditures. Then, when an incumbent monopolist in two complementary components practices bundling, it makes entry in one component completely dependent upon success in the other. Owing to bundling, an entrant can gain access to customers only if the entrant in the other product is also successful. Thus, by making the prospects of investment less certain, bundling discourages rivals from investing and innovating. Unlike Choi and Stefanadis who investigate R&D decisions, this paper focuses on the role of dynamic coordination when there are successive entry attempts. The paper also focuses on the importance of different technology types — generalist and specialist technologies. We illustrate how bundling can prevent the dynamic coordination of specialist innovators, inefficiently blocking entry.

Carlton and Waldman [2002] also construct a model of bundling with dynamic entry deterrence. In their two-period model, the incumbent initially has a monopoly position in both the primary and the complementary market. There is a potential rival that has the opportunity to enter the complementary market in period 1 and the primary market in period 2. Furthermore, the potential rival can recoup its fixed cost of entry into the complementary market only by actively operating in both periods. Then, by practicing bundling, the incumbent prevents the competitor’s complementary component from having access to customers in period 1, permanently blocking the product’s introduction. As a result, the rival also refrains from entering the primary market; entry without a complementary component would not be profitable. The incumbent maintains its monopoly profits in both periods.

This paper uses the same basis logic as Carlton and Waldman to examine the prospect of uncertain entry due to random cost realizations and the role of different entrant types, i.e., generalist and specialist rivals. We show that bundling can buttress the incumbent’s monopoly position by preventing the dynamic coordination of specialist innovators.

The paper is organized in the following way. In section 2, we present a model with a single entrant. In section 3, we examine a framework where the incumbent faces a
series of potential entrants. Section 4 considers some extensions to check the robustness of the basic model, while section 5 focuses on more general cost distributions. Finally, section 6 suggests some conclusions.

2. A MODEL WITH A SINGLE ENTRY ATTEMPT

We first examine a simple model where the incumbent faces a single potential entrant that makes a single entry attempt. Since there is only one entry attempt, the issue of dynamic coordination does not arise in this framework. The incumbent thus has no reason to practice bundling. In section 3, we will see how the results change in the presence of a series of entry efforts.

In particular, firm 1 is an incumbent monopolist for two complementary components, A and B, that can be used only in conjunction with one another. Consumers combine A and B in fixed proportions on a one to one basis to form a final product. Firm 1 faces a constant marginal cost \( \chi_A = \chi_B = \chi \) for each component. We refer to components A and B, when produced by firm 1, as A1 and B1. The measure of consumers is normalized at 1. Consumers are identical and have unit demands; each consumes either one or zero unit of the final product. Also, a consumer derives a value from consumption equal to \( V \), where \( V > \chi_A + \chi_B \).

Firm 2 is a potential entrant in the market for components A and B. Before firm 2 makes its entry decisions, it draws its marginal costs for the two components, \( c_A \) and \( c_B \), from a random distribution. For simplicity, we assume that \( c_i \) (\( i = A, B \)) can take one of two possible values, \( \underline{c} \) or \( \bar{c} \), where \( \underline{c} < \chi < \bar{c} \). If firm 2 draws the low cost \( \underline{c} \) in both components, it is a generalist. If, on the other hand, the potential entrant draws the low cost \( \underline{c} \) in only one component and the high cost \( \bar{c} \) in the other, it is a specialist. We assume that \( \underline{c} + \bar{c} > V \). This assumption implies that if firm 2 is a specialist, it cannot sell to customers unless the incumbent’s complementary product is available separately.

\[\text{[10] Carlton and Waldman [2002] also consider the case where firms encounter network externalities, rather than fixed costs.}\]
Consumers view the components produced by the monopolist and the entrant as perfect substitutes for each other.\[1\]

The probabilities of drawing a low marginal cost are $Pr(c_A = \zeta) = p$ and $Pr(c_B = \zeta) = q$ for components A and B respectively.\[12\] To economize on notation, we assume symmetry across components, i.e., $Pr(c_A = \zeta) = Pr(c_B = \zeta) = p$, where $0 \leq p \leq 1$. We also assume that cost realizations across components are independent. In section 5, we will consider an extension of the model where the potential entrant’s costs are drawn from a general joint distribution function $F(c_A, c_B)$.

Before firm 2 draws its marginal costs, firm 1 has the opportunity to practice bundling, making the sale of component A1 contingent upon the sale of component B1 and vice versa; A1 and B1 are not available individually. As, for example, in Whinston [1990] and Carbajo, De Meza and Seidmann [1990], the bundling decision is binding for the entire game. Precommitment to bundling can be achieved, for instance, through technological arrangements in the production process or in product design.

We thus have a three-stage game:
Stage 1: Firm 1 decides whether to bundle A1 and B1.
Stage 2: Firm 2 draws its marginal costs from a random distribution and decides whether to enter the market for each component.
Stage 3: Price competition.

We assume that if firm 2 is indifferent between entering the market for a component and not, it will stay out of the market. Furthermore, if firm 1 is indifferent between practicing bundling and not, it will refrain from bundling. To solve for the equilibrium of the model, we proceed by backward induction.

2.1. Price Competition

Components A and B are complementary and can only be used in fixed proportions. It is thus not possible to analyze the two markets independently even in the

---

11 Our conclusions would be exactly the same if the entrant drew its quality, rather than its marginal costs, from a random distribution.
12 Choi and Stefanadis [2001] endogenize the costs of entrants by focusing on the mechanics of the R&D process.
absence of bundling. Bertrand competition may yield multiple price equilibria when there is entry into only one component market.

