The Role of Cost in Determining When Firms Offer Bundles and Ties*

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Abstract: This paper examines the role of costs in explaining why products are bundled and specifically focuses on why they are tied; tying is a special case of bundling in which a product is not provided separately from the bundle. We assume that firms are not motivated by the standard price discrimination or foreclosure reasons discussed in the existing literature. With these assumptions, we show that marginal cost savings realized by producers or consumers are sufficient for explaining why firms bundle but are neither necessary nor sufficient for explaining why firms tie. Product-specific scale economies are necessary for explaining why costs drive firms to tie. Firms eliminate a choice desired by some group of consumers to realize these economies and thereby reduce prices overall. Our cost-based approach provides insights into bundling and tying in three markets—decongestants and pain relievers, foreign electrical adapters, and automobiles.

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I. Introduction

This paper presents a model of bundling and tying under competition and reports three case studies that illustrate the effects predicted by the model. Bundling is the practice of selling two or more goods in combination that could be sold separately. Tying occurs when goods are bundled and at least one of the goods is not available separately. In the economics literature, the term "mixed bundling" means that the goods are sold both separately as well as together, typically with a discount for the bundle relative to the sum of the component prices. "Pure bundling" means that only the bundle is available. Tying includes pure bundling, but the term also applies to cases when the bundle and only some of the components are available.[1]

The economics literature on bundling and tying has focused on why firms with market power might use these practices. In the price discrimination strand of the literature, the models typically explore how bundling and tying can be used to extract more consumer surplus than is possible from selling individual components.[2] Another strand of the literature explores the use of tying to foreclose competitors by deterring entry or encouraging exit.[3]

These models do not explain the prevalence of bundling and tying in competitive markets in which price discrimination and foreclosure are not plausible explanations. For

[1] We use the term "tying" to refer to any situation in which consumers who want one product can only get it if they buy another product. The courts have had a long-standing concern that firms with market power use tying for anti-competitive reasons. See Areeda (1991) at ¶1702. However, the courts would not necessarily attach the tying label to all of the situations that we do in this paper; moreover, the courts would undertake further analysis to determine whether tying raises anticompetitive concerns. We discuss the implications of our analysis for tying law in Evans and Salinger (2004).

[2] For a recent example, see Bakos & Eric Brynjolfsson (2000).

[3] See Whinston (1990), Carlton and Waldman (2002) and Nalebuff (2004) for specific models, and Nalebuff (2003) for a review of the economic literature and applications to antitrust cases.

that we must consider efficiencies realized by producers or consumers. It is obvious that firms may sell things in combination to realize cost savings for themselves (such as packaging costs) or for consumers (such as lower transaction costs). It is less obvious why firms do not sell components separately to consumers who do not want the entire bundle but do want the components. So we set out to address the question of why firms in competitive markets engage in tying.

This paper develops a model that clarifies the relationship between bundling efficiencies and tying and in the course of doing so answers that question. To make sense of tying under competition, we need to understand why a particular product is not offered even if there are some customers who would like to purchase it. An obvious explanation to consider is that there are scale economies associated with each product offering. For simplicity, we will assume that these scale economies arise because of product-specific fixed costs.

When we take account of these fixed costs, the model predicts that tying can occur in two distinct cases. First, modest product-specific fixed costs can give rise to pure bundling when a substantial fraction of customers want both components of the bundle and the fraction of customers who want one of the components is too small to justify offering it. Second, substantial product-specific fixed costs can give rise to tying even if no customers want both components.

We illustrate the main points of our model with case studies of three product groupings. In the case of over-the-counter pain relievers and cold medicines we find mixed bundling and we present some estimates of the marginal cost savings that give rise to the bundled offerings we observe. For automobiles, we show that there has been a

trend toward tying of optional equipment with certain mid-size sedans. We argue that this is an example of the first kind of situation in which tying can occur—modest fixed cost savings together with most consumers wanting certain options together results in tying that eliminates certain choices for some consumers. The fixed cost savings result from less product complexity—a relationship that was becoming better understood among the automobile manufacturers during this period. Finally, we consider foreign electrical plug adapters. RadioShack only offers a bundle of four plug adapters even though few consumers would ever need all four. We argue that this happens because tying makes it possible to satisfy the needs of different groups of customers with a single product and to economize on product-specific fixed costs.

The remainder of the paper is organized as follows. Section II presents our theory. Sections III presents the cases. Section IV contains conclusions.

II. The Theory of Cost-Based Bundling in Contestable Markets

In this section, we present our theoretical model. Part A lays out the assumptions. Part B analyzes market outcomes. Part C derives efficient outcomes and compares them to the results from part B.

A. Assumptions

We make what we believe are the simplest possible assumptions to capture the essential features of tying and bundling under competition. There are two goods that can be sold either separately or bundled. There are three classes of customers. Type 1 customers want just good 1, type 2 customers want just good 2, and type B customers want both. Customers of each type are willing to pay much more for the good they want

than what they might have to pay in the market to obtain them.[4] Let X_1, X_2, and X_B be the number of each type of customer.[5] Let c_1 and c_2 be the constant marginal costs of producing goods 1 and 2 and c_B be the constant marginal cost of producing the bundle. We consider the situation in which some consumers would prefer to buy goods 1 and 2 in bundled form. That might be because the bundle costs less to produce and can therefore be offered at a lower price. Or it could be because the bundle provides convenience so that consumers are willing to pay a premium for the bundled product. To keep the model simple we assume that this desire results entirely from marginal cost savings. We assume that $c_B \leq c_1 + c_2$.

We also consider the possibility that bundling enables firms to lower fixed costs. We could assume generally that $F_B \leq F_1 + F_2$. However, to simplify the presentation we consider the special case in which each product offering has the same fixed cost F; this case corresponds to the situation in which a product offering requires shelf-space, inventory control, and other similar costs. The fixed cost may provide an opportunity to obtain scale economies by offering only the bundle. But if the firm offers the two separate products it will have to incur an additional fixed cost to offer the bundle and it must weigh this fixed cost against the marginal cost savings from bundling discussed above.

[4] These assumptions are a special case of the demand assumptions from the price discrimination strand of the literature. In that literature, demand is typically modeled as a statistical distribution of reservation prices for the components. We are assuming that this distribution is concentrated at three points. One point entails a high value on good 1 and 0 on good 2. Another does the reverse. The third point entails a high value for both.

[5] Assuming variation in the willingness to pay within each group would complicate the exposition, but would not fundamentally alter our analysis of sustainable market outcomes. Given our contestability assumption below, prices are determined by the intersection of a demand curve and an average cost curve. The assumption of perfectly inelastic demand allows us to solve for the prices in closed form; and it simplifies the notation because entry would not change the quantity purchased by each group. Our approach to determining what outcomes are sustainable does not, however, depend on this assumption.

