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PRODUCT OFFERING COMPLEXITY: IMPLICATIONS FOR TYING DOCTRINE

Michael A. Salinger
Boston University
Questrom School of Business

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Abstract: Firms with multiple products that they can sell either separately or in bundles cannot, as a practical matter, offer every possible combination. I analyze bundling and tying by a firm that sells two products that it can sell individually and/or bundled. To capture the limiting factor on the number of distinct products, I assume a fixed product offering cost, with the individual items and the bundle each being a distinct product. The primary competitive constraint on the firm is the threat of entry. Potential entrants can be as efficient (no entry barriers) or less efficient (some entry barriers) than the incumbent. The model also allows for a potential entrant that is more efficient in the production of one of the two products. Pure bundling, which entails tying, can occur for two distinct reasons. One (exemplified by selling shoes in pairs) is that most people want both items and there are efficiencies in selling them as a bundle. The other (exemplified by newspapers) is that when the fixed cost of a product offering is high, a bundled product can meet the needs of a diverse set of customer preferences with a single offering. Mixed bundling permits each customer to buy exactly what she wants, but possibly at high prices. While pure bundling can appear to “force” customers to buy an item they do not want, the threat of entry by a firm selling individual goods restricts the price. In some cases, pure bundling makes all consumers better off. In others, customers who want just one of the items might pay more than they would if the seller offered the items separately; but those who want both items pay less, and aggregate consumer surplus is higher.

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Contact: Michael A. Salinger, Boston University, Questrom School of Business, 595
Commonwealth Ave., Boston, MA 02215
salinger@bu.edu
617-353-4408

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I. Introduction

When a firm engages in tying, it requires purchasers of one of its goods or services that it could sell separately (the “tying good”) to acquire from it another good or service (the “tied good”) that it could also sell separately. The practice can raise antitrust concerns when the seller has market power in the tying good and there are competing suppliers (or potential suppliers) of the tied good. When competitors or competition authorities allege an anticompetitive tie, they assert that the practice impedes competition on the merits for the tied good. The tying of Internet Explorer to Windows was the central allegation in *U.S. v. Microsoft* [253 F.3d 34 (D.C. Cir. 2001)].

A striking feature of the modern world economy is the success of Apple, Alphabet (Google), Amazon, Meta (Facebook), and Microsoft, among others. Even many of their critics concede that these companies achieved their early successes with innovations that brought consumers better products at better prices.¹ However, in continuing to expand the scope of what they do, these companies have offered services where they face competition. When Microsoft integrated MediaPlayer into Windows, a Windows license included a service that other companies (such as RealNetworks) also provided. Apple’s integration of a camera into the iPhone competed with camera producers. Google’s provision of Google Maps, including turn-by-turn driving directions, competed with stand-alone GPS systems offered by companies such as Garmin and TomTom.

The expanding size and scope of these companies have led many to question whether they have maintained their profitability and continued to grow by leveraging market positions in their core products into allegedly more competitive markets, whether such (alleged) leveraging has violated existing antitrust laws and, if not, whether new antitrust laws are needed to limit their growth. In 2020, the Antitrust Subcommittee of the U.S. House Judiciary Committee issued a report on competition in digital markets.² One of its recommendations was that Congress codify into law the per se ban against tying that the Supreme Court established in *International*

¹ A possible exception is Microsoft, as some might argue that it triumphed over Apple in the first “PC war” with software that was inferior to Apple’s. But personal computers with Intel microprocessors and a Microsoft system were cheaper than Apple’s products, and the lower price turned out to be the key to generating the network externalities that in turn led adoption as an effective standard.

² U.S. House of Representatives, Subcommittee on Antitrust, Commercial and Administrative Law of the Committee on the Judiciary (2020).

Salt v. U.S. [332 U.S. 392 (1947), *International Salt*] and upheld in Jefferson Parish v. Hyde [466 U.S. 2 (1984)].

In evaluating the appropriate antitrust treatment of tying, an important consideration is the pervasive use of tying in competitive markets. The ubiquity of the practice is strong evidence that it can be efficient. In her concurring opinion in Jefferson Parish, Justice O'Connor got to the heart of the issue when she wrote, "All but the simplest products can be broken down into two or more components that are 'tied together' in the final sale. Unless it is to be illegal to sell cars with engines or cameras with lenses, this analysis must be guided by some limiting principle."³

The economics literature on bundling and tying is not particularly helpful for identifying such limiting principles. Much of it is largely a reaction to "Chicago school" arguments that challenged the economic logic of the monopoly-leveraging claims in cases such as *International Salt*. Stigler's (1963) article about block booking spawned a literature on bundling and tying as a form of price discrimination.⁴ But price discrimination is in general a more compelling explanation for mixed bundling, which is not tying, than it is for pure bundling, which is.⁵ In the seminal "post-Chicago" article on tying, Whinston (1990) formalized how a firm with a protected monopoly in one product (A) and a monopoly subject to entry in another product (B) could prevent entry by committing to sell A only in a bundle with B. Doing so would foreclose part of the market for B to the entrant and thereby prevent it from achieving the scale needed to make entry profitable. In another influential article, Nalebuff (2004) considered a firm with current monopolies over two goods but faced by the threat of entry in both. He showed that selling them just as a bundle would raise entry barriers by making entry with just one of the goods unprofitable. These models and the literature that has built upon them show that tying can be a strategy for deterring entry.⁶ But, even granting that the motive for tying by firms with market power can be foreclosure and entry deterrence, it does not logically follow that all tying, even by firms with market power in one or more goods, is intended to foreclose equally or more efficient rivals.

³ Jefferson Parish Hospital District No. 2 v. Hyde, 466 U.S. 2, 39 (J. Connor, concurring).

⁴ See also Schmalensee (1984) and Salinger (1995).

⁵ See Adams and Yellen (1976) and McAfee, McMillan, and Whinston (1989).

⁶ Other notable articles are Choi and Stefanadis (2001), Carlton and Waldman (2002), Nalebuff (2005), and Carlton, Gans, and Waldman (2010).

When IBM was the dominant supplier of computers, it started integrating into its central processing units hardware that had previously been stand-alone “peripheral” devices. Some manufacturers of “plug-compatible” devices sued, alleging that the product integration constituted an illegal technological tie. In ruling for IBM in one of those suits, the court stated:

It is not difficult to imagine situations where a monopolist could utilize the design of its own product to maintain market control or to gain a competitive advantage.... It is more difficult to formulate a legal standard for design conduct than it is to imagine clearly illegal situations.⁷

The court’s point was that product design decisions can (and typically do) have procompetitive explanations. As a result, a ban or even an overly restrictive policy toward product integration that appears to foreclose rivals would inevitably act as a deterrent to beneficial innovation in product design.

Should the same point apply to bundled products that are not physically integrated? As Whinston observed in his discussion of *U.S. v. Microsoft*,

Ideally, decisions in the presence of such uncertainty would rely on knowledge of the typical effects of challenged practices, accumulated from a body of economic research. What is striking about the area of ... tying, however, is how little the current literature tells us about what these effects are likely to be. This state of (non)knowledge is, I think, responsible to a significant degree for the very strong but differing beliefs that economists often have about whether ... tying [is] ... likely to have welfare-reducing anticompetitive effects.⁸

While there is not an extensive economics literature documenting the efficiency of non-technological tying, the ubiquity of the practice under competition is strong evidence that it is often efficient. Tying occurs whenever something a company sells includes a component that it could have charged for separately. The question one wants to ask is why companies do not offer the individual items separately. A first-class airplane ticket typically includes not only a seat in the first-class section but also the right to check two bags without charge and free alcoholic beverages. Virtually all airlines charge coach class customers for alcohol and many now charge for each checked bag. Why do the airlines not offer discounted first-class tickets for those who do not want alcohol or to check a bag? Why are men’s suits typically sold as suits rather than as separates? Why do many restaurants not charge separately for bread and butter?

⁷ *In re IBM Peripheral EDP Devices Antitrust Litig.*, 481 F. Supp. 965 at 1003 (N.D. Cal. 1979), *aff’d sub nom.*

⁸ Whinston (2001), p. 79.

The answer to these questions is obvious. Unbundling necessarily results in a more complicated set of product offerings that increase costs. The cost of product-offering complexity is a first order effect that must be considered when formulating an economically rational antitrust policy toward tying – both technological and contractual. The literature that demonstrates the potential for tying to exclude a more efficient competitor does not take account of the cost of product-offering complexity. To the extent that the objective of those models was to refute Chicago school claims that monopoly leveraging allegations are inherently incoherent as a matter of economic theory, they accomplished their objective. But they do not provide a basis for a balanced policy.

Evans and Salinger (2005, 2008) presented a model of tying and bundling that takes account of product offering complexity. In the Evans-Salinger model, a single seller of two goods, A and B, can sell them separately and/or in a bundle. The key assumption that creates a cost of product-offering complexity is a fixed cost for each distinct product offering, with each good sold separately and the bundle being a distinct offering. As a result, pure bundling, i.e., offering only the bundle and not the individual goods separately, saves fixed costs of product offerings by simplifying the seller's product portfolio. In contrast, mixed bundling, i.e., offering the bundle and both individual goods, generates three fixed product-offering costs as it is the most complex set of offerings possible. More generally, the number of possible bundles grows exponentially with the number of possible components.⁹

The fixed product-offering costs imply economies of scale, which are inconsistent with perfect competition. But one can model a highly competitive environment in the presence of scale economies by assuming that markets are perfectly contestable, meaning that the complete absence of entry barriers precludes prices that would generate economic profits.

The literature on contestable markets dates back to work by economists at AT&T's Bell Labs.¹⁰ The contestability assumption underlying that literature evoked considerable controversy among economists, and one might argue that the profession rejected it. But the assumption of perfect contestability in the Evans-Salinger model yielded an important insight into tying that had not previously appeared in the formal economics literature. In the Evans-Salinger model, some customers want A, some want B, and some want both. In addition to the fixed costs of

⁹ With N possible components, the number of possible offerings is $2^N - 1$.

¹⁰ For background on the theory of contestable markets, see Buamol, Panzar, and Willig (1982) and Baumol (1982).

product offerings, the model assumes constant marginal costs of A, B, and the bundle with the possibility of marginal costs savings from the bundle. Given those assumptions, pure bundling can occur under two distinct types of conditions. Selling shoes in pairs exemplifies one of them. Almost everyone who wants to buy shoes wants both shoes in a pair and putting pairs of shoes in a single box rather than offering them separately presumably conserves both packaging and inventory management costs. That finding is not surprising. But pure bundling can also arise when no one wants both goods and there are no marginal cost savings from producing the bundle. That result might seem puzzling (or even wrong) at first, but the explanation is simple. When the fixed cost of a product offering is very high, pure bundling satisfies the needs of a diverse group of customers with a single product offering. A (literally) every day example is newspapers. Few if any customers want every section (much less every article) of a daily newspaper. But selling the individual sections of daily newspapers separately would surely increase transactions costs substantially.

Just as the models of tying to foreclose rivals abstracts away from the cost of product offering complexity and, more generally, the efficiencies from tying, the contestability assumption in the Evans-Salinger model abstracts away from any market power arising from the presence of entry barriers. Given the market capitalization of companies like Alphabet, Amazon, Apple, Meta, and Microsoft, the assumption that the threat of entry prevents them from earning economic profits would seem to miss an essential element of the markets in which they operate. In this paper, I allow for entry barriers in the form of cost advantages for incumbents over entrants. Given this assumption, the threat of entry remains a competitive constraint on firms, but that effect is not strong enough to prevent the incumbent from earning any economic profits. Not only does this assumption capture tech sector market reality better than the assumption of perfect contestability, it also captures tech sector market reality better than the assumption of unconstrained monopoly or static oligopoly. Even if, for the sake of argument (and, arguably ignoring business history), one assumes that a start-up could not displace one or more of the existing “giants,” they and other large companies pose a threat to each other. Microsoft’s Bing competes with Alphabet’s Google. Google Workspace competes with Microsoft Office. Alphabet sponsored Android to compete with Apple’s iPhone. WalMart and Target among many others compete with Amazon as retailers.