Consider the case of no bundling in which firm 2 enters only market A with the low marginal cost $c$. Such entry by a low cost producer creates a value of $S = \chi - c$ in the market. In this case, we have multiple price equilibria, which correspond to different distributions of the value created by the low cost entrant, $S = \chi - c$, between the incumbent and the entrant. For instance, one possible equilibrium is that the incumbent sets its prices equal to $\chi$ and $V - \chi$ for components A and B respectively, while the entrant charges a price equal to $\chi$. In this equilibrium, the entrant captures the entire surplus $S$ from its innovation. However, in a different equilibrium, the incumbent sets its prices equal to $c$ and $V - c$ for components A and B respectively, while the entrant charges a price equal to $c$. In this equilibrium, the incumbent practices a perfect price squeeze, taking advantage of its position as the sole supplier of complementary component B and extracting the entire surplus created by firm 2’s innovation (Ordover, Sykes and Willig [1985]).

There is a wide range of equilibria between these two polar cases, representing different distributions of the surplus created by innovation between the two parties. Any distribution can be sustained as equilibrium, depending on the degree of price squeeze practiced by the incumbent. In particular, when there is entry only into market A, the range of component A’s equilibrium price is $P_A \in [c, \chi]$, with the entrant selling A. The corresponding equilibrium price that the incumbent sets for component B is $P_B = V - P_A$, which is the effective reservation value of the complementary product B. The case where there is entry only into market B can be analyzed analogously.

In general, we can assume that in the case of partial entry where firm 2 enters only one market, a share $\sigma$ of the cost savings $S$ is captured by the incumbent, while a share $(1 - \sigma)$ is captured by the entrant, where $0 \leq \sigma < 1$. Thus, $\sigma$ serves as a parameter for the degree of price squeeze exercised by the incumbent. The assumption that $\sigma$ is strictly lower than 1 implies that in the absence of bundling, a specialist innovator always introduces its low-cost component into the market since it earns strictly positive profits. When firm 2 enters only market A, for example, equilibrium prices in each component
market are \( P_A = \xi + (1 - \sigma)(\chi - \xi) \) and \( P_B = V - \xi - (1 - \sigma)(\chi - \xi) \). In this case, the incumbent earns a profit of \( P_B - \chi = V - 2\chi + \sigma(\chi - \xi) \), which is higher than the profit \( V - 2\chi \) that the incumbent can earn without entry.

Consider now the case of bundling. When firm 2 enters only one market, say A, it cannot sell its product to consumers because B1 is not available separately. Thus, in the bundling case, an entrant has access to consumers only when it enters both markets. When firm 2 enters both markets, it is the sum of the two components’ prices (system price) that affects a consumer’s purchase decision. The firm with the overall advantage in production costs will set its price equal to the system cost of the rival firm and capture the entire market. Our assumption that \( \xi + \bar{\xi} > V \) implies that the entrant can enter profitably only when it has a cost \( \xi \) in both components. In such a case, the entrant will enter and sell at prices \( P_A \) and \( P_B \) such that \( P_A + P_B = 2\chi \).

2.2. Entry Decisions

Consider first the case of no bundling. Then, the entrant can earn a positive profit in a component market if it draws a low marginal cost \( \xi \). As a result, the probability of entry into both markets is \( p^2 \). The probability of partial entry (entry into only one market) is \( 2p(1 - p) \). The probability of entry into neither market is \( (1 - p)^2 \).

If A1 and B1 are bundled, on the other hand, the entrant has to decide between entry into both component markets and no entry at all. The entrant can then earn a profit only when it has the overall advantage in production costs. Thus, there is entry into both markets if and only if \( c_A + c_B < \chi_A + \chi_B \). Given that \( \xi + \bar{\xi} > V \), entry will take place only when the entrant draws a marginal cost \( \xi \) in both components. The probability of entry is \( p^2 \).

2.3. The Incumbent’s Bundling Decision

Entry into only one component market by firm 2 increases the incumbent’s profit. Entry creates a surplus of \( S = \chi - \xi \). Since the incumbent has the ability to practice a

---

13 If the entry is into market B, we have \( P_A = V - \xi - (1 - \sigma)(\chi - \xi) \) and \( P_B = \xi + (1 - \sigma)(\chi - \xi) \).
price squeeze, it can extract part of this surplus. The incumbent’s expected profit without bundling thus is

\[
\Pi = (1 - p^2) \pi^m + 2p(1 - p) \sigma S, \tag{1}
\]

where \( \pi^m = V - 2 \chi \) and \( S = \chi - c \).

The incumbent’s expected profit with bundling, on the other hand, is

\[
\Pi^\sim = (1 - p^2) \pi^m. \tag{2}
\]

It follows immediately that since \( 2p(1 - p) \sigma S \geq 0 \), bundling is weakly dominated as an entry-deterrence strategy for the incumbent in the one-entrant game. Even if \( 2p(1 - p) \sigma S = 0 \), the incumbent refrains from bundling because of the tie-breaking convention.

**Proposition 1:** In the model with a single entry attempt, the incumbent never practices bundling.

Specifically, bundling does not affect the entry decisions of a generalist rival. Such a competitor always introduces its two products into the market regardless of the actions of the incumbent. Similarly, a totally inept rival with high marginal costs in both components stays out of the market anyway. Bundling, however, has an effect on the decisions of a specialist competitor. By preventing specialist innovators from having access to customers, bundling blocks their entry into the market. In this way, bundling lowers the profits of the incumbent since the latter cannot practice a price squeeze. Proposition 1 is consistent with the Chicago School argument and Whinston [1990].

**3. A MODEL WITH A SERIES OF ENTRY ATTEMPTS**

The model developed in the last section allowed for only one entry attempt. We will now show that the outcome of the game changes completely when the incumbent’s rivals make a series of sequential attempts to enter the market. Specifically, during each period, a potential entrant appears and draws its marginal costs from the same distribution
function as in the last section. Cost realizations are independent across periods. After observing its costs, the rival decides whether to enter the market. For simplicity and without loss of generality, we assume that the potential entrant in each period is a different firm. The results would be similar, however, if the same firm made successive efforts to enter the market.