We cannot assume perfect competition given the existence of product-specific scale economies. Instead, we model markets as being perfectly contestable in the sense of Baumol, Panzar, Willig (1982). Despite the standard theoretical and empirical criticisms of contestability,[6] it provides a simple and convenient way of modeling markets that are quite competitive despite some product-specific scale economies and product differentiation. The theory captures the notion that the threat of entry makes prices track costs closely despite some short-run power over price.

Contestability eliminates the foreclosure explanations for tying discussed by, for example, Whinston (1990). Given our assumptions about costs, it also rules out the use of bundling to exploit different elasticities of demand across groups.[7] Bundling and tying can therefore only result from the marginal or fixed cost savings we do consider.

The objective of the model is to analyze what products are offered.[8] There are five possibilities.[9] With mixed bundling, the bundle and both components are offered. Under

[6] Stiglitz (1989) presented a model in which minor deviations from the contestability assumption implied large deviations from contestability. Morrison and Winston (1987) showed that actual entry into airline markets led to price reductions, which contradicted a prediction of the model. The airline industry had been held out as the prime candidate to apply contestability theory, so rejection for that industry cast doubt on whether it was a useful framework for understanding any industry.

[7] As we discuss in note 18 below, the model can be interpreted as allowing price discrimination, but at a cost. However, the threat of entry prevents the use of bundling to charge a monopoly price to a particular segment. Our ssumption that the fixed costs are associated with each product offering (rather than with the individual components) is essential to this point. If there were scale economies associated with the production of the individual components, then there would be economies of scope between the separate components and the bundle. The fixed cost for each component would then (under mixed bundling) be covered by the mark-ups over marginal cost for both the component and the bundle. We believe that Ramsey pricing principles would apply: the relative mark-ups would depend on demand elasticities and cross-price elasticities. With our assumptions, however, there are no economies of scope, so each product must cover its own costs. The price that does so is determined by the intersection of the demand curve and the average cost curve and not by the elasticity of demand at that or any other point.

[8] As a result, this paper should be viewed as part of the literature on product variety. The central issue addressed by that literature is whether, given heterogeneous customer preferences and product-specific scale economies, the set of product offerings is optimal. The models in that literature generally assume some form of monpolistic competition. (See Eaton and Lipsey (1989) for a review.) We have chosen the contestability framework rather than monopolistic competition because the latter models have two features that make them difficult to apply to the bundling and tying issues we address here. First, those models rest on demand structures that are difficult to adapt to a case in which there are two goods that can be sold

"components–selling," both components are offered but the bundle is not. With pure bundling, the bundle is offered but the separate components are not; good 1 and good 2 are tied to each other. There are two remaining cases of tying: the bundle and good 1 are offered; and the bundle and good 2 are offered. We note that, with the exception of mixed bundling, all of the possibilities entail some limitation on product choice.

The contestability assumption implies that price equals average cost. Table 1 contains the prices for each product in each possible set of product offerings.

Given the fixed cost, the average cost of an offering depends on how many customers buy it, which in turn depends on which products are available in the market. Compare the price of good 1 under mixed bundling and components selling. In the former outcome, only group 1 buys good 1, so the price is $c_1 + F/X_1$. In the latter, both groups 1 and B buy good 1. With additional purchasers to "share" the fixed cost, the price is $c_1 + F/(X_1 + X_B)$.

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either separately or in combination. (One alternative is a location model like the one introduced by Hotelling (1929) and subsequently used by, for example, Schmalensee (1978) and Salop (1979). A second alternative is a model that captures a taste for variety such as in Dixit and Stiglitz (1977). A third is the model of vertical product differentiation due to Shaked and Sutton (1983). None of these fits the problem we are addressing.) Second, those models assume that there are an infinite number of possible products; and it is the entry and exit of firms producing those products that act as the constraint on profits. In the problem we are analyzing, there are only three possible products: the two separate goods and the bundle. Limiting attention to those three goods brings the bundling and tying issues into sharp relief. The choice between the contestability assumption and monopolistic competition is not a matter of which one is literally true. Neither is. The justification for our choice is that it is tractable and it yields results that clarify what we observe in the cases.

[9] Recall that we have assumed that each customer group values the good(s) they want enough so that they will obtain them in some form. Without that assumption it would be possible for just one or none of the components to be offered.

Table 1. Offerings and Prices

Available Goods	*Outcome*	*Price* 1	2	B
All	Mixed Bundling	$c_1 + \frac{F}{X_1}$	$c_2 + \frac{F}{X_2}$	$c_B + \frac{F}{X_B}$
1 and 2	Components	$c_1 + \frac{F}{X_1 + X_B}$	$c_2 + \frac{F}{X_2 + X_B}$	
Bundle only	Pure Bundling			$c_B + \frac{F}{X_1 + X_2 + X_B}$
Bundle and Good 1	Good 1 tied to Good 2	$c_1 + \frac{F}{X_1}$		$c_B + \frac{F}{X_2 + X_B}$
Bundle and Good 2	Good 2 tied to Good 1		$c_2 + \frac{F}{X_2}$	$c_B + \frac{F}{X_1 + X_B}$

B. Sustainable market outcomes

We model market outcomes as "sustainable prices."[10] Sustainable prices must be equal to average cost to prevent entry from an identical good at a lower price. They must also prevent entry by firms that offer alternative combinations of the goods. Our proof of what outcomes are sustainable is left for the appendix. In general, we establish our results by determining the average cost for each set of product offerings (and allocation of customers to products). We then check to see whether it would be possible either to enter

[10] This description of sustainability is an adaptation of the formal definition given by Baumol, Panzar, and Willig (1982), pp. 192-3.

with a product not offered or to cut the price of an existing product to attract an additional group of customers.[11]

We provide a simple numerical example of our approach here. Suppose $c_1 = c_2 = 2$, $c_B = 3$, $X_1 = X_2 = X_B = 1$, and $F = 1$. With mixed bundling the price of the bundle would be 4 and the price of the components would be 3 each. If a firm just sold components its prices would be 3 each and the components combined would cost 6 to consumers who wanted both. If a firm just sold a bundle then the average cost would be 3 1/3.[12] That price would not, however, be low enough to attract groups 1 and 2 because it is not less than 3, the prices of the separate components. Thus, assuming all prices are set at average total cost, a firm offering a mixed bundle would defeat a firm that just sold the goods separately and a firm that offered a pure bundle. Mixed bundling is the only sustainable outcome.