The remainder of this paper is organized as follows. A key concept in this paper is “entrant sustainability,” which builds on the concept of sustainability from the contestable markets literature. Section II shows how “sustainability” applies in the context of tying and bundling when there are no entry barriers. Section III then introduces the meaning of entrant sustainability and how it applies in the model of tying and bundling in the presence of entry barriers. In general, entry barriers expand the set of sustainable outcomes, and the incumbent’s profits vary across those possibilities. Under some circumstances, the incumbent maximizes its profits with pure bundling even though (and, indeed, because) consumers end up buying a component they do not want. But the practice can benefit consumers because the incumbent has to offer a low enough price to prevent an entrant from offering the individual items separately. In other cases, the incumbent maximizes its profits with mixed bundling, which permits consumers to buy only the items they want. But mixed bundling can also give the incumbent the ability to charge higher prices. In combination, these results suggest that legal hostility to tying can have the unintended consequence of harming consumers.

While the model incorporates a critical cost savings from tying that the economics literature has largely ignored and reveals ways in which consumers can benefit from tying, it does not preclude the possibility that tying can be a strategy to exclude a more efficient single-product entrant. While the entry barriers in the model are cost disadvantages for entrants, allowing the “disadvantages” to be negative captures those situations like those addressed by Whinston and Nalebuff – namely that the incumbent engages in tying to prevent entry by a lower-cost supplier of one of the goods. Section IV presents an example of anticompetitive tying.¹¹

II. Bundling and Tying in the Absence of Entry Barriers

A monopolist sells two goods, 1 and 2, that it can sell separately and/or in bundled form. In general, it has five possible sets of product offerings. Pure bundling means that it offers just the bundle. Components selling means that it offers the two goods separately but not the bundle.

¹¹ There are some examples of tying that this model does not address. In particular, it does not address tying consumables (like paper or toner) to durable equipment (like a printer), which is a way to charge based on usage rather than a fixed fee. It also does not apply to bundled rebates such as those that were at issue in *LePage’s v. 3M* [324 F. 3rd 141, (3rd Cir. 2003) (en banc)]. In that case, the different products 3M sold were clearly distinct product offerings. The effective tying was merely a pricing formula that did not in any way conserve on the number of distinct product offerings.

Mixed bundling means that it offers both goods separately as well as the bundle. The other two strategies are to offer the bundle and just one of the goods separately. If it offers the bundle and Good 1 (Good 2), then anyone who wants Good 2 (Good 1) must purchase Good 1 (Good 2) as well. In that case, Good 1 (Good 2) is the tying good and Good 2 (Good 1) is the tied good.

A. Demand

There are three groups of customers, denoted groups 1, 2, and B. Members of group 1 primarily¹² want just good 1. Members of group 2 primarily want just good 2. Members of group B want both. As a simplification, assume that Goods 1 and 2 have the same costs and that Groups 1 and 2 have a common demand function.

Let:

p_B = price of bundle under pure bundling

p_C = price of individual good under components selling

$p_{MC}(k_M)$ = price of individual good under mixed bundling

$p_{MB}(k_M)$ = price of bundle under mixed bundling

$p_{TC}(k_T)$ = price of individual good under “tying”¹³

$p_{TB}(k_T)$ = price of bundle under “tying”

As I explain in more detail in Subsection C below, k_M and k_T are parameters that reflect the allocation of the fixed product costs between the bundle and the individual goods under mixed bundling and “tying,” respectively.

Members of all three groups might obtain the good(s) they want in one of two ways. Members of groups 1 and 2 buy either just the good they want or the bundle (discarding the other good if they get no value from it). Members of group B buy the two goods they want either bundled or separately. Let d be a disposal cost that Groups 1 and 2 incur if they buy a bundle of both goods and n be an inconvenience value that Group B gets from buying the two goods separately rather than in a bundle. While the labeling of the terms implies that Groups 1 and 2 prefer to buy just the good that they are primarily interested in and that Group B prefers to buy the goods as a bundle, both can take on negative values. If $d < 0$, the members of Group 1 (2) get

¹² As I explain below, I allow for the possibility that members of Group 1 (Group 2) get some utility (or disutility) from Good 2 (Good 1).

¹³ I will use “tying” (in quotation marks) to mean the strategy of selling the bundle and just one of the goods separately.

some utility from Good 2 (1). If $n < 0$, then members of group B get convenience from buying the goods separately even though they want both.

Let θ_C be the effective price that members of Groups 1 and 2 pay for the good they want and θ_B be the effective price that members of Group B pay for the bundle. When a member of Group 1 or 2 buys just the good they want, the price they pay is the effective price. When they buy the good they want in a bundle, the effective price is what they pay plus d , the disposal cost. When members of Group B buy the bundle, the price they pay is the effective price. When they buy the goods separately, the effective price for the bundle is the sum of the prices of the individual goods and n , the “inconvenience cost.”

Let $f_C(\theta_C)$ be the function that gives demand by Groups 1 and 2 as a function of the effective price they face and $f_B(\theta_B)$ be the function that gives the demand by Group B as a function of the effective price they face with $f_C'(\theta_C)$ and $f_B'(\theta_B)$ both being weakly negative.¹⁴

B. Costs

The incumbent incurs a constant marginal cost c_S for the production of a separate good and c_B for the production of the bundled product. Assume $c_S \leq c_B \leq 2c_S$. The incremental (and wasted) marginal cost of providing the bundle to consumers who want just one product is $c_B - c_S$. The marginal cost savings from providing the bundle rather than the separate products to consumers who want both is $2c_S - c_B$.

A key assumption is that firms incur two types of fixed costs. F is a fixed cost of each product offering, where goods 1 and 2 and the bundle are all separate offerings. G is a fixed product (or good) cost.

Both types of fixed costs are essential for understanding bundling and tying. The fixed offering cost creates a cost of a more complex set of product offerings (and therefore efficiencies from conserving on the set of product offerings). The fixed product costs are important because, for a firm that sells a good both separately and as part of a bundle, the fixed product cost is joint between the two offerings. As a result, a firm that offers just one of the products (Good 1, say) can be at an inherent cost disadvantage relative to a multi-product firm that can sell the good both separately and as part of a bundle.

¹⁴ Because the threat of entry constrains prices in this model, I allow for perfectly inelastic demand.

To illustrate with a simple numerical example, suppose $c_S = 4$, $c_B = 6$, $F = 100$, and $G = 200$.¹⁵ Further, suppose Groups 1, 2, and B all have 100 members, each of whom demand one unit perfectly inelastically. A firm that sells just Good 1 to sell just to Group 1 has average costs of $4 + \frac{100+200}{100} = 7$. In contrast, consider a firm that sells Goods 1 and 2, both individually for Groups 1 and 2 and as bundle for Group B. To make the bundle available to Group B, it must incur an extra fixed offering cost of 100, but doing so is efficient because it saves marginal costs of 200. Because it sells the bundle in addition to the individual good, it can divide the fixed product cost over the two products. This gives it a cost advantage over a firm that sells Good 1 just to Group 1. If, for example, it allocates half of each fixed product cost to the individual products and half to the bundle, its average cost of the individual item is $4 + \frac{100 + \frac{1}{2} \cdot 200}{100} = 6$, which is less than the single-product firm's average cost of 7.

C. Sustainability

Following the contestable markets literature, a possible market outcome is a set of offerings and associated prices that are “sustainable,” which means that the offerings and prices are immune from entry either by a company offering the same set of offerings (“copycat entry”) or an alternative set that would allow it to profitably undercut the incumbent.¹⁶

To be sustainable against copycat entry, prices must result in zero economic profits. Under both pure bundling and components selling, there is a unique “break-even” price (equal to average cost) for each offering. The equations that implicitly define those prices are:

$$(1) \quad p_B = c_B + \frac{F+2G}{2f_C(p_B+d)+f_B(p_B)}$$

$$(2) \quad p_C = c_S + \frac{F+G}{f_C(p_C)+f_B(2p_C+n)}$$

¹⁵ One might question whether fixed product offering costs can plausibly be the same order of magnitude as product fixed costs (particularly in R&D intensive industries). With only two underlying goods, the number of distinct product offerings (3) is only slightly greater than the number of underlying products. Most and perhaps all real businesses for which tying is an issue sell more than two underlying products. Because the set of possible product offerings is an exponential function of the number of underlying products, the number of possible product offerings generally greatly exceeds the number of products. Thus, even if the fixed product offering cost of an individual product offering is small, the potential aggregate product offering costs can be substantial enough to make it necessary to economize on the set of product offerings. To generate numerical examples based on two underlying goods to illustrate the incentive to limit the number of product offerings because of the cost of product offering complexity, it is necessary to assume a substantial fixed product offering cost.

¹⁶ In contestability games, ties go to the incumbent.

For mixed bundling and “tying,” there is a range of break-even prices depending on the allocation of the fixed product costs between the bundle and the individual products. Let k_M and k_T be the fraction of fixed product costs allocated to the separate products under mixed bundling and “tying,” respectively. Equations (3) and (4) give the set of break-even prices for mixed bundling:

$$(3) \quad p_{MC}(k_M) = c_S + \frac{F+k_M G}{f_C[p_{MC}(k_M)]}$$

$$(4) \quad p_{MB}(k_M) = c_B + \frac{F+2(1-k_M)G}{f_B[p_{MB}(k_M)]}$$

While any value for k_M results in 0 profits, values outside the range $[0,1]$ entail cross-subsidization and therefore entail a risk of violating the prohibition against predatory pricing. An additional restriction on k_M in mixed bundling is that $p_{MB}(k_M)$ must fall within the range $[p_{MC}(k_M) - d, 2p_{MC}(k_M) + n]$.¹⁷ If $p_{MB}(k_M)$ is below that range, customers who want just one product would buy the bundle. If it is above that range, customers who want both products would buy them separately. Define k_{ML}^* and k_{MH}^* so that they satisfy:

$$(5) \quad p_{MB}(k_{MH}^*) = p_{MC}(k_{MH}^*) - d$$

$$(6) \quad p_{MB}(k_{ML}^*) = 2 p_{MC}(k_{ML}^*) + n$$

k_{ML}^* and k_{MH}^* can fall outside the range $[0,1]$. If the price of the individual components is below the sum of the bundle price and disposal cost even when all the fixed product costs are allocated to the individual components, then $k_{MH}^* > 1$. Similarly, if the bundle price is less than the sum of the two components prices and the “inconvenience cost” even when all the product fixed costs are allocated to the bundle, then, $k_{ML}^* < 0$. If $k_{MH}^* < 0$, members of Group 1 and 2 buy the bundle even when all the product fixed costs are allocated to the bundle. Similarly, if $k_{ML}^* > 1$, Group B buys the individual goods separately even when all the product fixed costs are allocated to the individual goods. Thus, the feasible range for k_M is $k \in [k_{ML}, k_{MH}]$, where $k_{ML} = \min[\max(0, k_{ML}^*), 1]$ and $k_H = \max[\min(1, k_{MH}^*), 0]$.