For ease of exposition, we consider a two-period model with two potential entrants, firm 2 and firm 3. The results are the same for any finite number of entrants. Furthermore, in the Appendix we show that the game can be easily extended to allow for an infinite number of successive rivals.

To preserve its technology in a component, a rival has to enter the market in the first period that it appears in the game. In this way, the rival can maintain its technological capabilities even when it makes no sales to customers. If the rival does not enter, however, its technology is lost; it is not allowed to enter in a later period. This assumption is suitable, for example, for the high-technology sector, where thanks to rapid technological progress, market presence and customer feedback are important elements in keeping abreast with new developments.

For simplicity and without loss of generality, we also assume that a rival decides not to enter a component market unless it expects to earn strictly positive profits in the first period that it enters. For example, potential entrants may face financial constraints that must be met (Fudenberg and Tirole [1986], Scharfstein and Bolton [1990]). It follows that a specialist rival only enters the market if a more efficient producer — either the incumbent or a low cost entrant — already sells the other component as a separate product. The assumption about financial constraints can be especially appropriate for the high-technology sector where potential sectors are often small firms, facing difficulties in raising sufficient resources to carry on due to the agency problem.

We must stress that the assumption about financial constraints is made without loss of generality. For example, our results would be similar even if potential entrants had no financial constraints, but instead faced a fixed cost of entry into a component market $F > 0$. In this version of the model, the rival would have to incur the fixed cost $F$ and enter the market in the first period that it appears in the game to preserve its technology in a component. Then, if $\delta[p(1-p)(\chi-\zeta)] < F < (1-\sigma)(\chi-\zeta)$, where $\delta$
stands for the discount factor, the rival would need to gain immediate access to customers for market entry to be justified. Otherwise, the rival’s fixed cost $F$ of entering the market today and preserving the technology would outweigh the expected profits that the rival would earn in the future if another specialist innovator introduced the complementary component\footnote{Assume that $F$, the fixed cost of entry into a component market, satisfies the following condition: $\delta[p(1−p)(\chi−\zeta)] < F < (1−\sigma)(\chi−\zeta)$. The second inequality, $F < (1−\sigma)(\chi−\zeta)$, implies that the degree of price squeeze is sufficiently low, so that when firm 2 or 3 is a specialist, it always introduces its low cost component into the market in the absence of bundling. The first inequality, $\delta[p(1−p)(\chi−\zeta)] < F$, implies that a specialist rival does not find entry profitable unless it has immediate access to customers, i.e., unless a more efficient producer — either the incumbent or a low cost entrant — already sells the other component as a separate product. To understand the condition, suppose that firm 2 is a specialist, say in component A, with no access to customers in period 1. If firm 2 incurs $F$ and enters the market, it will earn an operating profit $\chi−\zeta$ in period 2 in the case that firm 3 is a specialist in component B. The probability of this event is $p(1−p)$. If firm 3 is a generalist, on the other hand, it will sell both components to customers, setting its price for A and B equal to $\zeta$ and $2\chi−\zeta$ respectively and driving firm 2’s operating profits to zero. The
}

Although the presence of a fixed cost would lead to similar results, it would unnecessarily complicate our calculations. For this reason, we prefer to assume the existence of financial constraints, rather than fixed costs. This assumption allows us to bring out the mechanics of bundling in a clear and straightforward way.

We have a five-stage game:
Stage 1: Firm 1 decides whether to bundle A1 and B1.
Stage 2: Firm 2 draws its marginal costs from a random distribution and decides whether to enter the market for each component.
Stage 3: Price competition in period 1.
Stage 4: Firm 3 draws its marginal costs from a random distribution and decides whether to enter the market for each component.
Stage 5: Price competition in period 2.

3.1. Equilibrium of the Model

When the incumbent practices bundling and two complementary specialist rivals enter the market, there are multiple equilibria in price competition (similarly to section 2.1). Any combination of prices by the specialist firms so that the sum of these prices is equal to $2\chi$ (and each price is at least as high as marginal cost $\zeta$) can be sustained as an
equilibrium, whereas the incumbent charges a price $2\chi$ for the bundled product. For simplicity and with no loss of generality, we focus on the unique symmetric equilibrium in which each entrant obtains the full reward for its innovation, i.e., each specialist rival sets its price equal to $\chi$.

In the absence of bundling, there are two subgames in which the incumbent earns a positive profit. First, if there is entry into neither market in period 1, the probability of which event is $(1 - p)^2$, the incumbent’s period 1 profit is equal to $\pi^m$ and its expected period 2 profit is equal to $(1 - p^2)\pi^m + 2p(1 - p)\sigma S$. Second, if there is entry into only one component market in period 1, the probability of which event is $2p(1 - p)$, the incumbent earns a profit equal to $\pi^m + \sigma S$ in period 1 thanks to its ability to practice a price squeeze. The incumbent, however, faces a higher probability of earning a zero profit in period 2 ($p$, rather than $p^2$). The potential entrant in period 2 only has to draw a low marginal cost in a single component to totally displace the incumbent. The incumbent’s expected period 2 profit in this subgame is $(1 - p)(\pi^m + \sigma S)$.

It follows that overall, the present value of the incumbent’s expected profit in the absence of bundling is

$$\Pi = (1 - p^2)\pi^m + 2p(1 - p)\sigma S$$
$$+ \delta[(1 - p)^2 [[(1 - p^2)\pi^m + 2p(1 - p)\sigma S] + 2p(1 - p)[(1 - p)(\pi^m + \sigma S)]]]. \quad (3)$$

The present value of the incumbent’s expected profit if it bundles A1 and B1 is

$$\tilde{\Pi} = (1 - p^2)\pi^m + \delta(1 - p^2)^2\pi^m. \quad (4)$$

Let us define $\Delta$ as the changes in the present value of the incumbent’s expected profit due to bundling. We have

$$\Delta = \tilde{\Pi} - \Pi = \delta[2p^2(1 - p)^2\pi^m] - (2p(1 - p)\sigma S + \delta[2p(1 - p)^2(2 - p)\sigma S]]. \quad (5)$$

The present value of firm 2’s expected future profits is thus $\delta[p(1 - p)(\chi - \zeta)]$. We thank Mike Waldman for suggesting this approach.
The changes in the present value of the incumbent’s expected profit can be decomposed into two opposing effects.