The proof makes use of a set of "stand-alone" conditions. These are equations that determine whether a particular good must be included in a sustainable outcome. Good i must be part of a sustainable outcome if:

$$(1) \qquad c_i + \frac{F}{X_i} < c_B + \frac{F}{X_1 + X_2 + X_B} \qquad i = 1, 2 .$$

The left-hand side of equation (1) is the price of good i when the only group purchasing it is group i. That is the highest possible price for good i if it is offered. The right-hand side of equation (1) is the price of the bundle when all three groups buy it. That is the lowest possible price of the bundle. Equation (1) says that the highest possible

[11] For example, under mixed bundling, we analyze whether it would be possible to lower the price of the bundle to attract groups 1 and 2. Also, we analyze whether it would be possible to offer the components at low enough prices to attract group B.

price for good i is lower than the lowest possible price for the bundle. If it holds, pure bundling is not sustainable because it would be subject to entry with good 1.

Equation (1) is a sufficient condition for good i to be part of a sustainable offering, but it is not necessary. Suppose, for example, that equation (1) holds for good 1 but not for good 2. Since good 1 would be included in any sustainable outcome, the right-hand side of (1) does not give a possible price of the bundle. In this case, the condition that ensures that good 2 must be included in a sustainable outcome is (for i = 2):

$$(2) \qquad c_i + \frac{F}{X_i} < c_B + \frac{F}{X_i + X_B} \qquad i = 1, 2$$

The left-hand side of (2) is the same as (1). The right-hand side is the price of the bundle when groups i and B buy the bundle. Equation (2) says that if good 1 and the bundle were the only goods available, entry with good 2 would be profitable. As a result, the outcome in which good 2 is tied to good 1 would not be sustainable. We refer to equation (1) as the "strong stand-alone condition" for good i and equation (2) as the "weak stand-alone condition."

The stand-alone equation for the bundle is:

$$(3) \qquad c_B + \frac{F}{X_B} < c_1 + c_2 + \frac{F}{X_1 + X_B} + \frac{F}{X_2 + X_B}$$

The left-hand side of (3) is the price of the bundle when only group B buys the bundle. That is the highest possible price of the bundle. The right-hand side of (3) is the sum of the components prices under components pricing. Equation (3) says that if the

[12] That is, it is the sum of the marginal cost of the bundle, 3, and the average fixed cost, which is the fixed cost of 1 divided by the number of customers who buy the bundle, which is 3.

components were the only goods available, entry with the bundle would be profitable. If so, pure components selling is not a sustainable outcome.

Equation (3) determines whether it is profitable to offer the bundle at a price that attracts just group B. Pure components selling is also potentially subject to entry by a firm selling the bundle at a price that attracts all three groups. Such entry would be profitable if the following condition holds for both goods 1 and 2:

$$(4) \qquad c_B + \frac{F}{X_1+X_2+X_B} < c_i + \frac{F}{X_i+X_B} \qquad i=1,2$$

The left-hand side of equation (4) is the price of the bundle under pure bundling. The right-hand side is the price of the component goods under components selling. If equation (4) holds for both goods, then pure components selling is not sustainable. For entry with the bundle to be profitable, equation (4) must hold for both goods because the price for the bundle on the left-hand side of (4) is profitable only if both groups buy the bundle. Because pure bundling is the only sustainable outcome when equation (4) holds, we refer to it as the "pure bundling sufficiency condition."

With these four equations as background, we can now establish our basic result about which outcomes are sustainable for each possible set of parameters.

> *Theorem 1*: When equation (4) holds, pure bundling is the only sustainable outcome. When equation (4) does not hold, then the sustainable outcomes are given by Table 2.

Note that Table 2 is divided into two panels, A and B. The first covers those cases when the bundle stand-alone condition, equation (3), holds. The second covers when it does not. Within each panel, the entries in the rows and columns indicate which of the stand-alone conditions for the indivdual goods holds.

Table 2. Sustainable Scenarios

(A) Bundle Stand-Alone Condition Holds

		Good 1 Stand-Alone Conditions		
		Neither	Weak	Strong
Good 2	Neither	B	B	T1
Stand-Alone	Weak	B	B	M
Conditions	Strong	T2	M	M

(B) Bundle Stand-Alone Condition Does Not Hold

		Good 1 Stand-Alone Conditions		
		Neither	Weak	Strong
Good 2	Neither	B or C	B or C	C or T1
Stand-Alone	Weak	B or C	B or C	C
Conditions	Strong	C or T2	C	C

Legend:
B: Pure bundling
C: Components selling
M: Mixed bundling
T1: Tying – bundle and good 1 available
T2: Tying – bundle and good 2 available
Panels (A) and (B) assume that the pure bunding sufficiency condition (Equation (4) in the text) does not hold. The strong and weak stand-alone conditions for the individual goods are equations (1) and (2), respectively. The stand-alone condition for the bundle is equation (3).

While we leave the proof of Theorem 1 to the appendix, the logic behind it is intuitive. There are three possible products. When all three stand-alone conditions hold, all must be offered in a sustainable configuration, so mixed bundling results.[13] When the stand-alone conditions for two of the goods hold but the other does not, then those two are offered in a sustainable configuration and the other is not. When the bundle stand-alone condition holds and neither strong stand-alone condition holds for the individual goods, pure bundling is the only sustainable outcome.[14] When the strong stand-alone condition for one of the separate goods (good 1, say) holds but none of the other stand-

[13] A nuance in this result is that if the bundle stand-alone condition and the strong stand-alone condition for one of the separate goods holds, then only the weak stand-alone condition for the other good is needed for mixed bundling to be the only sustainable configuration.
[14] The bundle stand-alone condition ensures that the bundle is part of a sustainable configuration. Given that the bundle is offered, the failure of the strong stand-alone conditions for the components implies that they are not offered.

alone conditions hold, then there are two sustainable outcomes.[15] Good 1 is offered in both, with the other good being either good 2 or the bundle. When neither the bundle stand-alone condition nor either of the strong stand-alone conditions for the separate goods holds, either pure bundling or pure components selling are the two sustainable equilibria.[16]

An important corollary of Theorem 1 is that pure bundling can occur under two quite different types of circumstances. The first is when equation (4) holds. Equation (4) can be written as:

$$(4') \qquad F\frac{X_j}{X_1+X_2+X_B} > (c_B - c_i)(X_i + X_B) \qquad i, j \in (1,2) \quad j \neq i$$

Because it places a lower bound on the level of fixed costs, equation (4) says that pure bundling occurs when fixed costs are very high.[17] Indeed, if fixed costs are sufficiently high, (4') could hold even if X_B were equal to 0, which would mean that no one would want both components of the bundle. The intuition behind the result is simple. With pure bundling, only one fixed cost must be incurred to meet the demands of both groups 1 and 2 (and, if $X_B > 0$, group B). When fixed costs are high enough, the saving in fixed costs more than compensates for the additional marginal costs from providing groups 1 and 2 with a component they do not want. Cost savings lie at the heart of the result, but the savings are of fixed costs of product offerings, not marginal costs.