For “tying,” the equations that implicitly define the break-even prices are:

$$(7) \quad p_{TC}(k_T) = c_S + \frac{F+k_T G}{f_C[p_{TC}(k_T)]}$$

$$(8) \quad p_{TB}(k_T) = c_B + \frac{F+(2-k_T)G}{f_B[p_{TB}(k_T)]}$$

¹⁷ Assume that $2p_{MC}(k_M) + n > p_{MC}(k_M) - d$ for all k_M . The inequality holds if d and n are both positive. They can be negative, but the inequality will still hold for some negative values of d and n .

As with mixed bundling, the allocation must be such that those who want just the item offered separately choose to buy the individual item rather than the bundle. Define:

$$(9) \quad p_{TB}(k_{TH}^*) = p_{TC}(k_{TH}^*) - d$$

With “tying,” there is no constraint analogous to equation (6) because those who want Good 2 have no alternative to buying the bundle. Thus, the feasible range for k_T is $k_T \in [0, k_{TH}]$ where $k_{TH} = \max[\min(k_{TH}^*, 1), 0]$.

1. No Fixed Product Costs

The analysis of what product offerings are sustainable is simpler when there are no fixed product costs. In that case, which product configuration(s) is (are) sustainable depends on which of three basic conditions hold.¹⁸ The first is the “separate products stand-alone condition”:¹⁹

$$(10) \quad p_{MC}(1) < p_B + d$$

The left-hand side of (10) is the price an entrant would have to charge to sell a separate product to the group that wants just that product. The right-hand side is the effective price that Groups 1 and 2 pay to get just the good they want under pure bundling. If equation (10) holds, any sustainable set of product offerings must include the separate products, which rules out pure bundling. Note that a positive (negative) value of d increases (decreases) the range of the other parameters for which the separate products stand-alone condition holds, in which case pure bundling is not sustainable.

The “bundle stand-alone condition” is:

$$(11) \quad p_{MB}(0) < 2p_C + n$$

The left-hand side of (11) is the price an entrant would have to charge to sell the bundle just to the group that wants both products. If it holds, pure components selling is not sustainable.

The third condition is the “pure bundling sufficiency condition:”

$$(12) \quad p_B + d < p_C$$

¹⁸ With asymmetric demand and costs, the separate products stand-alone conditions are different for the two goods and there are strong and weak versions of both. With asymmetric demand, offering the bundle and just one of the goods can be sustainable. See Evans and Salinger (2008).

¹⁹ With no fixed product costs, the prices under mixed bundling do not depend on k_M . However, equations (10) and (11) are stated with values of k_M that generalize to when there are fixed product costs.

If it holds, a firm selling the bundle to all can undercut a firm selling the goods separately even for the customers who want just one of the goods. As with equation (10), a positive (negative) value for d reduces (increases) the range of the other parameters for which (12) holds.

When equation (12) holds, pure bundling is the only sustainable outcome. When it does not hold, which outcomes are sustainable depends on which among the stand-alone conditions [equations (10) and (11)] hold. Table 1 gives the sustainable outcomes when equation (12) does not hold, conditional on which of equations (10) and (11) hold. Appendix A presents numerical examples of the five possible qualitative outcomes with no entry barriers, no product fixed costs, and symmetric demand. To make the calculations as transparent as possible, the examples in Appendix assume that each group's demand is perfectly inelastic. Appendix B extends the examples to allow for demand elasticity.

The most surprising result from this analysis is that pure bundling can occur under two distinct conditions. The first – “shoes” – is when the bundle stand-alone condition holds but the separate products stand-alone condition does not. The second – “newspapers” – is when the pure bundling sufficiency condition holds. Table 2 provides a numerical example of the latter. The top portion of Table 2 gives the assumed values and the bottom portion gives the break-even prices. In Table 2, demand for each individual good is 100 and no customer wants both products. Given that no one wants both products, mixed bundling is not a feasible outcome. Either the bundle is cheaper than the individual products, in which case Groups 1 and 2 buy the bundle to get just the good they want, or the sum of the individual products are cheaper than the bundle, in which case Group B buys the individual products. The price of the bundle under pure bundling is 80, which is less than the price of 85 for the individual products under components selling. Because of the high fixed offering cost of 6,000, equation (12) holds. Having a single bundled product satisfies the needs of both groups of customers with a single offering.

Given fixed product costs and contestable markets, additional product offerings create a negative externality by syphoning off customers to share the fixed offering costs. To see this point, suppose demand by each group is perfectly inelastic, in which case welfare maximization is equivalent to cost minimization. Conditional on the two individual items being available separately, it is efficient to add the bundle if:

$$(13) \quad F < (2c_S + n - c_B)f_B(2p_C + n),$$

or

$$(13') \quad \frac{F}{f_B(2p_C+n)} + c_B < 2c_S + n$$

The bundle stand-alone condition (11) can be written as:

$$(11') \quad \frac{F}{f_B(p_{MB}(0))} + c_B < 2 \left(c_S + \frac{F}{f_B(2p_C+n)+f_C(p_C)} \right) + n$$

With perfectly inelastic demand, $f_B(p_{MB}(0)) = f_B(2p_C + n)$. The right-hand side of (11') is larger than the right-hand side of (13'); so equation (11') holds whenever (13') does, but it can also hold when (13') does not.²⁰

2. Fixed Product Costs

With fixed offering costs but no fixed product costs, there are no joint costs between offerings. Thus, an entrant with a single offering has no inherent total cost disadvantage compared with an incumbent that can sell to all groups of customers.²¹ Because, however, fixed product costs are joint between the bundle and the separate product, an incumbent selling one of the goods both separately and as part of the bundle has an inherent cost advantage over an entrant with a single offering aimed at a single customer group because it can share the fixed cost of the product between the group that wants just that product and the group that wants both.²²

a) Pure Bundling

Consider first firms engaged in pure bundling. A firm seeking to sell just a single product to the group that wants it must charge $p_{MC}(1)$ (because $k = 1$ means that the entire fixed product cost is allocated to the separate product). If $p_{MC}(1) < p_B + d$, then pure bundling is not sustainable because the component stand-alone condition, equation (10), holds. Suppose, however, $k_{MH} < 1$ and $p_{MB}(k_{MH}) < p_B$. In that case, pure bundling would not be sustainable because all groups would prefer $p_{MB}(k_{MH})$ to p_B .

²⁰ When demand is not perfectly inelastic with respect to price, the introduction of the bundle given provision of the individual goods would result in changes in deadweight loss with respect to all three Groups. These changes would be second-order effects and they would go in opposite directions. The reduction in the effective price to Group B would reduce the deadweight loss associated with that group, but the higher price of the individual goods sold separately would increase the deadweight loss associated with Groups 1 and 2.

²¹ The incumbent's first mover advantage does give it an average cost advantage.

²² To use the vocabulary of the literature on contestable markets, fixed product costs create "economies of scope" between the individual offerings and the bundle.

b) Components Selling

Now consider components selling. An incumbent selling just the individual items faces three types of entry threats. One is from a firm that seeks to sell the bundle just to Group B and another is from a pure bundler. Protection against these threats requires that neither the bundle stand-alone condition nor the pure bundling sufficiency condition holds. The third potential form of entry is from a mixed bundler and arises only when there are fixed product costs. If $k_{ML} > 0$ and $p_{MC}(k_{ML}) < p_C$, all groups would prefer $p_{MC}(k_{ML})$ to p_C (and Group B would end up paying $p_{MB}(k_{ML})$).

c) Mixed Bundling

An entrant cannot succeed by engaging in mixed bundling with a different value of k_M . Successful entry requires offering a better deal to all three customer groups, and changing k_M raises price(s) to at least one of them. But, to be sustainable, a set of mixed bundling prices must be immune from entry by either a pure bundler or a firm that sells just the individual products.

To be immune from entry from a pure bundler, the mixed bundle price must be better than the pure bundle price for at least one customer group. Thus, one of the two following conditions must hold:

$$(14) \quad p_{MC}(k_M) \leq p_B + d$$

$$(15) \quad p_{MB}(k_M) \leq p_B$$

Since a feasible mixed bundling strategy requires $p_{MC}(k_M) \leq p_{MB}(k_M) + d$, equation (15) implies equation (14). But only one needs to hold for mixed bundling to be sustainable. Thus, equation (14) is sufficient for mixed bundling to be protected from entry against pure bundling.

To be immune from entry from a firm selling the two products separately, one of the two following conditions must hold:

$$(16) \quad p_{MC}(k) \leq p_C$$

$$(17) \quad p_{MB}(k) \leq 2p_C + n$$

Equation (16) implies equation (17) for feasible values of $p_{MC}(k)$ and $p_{MB}(k)$. Again, only one needs to hold, so equation (17) is sufficient for mixed bundling to be sustainable. Define k_{MB} and k_{MC} to be the values of k that cause (14) and (17), respectively, to hold with equality. Since $p_{MC}(k)$ is decreasing in k_M and $p_{MB}(k_M)$ is increasing in k_M , a sustainable value

of k_M must fall within the range $[k_{MC}, k_{MB}]$. Then, for mixed bundling to be sustainable, this range must overlap with the range $[k_{ML}, k_{MH}]$.

d) “Tying”

If the incumbent offers the bundle and just one of the goods (Good 1, say) – a set of offerings that I will refer to as “tying” - the price of the individual item cannot exceed the effective price Group 1 would pay the incumbent for the bundle:

$$(18) \quad p_{TC}(k_T) \leq p_{TB}(k_T) + d$$

This condition places a ceiling on the fraction of the fixed product cost for Good 1 that the incumbent can allocate to the individual item. Another constraint on the maximum allocation of the Good 1 product fixed cost to the individual item is that the price for the individual item must be less than the effective price a member of Group 1 would pay a pure bundler:

$$(19) \quad p_{TC}(k_T) \leq p_B + d$$

The price of the bundle must give members of Group 2 as low an effective price as they would receive from a firm selling Good 2 to attract just group 2:

$$(20) \quad p_{TB}(k_T) + d \leq p_{MC}(1)$$

This constraint places a cap on the fraction of the Good 1 product fixed cost that the incumbent can allocate to the bundle (and therefore places a floor on the fraction that it must allocate to the individual item). Finally, however, the allocation of the fixed costs must not create so large a spread between the incumbent’s prices for the bundle and individual item for Group B to choose to buy Good 1 from the incumbent and Good 2 from an entrant. For this constraint, the relevant price for the entrant is what it could charge if it attracted both Groups 2 and B, i.e., p_C :

$$(21) \quad p_{TB}(k_T) \leq p_C + p_{TC}(k_T) + n$$

This constraint also places a cap (floor) on the fraction of the Good 1 product fixed cost allocated to the bundle (individual good). Let k_{TH}, k_{TB}, k_{TC} , and k_{TS} be the allocations of the product fixed costs needed to make equations) (18) – (21) hold with equality. For “tying” to be sustainable, there must be an allocation of the product fixed cost that satisfies all four constraints.

Table 3 summarizes the sustainability conditions for each possible set of product offerings.

e) Example

As Appendix A shows, multiple sets of products can be sustainable even when there are no fixed product costs. However, the presence of fixed product costs expands the scope for multiple sets of product offerings to be entrant sustainable. When potential entrants are just as efficient as the incumbent, all the sustainable product offerings give the incumbent the same (0) profits. But, as we will see in the next section, when the incumbent has a cost advantage, different sets of product offerings yield different profits. As a result, the possibility of multiple sustainable outcomes will underly the incumbent's choice of which products to offer.