(a) **Displacement Effect.** When potential entrants enter successfully the markets for both components, the incumbent is displaced and its profit is driven to zero for the remaining of the game. Bundling lowers the probability of this event by preventing the dynamic coordination of specialist innovators. This effect is *positive* and is given by the first term in (5), i.e., \( \delta [2p^2(1-p)^2 \pi^m] \geq 0 \).

(b) **Price Squeeze Effect with Partial Entry.** When the incumbent does not practice bundling, entry into only one component is possible. In such a case of partial entry, the incumbent obtains a share \( \sigma \) of the realized cost savings \( S \). By practicing bundling, on the other hand, the incumbent gives up the opportunity to capture a share of the value created by an entrant’s lower cost. This effect is *negative* and is described by the second term in (5), i.e., \( -\{2p(1-p)\sigma S + \delta [2p(1-p)^2(2-p)\sigma S] \} \leq 0 \).

As a result, the incumbent decides to bundle A1 and B1 when \( \Delta > 0 \), i.e., when the positive displacement effect dominates the negative price squeeze effect. We have \( \Delta > 0 \) if and only if the degree of price squeeze \( \sigma \) is lower than \( \sigma^* \), where \( \sigma^* = \frac{\delta p(1-p)\pi^m}{[1+\delta(1-p)(2-p)]S} \). Of course, it is possible that we sometimes have \( \sigma^* > 1 \). In this case, the incumbent always practices bundling. When \( \sigma^* = 0 \), i.e., when \( p = 0 \) or \( p = 1 \), on the other hand, the incumbent never practices bundling.\(^\text{15}\)

\(^{15}\) It is worthwhile to comment on how \( \sigma^* \) depends on \( p \). It can be easily verified that \( \sigma^* \) is equal to 0 when \( p \) is either 0 or 1, implying that any \( p \)-region for which the value of bundling is positive must lie strictly in \((0, 1)\). This result is not surprising because \( p = 0 \) or 1 correspond to the cases where entry is either irrelevant or the incumbent is certain that it will lose both markets regardless of the bundling decision. We can also show that \( \sigma^* \) is a concave function of \( p \), which is strictly increasing at \( p = 0 \) and strictly decreasing at \( p = 1 \). This implies that the value of bundling is highest when \( p \) takes intermediate values and the prospect of entry is uncertain.
**Proposition 2:** In the model with two entry attempts, the incumbent practices bundling when \( \sigma < \sigma^* \), where \( \sigma^* = \frac{\delta \bar{p}(1 - p)\pi^m}{[1 + \delta(1 - p)(2 - p)]S} \).

The idea is that bundling prevents the dynamic coordination of specialist entrants. When firms 2 and 3 draw specialist technologies, they are kept out of the market, allowing the incumbent to maintain its monopoly position. Thanks to bundling, the incumbent can only be displaced by generalist rivals. By binding products A1 and B1, on the other hand, the incumbent loses out on the prospective benefit of innovation in a single component. Bundling is thus a profitable strategy when the degree of price squeeze is low, so that the possibility of profit in the case of partial entry is outweighed by the risk of displacement in both components.

### 3.2. Welfare Effects

Bundling leads to lower social welfare. For one thing, specialist entrants cannot market their low-cost products because they do not have access to the complementary component. Also, by preventing the dynamic coordination of specialist innovators, bundling lowers the probability of low-cost entry. In particular, bundling reduces social welfare by \( 2p(1 - p)(\chi - \zeta) > 0 \) in period 1 and by \( 2p(1 - p)^2(2 + p)(\chi - \zeta) > 0 \) in period 2.

In both the bundling and no-bundling cases, consumer surplus is zero unless there is entry into both markets, in which case consumer surplus becomes \( V - 2\chi \) per period. The probability of simultaneous entry in both markets in period 1, \( p_1^2 \), is the same regardless of the bundling decision of the incumbent. In period 2, however, the probability of having low cost rivals operating in both markets is higher without bundling, i.e., \( p_2^2 + 2p_2^2(1 - p) + (1 - p)^2p_2^2 - p_2^2(2 - p_2^2) = 2p_2^2(1 - p)^2 > 0 \). Bundling thus leads to lower consumer welfare.

---

16 In the absence of bundling, expected social welfare in period 1 and period 2 is \( (1 - p)^2(V - 2\chi) + p^2(V - 2\zeta) + 2p(1 - p)(V - \chi - \zeta) \) and \( V - 2[(1 - p)^2\chi + pg(2 - p)] \) respectively. If the incumbent practices bundling, on the other hand, expected social welfare in period 1 and period 2 is \( (1 - p^2)(V - 2\chi) + p^2(V - 2\zeta) \) and \( V - 2[(1 - p^2)^2\chi + p^2\zeta(2 - p^2)] \) respectively.
**Proposition 3:** In the model with two entry attempts, bundling reduces consumer and social welfare.

4. ROBUSTNESS AND EXTENSIONS

In this section, we test the robustness of our results to changes in the underlying assumptions. We show that when the incumbent faces competition from an existing rival, our basic conclusions are similar. Furthermore, we examine a situation in which there is cost correlation between successive entrants.

4.1. Existing Rival

In the basic model, incumbent firm 1 initially has a monopoly position. Let us now assume that at the beginning of the game, there is also another firm, firm 1′, in the market. The social value of firm 1′’s product is positive, i.e., $V > 2\chi'$, where $\chi_A' = \chi_B' = \chi'$ is firm 1′’s marginal cost for each component. Firm 1 is still the dominant supplier, in that it has a superior technology in both components, i.e., $\chi < \chi'$. As before, the incumbent faces a series of potential entrants, firms 2 and 3, that draw their costs from a random distribution. Furthermore, we have $2\chi < \epsilon + \chi'$. Then the results are similar to those in the basic model.