[15] The possibility of multiple sustainable outcomes is not an unusual feature of sustainability models. See Baumol, Panzar, and Willig (1982), pg. 195 for a graph with many sustainable price vectors.
[16] As we note in the appendix, in this formulation it is possible to have multiple sustainable equilbria.
[17] Equation (4) cannot hold if X_1 or X_2 is 0. Under such circumstances, there would be no reason to offer the separate component that no one wants. The bundle would definitely be offered. Whether the other good

The second case in which pure bundling is the only sustainable outcome is covered in the upper left-hand quadrant in panel A. Here, the bundle stand-alone equation (3) holds but strong stand-alone conditions given by equation (1) do not hold for either good. To better understand this set of circumstances, note that if equation (1) does not hold, then:

$$(5) \qquad \frac{X_j + X_B}{X_1 + X_2 + X_B} F > \left(c_B - c_i\right) X_i \qquad i, j \in \{1, 2\} \;\; j \neq i$$

Also, we can rewrite (3) as:

$$(3') \qquad \frac{X_1 X_2 - X_B^2}{\left(X_1 + X_B\right)\left(X_2 + X_B\right)} F < (c_1 + c_2 - c_B) X_B$$

Equation (5) says that fixed costs must be high enough to make it unprofitable to offer the separate components, so it implies a lower bound on F. Equation (3') says that fixed costs must be low enough that it is profitable to offer the bundle even if the components are also available. It therefore places an upper bound on fixed costs. Both can hold only if the upper bound implied by (3') is greater than the lower bound implied by (5). The factors that would tend to make that happen are that groups 1 or 2 are small relative to group B and that there are substantial marginal cost savings (in which case c_B

Indeed, if $X_1X_2 < X_B^2$, then (3') must hold. To understand this result, suppose that all three groups are of equal size, in which case $X_1X_2 = X_B^2$. Then, if members of group B buy components, they pay half the fixed cost for good 1 and half the fixed cost for good 2. Their aggregate contribution to fixed costs would then be the same as when they buy the bundle and pay all of one fixed cost. In that event, any marginal cost savings from the bundle would cause (3') to hold. It follows that if X_1X_2 is strictly less than X_B^2, no marginal costs savings from bundling are needed to ensure that the bundle exists.

Both sets of conditions for pure bundling reveal a subtle relationship between marginal cost savings from bundling and fixed costs. Marginal cost savings are not necessary for either (3') and (5) to hold or for (4) to hold. Given enough people who demand both components and few enough who demand just one or given sufficiently high fixed costs, pure bundling can arise simply because of product-specific scale economies. Marginal cost savings from bundling do, however, weaken the conditions on the other variables for both sets of conditions. Thus, marginal cost saving can be a factor that contributes to whether tying occurs, but they are neither necessary nor sufficient for tying.

C. Welfare Analysis

Given the assumption that all customers buy, the efficient outcome is the one that minimizes total cost. Table 3 summarizes the results and is structured along the lines of the following discussion.

Table 3. Efficient Outcomes

Outcome	*Sufficient Conditions for Outcome to be Efficient*	*# of Efficiency Stand-Alone Conditions*
Mixed Bundling	$F<(c_B-c_2)X_2$ * $F<(c_1+c_2-c_B)X_B$	3
Good 2 Tied (T1)	$(c_B-c_1)X_1 > F > (c_B-c_2)X_2$ $F < (c_1+c_2-c_B)X_B$	2
Components	$(c_B-c_2)X_2 > F > (c_1+c_2-c_B)X_B$ *	2
Pure Bundling	$(c_1+c_2-c_B)X_B > F > (c_B-c_1)X_1$ *	1
Good 2 Tied (T1)	$(c_B-c_1)X_1 > F > (c_B-c_2)X_2$ $F > (c_1+c_2-c_B)X_B > (c_B-c_2)X$	1
Components	$(c_B-c_1)X_1 > F > (c_B-c_2)X_2$ $(c_B-c_2)X_2 > (c_1+c_2-c_B)X_B$	1
Components	$F>(c_1+c_2-c_B)X_B$ $F>(c_B-c_1)X_1$ * $F<(c_B-c_1)X_1+(c_B-c_2)X_2-(c_1+c_2-c_B)X_B$	0
Pure Bundling	$F>(c_B-c_1)X_1$ * $F>(c_B-c_1)X_1+(c_B-c_2)X_2-(c_1+c_2-c_B)X_B$	0
Note: Table assumes the labeling convention $(c_B - c_1)X_1 > (c_B - c_2)X_2$. An "*" means that a condition and the labeling convention imply that an additional condition holds.		

Which outcome is efficient depends critically on which of the following conditions hold:

(6) $F<(c_B-c_i)X_i \quad i=1,2$

(7) $F<(c_1+c_2-c_B)X_B$

Equation (6) is an efficiency stand-alone condition for the individual goods. It says that the fixed cost of offering good i is less than the extra marginal cost from having group i

purchase the bundle. When it holds, it is efficient to offer good i whether or not the bundle is also offered. Equation (7) is an efficiency stand-alone condition for the bundle. If it holds, then the fixed cost of adding the bundle is less than the additional marginal cost from having group B buy the components separately.

It will be useful to adopt the labeling convention that $(c_B - c_1)\ X_1 \geq (c_B - c_2)\ X_2$. The assumption implies that if it is efficient to have the bundle and one of the component goods available, then the separately available item should be good 1.

To establish the conditions for efficient outcomes, we first assume that all three stand-alone conditions hold. Then we assume that two hold, that one holds, and that none hold. If all three stand-alone conditions hold, then all three goods should be offered and mixed bundling is the efficient outcome. If two hold, then the one that does not hold is either the one for the bundle or the one for good 2. If it is the former, then components selling is efficient. If it is the latter, then it is efficient for good 1 and the bundle to be offered.

If only one efficiency stand-alone condition holds, then it must be the one for the bundle or for good 1. If it is the former, then pure bundling is efficient. If it is the latter, then it is efficient to offer good 1. It is not efficient to offer both good 2 and the bundle, but one of them must be offered. Consider the condition:

(8) $$(c_1 + c_2 - c_B)\ X_B > (c_B - c_2) X_2$$

The left-hand side is the extra marginal cost that results when group B buys components. The right-hand side is the extra marginal cost when group 2 buys the bundle. If (8) holds, then the bundle should be offered along with good 1. That is, tying is efficient. If (8) does not hold, then components selling is efficient.