Table 4 illustrates how the allocation of fixed costs between the bundle and components affects break-even prices and, in turn, what sets of offerings and prices are sustainable. In Table 4, components selling and mixed bundling are both sustainable. The fixed product cost is 600 and the fixed offering cost is 900. When $k_M = 0$, *i.e.*, when all the fixed product costs are allocated to the bundle, the bundle price of 77 is more than double 34, the price of the separate products. Thus, $k_M = 0$ is not feasible. The minimum feasible value for k_M is $k_{ML} = 0.25$, which yields a price for the separate products of 35.5 and a bundle price of 71. But that set of prices is not sustainable because the price of the bundle exceeds the sum of the two prices under components. To insulate itself from entry by a firm selling the two separate goods, the minimum value of k_M is $k_{MC} = 0.29$, which gives a bundle price of 70 and a price for a separate product of 35.8. When $k_M = 1$, the prices of the separate items are below the incumbent's price for the bundle and the price a pure bundler would need. As a result, mixed bundling with prices based on any value of k_M between 0.29 and 1 is sustainable.

Components selling with the price of each good equal to 35 is also sustainable. A firm entering with the bundle to sell just to Group B would need to charge 77, which is above the sum of the individual items under components prices. If a mixed bundler reallocated the product fixed costs to reduce the price of the bundle to 70, it would have to charge 35.8 for the individual items. That price is above the 35 charged by the incumbent if it sells just the separate items. Similarly, the price of the bundle under pure bundling, 43.4, would not be low enough to attract Groups 1 and 2.

“Tying” is not feasible because the minimum price for the bundle under “tying,” 45, is greater than 40, the price an entrant can charge for Good 2 even if it sells just to Group 2. Pure bundling is not sustainable for the same reason.

Appendix C contains two more examples that illustrate the possible allocations of fixed costs and the effect on what outcomes are sustainable.

III. Bundling and Tying with Entry Barriers

Bain (1956) defined an entry barrier as a condition of a market that makes it feasible for incumbents to earn economic profits without attracting entry. The presence of entry barriers does not preclude the threat of entry as a constraint on an incumbent’s prices. Rather, it means that the threat of entry is not so strong that it prevents an incumbent from earning some economic profits. With no sunk costs and no cost disadvantage for entrants relative to incumbents, an incumbent must set prices to earn 0 economic profits, so there are no entry barriers. In this section, I introduce entry barriers in the form of a cost disadvantage for entrants. With this modification, potential entry remains the primary competitive constraint on the incumbent, but the incumbent can earn economic profits because the entrants’ cost disadvantage weakens that constraint.

The cost disadvantage can take one of three forms: marginal costs, fixed offering costs, or fixed product costs. Let c_S^D be an entrant’s marginal cost disadvantage for a separate product, c_B^D be the entrant’s marginal cost disadvantage in producing the bundle, F^D be the entrant’s fixed offering cost disadvantage, and G^D be the entrant’s cost disadvantage with respect to fixed product costs.²³ While the fixed offering cost is essential for understanding tying, the possibility that an entrant’s disadvantage might stem from this type of cost might seem contrived at first. However, what matters about the fixed cost is its size relative to the number of purchases. Suppose that some customers simply refuse to purchase the entrant’s product, which would be a product differentiation barrier to entry. If so, the entrant would need a higher price to break even than would the incumbent to cover its higher fixed cost per customer.²⁴

²³ The difference between these fixed offering costs and fixed product costs is that the latter is a common cost for product sold separately and as part of a bundle.

²⁴ Product differentiation can manifest itself in other ways. Another possibility is that all customers are willing to pay the same premium for the incumbent’s product over an entrant’s. This type of advantage would have the same effect as a marginal cost advantage, not a fixed cost advantage. More generally, there can be a distribution of the premium customers are willing to pay for the incumbent’s product.

With a single product and a cost disadvantage for entrants, the incumbent would charge the entrant's average cost and earn an economic profit per unit equal to the difference between the entrant's average cost and its own.²⁵ To extend the analysis to allow for entry barriers, define "entrant sustainable" prices as:

Definition: Suppose an incumbent faces potential entrants with costs that are 1) equal to each other and 2) weakly greater than the incumbent's. Prices (and the associated set of product offerings) are "entrant sustainable" if they would be sustainable if 1) all firms (including the incumbent) had costs equal to those of the potential entrants.

Given this definition, all the results from the previous section about sustainable outcomes in the absence of entry barriers apply to entrant sustainability in the presence of entry barriers with the qualification that the conditions depend on entrants' costs, not the incumbent's.

We can establish the following theorem:

Theorem 1: Any entrant sustainable set of offerings and prices is feasible for the incumbent. If it chooses an entrant sustainable set of offerings and prices, the incumbent's economic profits are equal to its cost advantage over the potential entrants given the set of offerings.

The first part of the theorem is an obvious implication of the definition of entrant sustainable prices. The second part follows because the revenues from an entrant sustainable set of offerings and prices equal the entrant's costs.

While the incumbent can choose any entrant sustainable set of offerings, it is not limited to them. Suppose, for example, that given entrant costs, pure bundling is the unique entrant sustainable offering. From the definition of entrant sustainability, any entrant choosing mixed bundling would be unable to break even. Because it has lower costs, however, an incumbent might be able to earn a profit with mixed bundling even if an entrant could not.

While the incumbent can in some cases profitably offer a product set that is not entrant sustainable, it cannot capture its full cost advantage over the entrant for such a product set. For example, suppose mixed bundling is entrant sustainable but pure bundling is not. If the incumbent could charge the entrant's average cost for pure bundling, its profits would be its cost advantage. Since pure bundling is not entrant sustainable, however, such a price would leave the incumbent susceptible to entry. To offer just the bundle, the incumbent would have to charge less than an entrant's average cost under pure bundling. Such a price might be above its own average

²⁵ In the model of perfect contestability, ties go to the incumbent by assumption. Thus, the incumbent can charge the entrant's average cost rather than undercutting it slightly.

cost and therefore generate positive profits, but those profits must be less than the incumbent's cost advantage. As a result, we can state the following theorem:

Theorem 2: If the incumbent chooses a set of product offerings that is not entrant sustainable, its profits must be strictly less than its cost advantage with respect to the entrants for the set of offerings it chooses.

A. Incumbent profit maximization

The incumbent's opportunity to earn economic profits lies in its cost advantage over entrants. In general, the incumbent's advantage depends both on the nature of its cost advantage and the set of product offerings. With an advantage in the fixed cost per offering, the incumbent's total cost advantage is proportional to the number of product offerings, *i.e.*, $3 F^D$ for mixed bundling, $2 F^D$ for components selling and "tying," and F^D for pure bundling. In contrast, if the firm has a marginal cost advantage over entrants and if its marginal cost advantage with respect to the bundle is at least as great as the sum of its marginal cost advantages with respect to the goods sold separately, its cost advantage is greatest under pure bundling, in which case all three groups buy both goods, and second greatest under "tying," in which case Groups 2 and B buy both goods. As a result, to analyze the profit-maximizing product offerings and prices, we treat the three possible types of cost advantages separately.

1. Fixed Product Cost Advantage

When the incumbent has an advantage in the fixed product costs (as distinct from fixed offering costs), its cost advantage is $2 G^D$ for any set of product offerings. From this observation, Theorems 1 and 2 imply that when the incumbent has only a fixed product cost advantage over entrants, its profit-maximizing strategy is to choose an entrant-sustainable set of offerings and prices. When two or more sets of offerings are entrant-sustainable, the incumbent is indifferent among them.

Even though an advantage in fixed product costs does not affect an incumbent's choice of product offerings, fixed product costs (that are the same for entrants as for the incumbent) do. Just as fixed product costs affect what outcome(s) is (are) sustainable in the absence of entry barriers, they effect the entrant sustainable outcome(s) in the presence of entry barriers. As a result, they affect the feasible options for the incumbent. In Table 4, for example, components

selling and pure bundling are both sustainable. If those parameters applied to entrants, then the incumbent could choose which of those offerings gives it the higher profits.

2. Fixed Offering Cost Advantage

As noted above, when the incumbent has lower fixed offering costs, its cost advantage is proportional to the distinct number of offerings. Because mixed bundling maximizes the number of offerings, the incumbent chooses mixed bundling and earns $3 F^D$ whenever it is entrant sustainable regardless of whether other sets of product offerings are also entrant sustainable. Thus, the interesting cases to consider are when mixed bundling is not entrant sustainable.

a) Entrant Sustainable Components Selling

Whenever components selling is entrant sustainable but mixed bundling is not,²⁶ the incumbent can earn at least $2 F^D$ with components selling. It might, however, be able to do still better with mixed bundling even though it cannot earn $3 F^D$.

Let the superscript E denote prices that would cover an entrant's costs, so that p_C^E is the price an entrant would have to charge under components-selling (whether or not components selling is entrant sustainable). Let the superscript $j \in (M, B, C)$ denote what the incumbent has to charge against an entrant sustainable offering set j . For example, p_{MB}^C is the price the incumbent must charge for the bundle under mixed bundling to prevent entry by a firm that offers just the two separate goods.²⁷

If components selling is entrant sustainable but mixed bundling is not, the bundle stand-alone condition does not hold. That is, $p_{MB}^E > 2p_C^E + n$. To offer the bundle in a way that attracts Group B and is not susceptible to entry from a firm that offers just the two individual items for $2p_C^E$, the incumbent's price for the bundle must be:

$$(22) \quad p_{MB}^C = 2p_C^E + n$$

As this price will prevent Group B from buying the individual items from an entrant, the incumbent's prices for the individual the items only have to prevent entry by firms offering those items to the groups that want just one of the goods:

²⁶ When pure bundling and components selling are both entrant-sustainable, the incumbent prefers components selling, which generates a profit of $2 F^D$.

²⁷ Note that M_B^C is a single number and not a function defined over a range of k .

$$(23) \quad p_{MC}^C = p_{MC}^E(1)$$

Since $p_{MC}^E(1) > p_C^E$ as long as there are some customers who want both goods, the incumbent's use of mixed bundling, which entails no tying, lowers consumer surplus relative to selling just the separate items.

Table 5 contains an example in which the incumbent finds mixed bundling profitable when components selling is entrant sustainable. Fixed product costs are 0, bundling does not lower marginal costs, and entrants' marginal costs equal the incumbent's.²⁸ There are fixed offering costs, and they are higher for entrants than for the incumbent. The middle section of Table 5 gives break-even prices for an entrant conditional on the set of product offerings. Components selling is entrant sustainable.²⁹ Mixed bundling is not because the sum of the individual goods prices under components selling is 90, which is less than the bundle price under mixed bundling.³⁰ Pure bundling is not because the individual goods prices under mixed bundling (55) are less than the bundle price under pure bundling (62).

The bottom panel shows possible prices for the incumbent and the profits associated with them. As it shows, the incumbent can make more with mixed bundling than with components selling. Components selling with prices equal to break-even prices for an entrant is feasible and yields profits equal to the incumbent's cost advantage.³¹ If, instead, it opts for mixed bundling, a price of 90 for the bundle ensures that it would continue to sell to group B even with entry by a firm charging 45 for the individual goods. Without attracting group B, the entrant cannot achieve an average cost of 45 for the individual goods. To break even selling to groups 1 and 2, it would have to charge 55 for each. Thus, with mixed bundling, the incumbent can charge 90 for the bundle and 55 for the goods sold separately. As the last column of the last line indicates, its profits from doing so are 2,750.³²

²⁸ Because product fixed costs tend to make mixed bundling entrant sustainable and, given an advantage in product offering fixed costs, the incumbent chooses mixed bundling when it is entrant sustainable, the numerical examples in this section assume no product fixed costs.

²⁹ In Table 5 to Table 9, bold type for price indicates entrant sustainability.

³⁰ With fixed offering costs and $X_B > 0$, the components prices are lower under components selling than under mixed bundling.

³¹ The incumbent's cost advantage is 1,250 per offering. Components selling entails two offerings, so the incumbent's total advantage is 2,500.