Notice that in the presence of firm 1′, there is no price squeeze effect with partial entry. When a specialist rival enters the market for a component, say A, the incumbent is unable to raise its price for complementary component B — the price is equal to $\chi'$ regardless of the specialist’s entry — because otherwise, the incumbent would be undercut by its existing rival, firm 1′. The specialist thus captures the entire market for A by charging a price $\chi$. The incumbent’s profit loss due to the specialist’s entry is equal to $\chi' - \chi$. Since the incumbent also faces a displacement effect, it always practices bundling.

In particular, the incumbent’s expected profit in the absence of bundling is equal to:

$$2(1-p)^2(\chi' - \chi) + 2p(1-p)(\chi' - \chi) + \delta 2p(1-p)^3(\chi' - \chi) + 2(1-p)^4(\chi' - \chi) + 2p(1-p)^2(\chi' - \chi) \].$$

When the incumbent bundles A1 and B1, on the other hand, its expected profit

---

17 A similar point has been noted in Ordover, Sykes, and Willig [1985].
profit is $2(1 - p^2)(\chi' - \chi) + 2\delta(1 - p^3)^2(\chi' - \chi)$. The difference between the incumbent’s bundling and no-bundling profits is equal to $2p[1 - p + \delta(2 - 3p + p^3)](\chi' - \chi) > 0$. The incumbent thus always practices bundling.

**Proposition 4:** If the incumbent faces an existing rival with inferior technology at the beginning of the game, it always practices bundling.

The idea is similar to the basic model. By practicing bundling, the incumbent supplier forces specialist innovators to sell their product in conjunction with the inferior complementary component of firm 1’, preventing them from making any sales to customers in the current period and driving their current profit to zero. The incumbent thus keeps specialist innovators out of the market, bolstering its position.

### 4.2. Correlation Between Entrants

So far we have assumed that cost realizations are independent through time. We now investigate the effects of correlation between entrants. For ease of exposition, we assume that all potential entrants are specialist innovators. An entrant draws a low marginal cost $c$ in exactly one component, A or B.\(^{19}\) The unconditional probability that an entrant will specialize in either component is 1/2. Given the type of the first rival, however, the probability that the second rival will of be of the same type is given by $(1 + \rho)/2$, where $\rho$ is the correlation parameter $(-1 \leq \rho \leq 1)$. Then, we can write the expected profit of the incumbent under no bundling and bundling respectively as

$$
\Pi(\rho) = (\pi^n + \sigma S) + \delta(\frac{1+\rho}{2})(\pi^n + \sigma S),
$$

$$
\bar{\Pi}(\rho) = (1 + \delta)\pi^n. \tag{6b}
$$

\(^{18}\) Whinston [1990] also examines bundling in the presence of an inferior supplier of a monopolized product. Our analysis is different from Whinston, however, in that the incumbent firm practices bundling to prevent entry into both complementary components. In Whinston, on the other hand, there is an inferior rival product in only one component and the incumbent practices bundling to block entry into the other component.

\(^{19}\) Considering the possibility that a rival can draw a low cost in both components or in neither component does not change the basic conclusions.
Bundling leads to the following changes in the incumbent’s profit:

\[ \Delta(\rho) = \tilde{\Pi}(\rho) - \Pi(\rho) = (1 + \delta)\pi^n - [\pi^n + \sigma S] + \delta \left( \frac{1 + \rho}{2} \right)(\pi^n + \sigma S). \quad (7) \]

The incumbent thus practices bundling when the degree of price squeeze \( \sigma \) is lower than \( \frac{\delta(1 - \rho)\pi^n}{(2 + \delta + \delta \rho)S} \). Furthermore, the range of values of \( \sigma \) under which the incumbent decides to bundle becomes broader as \( \rho \) decreases since we have

\[ \frac{\partial}{\partial \rho} \frac{\delta(1 - \rho)\pi^n}{(2 + \delta + \delta \rho)S} = -\frac{2\delta(1 + \delta)\pi^n}{(2 + \delta + \delta \rho)S} < 0. \quad (8) \]

In particular, the dynamic coordination of entrants is possible only when innovators specialize in different components. As the correlation between firm 2 and 3 becomes lower, the probability that entrants will innovate in different products, eventually displacing the incumbent, increases. The benefits of bundling to the incumbent are then greater.

**Proposition 5:** When there is cost correlation between entrants, the incumbent practices bundling when the degree of price squeeze \( \sigma \) is lower than \( \frac{\delta(1 - \rho)\pi^n}{(2 + \delta + \delta \rho)S} \). We have

\[ \frac{\partial}{\partial \rho} \frac{\delta(1 - \rho)\pi^n}{(2 + \delta + \delta \rho)S} < 0. \]

### 5. More General Cost Distributions

So far we have assumed a discrete distribution of an entrant’s marginal cost as \( c_i \) can take one of two possible values, \( c \) or \( \bar{c} \), where \( c < \chi < \bar{c} \) (i = A, B). We now
consider a more general cost distribution where a potential entrant draws its costs for each component, \(\hat{c}_A\) and \(\hat{c}_B\), from a joint distribution \(F(c_A, c_B)\) with density \(f(c_A, c_B)\). We first examine the case of a single entry attempt.

Let \(f_A(c_A)\) and \(f_B(c_B)\) be the marginal density and \(F_A(c_A)\) and \(F_B(c_B)\) be the corresponding marginal cumulative distribution functions of \(\hat{c}_A\) and \(\hat{c}_B\) respectively. If \(\hat{c}_A\) and \(\hat{c}_B\) are distributed independently, we have \(F(c_A, c_B) = F_A(c_A)F_B(c_B)\) and \(f(c_A, c_B) = f_A(c_A)f_B(c_B)\). Also, let \(\hat{s} = \hat{c}_A + \hat{c}_B\), and \(G(s)\) be the corresponding cumulative distribution, i.e., \(G(s) = Pr[\hat{s} \leq s]\).