Finally, suppose that none of the efficiency stand-alone conditions hold. If so, it would be inefficient to offer the bundle along with any of the separate goods. Thus, the choice is between pure bundling and components selling. The efficient choice turns on:

$$F > (c_B - c_1)X_1 + (c_B - c_2)X_2 - (c_1 + c_2 - c_B)\,X_B \qquad (9)$$

The right-hand side of (9) is the net marginal cost savings of offering components rather than the bundle. It is the difference between the marginal cost savings to groups 1 and 2 from being able to buy the separate good less the marginal cost of meeting the needs of group B with the separate components rather than the bundle. The condition states that these savings are less than the fixed cost of the additional offering involved in components selling as compared to pure bundling. If (9) holds, then pure bundling is efficient. If it does not, then components selling is.

With these results, we can now address whether sustainable outcomes are efficient. One immediate point to note is that there are some conditions under which there are multiple sustainable outcomes. Yet, except when the conditions hold with equality, there is a unique efficient outcome. Thus, sustainable outcomes are not necessarily efficient outcomes.[18]

Rather than attempting a complete characterization of when sustainable outcomes are or are not efficient, we identify the general sources of deviations. It is instructive to

[18] The result that sustainable outcomes are not efficient rests on the assumption that firms cannot costlessly price discriminate between groups. If, for example, the sellers of goods 1 and 2 could charge different prices to group B, then it would not be possible for the bundle to survive in a sustainable outcome when $F > (c_1 + c_2 - c_B)X_B$. Indeed, with costless price discrimination, there would be economies of scope between the production of the component goods and the bundle. One interpretation of the model is that it allows for costly price discrimination where F is the cost of, say, segmenting group B. While a bundle discount in this model can be understood as price discrimination, the contestability assumption rules out the use of price discrimination to exploit differences in the elasticity of demand across groups.

compare the stand-alone conditions, equations (1) and (3), with the efficiency stand-alone conditions.

We can rewrite equation (1), the stand-alone condition for the separate goods as:

(1') $$\frac{X_j + X_B}{X_1 + X_2 + X_B} F < \left(c_B - c_i\right) X_i \qquad i, j \in \{1,2\} \;\; j \neq i$$

The right-hand side of (1') is identical to the right-hand side of equation (6), the efficiency stand-alone condition for the separate goods. The left-hand side of (6) is F while the right-hand side of (1') is F multiplied by a fraction less than 1. Thus, (1') is a strictly weaker condition than (6). A comparison of (3) and (7) lead to a similar conclusion and for the same reason.

To understand the nature of the distortion, consider whether components selling is sustainable and efficient. It is not efficient if the fixed cost of offering the bundle is less than the extra marginal cost of having group B buy components. It is not sustainable if the *additional* fixed costs that members of group B pay if they buy the bundle are less than the savings in marginal costs. These additional fixed costs are the full fixed cost of the bundled offering less the share of the fixed costs of the components that members of group B pay when they buy components. The additional fixed cost of the bundled offering is a social cost, but the savings from avoiding a share of the fixed costs of the components is not.

Relaxing the contestability assumption would likely strengthen the result that mixed bundling can occur even when it is efficient to have some limitation on the set of products offered. The highly competitive pricing that is implicit in the contestability

assumption makes it harder for a particular good to cover its fixed costs. Less intense price competition would facilitate entry.[19]

It is also of interest to compare equations (4'), one of the two sets of conditions for pure bundling to be the unique sustainable outcome, with (9), a condition for pure bundling to be the efficient outcome. Adding (4') together for both goods gives:

$$(10) \qquad F\frac{X_1+X_2}{X_1+X_2+X_B} > (c_B-c_1)X_1+(c_B-c_2)X_2-(c_1+c_2-c_B)X_B$$

Equation (10) is weaker than equation (4) but stronger than equation (9). It follows that components selling can be sustainable even if pure bundling is efficient.

It is possible in this model for tying to occur when it is not efficient. In general, entry decisions in this model are distorted because each group gets a private benefit from avoiding the share of fixed costs it would pay if it purchased a good that would otherwise be available. The bigger the group, the bigger the distortion. Thus, there is a bias in the model toward providing what the biggest group wants. If group B is the biggest group, then the bundle can be offered in a sustainable outcome even when components selling is efficient; and the existence of the bundle might preclude entry by one of the component goods. But the reverse effect is present as well. If groups 1 or 2 are particularly large, they might get their most preferred good and thereby prevent the bundle from being offered even when there are substantial marginal cost savings from bundling.

Based on the existing product selection literature, it is not surprising that the number of goods in the market or the selection of goods in the market is different from what maximizes welfare. It is also not surprising that the distortion on the number of goods can go in either direction. Still, one could interpret this model to suggest that the

[19] This result is consistent with similar results in the product selection literature. See Spence (1976).

market is biased toward mixed bundling and therefore away from tying. We do not see any way to interpret the model to suggest that the market is systematically biased toward tying.

III. Empirical Analysis of Bundling and Tying in Competitive Markets

This section uses the results of our simple model to help understand practices we observe in three markets: cold and pain relief medicines, automobiles, and foreign electrical adapters. We chose these products mainly because it was easy to obtain data and because we were familiar with them from practical experience. They do not even begin to represent a random sample of products. As it happens though, it appears that they reflect three important cases of the model. Cold and pain relief medicines provide an example of mixed bundling. Bundling appears to occur because of marginal cost savings, but the the components are also provided separately. Automobiles provides an example of the first set of circumstances in which tying can occur for cost-based reasons. There are modest fixed costs and a substantial portion of consumers who prefer the bundle. Foreign electrical adapters may provide an example of the second set of circumstances in which pure bundling can occur for cost-based reasons. It appears that fixed costs of stocking these adapters is large enough that even though few consumers want all of the adapters in the bundle, it is more profitable for the seller to package them together.

A. Cold and Pain Relief Medicines

The products we analyze contain the pain relievers ibuprofen or acetaminophen, the decongestant pseudoephedrine HCl, the antihistamines chlorpheniramine maleate or diphenhydramine HCl, or combinations of at least two. These are examples of “over-the-

counter" pharmaceuticals,[20] products that are available both in branded[21] and generic (or store-brand) versions. Tablets targeted at specific conditions often contain more than one active ingredient. For example, both Tylenol Sinus and Sudafed Sinus Headache tablets contain acetaminophen and pseudoephedrine HCl. The brand Coricidin contains acetaminophen and chlorpheniramine maleate.