³² Mixed bundling is not always the profit-maximizing strategy whenever the incumbent's advantage is with respect to fixed offering costs and components selling is entrant sustainable. Consider, for example, modifying the example in Table 5 so that the incumbent's fixed offering cost is 2,250 and the entrants' disadvantage is 750 per offering. The change would not affect break-even prices for entrants or, therefore, entry-detering prices for the incumbent.

This result is reminiscent of Schmalensee’s (1978) result about the use of brand proliferation as a device to deter entry and elevate prices. The demand structure is different than in the Schmalensee model, but the effect is the same. By incurring more fixed costs to have more distinct product offerings, the incumbent insulates itself from entry and can charge higher prices accordingly.

b) Entrant Sustainable Pure Bundling

When pure bundling is the only entrant sustainable set of offerings, the incumbent’s cost advantage is greater with more products. If it offers all three products, its strategy is mixed bundling. If it offers two products, at least one of them must be one of the individual items – Good 1, say. The second product can then either be the second individual item (in which case it engages in components selling) or the bundle, in which case it ties Good 2 to Good 1. Let $p_{TB}^E(0)$ be an entrant’s average cost of a bundle if it sells to Groups 2 and B and allocates all the product fixed costs to the bundle.

(1) Pure Bundle Sufficiency Condition Holds

Pure bundling can be the only entrant sustainable outcome for one of two reasons. One is that the pure bundle sufficiency condition holds for entrant costs:

$$(24) \quad p_B^E + d < p_C^E$$

In that case, for the incumbent to offer an alternative set of products, it must sell one of the individual items (Good 1, say) for $p_B^E + d$. By doing so, it prevents those who want just Good 1 from purchasing the bundle from the entrant which in turn prevents entry by a firm offering just the bundle for p_B^E . Thus:

$$(25) \quad p_{M1}^B = p_{C1}^B = p_{TC}^B = p_B^E + d,$$

where the notation p_{M1}^B and p_{C1}^B allows for the possibility of charging different prices for Goods 1 and 2.

However, the additional 500 in fixed cost per offering would lower the incumbent’s profits by 1,000 (to 1,500) for components selling and by 1,500 (to 1,250) for mixed bundling. The incumbent’s ability to choose mixed bundling at prices lower than an entrant could charge arises from its advantage in offering fixed costs. However, it still has to incur an additional offering fixed cost for mixed bundling rather than components selling. If that fixed cost is too high (because its advantage over entrants is too small), then components selling is the better option.

Given such a price for Good 1, the incumbent can then offer just Good 2, just the bundle, or both. If it offers just Good 2, then both Group 2 and Group B will purchase it. To prevent entry by a firm offering just Good 2 to both groups, it must offer p_C^E .

If it offers just the bundle in addition to Good 1, it must prevent entry by a firm offering Good 2 and selling just to Group 2, a firm offering Good 2 to sell to both Groups 2 and B (with Group B also buying Good 1 from the incumbent), and a firm offering the bundle to sell to Groups 2 and B:

$$(26) \quad p_{TB}^B = \min[p_{MC}^E(1) - d, p_{TC}^B + p_C^E + n, p_{TB}^E]$$

If it offers both Good 2 (to sell to Group 2) and the bundle (to sell to Group B), it must protect itself against an entrant that would offer Good 2 to sell just to Group 2 and an entrant that would offer Good 2 to sell to both Groups 2 and B (again, with Group B purchasing Good 1 from the incumbent). It must then charge a bundle price that induces Group B to buy the bundle (rather than buying it from the entrant or from buying the individual goods it sells). Thus,

$$(27) \quad p_{M2}^B = \min [p_{MC}^E(1), p_C^E + n]$$

$$(28) \quad p_{MB}^B = \min[p_{M1}^B + p_{M2}^B + n, p_{MB}^E(0)]$$

Table 6 provides an example of pure bundling being the only entrant sustainable product configuration because the pure bundle sufficiency condition holds. The parameters are largely the same as in Table 5 with two key differences. First, the marginal cost of the bundle, 35, is less than the sum of the marginal cost of the individual goods sold separately. Second, an entrant's fixed offering cost disadvantage is 2,750 rather than 1,250, which makes its total fixed offering cost 4,500, compared with 3,000 in Table 5.

With a bigger fixed offering cost and substantial marginal cost savings from bundling, pure bundling is the unique entrant sustainable product offering. As the middle portion of the table indicates, the break-even price for an entrant pursuing pure bundling is 53. This is less than the break-even prices for the individual goods sold separately for an entrant that pursues components selling (55), so an entrant selling a bundle at 53 would be immune from entry by another firm seeking to sell the individual goods.

As the bottom portion of Table 6 shows, while there is only one entrant-sustainable set of product offerings, the incumbent has four profitable alternatives. One is pure bundling with a price of 53. The profit from doing so is 2,750, which is exactly the incumbent's cost advantage relative to the entrant. The other three, which entail a larger number of distinct products, generate

higher profits (albeit profits that are lower than the incumbent's cost advantage). Of these, selling just the individual items generates the highest profits.

While offering just the two individual goods would be consistent with any restriction on tying and, for that matter, bundling, consumers are worse off than they would be with entrant-sustainable pure bundling. Members of Group 2 pay 55 instead of 53 while members of Group B pay 108 rather than 53.

(2) Pure Bundling when Pure Bundle Sufficiency Condition Does Not Hold

If the pure bundling sufficiency condition does not hold, pure bundling can still be the unique entrant sustainable outcome if the bundle stand-alone condition holds but the components stand-alone condition does not.

Under such circumstances, components selling is not entrant sustainable because an entrant selling the individual items cannot charge low enough price to prevent entry by a firm selling the bundle just to Group B. For the incumbent to sell just the individual items and prevent such entry, it must cut its prices below what an entrant could profitably charge. If the prices are to be equal to each other, then incumbent's prices must be:

$$(29) \quad p_C^B = \frac{p_{MB}^E(0)-n}{2}$$

If pure bundling is entrant sustainable but mixed bundling is not, the lowest possible price an entrant could charge for the individual items under mixed bundling entails a higher effective price for Groups 1 and 2 than an entrant's bundle price under pure bundling. For the incumbent to prevent entry by a pure bundler, it must offer Groups 1 and 2 an effective price that meets the entrant's pure bundle price:

$$(30) \quad p_{MC}^B = p_B^E + d$$

Then, having attracted Groups 1 and 2 away from a pure bundler, its bundle price must match what an entrant selling the bundle just to Group B would charge:

$$(31) \quad p_{MB}^B = p_{MB}^E(0)$$

Finally, to sell just Good 1 and the bundle (to sell to Groups 2 and B), the price of the bundle must prevent entry by a firm that would sell the bundle to those same groups:

$$(32) \quad p_{TB}^B = p_{TB}^E(0)$$

Compared with the entrant sustainable pure bundling price, the effective price to Group 2 is higher by $p_C^E - p_B^E - d$ and the effective price to Group B is higher by $p_C^E + n$.³³ The strategy also affects costs as the incumbent incurs marginal cost of c_S rather than c_B in supply Groups 1 and 2, but it incurs marginal cost of $2c_S$ rather than c_B in supplying Group B. It also entails an extra product offering fixed cost.

In Table 7, pure bundling is the only entrant sustainable outcome and the pure bundle sufficiency condition does not hold. The parameters resemble those in Table 3 – the “shoes example” – except that the incumbent’s fixed offering costs are only 750 rather than 1,500. Pure bundling is the only entrant sustainable product configuration. If the incumbent charges an entrant’s pure bundling price of 50, it earns its cost advantage of 750. The strategy that maximizes its profits is mixed bundling, with a price of 50 for the individual items and 52.50 for the bundle.³⁴

3. Marginal Cost Advantage

The third possible type of incumbent cost advantage concerns marginal cost. Again, the incumbent’s profits cannot be greater than its cost advantage for its set of product offerings. If it charges entrant-sustainable prices, its advantage is $c_B^D [2f_C(p_B^E + d) + f_B(p_B^E)]$ under pure bundling, $2c_S^D [f_C(p_C^E) + f_B(p_C^E + n)]$ under components selling and $2c_S^D f_C(p_{MC}^E) + c_B^D [f_B(p_{MB}^E)]$ under mixed bundling.

A natural base case to consider is $c_B^D = 2c_S^D$. In that case, the incumbent’s cost advantage tends to be greatest for pure bundling, second greatest for “tying,” and approximately equal for mixed bundling and components selling.³⁵ The source of the higher cost advantage with pure bundling is that all consumers buy both goods and the incumbent has a cost advantage with respect to each good each customer buys. Thus, in this base case, the incumbent chooses pure bundling if it is entrant sustainable. The question then becomes whether the incumbent can

³³ The effective price is higher by $p_C^E - p_B^E - d$, but the incumbent does not adjust the price of Good 2 by d because the competitive threat with respect to Good 2 is from a seller of just Good 2, not the bundle.

³⁴ Given the parameters, there are no feasible mixed bundling or “tying” prices. Because the demand for the individual goods is so limited, it is not possible to offer the individual good at a price lower than the bundle price without cross-subsidization. Table (13) the reported prices of the bundle for mixed bundling and “tying” are an entrant’s average cost of providing the bundle to just Group B.

³⁵ With perfectly inelastic demand, the incumbent’s cost advantage is greatest with pure bundling, second greatest with “tying,” and lowest and equal for components selling and mixed bundling.

improve upon mixed bundling or components selling when pure bundling is not entrant sustainable.

a) Pure Bundling when Only Mixed Bundling is Entrant Sustainable

When mixed bundling is the only entrant sustainable outcome, an entrant's price for the bundle under pure bundling is not low enough to attract Groups 1 and 2. To take advantage of its greater cost advantage under pure bundling, the incumbent must charge a bundle price of:

$$(33) \quad p_B^M = p_{MC}^E(k_{MH}) - d$$

If the incumbent finds this strategy to be more profitable than mixed bundling, those who want both goods benefit. The cost an entrant charges Group B under mixed bundling exceeds what it would need to charge for the bundle under pure bundling, and the price the incumbent charges for the bundle under pure bundling is less than what an entrant would have to charge. Those who want just one good pay a price that an entrant could charge under mixed bundling. But the incumbent can choose the highest possible price that would attract Groups 1 and 2. As a result, when there are fixed product costs, those in Groups 1 and 2 pay more to the incumbent under pure bundling than they would pay an entrant under all but the highest possible prices for the individual goods under mixed bundling.³⁶

If there are no fixed product costs, in which case there is only one entrant sustainable set of prices under mixed bundling, members of Groups 1 and 2 pay the same effective price to the incumbent for the bundle as they would to an entrant for just one of the goods. Table 8 illustrates the point. The incumbent's advantage is with respect to marginal costs and mixed bundling is the only entrant sustainable set of product offerings.³⁷ Under mixed bundling, the pricing that is most favorable to Group B is a price of 41.0 for just one good and 65.0 for the bundle. The pricing that is most favorable to Groups 1 and 2 is 40.0 for just one good and 69.0 for the bundle. An

³⁶ For perfectly inelastic demand, total consumer surplus is higher given the incumbent's strategy of pure bundling compared with the entrant's strategy of mixed bundling. Any allocation of product fixed costs between the individual goods and the bundle generates exactly the same revenues. With an allocation based on k_{MH} , Group B benefits and Groups 1 and 2 pay the same relative to an entrant's prices under mixed bundling. For any different allocation of the product fixed cost by the entrant, the reduction in price to Group B would exactly offset the increase prices to Groups 1 and 2.