Under bundling, the monopolist is committed to defending both markets rather than each one on an individual basis. As with discrete distributions, there can be only two possible states of nature: entry into both markets (AB) or no entry at all (\(\phi\)) (see figure 1-(ii)). Let the probabilities of these two events in the presence of bundling be denoted by \(\beta_{AB} = G(\chi_A + \chi_B)\) and \(\beta_{\phi} = 1 - G(\chi_A + \chi_B)\) respectively. Thus, with a single entrant, the incumbent’s expected profit under bundling is given by

\[
\tilde{\Pi} = [1 - G(\chi_A + \chi_B)] \pi^m,
\]

where \(\pi^m = V - \chi_A - \chi_B\).

Now consider the case of no bundling. With general cost distributions, we have to consider the possibility that a potential entrant may enter both markets even if it has a cost disadvantage in one of the markets solely for the purpose of preventing the incumbent’s price squeeze by capping the incumbent’s price. To abstract from this complication, we assume that the entrant is able to appropriate the entire surplus created by its lower production cost in the case of partial entry, that is, \(\sigma = 0\). For instance, if an entrant with a cost \(\hat{c}_A < \chi_A\) enters only market A, the equilibrium market prices are \(\chi_A\)

---

20 As an example, consider the case where \(\chi_A = \chi_B = 6, \hat{c}_A = \xi = 2, \hat{c}_B = \xi = 7, V = 14,\) and \(\sigma = 1/2\). In this case, if the entrant enters only market A, it will earn a profit equal to 2 with \(P_A = 4\) (and \(P_B = 10\)). However, if it enters both markets despite having a cost disadvantage in market B, it can put a cap on the incumbent’s price of B at 7, and it can earn a profit equal to 3 by charging \(P_A = 5\).
and $V - \chi_A$ for components A and B respectively, as in the standard Bertrand game with independent products.\footnote{Farrell and Katz [2000] also make the same assumption in their analysis of vertical integration in systems markets. In contrast, Carlton and Waldman [1998] employ a Nash bargaining solution in the division of the surplus created by partial entry, which corresponds to $\sigma = 1/2$.} The assumption that $\sigma = 0$ is made for simplicity and with no loss of generality. Although considering the possibility of a price squeeze under general cost distributions would not be conceptually difficult, it would entail significant complexity in notation and exposition without affecting the main results.

With the assumption that $\sigma = 0$, there will be entry into market $i$ if and only if $\hat{c}_i < \chi_i$, where $i = A, B$. From the monopolist's perspective, there can be four possible states of nature depending on the realizations of the entrant's costs: entry into market A only (AO), entry into market B only (BO), entry into both markets (AB), and no entry into either markets ($\phi$) (see figure 1-(i)). The thickly drawn lines in the figures divide the space of cost realizations for entrants into relevant entry events. Let $S = \{AO, BO, AB, \phi\}$ denote the set of all possible states. Let $\alpha_{AO}$, $\alpha_{BO}$, $\alpha_{AB}$, and $\alpha_{\phi}$ denote the probabilities of each event under no bundling. Then, $\alpha_k$'s are the volume under the density function in area $k$ in figure 1-(i), where $k = AO, BO, AB, \phi$.

Figure 2 superimposes figure 1-(ii) over figure 1-(i) to compare post-entry industry configurations. It is clear that when the entrant has a cost advantage or disadvantage in both components, there will be no difference between bundling and no bundling. In both cases, there will be either no entry at all or entry into both components. The difference exists when the incumbent and the entrant each have an advantage in one component and as a result, there is entry into only one component market without bundling.

Suppose that cost realizations lie in area AO in figure 1-(i), implying that without bundling there will be entry into market A only. According to whether $(\hat{c}_A + \hat{c}_B)$ is greater than or less than $(\chi_A + \chi_B)$, we can partition area AO into two disjoint areas, $G_A$ (interpreted as a gain in component A) and $L_B$ (interpreted as a loss in component B). This is done in figure 2. If cost realizations are in area $G_A$, i.e., $(\hat{c}_A + \hat{c}_B) \geq (\chi_A + \chi_B)$, there will be no entry into either component under bundling; the total production cost of
the bundled components is higher for the potential entrant. However, if cost realizations are in area $L_B$, there will be entry into both markets under bundling since the total production cost of the bundled components is lower for the potential entrant. Area BO in figure 1-(i) can be partitioned in a similar way. As a result, the effect of bundling is the elimination of the events of partial entry at the expense of higher probability of losing both markets.

<< INSERT FIGURE 2 HERE >>

With partial entry, say into market A, the incumbent earns a profit of $V - \chi_A - \chi_B$ by charging the effective reservation value $V - \chi_A$ for the complementary product B, which is the same profit that the incumbent would earn without entry. The same is true for partial entry into market B. Monopoly power in only one component is thus sufficient for the incumbent to extract the entire monopoly surplus. It follows that in the absence of bundling, unless we have both $\hat{\chi}_A < \chi_A$ and $\hat{\chi}_B < \chi_B$ and there is entry into both markets, an event that occurs with probability $F(\chi_A, \chi_B) = \alpha_{AB}$, the incumbent can earn the monopoly profit $V - \chi_A - \chi_B$. With a single entrant, the expected profit of the incumbent under no bundling is given by

$$\Pi = [1 - F(\chi_A, \chi_B)] \pi^n = (1 - \alpha_{AB}) \pi^n.$$  

(10)