Consumers pay substantially less for bundled products than they would for components separately. Table 4 illustrates the point. It lists the prices that we downloaded from www.cvs.com[22] for 24-tablet packages of extra Strength[23] Tylenol, Maximum Strength[24] Sudafed, and Tylenol and Sudafed brand tablets that combine both. We also downloaded the prices of the CVS versions of the same products.[25] As shown in Table 4, the prices of the branded combination products are $5.99, whereas the sum of the prices of the separate branded items is $8.58; for the CVS brand, the price of the combination product is $3.99, whereas the sum of the prices of the separate products is $6.48. These savings are a substantial percentage of the prices of the items.

[20] Over-the-counter medications are those that can be obtained in the United States without a prescription. Drugs for which consumers need a prescription are referred to as "ethical pharamaceuticals."
[21] Tylenonl is a brand of acetaminophen. Advil and Motrin are brands of ibuprofen. Sudafed and Contac are brands of pseudoephedrine HCl. Chlor-Trimeton is a brand of chlorpheniramine maleate. Benadryl is a brand of diphenydramine HCl.
[22] CVS is a large drug store chain. The web site www.cvs.com is its "on-line pharmacy."
[23] Extra Strength Tylenol tablets contain 500 mg of acetaminophen. In contrast, "Regular Strength" acetaminophen tablets contain 325 mg while "Arthritis Strength" tablets contain 650 mg.
[24] Maximimum Strength pseudoephedrine HCl tablets contain 30 mg of active ingredient.
[25] The regressions in this paper are based on prices we observed at a drug store. We use data from the web for this example because our data set did not include as clean a comparison as this one for both branded and store-brand products.

Table 4. Prices for 24 Tablet/Caplet Packages

Brand	Combination	Pseudoephedrine HCl alone	Acetaminophen alone
Tylenol	$5.99	NA	$3.99
Sudafed	$5.99	$4.59	NA
CVS	$3.99	$3.49	$2.99

Notes: Tylenol: "Tylenol Sinus Caplet" (the combination product) and "Tylenol Extra Strength Caplets." Sudafed: "Sudafed Sinus and Headache Caplet" (the combination product) and "Sudafed Sinus & Cold." CVS: "Non-Aspirin Sinus Caplets Maximum Strength" (the combination product), "Nasal Decongestant Tablets Maximum Strength," and "Non-Aspirin Caplets Extra Strength." NA denotes a combination that was not offered.
Doses are 30mg of pseudoephedrine HCl and 500mg of acetaminophen.
Source: Downloaded from CVS Web site, http://www.cvs.com, Feb. 11, 2004.

To more completely understand the benefit consumers get from bundled products, we collected data on the prices of all cold[26] and pain relief medications sold at the Walgreen's at 757 N. Michigan Ave in Chicago on April 3, 2003. For each package, we observed the seller, the price, the dosage form,[27] the quantity of each active ingredient per unit, and the number of units.[28]

We estimated a regression in which the price of a package is a function of the amount of active ingredient, the number of tablets, and whether or not the product is branded. Specifically, we selected the following functional form:

$$(11)\quad R_i = b_0 + b_1 D_i + b_2 T_i + b_3 T_i^2 + b_4 T_i D_i + b_5 T_i^2 D_i + \sum_{j=1}^{N} c_j Y_{ij}$$

where:

R_i is the price of package i
T_i is the number of tablets in package i
D_i is a brand name dummy for package i
Y_{ij} is the amount of active ingredient j in package i

[26] We use the term "cold" to include medications labeled as sinus, allergy, and cough as well.
[27] Doseage forms include tablets, caplets, liquid, "gel tabs," etc.
[28] We have checked prices on the web and at other outlets to confirm that the regularties we document are not specific to this particular location and time.

We included quadratic terms for the number of tablets because plots of prices against package size for products available in a wide range of package sizes revealed significant curvatures to the relationships.[29] The brand name dummy enters separately and in interaction terms with the linear and quadratic tablet terms. This approach provides for flexibility in how the brand name premium is extracted.[30]

The data set we collected had 305 observations. For an observation to be included in the data set, however, we required that the package meet the following conditions:

1. The package contained tablets or dosage forms typically priced the same as tablets.[31]
2. The active ingredients be limited to the pain relievers acetaminophen and ibuprofen, the decongestant pseudoephedrine hydrochloride, and the antihistimines chlorpheniramine maleate and diphenhydramine HCl.[32]

We restricted attention to tablets to avoid any misspecification that could arise from modeling the effect of delivery form inappropriately. We chose this set of active ingredients because they are available both separately and in bundled form.

[29] A possible cost-based explanation for this curvature is that package expense increases non-linearly with the number of tablets.

[30] With more data, we would have also included interactions between the brand name dummy and the variables measuring the amount of active ingredient. In comparing, say, the prices of the different strengths of Tylenol, it would be interesting to understand whether Johnson & Johnson extracts the rents on a per tablet based on the number of tablets or on the amount of active ingredient.

[31] This filter excluded any medicines in liquid or packet form as well as "liquigels," which typically sell for a premium. It includes caplets.

[32] Thus, we excluded medicines with cough suppressants. The products we observed contained a much greater variety of cough suppressants than of the other types of ingredients, and we were concerned that we did not have sufficient data to estimate with much accuracy the price effects of each cough suppressant.

The estimated equation is:

$$R_i = \underset{(7.25)^*}{2.31} + \underset{(1.89)}{0.029 T_i} - \underset{(4.12)^*}{3.3\times10^{-5} T_i^2} + \underset{(1.47)}{0.63 D_i} + \underset{(5.15)^*}{0.54 T_i D_i} - \underset{(2.85)^*}{1.54\times10^{-4} T_i^2 D_i}$$

$$(12) \qquad + \underset{(0.95)}{0.014 IB_i} + \underset{(0.85)}{0.012 AC_i} + \underset{(5.13)^*}{0.065 PH_i} + \underset{(1.89)}{0.035 CM_i} + \underset{(2.90)^*}{0.042 DI_i}$$

$$s = 1.24, R^2 = 0.91, F = 132.31^*, N = 112$$

(Note: Values in parenthesis are absolute values of asymptotic t-statistics based on heteroskedasticity-consistent standard errors. * denotes significance at 1% (two-tailed) level.)