³⁷ Components selling is not because the price of the bundle under mixed bundling (78) is less than the sum of the prices of Goods 1 and 2 under components selling ($40 + 40 = 80$). Pure Bundling is not entrant sustainable either because the prices of products 1 and 2 under mixed bundling (55) are less than the bundle price under pure bundling (58).

entrant's cost for the bundle under pure bundling would be 41.8, which is too high to prevent an entrant that sells Goods 1 and 2 separately. But, given its lower costs, the incumbent can profitably attract all three customer groups by offering just the bundle and charging 41.0. Since members of Group B would pay between 65.0 and 69.0 to an entrant (or entrants) who sell the goods separately, they do substantially better paying the incumbent 41.0 for the bundle. Those who want just one good would pay between 40.0 and 41.0 to an entrant; the 41.0 that they pay the incumbent for the bundle is at the top of that range.

When there are no product fixed costs, members of Groups 1 and 2 pay the same effective price to the incumbent for bundle as they would pay an entrant for just one good. Thus, while pure bundling appears to “force” them to buy a good they do not want, the strategy does not harm them because they get the additional good for free.

With product fixed costs, consumers in Groups 1 and 2 can pay a higher effective price to the incumbent than to the entrant. But an entrant that would give them a better price would have to be a multi-product entrant. Thus, examples like this one do not support an argument that a ban on tying would benefit some consumers by protecting an inefficient supplier of just one of the goods.

b) Pure Bundling when Only Components Selling is Entrant Sustainable

When components selling is the only entrant sustainable outcome and the incumbent chooses pure bundling, a price of $2p_C^E + n$ prevents the entrant from attracting those who want both goods. For the strategy to succeed, it must choose a price so that the entrant cannot offer the individual goods to those who want just one good. That is:

$$(34) \quad p_B^C = p_{MC}^E(1) - d,$$

which leaves those who want just one good paying an effective price of $p_{MC}^E(1)$. Since $p_{MC}^E(1) \geq p_C^E$, those who want just one good pay a higher effective price to the incumbent for the bundle than they would to the entrant just for the good they want. However, as long as $p_{MC}^E(1) - d \leq 2p_C^E + n$, those who want both goods pay less for the bundle to the incumbent than the effective price they would pay the entrant.

Table 9 contains an example. Components selling with a price of 35.7 for each good is entrant sustainable. If the incumbent chooses components selling at a price of 35.7, its profit is

4,500, which is its cost advantage. If it chooses pure bundling, it can charge 40 and earn a profit of 4,800. Those who want both goods pay 40 to the incumbent for the bundle compared to the combined price of 71.4 that they would pay an entrant that sold the goods separately. Those who want just one of the goods pay 40 for the bundle rather than the 35.7 they would pay an entrant for just one of the goods.³⁸

The result that some consumers (in this case, Groups 1 and 2) would prefer a different set of product offerings than the one that prevails in the market is typical of the literature on product selection. If there were no fixed costs (or, more generally, scale economies), we would expect to see complete customization of product offerings, not only under competition but also by a monopolist that is not constrained by the threat of entry. When the only goods available in the market are the separate items, the set of product offerings is customized to the desires of those who want just one of the goods, and they benefit from having those who want both goods buy them in an inefficient manner. Similarly, pure bundling is a set of product offerings that is customized for those who want both goods, and they benefit from having those who want just one good buy the bundle. Given diversity of preferences and a cost of having a more complex set of product offerings, a trade-off is unavoidable.

IV. More efficient entrants

The analysis above suggests that a legal hostility to tying can harm consumers. It does not mean that an incumbent can never use tying in a way that harms consumers (as well as a competitor). The previous section contains an analysis of bundling and tying when potential entrants have a cost disadvantage relative to the incumbent. In general, however, antitrust enforcement is more concerned with the exclusion of more efficient competitors, not less efficient competitors.³⁹

The model in this paper can address such concerns by allowing an entrant to have a cost advantage in Good 1 and a cost disadvantage in Good 2. The use of tying to exclude a more efficient entrant arises when there are fixed product costs. Table 10 presents an example. The incumbent has marginal costs of 25 for the individual goods and 45 for the bundle (so there are

³⁸ Under entrant-sustainable prices for the individual goods, total expenditure would be $50 \cdot 71.4 + 200 \cdot 35.7 = 10,710$. If the incumbent engages in pure bundling to prevent entry, total expenditure is $40 \cdot 250 = 10,000$.

³⁹ See Whinston (1990) and Nalebuff (2004).

some marginal cost savings from bundling). There is a product fixed cost of 3,000 and no offering fixed cost. The incumbent faces a potential entrant for Good 1 that has the same fixed cost but a marginal cost of 15 rather than 25. The potential entrants for Good 2 are less efficient. While they have the same fixed cost as the incumbent, their marginal cost is 50 rather than 25.

Given these parameters, one option for the incumbent is to accommodate the Good 1 entrant and to offer just Good 2 separately. If so, the sustainable price for Good 2 would be the Good 2 entrant's average cost (assuming it sells to both Groups 2 and B) of \$65. Its alternative is not to offer Good 2 separately but, instead, to offer Good 2 only bundled with Good 1. With that strategy, any customer who wants Good 2 must obtain Good 1 from the incumbent which, in turn, reduces the potential market for the entrant. The price for the bundle is limited by the possibility that the customers who want both goods would buy them separately from the two entrants. That price is 95. With a smaller set of potential customers, the Good 1 potential entrant would have to charge 45. If the incumbent offered Good 2 separately, its average cost of supplying Good 1 would be 40, which is above the entrant's average cost. Thus, its profits would be limited to $(65.0 - 25.0) \times 200 - 3000 = 5,000$. If, instead, it offers the bundle rather than just Good 2, it can charge 95 for the bundle. In addition, because the entrant's customers are limited to Group 1, its average cost is 45, which is below the incumbent's incremental cost of supply Good 1 to Group 1 given that it incurs the Good 1 fixed cost to include it in the bundle. By charging 45 for Good 1 and 95 for the bundle, its profits are $(95 - 45) \times 200 + (45 - 25) \times 100 - 6,000 = 6,000$, which is greater than the 5,000 it earns if it accommodates entry in the sale of Good 1.

Consumers would be better off if the incumbent accommodated entry. While Group B pays the same effective price of 95 with either strategy, Group 1 pays 45 instead of 30 when the incumbent ties Good 1 to Good 2 and Group 2 pays 95 instead of 65.⁴⁰

V. Conclusions

When people purchased computer software in boxes that contained diskettes with the software loaded on them, some software sellers included both PC and Mac diskettes in the same

⁴⁰ If there were fixed costs of product offerings, then the incumbent's strategy of selling Good 1 and the bundle would entail an extra product offering fixed cost relative to offering just Good 2. All else equal, therefore, product offering fixed costs reduce the profitability of tying to exclude a more efficient entrant.

box. Presumably, very few customers wanted both. Even if the cost of producing the diskettes was small, it was not zero. The likely explanation was that it was cheaper to have a single product offering even if it entailed some wasted cost for each customer than to have separate offerings for Mac and PC users. While admittedly a small (and old) example, it illustrates a quite general phenomenon that companies have to limit their portfolio of product offerings and, when they do, customers end up buying goods and services that include elements they do not want or might prefer to buy from some other seller. An economically far more important example is the practice of virtually all automobile companies of selling optional equipment only in bundles. For example, compared with the base model Toyota Camry LE, the premium Toyota Camry XLE comes with a larger touch screen infotainment system, leather-trimmed heated front seats, additional safety features, and wireless smartphone charging. Someone who wants the additional safety features but does not care about the other features must either pay for all the added features or go without the safety features she wants. As Evans and Salinger (2005) document, United States automobile companies used to offer all their options a la carte. When Japanese automobile companies started penetrating the U.S. market, they offered optional equipment only in bundles. While the United States companies believed that their ability to customize options gave them a strategic advantage, experience proved that it did not. As the U.S. automobile market became more competitive with the growth of import competition and the investment by foreign companies in manufacturing facilities in the U.S., the U.S. automobile companies adopted the strategy of tying optional equipment together. It is hard to understand why offering only a small number of packages of optional equipment became standard industry practice without recognizing a substantial cost of product offering complexity.

Because of the cost of a more complex set of product offerings, pure bundling of goods that could be sold separately can occur under two quite distinct types of conditions. One is that virtually everyone wants all the components of the bundle. In that case, even a small cost of product offering complexity can cause firms to sell the two items only as pairs. But the other set of circumstances is when the cost of having multiple distinct products is very high. When it is, sellers might offer a single product to meet the needs of customers with diverse tastes even if none of them want all the goods in the bundled offering. Both types of pure bundling, which is a form of tying, can occur even when the absence of entry barriers precludes using tying to earn positive economic profits.

With entry barriers, the choice a firm makes about the portfolio of distinct products to offer does affect the profits they can earn. As the above analysis shows, the profit-maximizing strategy depends on the nature of the incumbent's cost advantage. When the incumbent has a marginal cost advantage, it benefits from having people buy as many goods as possible including those they do not want. Pure bundling can bring about this effect. In some cases, however, all consumers benefit when a firm chooses pure bundling even when entrants would opt for mixed bundling (and therefore sell the individual products separately). In these cases, the incumbent's price for the bundle is what the entrants would charge for the individual goods, in effect giving consumers the second good for "free" (whether they want it or not). In those cases in which pure bundling does raise the effective price to consumers who want just one of the goods, those who want both goods get lower prices than they would from an entrant.

In this model, when the incumbent's cost advantage is in the fixed cost of a product offering, it sometimes chooses mixed bundling because it prefers to have as many distinct product offerings as possible. By tailoring its offerings to the desires of each group, the incumbent makes it harder for entrants to gain adequate scale. While the increased diversity of offerings might initially appear to be in consumers' interests as they are able to buy precisely what they want, the wider selection can come at the cost of higher prices that leave consumers worse off than they would be under a more limited set of product offerings.

In combination, the results that pure bundling can benefit consumers while mixed bundling and components selling can make them worse off suggests that legal hostility to tying can end up harming consumers rather than helping them. As the example in Section IV showed, anticompetitive bundling can occur. But, taken together, the results in this paper show suggest that an economically sound antitrust treatment of bundling and tying must be more nuanced than a per se prohibition.