Let $\gamma_k$ and $\lambda_k$ be the volume under the density function in areas $G_k$ and $L_k$ respectively in figure 2, where $k = A, B$. Since $\beta_\phi$ is the integration of the joint density function over $\phi \cup G_A \cup G_B$, we can write $\beta_\phi$ as

$$\beta_\phi = \alpha_\phi + \gamma_A + \gamma_B$$

$$= \int_{\chi_B}^{\infty} \int_{\chi_A}^{\infty} f(c_A, c_B) dc_A dc_B + \int_{\chi_B}^{\infty} \int_{\chi_A + \chi_B - c_B}^{\chi_A} f(c_A, c_B) dc_A dc_B + \int_{\chi_A}^{\infty} \int_{\chi_A + \chi_B - c_A}^{\chi_B} f(c_A, c_B) dc_B dc_A.$$  

(11)

22 Notice that in our earlier model with discrete distributions, we have $L_i = \phi$, where $i = A, B$. Bundling thus does not entail higher probability of losing both markets. Instead, the cost of bundling arises from the loss of opportunity to extract rents in the market where partial entry takes place.

23 As Bowman [1957] puts it, "a monopoly of bolts ... is as good as a monopoly of bolts and nuts."
Similarly,

\[ \alpha_{AO} = \gamma_A + \lambda_B, \quad (12a) \]
\[ \alpha_{BO} = \gamma_B + \lambda_A. \quad (12b) \]

Since \( [1 - F(\chi_A, \chi_B)] = \alpha_{\phi} + \alpha_{AO} + \alpha_{BO} = \alpha_{\phi} + (\gamma_A + \lambda_B) + (\gamma_B + \lambda_A) \geq \alpha_{\phi} + \gamma_A + \gamma_B = \beta_{\phi} = [1 - G(\chi_A + \chi_B)] \), we have \( \Pi \geq \bar{\Pi} \). We conclude that if there is a single entrant, bundling is never an optimal strategy for the incumbent, as in the basic model.

Now suppose that there are sequential entry attempts by rivals. Once again, we assume that the potential entrant in each period is a different firm. There are two potential entrants, and cost realizations are independent across periods (the infinite horizon case is discussed in the Appendix). Then, the present value of the expected profit of the incumbent under bundling is given by

\[ \bar{\Pi} = \beta_{\phi} \pi^m + \delta \beta_{\phi}^2 \pi^m. \quad (13) \]

The present value of the incumbent’s expected profit under no bundling is

\[ \Pi = \alpha_{\phi} [1 + \delta (1 - \alpha_{AB})] \pi^m + \alpha_{AO} [1 + \delta (\alpha_{AO} + \alpha_{\phi})] \pi^m \\
+ \alpha_{BO} [1 + \delta (\alpha_{BO} + \alpha_{\phi})] \pi^m. \quad (14) \]

We thus have

\[ \bar{\Pi} - \Pi = (\Delta_A + \Delta_B) \pi^m, \quad (15) \]

where

\[ \Delta_A = -\lambda_B + \delta [\gamma_A \gamma_B - \lambda_B (\lambda_B + 2 \gamma_A + 2 \alpha_{\phi})], \quad (16a) \]
\[ \Delta_B = -\lambda_A + \delta [\gamma_A \gamma_B - \lambda_A (\lambda_A + 2\gamma_B + 2\alpha \phi)]. \]  

(16b)

We can interpret \( \Delta_i \) as the effect of offering component i (i = A, B) only as a part of the bundle. \( \Delta_i \) consists of two parts, a short-term loss \( \lambda_j \) (j = A, B, j \neq i) and a potential long-term gain, the expression in the square bracket discounted by \( \delta \). As shown above, there is always a current profit loss \( \lambda_j \) due to bundling. However, bundling can also change the probability of future entries. This effect depends on the probabilities of each event in expression (15). Basically, the merit of the bundling strategy is determined by a comparison of the relative magnitudes of \( \gamma_i \)'s and \( \lambda_i \)'s. If the \( \gamma_i \)'s are sufficiently large compared with the \( \lambda_i \)'s, bundling is more attractive for the incumbent. For the symmetric case where \( \gamma_A = \gamma_A = \gamma \) and \( \lambda_A = \lambda_B = \lambda \), a straightforward calculation yields the following proposition.

**Proposition 6:** With general cost distributions, bundling is a profitable strategy if \( \gamma > \lambda + 2\sqrt{\lambda (\lambda + \alpha \phi + 1)} \).

6. CONCLUSIÓN

We show that an incumbent monopolist may bundle two complementary components to buttress its dominant position. In the model, the incumbent faces rivals that make a series of entry attempts with random cost realizations. Bundling prevents specialist innovators — i.e., rivals with low marginal costs in only one component — from coordinating in the dynamic entry process, thereby lowering the probability of an eventual displacement of the incumbent. Customer and social welfare are reduced.

The model can be extended in a number of ways that were not discussed in the paper. First, we can identify circumstances in which the incumbent prefers to practice **partial mixed bundling**. In the paper, we have focused on **pure** bundling in that the

---

24 Notice that in the main analysis, there is always bundling when \( \sigma = 0 \). With more general cost distributions, however, bundling sometimes does not occur in equilibrium even when \( \sigma = 0 \). The reason is that in the general cost analysis, bundling sometimes leads to entry into both markets when no bundling would lead to entry into only one market. This would be the case if the entrant’s cost advantage in one
incumbent sells the two products only as a bundle, while the individual components are not available separately. Another type of bundling is mixed bundling in which the firm sells the individual components separately, as well as in the form of a bundle. In our model with identical consumers and no motive for price discrimination, complete mixed bundling is strategically equivalent to no bundling at all (also see Whinston [1990]).

However, we can consider what we call partial mixed bundling where one component is offered both as part of the bundle and as an independent product, while the other component is offered only as part of the bundle. It can be demonstrated that partial mixed bundling may be a preferred option if we depart from the symmetry assumption and assume that there is asymmetry across components (see Choi and Stefanadis [2002] for details).