Where:

IB_i = ibuprofen in package i in units of 200 mgs
AC_i = acetaminophen in package i in units of 500 mgs
PH_i = pseudoephedrine HCl in package i in units of 30 mgs
CM_i = chlorpheneramine maleate in package i in units of 2 mgs
DI_i = diphenhydramine in package i in units of 25 mgs

In equation (12), the intercept is estimated to be 2.31 and is highly significant. The next two terms reflect the increase in the price of a package as the number of tablets increases, holding constant the amount of active ingredient.[33] They suggest that at low quantities, each additional tablet adds $0.029 to the price of a package for small package sizes. The coefficient on the quadratic term is negative and highly significant, thus confirming a non-linearity in the package-size price relationship. The next three terms represent branding effects. The coefficient on the brand dummy is measured to be 0.63 but is not significant at the 5% level. The coefficients on the interactions between brand

[33] The coefficient on the linear term is not quite significant at the 5% level. It is apparently collinear with the variables that measure the quantity of active ingredients. (Dropping the linear term measuring the number of tablets results in substantially lower standard errors for the variables that measure the quantity of active ingredient.) This feature of the data limits the precision with which this coefficient is estimated.

and both the number of tablets and the square of the number of tablets are highly significant. The remaining coefficients all reflect the effect of the quantity of active ingredients.[34] While all of them have the expected sign, the coefficients on chlorpheniramine maleate, ibuprofen, and acetaminophen are not statistically significant.[35]

We now turn to the parts of the results that do reflect factors contained in our model.[36] The coefficients on the two tablet variables pick up costs that increase with the number of tablets. These costs include the marginal cost of producing a tablet; they could also include some packaging expense since package costs likely increase with package size. Indeed, a cost-based explanation for the significant coefficient on the quadratic term is that marginal packaging expense is a decreasing function of package size. These two variables imply a marginal cost saving of $0.68 for a package of 24 tablets and $1.32 for a package of 48 tablets.[37]

The intercept of $2.31 also reflects the price savings consumers get from buying bundled goods. The interpretation is more complicated than the package size effects discussed in the previous paragraph. The intercept reflects costs that are fixed *with respect to package size.* Some of these are, however, marginal *with respect to the*

[34] The precision of the estimates is about the same for all the active ingredients. The difference in significance is primariy a consequence of the size of the estimated coefficeints.

[35] While we considered omitting these variables, we did not because there is strong theoretical reason to believe that the coefficients on them are in fact positive. In addition, it is quite plausible that the size of the effects is small relative to the precision with which we can measure them with these data. The price of bulk acetaminophen is approximately $8/kg, or $0.004 per 500 mg tablet. (Source: Mark Kirschner, *Acetaminophen: August 11, 2003. (Chemical profile),* CHEMICAL MARKET REPORTER, 11 Aug., 2003.) The standard error of the estimated coefficient is 0.0137.

[36] The results on the branding coefficients are of independent interest because they provide evidence about how sellers of brand-name products extract the brand name premium. They also indicate that the brand name effect is the source of a substantial fraction of the bundle discount for purchasers of branded versions of these pharmaceuticals. The interpretation of this finding is subject to debate. As it reflects an effect outside our model, we do not dwell on it further here.

customer; that might include the fixed component of packaging expense and the cost of the time it takes to process each transaction. Others are fixed with respect to the customer; those might include the cost of shelf space and organizational costs that are increasing functions of the distinct number of products offered.

Without dividing the $2.31 into a fixed and marginal component,[38] we are left with a wide range for our estimate of marginal cost savings. Even with this wide range, though, we offer the following conclusions. First, the marginal cost savings from bundling are substantial. The $0.68, which is a lower bound on these savings, is a non-trivial percentage of the price of these products, and that is for tablets that combine only two active ingredients. Tablets that combine more than two would entail even larger marginal cost savings from bundling. Second, not all the savings consumers get from bundled products reflect marginal cost savings. This point is quantitatively more important for the savings consumers get from branded versions of bundled products, but it applies to store brands as well.

It is possible that price discrimination accounts for some of the cost savings we have inferred from price differences. But the facts suggest that cost savings are a more plausible explanation for what we observe than price discrimination. The bundled products provide convenience. We would expect a model of monopolistic price discrimination to predict a premium for the bundled product but, instead, we observe a substantial discount. Cost savings provides a better explanation of another phenomenon. Individual drugs are available in different dosage strengths (e.g. aminophen comes in

[37] The calculations are $0.029 \cdot 24 - 0.000033 \cdot 24^2 = 0.68$ and $0.029 \cdot 48 - 0.000033 \cdot 48^2 = 1.32$.
[38] In Evans and Salinger (2004), we do divide this cost into a fixed and marginal component, but we need to make strong assumptions to do so.

Regular Strength, Extra Strength, and Arthritis Strength). The price per unit of active ingredient is much lower for the stronger dosage forms. Cost-savings provide a single explanation for both the bundling and dosage size effects. Lastly, there are obvious physical features of the products that make it likely that the marginal cost of a bundled product is lower than the sum of the marginal costs of the separate products. The bundled product requires one package rather than two and the production of half the number of tablets. As long as the production of each package and each tablet entails some marginal cost, there have to be some marginal cost savings from bundling.

B. Automobiles

Models of automobiles (such as the two we focus on here: the Ford Taurus and the Honda Accord) can be purchased with optional equipment. Each model typically comes in a variety of series. One is the base model while the others include bundles of additional features. For example, the Honda Accord came in three series in 1986: the DX, the LX, and the LXi, with the DX being the base model and the LXi being the most feature-laden. In addition, options can be made available separately. Finally, each series might have available one or more equipment packages, which are also bundled options.

As Nalebuff suggests,[39] the case we analyze is typical of a general trend in the automobile industry. When Japanese imports first started to gain penetration into the United States market, they offered customers much less flexibility in choosing options than did United States manufacturers. That is, the Japanese companies tied options together while United States manufacturers did not. Over the past two decades, when

[39] See Nalebuff (2003), p. 31. We believe that a careful reading of his account supports our claim that the distinction we draw between marginal and fixed cost effects has not been adequately appreciated.

there has been apparently intense competition between the companies and large shifts of market share, the United States manufacturers came to tie options together to a greater extent than they had. Thus, tying appears to be a strategy that emerged as the result of competition.

We illustrate and explore this trend by comparing two popular, competing mid-sized sedans, the Ford Taurus and the Honda Accord.[40] We gathered data on available series and options and on prices for these cars in different years. Our source for earlier years was *Kelly's Blue Book*. For more recent years, we collected data from www.edmunds.com and from the companies' own web sites. Here, we report data for just two years, 1986 and 2004.