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Table 1
Sustainable Outcomes when Pure Bundling Self-Sufficiency Condition Does Not
(No Entry Barriers, No Fixed Product Costs)

		Bundle Stand-Alone	
		<i>Holds</i>	<i>Does not hold</i>
Separate Products Stand-Alone	<i>Holds</i>	Mixed Bundling	Components
	<i>Does not hold</i>	Pure Bundling	Pure Bundling or Components

Table 2
Pure Bundling (“Newspapers”)
(No Entry Barriers, No Fixed Product Costs)

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>
<i>Demand</i>	100	0
<i>Marginal Cost (c_S, c_B)</i>	25	50
<i>Fixed Offering Cost (F)</i>	6,000	6,000
Break-Even Prices		
<i>Components</i>	85	
<i>Pure Bundling</i>		80

Table 3
Sustainability Conditions with Product Fixed Costs

Product Set			
<i>Pure Bundling</i>	<i>Components</i>	<i>Mixed Bundling</i>	<i>Tying</i>
$p_{MB}(k_{MH}) \geq p_B$	$p_{MC}(k_{ML}) \geq p_C$	$k_{MH} > k_{MC}$	$1, k_{TH}, k_{TB}$
and	and	and	$\geq k_{TC}, k_{TS}, 0$
$p_{MC}(1) \geq p_B + d$	$p_{MB}(0) \geq 2p_C + n$	$k_{ML} < k_{MB}$	
or	and	and	and
$p_B + d < p_C$	$p_B + d > p_C$	$p_B + d > p_C$	$p_B + d > p_C$

Table 4
Components Selling and Mixed Bundling Sustainable

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>	<i>k</i>
<i>Demand</i>	100	50	
<i>Marginal Cost (c_S, c_B)</i>	25	35	
<i>Fixed Offering Cost (F)</i>	900	900	
<i>Fixed Product Cost (G)</i>	600	600	
Break-Even Prices			
<i>Components</i>	35.0		
<i>Mixed Bundling ($k_M = 0$)</i>	34.0	77.0	0.00
<i>Mixed Bundling ($k_M = k_{ML}$)</i>	35.5	71.0	0.25
<i>Mixed Bundling ($k_M = k_{MC}$)</i>	35.8	70.0	0.29
<i>Mixed Bundling ($k_M = 1$)</i>	40.0	53.0	1.00
<i>“Tying” ($k_T = 0$)</i>	34.0	49.0	0.00
<i>“Tying” ($k_T = 1$)</i>	40.0	45.0	1.00
<i>Pure Bundling</i>		43.4	
Sustainable			
<i>Components</i>	35.0		
<i>Mixed Bundling – lowest p_{MC}</i>	35.8	70.0	0.29
<i>Mixed Bundling – highest p_{MC}</i>	40.0	53.0	1.00

Table 5
Mixed Bundling with Entrant Sustainable Components Selling

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>	<i>Profits</i>
<i>Demand</i>	100	50	
<i>Incumbent</i>			
Marginal Cost (c_S, c_B)	25	50	
Fixed Offering Cost (F)	1,750	1,750	
<i>Entrant's Disadvantage</i>			
Marginal Cost (c_S^D, c_B^D)	0	0	
Fixed Offering Cost (F^D)	1,250	1,250	
Entrant Break-Even Prices			
Components	45		
Mixed Bundling	55	110	
Pure Bundling		62	
"tying"	55	70	
Incumbent's Options			
Components	45		2,500
Mixed Bundling	55	90	2,750

Table 6
Components Selling with Entrant Sustainable Pure Bundling

Assumed Values	Good			Profits
	<i>1</i>	<i>2</i>	<i>Bundle</i>	
<i>Demand</i>	100	100	50	
<i>Incumbent</i>				
Marginal Cost (c_i)	25	25	35	
Fixed Offering Cost (F)	1,750	1,750	1,750	
<i>Entrant's Disadvantage</i>				
Marginal Cost (c_i^D)	0	0	0	
Fixed Offering Cost (F^D)	2,750	2,750	2,750	
Entrant Break-Even Prices				
<i>Components</i>	55	55		
<i>Mixed Bundling</i>	70	70	125	
<i>Pure Bundling</i>			53	
<i>"Tying"</i>	70*		65	
Incumbent's Options				
<i>Components</i>	53	55		6,700
<i>Mixed Bundling</i>	53	55	108	4,200
<i>Pure Bundling</i>	53			2,750
<i>"Tying"</i>	53		65	3,800

* Group 1 would buy the bundle rather than Good 1 at these prices.

Table 7
Components Selling with Entrant Sustainable Pure Bundling

Assumed Values	Good			Profits
	<i>1</i>	<i>2</i>	<i>Bundle</i>	
<i>Demand</i>	50	50	200	
<i>Incumbent</i>				
Marginal Cost (c_i)	25	25	45	
Fixed Offering Cost (F)	750	750	750	
<i>Entrant's Disadvantage</i>				
Marginal Cost (c_i^D)	0	0	0	
Fixed Offering Cost (F^D)	750	750	750	
Entrant Break-Even Prices				
<i>Components</i>	31	31		
<i>Mixed Bundling</i>	55*	55*	52.5	
<i>Pure Bundling</i>			50	
<i>"Tying"</i>	55*		51	
Incumbent's Options				
<i>Components</i>	26.25	26.25		-875
<i>Mixed Bundling</i>	50	50	52.5	1,750
<i>Pure Bundling</i>	50			750
<i>"Tying"</i>	50		51	1,250

* Groups 1 and 2 would buy the bundle rather than the individual goods at these prices.

Table 8
Pure Bundling with Entrant Sustainable Mixed Bundling

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>	<i>Profits</i>
<i>Demand</i>	100	50	
<i>Incumbent</i>			
Marginal Cost (c_S, c_B)	20	25	
Fixed Offering Cost (F)	1,500	1,500	
Fixed Product Cost	100	100	
<i>Entrant's Disadvantage</i>			
Marginal Cost (c_S^D, c_B^D)	5	10	
Fixed Offering Cost (F^D)	0	0	
Entrant Break-Even Prices			
<i>Components</i>	35.7		
Mixed Bundling ($k_M = 1$)	41.0	65.0	
Mixed Bundling ($k_M = 0$)	40.0	69.0	
<i>Pure Bundling</i>		41.8	
"tying" ($k_T = 1$)	41	45.7	
"tying" ($k_T = 0$)	40	46.3	
Incumbent's Options			
<i>Mixed Bundling</i>	41.0	65.0	1,500
<i>Pure</i>		41.0	2,300
"tying"	41.0	45.7	1,300

Table 9
Pure Bundling with Entrant Sustainable Components Selling

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>	<i>Profits</i>
<i>Demand</i>	100	50	
<i>Incumbent</i>			
Marginal Cost (c_S, c_B)	10	15	
Fixed Offering Cost (F)	1,500	1,500	
Fixed Product Cost	100	100	
<i>Entrant's Disadvantage</i>			
Marginal Cost (c_S^D, c_B^D)	15	30	
Entrant Break-Even Prices			
Components	35.7		
<i>Mixed Bundling</i> ($k_M = 1$)	41.0	75.0	
<i>Mixed Bundling</i> ($k_M = 0$)	40.0	79.0	
<i>Pure Bundling</i>		51.8	
"tying" ($k_T = 1$)	41.0	55.7	
"tying" ($k_T = 0$)	40.0	56.3	
Incumbent's Options			
<i>Components</i>	35.7		4,500
<i>Pure Bundling</i>		40.0	4,800
<i>"tying"</i>	40.0	40.0	3,800

Table 10
Anticompetitive "tying"

Assumed Values	<i>Good 1</i>	<i>Good 2</i>	<i>Bundle</i>	<i>Profits</i>
<i>Demand</i>	100	100	100	
<i>Incumbent</i>				
Marginal Cost (c_S, c_B)	25	25	45	
Fixed Offering Cost (F)	0		0	
Fixed Product Cost	3000	3000		
<i>Entrant's Cost Differences</i>	-10	25		
Entrant Break-Even Prices				
<i>To both groups</i>	30.0		65.0	
<i>To one group</i>	45.0		80.0	
Incumbent's Options				
<i>Accommodate</i>		65.0		5,000
<i>Tie</i>	45.0		95.0	6,000

Appendix A

Numerical Examples of Five Possible Qualitative Outcomes – No Entry Barriers, No Product Fixed Costs

Tables A1- A5 contain numerical examples of the five possible qualitative outcomes assuming perfectly inelastic demand and $d = n = 0$.⁴¹ The top half of those tables gives the parameter values. In Table A1, the marginal cost of each individual item is 25 the marginal cost of the bundle is 35. Thus, the marginal cost savings of providing the bundle to those who want both items is $2 \times 25 - 35 = 15$, while the marginal cost savings from providing just the good they want to those who want only one of the items is $35 - 25 = 10$. In Table A1 , equations (10) and (11) both hold.⁴² As a result, the only sustainable outcome is mixed bundling. Equation (10) holds because the price of the individual components under mixed bundling, 35, is less than the price of the bundle under pure bundling (41). Equation (11) holds because the price of the bundle under mixed bundling, 65, is less than the sum of the prices of the goods under components selling ($2 \times 35 = 70$).

In Table A2, the parameters are the same as in Table A1 except that the marginal cost of producing the bundle is 45, not 35. With a smaller marginal cost savings from bundling, components selling is the unique sustainable outcome. The bundle price under mixed bundling, 75, is greater than the sum of the prices of the separate products under components selling. Thus, equation (11) does not hold, but equation (10) does.

Table A3 illustrates the class of pure bundling that includes the selling of shoes only in pairs. Most customers want both goods, there are marginal cost savings from offering the bundle, and some fixed product offering costs. The parameters are the same as in

Table A2 except for the size of the different customer groups. 200 consumers want both goods while demand for each separate good is only 50. Equation (10) does not hold, but equation (11) does, so pure bundling is the only sustainable outcome.⁴³

⁴¹ See the appendix for cases when demand is not perfectly inelastic.

⁴² If equation (10) holds, then equation (12) cannot hold since $p_C \leq p_{MC}(1)$.

⁴³ Mixed bundling is not sustainable because the price of 50 with pure bundling is lower than the price of the separate products under mixed bundling (which is why equation (10) does not hold). Those who want just one of the products would prefer components selling with $P = 31$ to pure bundling. That outcome is not sustainable, however, because it is not immune from entry by a company selling the bundle just to those who want both products.

Table A4, which is identical to Table 2 in the text, exemplifies the other class of pure bundling – the one that includes newspapers. In Table A4, no customer wants both products and bundling does not save marginal costs. Given that no customer wants both products, mixed bundling is not a feasible outcome. Either the bundle is cheaper than the individual products, in which case Groups 1 and 2 buy the bundle to get just the good they want, or the individual products are cheaper. Thus, the only options considered in Table 2 are the sale of separate products and pure bundling. The price of the bundle under pure bundling is 80, which is less than the price of 85 for the individual products under components selling. Because of the high fixed offering cost of 6,000, equation (12) holds. Having a single bundled product satisfies the needs of both groups of customers with a single offering.

Table A5 illustrates the final qualitative possibility. None of equations (10) - (12) hold, so components selling and pure bundling are both sustainable. Multiple outcomes can be sustainable in a contestable market because a successful entrant has to beat the incumbent with respect to all its (i.e., the entrant's) intended customers. Thus, in Table A5, customers who want both products prefer the bundle at 52, the price under pure bundling, to the two separate products at 45 each. However, if the incumbent charges 45 for the components, an entrant cannot offer the bundle at 52 because the customers who want just one of the products will not purchase from the entrant. Without selling to those customers, the entrant cannot achieve average costs of 52.

Table A1
Mixed Bundling
(No Entry Barriers, No Fixed Product Costs)

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>
<i>Demand</i>	100	50
<i>Marginal Cost (c_S, c_B)</i>	25	35
<i>Fixed Offering Cost (F)</i>	1,500	1,500
Break-Even Prices		
<i>Components</i>	35	
<i>Mixed Bundling</i>	40	65
<i>Pure Bundling</i>		41

Table A2
Components
(No Entry Barriers, No Fixed Product Costs)

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>
<i>Demand</i>	100	50
<i>Marginal Cost (c_S, c_B)</i>	25	45
<i>Fixed Offering Cost (F)</i>	1,500	1,500
Break-Even Prices		
<i>Components</i>	35	
<i>Mixed Bundling</i>	40	75
<i>Pure Bundling</i>		51

Table A3
Pure Bundling (“Shoes”)
(No Entry Barriers, No Fixed Product Costs)

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>
<i>Demand</i>	50	200
<i>Marginal Cost (c_S, c_B)</i>	25	45
<i>Fixed Offering Cost (F)</i>	1,500	1,500
Break-Even Prices		
<i>Components</i>	31.0	
<i>Mixed Bundling</i>	55.0	52.5
<i>Pure Bundling</i>		50.0

Table A4
Pure Bundling (“Newspapers”)
(No Entry Barriers, No Fixed Product Costs)

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>
<i>Demand</i>	100	0
<i>Marginal Cost (c_S, c_B)</i>	25	50
<i>Fixed Offering Cost (F)</i>	6,000	6,000
Break-Even Prices		
<i>Components</i>	85	
<i>Pure Bundling</i>		80

Table A5
Multiple Sustainable Outcomes
(No Entry Barriers, No Fixed Product Costs)

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>
<i>Demand</i>	100	50
<i>Marginal Cost (c_S, c_B)</i>	25	40
<i>Fixed Offering Cost (F)</i>	3,000	3,000
Break-Even Prices		
<i>Components</i>	45	
<i>Mixed Bundling</i>	55	100
<i>Pure Bundling</i>		52

Appendix B

Examples with Price-Sensitive Demand

The tables in Appendix A are based on the assumption that demand is perfectly inelastic. When the threat of entry is the primary constraint on prices, demand elasticity plays a less central role in determining prices; and the assumption of perfectly inelastic demand helps elucidate the key ideas by simplifying the numbers. To show that the key ideas of those tables do not depend on the assumption of perfectly inelastic demand, this appendix presents examples that resemble those in Appendix A but which allow demand to be a function of price. Specifically, I assume constant elasticity demand functions of the form:

$$(B1) \quad f_i(\theta_i) = k_i^{\varepsilon_i} \quad i \in (C, B)$$

The following tables correspond to Tables A1 – A4 in Appendix A. In all the tables in this appendix, the assumed elasticities are low. Because fixed costs are a substantial fraction of total costs in the examples in the text, relatively high margins over marginal cost are necessary for the seller to cover all its fixed costs. With higher elasticities, the profit-maximizing margins would be below those necessary to cover costs. Thus, for the threat of entry to be the primary constraint on entry given the high fixed costs, demand has to be relatively inelastic.