We can also extend the basic model by considering a situation where potential entrants have to allocate their limited R&D resources between the two components. In this case, bundling induces rivals to split their resources evenly in an attempt to become generalists. In the absence of bundling, on the other hand, the optimal strategy for the first entrant is also to distribute its resources evenly, aiming at becoming a generalist. However, once there is specialist entry into one of the two components, say A, in the first period, the optimal strategy for the second entrant is to devote all the available R&D resources to the complementary component, facilitating the eventual displacement of the incumbent. This implies that in the presence of an R&D investment, there is an additional incentive for the incumbent to practice bundling. By inducing rivals to have less focus in their R&D efforts, bundling can lower the probability of successful innovation (see Choi and Stefanadis [2002] for details).

25 Adams and Yellen [1976], for instance, examine how mixed bundling can be used as an instrument of price discrimination. Adams and Yellen consider the case of complete mixed bundling, where all component products are available both independently and as part of a bundle.

26 As an example, Microsoft offers the Internet Explorer both as an independent product and as part of a bundle with the Windows operating system. The Windows operating system, on the other hand, is only sold together with the Internet Explorer.

27 For instance, we can assume that the threat levels of entry across markets are not equal, i.e., the probabilities of drawing a low marginal cost are different for components A and B, that is, \( \Pr(c_a = \bar{c}) = p \) and \( \Pr(c_b = \bar{c}) = q \) with \( p \neq q \).
The main implication of the model for antitrust policy is that bundling by an incumbent firm often needs to receive close scrutiny. The entry deterrence theory of bundling must not be misinterpreted, however. Our argument is applicable only when the incumbent firm has a monopoly position in both components, or if it does not have a monopoly position, it instead enjoys a significant technological advantage over its existing rivals that already operate in the market. Furthermore, our conclusions depend on the assumption that a specialist innovator needs to gain rapid access to customers to overcome financial constraints or to recover its fixed cost of entry. When these conditions are not met, our reasoning may not be relevant.
APPENDIX: INFINITE TIME HORIZON AND GENERAL COST DISTRIBUTIONS

Let $\delta$ denote the discount factor and $\pi^m = V - \chi_A - \chi_B$. Then, the present value of the incumbent’s expected profit under no bundling, $V_{NB}$, satisfies the following:

$$V_{NB} = \alpha \phi (\pi^m + \delta V_{NB}) + \alpha_{BO} (\pi^m + \delta V_{A}) + \alpha_{AO} (\pi^m + \delta V_{B}),$$ \hspace{1cm} (A1)

where $V_A$ and $V_B$ denote the present value of the expected profit of the incumbent when it has a monopoly position only in markets A and B respectively. $V_A$ and $V_B$ are defined by the following relationships.

$$V_A = [1 - F_A(\chi_A)](\pi^m + \delta V_A) = (\alpha_{BO} + \alpha_\phi)(\pi^m + \delta V_A),$$ \hspace{1cm} (A2a)

$$V_B = [1 - F_B(\chi_B)](\pi^m + \delta V_B) = (\alpha_{AO} + \alpha_\phi)(\pi^m + \delta V_B).$$ \hspace{1cm} (A2b)

Meanwhile, the present value of the incumbent’s expected profit under bundling, $V_{PB}$, satisfies

$$V_{PB} = \beta \phi (\pi^m + \delta V_{PB}) = (\alpha_\phi + \gamma_A + \gamma_B)(\pi^m + \delta V_{PB}).$$ \hspace{1cm} (A3)

Notice that $V_{PB}$ can be written as

$$V_{PB} = \frac{\beta \phi}{1 - \delta \beta_\phi} \pi^m = \Psi(\beta_\phi) \pi^m,$$ \hspace{1cm} (A4)

where $\Psi(x) = \frac{x}{1 - \delta x}$. Similarly, $V_A = \Psi(\alpha_{BO} + \alpha_\phi) \pi^m$ and $V_B = \Psi(\alpha_{AO} + \alpha_\phi) \pi^m$. It is straightforward to show that $V_{PB} - V_{NB} \geq 0$ if and only if $(ST + LT) \geq 0$, where

$$ST = -(\lambda_A + \lambda_B) \pi^m,$$ \hspace{1cm} (A5a)
\[ LT = \delta \{ [\gamma_B (V_{PB} - V_A) + \gamma_A (V_{PB} - V_B)] - [\lambda_B V_A + \lambda_A V_B] \}. \quad \text{(A5b)} \]

ST represents the short-term loss due to bundling that is explained in detail in the one potential entrant case in section 5. With multiple entrants, we have to consider future benefits and costs of bundling, \( LT \), which were nonexistent in the one entrant case. The terms in the first square bracket in \( LT \) represent the potential benefit of bundling. For bundling to generate a positive gain for the incumbent, it is necessary that \( V_{PB} \) is larger than at least one of \( V_A \) and \( V_B \).

By substituting (11) and (12) in the text into (A.4) and (A.5), we have \( V_{PB} = \Psi(\alpha \phi + \gamma_B) \pi^m \), \( V_A = \Psi(\alpha \phi + \gamma_B + \lambda_A) \pi^m \) and \( V_B = \Psi(\alpha \phi + \gamma_A + \lambda_B) \pi^m \). Since \( \Psi(x) \) is equal to \( \frac{x}{1-\delta x} \) and is increasing in \( x \), the necessary condition for bundling to be a profitable strategy is that the \( \lambda_i \)'s must be sufficiently small in comparison with the \( \gamma_i \)'s. If the prospect of future gains outweighs the prospect of both future and short-term losses, bundling is a profitable strategy for the incumbent.
REFERENCES


Figure 1. Entry Configurations

- Entry into Market A Only [AO]
- Entry into Both Markets [AB]
- No Entry [\(\varnothing\)]

Figure 1-(i) Entry Configuration without Bundling.

Figure 1-(ii) Entry Configuration with Pure Bundling.

Figure 2. Partitioning of AO and BO events.