In Table B2, the bundle price under mixed bundling is above the sum of the prices of the individual goods. As a result, mixed bundling is not a feasible strategy. But the price of the individual goods under mixed bundling is still relevant. They are the price an entrant selling just the individual goods could charge even if it sells just to the group(s) that want just one of the products. Because those prices (38.25) are below the price of the bundle under pure bundling (50.1), pure bundling is not sustainable.

Tables B3 and B4 show examples of the two classes of cases in which pure bundling is the only sustainable outcome. The explanations are similar to the explanations of Tables A3 and A4 in the Appendix A.

Table B1
Mixed Bundling with Price-Sensitive Demand

Assumed Values		<i>Separate Products</i>	<i>Bundle</i>
<i>Demand</i>	Intercept	640	105
	Elasticity	-0.5	-0.2
<i>Incumbent</i>	Marginal Cost	25	35
	Fixed Offering Cost	1500	1500
Break-Even			
<i>Prices</i>	Components	34.77	
	Mixed Bundling	39.78	68.24
	Pure Bundling		41.00
<i>Quantities</i>	Components	108.53	44.95
	Mixed Bundling	101.47	45.12
	Pure Bundling	99.95	49.96

Table B2
Components Selling with Price-Sensitive Demand

Assumed Values		<i>Separate Products</i>	<i>Bundle</i>
<i>Demand</i>	Intercept	700	350
	Elasticity	-0.5	-0.5
<i>Incumbent</i>	Marginal Cost	25	45
	Fixed Offering Cost	1500	1500
Break-Even			
<i>Prices</i>		31.29	
		38.25	84.36
			51.1
<i>Quantities</i>		125.14	44.24
		113.18	38.11
		97.90	48.95

Table B3
Pure Bundling (“Shoes”) with Price-Sensitive Demand

Assumed Values		<i>Separate Products</i>	<i>Bundle</i>
<i>Demand</i>	Constant Intercept	350	1400
		-0.5	-0.5
<i>Incumbent</i>	Marginal Cost	25	45
	Fixed Offering Cost	1500	1500
Break Even			
<i>Prices</i>	<i>Components</i>	31.26	
	<i>Mixed Bundling</i>	57.50	52.78
	<i>Pure Bundling</i>		50.05
<i>Quantities</i>	<i>Components</i>	62.60	177.06
	<i>Mixed Bundling</i>	46.16	192.70
	<i>Pure Bundling</i>	49.47	197.88

Table B4
Pure Bundling (“Newspapers”) with Price-Sensitive Demand

Assumed Values		<i>Separate Products</i>	<i>Bundle</i>
<i>Demand</i>		900	0
		-0.5	-0.5
<i>Incumbent</i>	Marginal Cost	25	50
	Fixed Offering Cost	6000	6000
Break-Even			
<i>Prices</i>	Components	87.28	
	Pure Bundling		79.77
<i>Demand</i>	Components	96.33	0.00
	Pure Bundling	100.77	0.00

Appendix C

Further Examples of Multiple Sustainable Outcomes with Product Fixed Costs

In Table C1, pure bundling, “tying,” and mixed bundling are all sustainable. The product fixed cost is 300 and the offering fixed cost is 1,200. Components selling is not sustainable because the price an entrant offering the bundle expecting to attract just Group B could charge, 54, is below the sum of the prices a components seller would have to charge.

Now consider mixed bundling. If the incumbent allocates all the product fixed costs to the individual goods, the prices of the goods (55) would exceed the price of the bundle (51). To change the allocation so that the prices of the individual goods do not exceed the price of the bundle, the incumbent would have to charge 52.3 for both (based on $k_M=0.56$). That price is not, however, sustainable, as a pure bundler could attract all the customers with a price of 51. To lower the price of the individual goods to 51, the incumbent would have to raise the price of the bundle to 53. The allocation underlying those prices is $k_M=0.33$. Any allocation based on k_M between 0 and 0.33 generates sustainable prices. Within that range, the price of a pure bundler would not attract Groups 1 and 2 and the price of a components seller would not attract Group B.

“Tying” is also sustainable. As with mixed bundling the allocation of the product fixed costs to Good 1 must generate a price for Good 1 that does not exceed the price a pure bundler can charge for the bundle. The maximum portion of the product fixed cost that can be allocated to Good 1 is 0.33, generating a price of 51. The price of the bundle associated with $k_T = 0.33$ is 51.8. It is lower than the price of the bundle associated with $k_M = 0.33$ because Groups 2 and B buy the bundle under “tying” whereas only Group B buys it under mixed bundling.

Finally, pure bundling at a price of 51 is sustainable. To enter by selling Good 1 just to Group 1 would have to charge 55. If an entrant offering both goods and the bundle charged 51 for the individual goods, it would not attract Group B as it would have to charge 53 for the bundle.

In Table C2, components selling, mixed bundling, and pure bundling are all sustainable. Consider first the feasible ranges on mixed bundling and “tying.” For mixed bundling, even if all the product fixed costs are allocated to the individual goods, the price of the bundle, 86.0, exceeds the price of the individual goods, 55.0. However, because a price of 55.0 for the individual goods exceeds 54.8, the price a pure bundler could charge, enough of the product

fixed costs must be allocated to the bundle to bring the price of the individual goods down to 54.8. The same point applies to “tying.” On the other end, if all the product fixed costs were allocated to the bundle, Group B would buy the individual items since the bundle price of 114.0 exceeds the sum of the prices of the individual goods. For Group B to buy the bundle rather than the individual items from the incumbent, k_M must be at least 0.43, which would reduce the price of the bundle to 102 and increase the prices of the individual items to 51. Those prices would not, however, be sustainable because an entrant that sells just the individual goods could charge 45, which would be better for all three groups. To insulate itself from entry by a components seller, the incumbent must price based on a k_M of at least 0.86, which would generate a bundle price of 90.0 and a price of the individual goods of 54.0. With “tying,” allocating all the product fixed costs to the bundle does not result in as high a price as it does under mixed bundling because the fixed costs are spread over a larger customer base. As a result, a firm selling just the individual goods for 45 each would not attract Group B given the incumbent’s price of 64.7 for the bundle.

As the bottom portion of Table C2 shows, components selling at a price of 45 is sustainable. A firm offering the bundle just to Group B would have to charge 114. The minimum price of the individual items under both mixed bundling and “tying” is 48 and the price of the bundle under pure bundling is 54.8. As a result, none of these strategies would threaten a price of 45 for both individual items. Pure bundling at a price of 54.8 is sustainable because a firm offering just one of the goods targeted at the group that wants just that good would have to charge 55; and there is no strategy that gives Group B a better price than 54.8. The range of sustainable prices for mixed bundling is narrow, as the price of the individual goods cannot exceed 54.8 while the bundle price cannot exceed 90. However, there is a range of prices that meets those constraints. “Tying” is not sustainable because the minimum price of the bundle, which Group 2 buys, is 60.0; and an entrant selling Good 2 just to Group 2 can charge 55.0.

Table C1
Pure Bundling, “Tying,” and Mixed Bundling Sustainable

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>	<i>k</i>
<i>Demand</i>	50	200	
<i>Marginal Cost (c_S, c_B)</i>	25	45	
<i>Fixed Offering Cost (F)</i>	1200	1200	
<i>Fixed Product Cost (G)</i>	300	300	
Break-Even Prices			
<i>Components</i>	31.0		
<i>Mixed Bundling ($k_M = 0$)</i>	49.0	54.0	0.00
<i>Mixed Bundling ($k_M = k_{MB}$)</i>	51.0	53.0	0.33
<i>Mixed Bundling ($k_M = k_{MH}$)</i>	52.3	52.3	0.56
<i>Mixed Bundling ($k_M = 1$)</i>	55.0	51.0	1.00
<i>“Tying” ($k_T = 0$)</i>	49.0	52.2	0.00
<i>“Tying” ($k_T = k_{TB}$)</i>	51.0	51.8	0.44
<i>“Tying” ($k_T = k_{TH}$)</i>	51.7	51.7	0.44
<i>“Tying” ($k_T = 1$)</i>	55.0	51.0	1.00
<i>Pure Bundling</i>		51.0	
Sustainable			
<i>Pure Bundling</i>		51.0	
<i>“Tying” (lowest p_{TC})</i>	49.0	52.2	0
<i>“Tying” (highest p_{TC})</i>	51.0	51.8	0.33
<i>Mixed Bundling – lowest p_{MC}</i>	49.0	54.0	0
<i>Mixed Bundling – highest p_{MC}</i>	51.0	53.0	0.33

Table C2
Components, Mixed Bundling, and Pure Bundling Sustainable

Assumed Values	<i>Separate Product</i>	<i>Bundle</i>	<i>k</i>
<i>Demand</i>	100	50	
<i>Marginal Cost (c_S, c_B)</i>	25	40	
<i>Fixed Offering Cost (F)</i>	2300	2300	
<i>Fixed Product Cost (G)</i>	700	700	
Break-Even Prices			
<i>Components</i>	45.0		
<i>Mixed Bundling ($k_M = 0$)</i>	48.0	114.0	0.00
<i>Mixed Bundling ($k_M = k_{MC}$)</i>	51.0	102.0	0.43
<i>Mixed Bundling ($k_M = k_{MC}$)</i>	54.0	90.0	0.86
<i>Mixed Bundling ($k_M = k_{MB}$)</i>	54.8	86.8	0.97
<i>Mixed Bundling ($k_M = 1$)</i>	55.0	86.0	1.00
<i>“Tying” ($k_T = 0$)</i>	48.0	64.7	0.00
<i>“Tying” ($k_T = k_{TB}$)</i>	54.8	60.1	0.97
<i>“Tying” ($k_T = 1$)</i>	55.0	60.0	1.00
<i>Pure Bundling</i>		54.8	
Sustainable			
<i>Components</i>	45.0		
<i>Mixed Bundling – lowest p_{MC}</i>	54.0	90.0	0.86
<i>Mixed Bundling – highest p_{MC}</i>	54.8	86.8	0.97
<i>“Tying” (lowest p_{TC})</i>	48.0	64.7	0
<i>“Tying” (highest p_{TC})</i>	54.8	60.1	0.97
<i>Pure Bundling</i>		54.8	