As noted above, there were three models of the Honda sedan[41] in 1986. The LX had nine[42] features that were not on the DX, and the LXi added four more features. Each series came with exactly one option: an automatic transmission. None of the additional features on the high-end models were available individually on the lower-end models. Thus, the nine additional features on the LX were tied together. The incremental list price of the package was $2,100. The additional four features on the LXi were also tied together at an incremental list price of $1,660; and these features that were unique to the LXi had the nine LX features tied to them.[43]

The way in which Ford made options available on the 1986 Taurus provides a stark contrast to Honda's strategy with the Accord. Like the Accord, it came in three

[40] In Evans and Salinger (2004), we also consider the Toyota Camry. We restrict attention here to the Accord and Taurus because they offer the biggest contrast. The strategy of Toyota with respect to the Camry was, however, closer to that of Honda than to Ford.
[41] The Accord also came as a hatchback. We restrict attention to the sedan.
[42] This count treats the AM/FM radio and cassette player as two separate features.

series,[44] which were labeled the L, the GL, and the LX. The GL had 15 features that were not standard on the L, and the LX had 17 features that were not standard on the GL. However, many of the features that were standard on the GL and LX were available on the L either separately or as part of an option package. We counted 50 options on the L that at least in principle were separately available.[45] Remarkably, all models of the Taurus came with a "radio delete" option (that included a credit), so not even a car radio was tied to the car.[46]

Table 5 lists the additional features on the Accord LX and LXi that did not come with the DX. It also indicates how those features (or apparently comparable ones) were treated on the Taurus. Of the thirteen options available on the Accord only in tied form, eleven were available separately on the Taurus. One was a standard feature on the GL and unavailable on the L. One was not available at all.

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[43] That is, one could not get the four additional items on the LXi without also getting the options tha t came with the LX.

[44] The Taurus was also available as a wagon. As with the Accord, we restrict attention to the Taurus sedan.

[45] It is hard to ascertain now whether a customer could in fact have purchased exactly the features he wanted. In principle, though, one could have ordered from the manufacturere a car with a specific set of features. Doing so might have entailed a long delivery lag and it might have limited a customer's ability to negotiate a discount from the sticker price. Still, Ford at least claimed to offer flexibility not offered by Honda at the time (or now) and that it no longer offers.

[46] The GL and the LX came with an AM/FM radio with stereo sound while the L came with just an AM radio. While the GL and LX did have a radio delete option, the option to downgrade to just an AM radio was not available. It is interesting that on the L, the radio delete option came with a $39 credit while the price of the upgrade to the AM/FM radio with stereo sound was $157. The sum of these two is $196, which was exactly the "radio delete" credit on the GL and LX.

Table 5. Tied Options on the 1986 Accord

	Accord	Taurus	
Bundled on Accord	**Standard Equipment on**	**Price as Separate Option**	**Standard on Series**
Air Conditioning	LX, LXi	$762	LX
Antenna, Power	LX, LXi	$71	-
Bumpers, Color-Keyed	LX, LXi	N/A	-
Door Locks, Power	LX, LXi	$221	LX
Mirrors, Dual Power Remote Control	LX, LXi	$96	GL, LX
Radio, AM/FM Stereo W/ Cassette	LX, LXi	$157	GL,LX
Cassette Player	LX, LXi	$127	-
Tires, Michelin Steel Belted Radial	LX, LXi	$72	GL,LX
Windows, Power	LX, LXi	$282	LX
Engine: 4-Cyl., 1955cc, 110 HP, EFI, 2.0 Liter	LXi	$672	LX
Moon Roof, Power	LXi	$701	-
Stabilizer Bar, Front and Rear	LXi	-	GL, LX
Wheels, Custom Alloy	LXi	178	-

Notes: AM/FM Radio and Cassette are listed as a single option on the Accord. We separate them because they are treated separately on the Taurus. Taurus prices for steel belted radial tires, 110 HP engine, and custom alloy wheels are for a tire upgrade, wheel upgrade, and engine upgrade.

Several features of these options are noteworthy. First, they are sufficiently diverse that it is unlikely that they entail marginal cost savings from bundling. For example, it is hard to see how the marginal cost of upgraded tires or wheels depends in any way on whether the car has an air conditioner. Also, the diversity of the items makes it likely that some people would want some but not all of them. A music lover who lives in a temperate climate might want the CD player and not the air conditioner. A Houston resident who is happy listening to AM radio stations might want the air conditioner but not the CD player. Third, the prices of the individual items on the Taurus are substantial. These prices are retail list prices, so one cannot reasonably interpret them as literally equaling either average or marginal cost. Still, the marginal costs of a car air conditioner, a more powerful engine, and a power moonroof – to take the three options that commanded the highest price on the Taurus – are likely non-trivial fractions of the cost of a car.

In 2004, Honda's strategy with respect to the tying of options remained virtually unchanged. Its offerings were a bit more complicated. It had six series rather than three and a very small number of the options on one series were available separately on a lower series. Still, each progression from one series to the next represented a set of tied options. In contrast, the offerings on the Taurus were much different in 2004 than in 1986. Whereas the most basic model in 1986 had fifty separately available features, the base model in 2004 had only five. This simplification resulted from three changes. First, some features that had been optional in 1986 were standard equipment on the basic series in 2004. Second, the total number of options within specific categories, such as tires and wheels, was reduced. Third, in contrast to 1986, there were many more options available only on the high-end models.[47]

To take just one notable option, the base Taurus model came with a standard air conditioner in 2004. Interestingly, Ford continued to make air conditioners optional equipment on some of its cars. For example, on the Escort, which is a smaller, less expensive model, an air conditioner was a $910 option in 2004.

The existing models of bundling and tying cannot explain this movement toward tying. Foreclosure is not a plausible explanation. Some of the features in question, such as tires or even a sound system, are items that some customers might want to buy from someone other than the manufacturer. In general, though, the features are ones that

[47] Ford's tying strategy in 2004 was more nuanced than was Honda's in 1986. In comparing two successive series (the LX and the SE, say), a substantial portion of the standard features on the more expensive series were available as separate options on the less expensive series. However, because the more expensive series had as options features that were not available on the less expensive series, tying was present to a greater degree than with the 1986 Taurus. For example, the additional standard equipment on the SES over the SE were a power driver seat, a sound system with a CD player, power antilock brakes, and aluminum wheels. The incremental price of the upgrade was $1,470. On the SE, the power seat was available

consumers are going to get from the manufacturer or not at all. Car companies do not tie a moon roof to a more powerful engine because they want to foreclose independent moon roof installers. As we will see in the adapter case, the price discrimination explanation goes in the wrong direction. By tying options together, Ford has limited its opportunities to use the pricing of options to segment the market.

As Nalebuff notes, cost savings are the most plausible explanation for Ford's change in behavior.[48] It is important to be clear, however, on the nature of the cost savings. They are not marginal cost savings like those that arise from putting two active ingredients into a single pill. Rather, they are product-specific scale economies that arise from a cost of product complexity. Moreover, the source of these costs is not as transparent as the cost of linear shelf space in a retail setting. Rather, they are the result of organizational and transactions costs, which are generally not well understood and might be quite difficult to measure.[49]

C. Foreign Plug Electrical Adapters

Electrical outlets vary across countries, so a plug that fits directly into outlets in, say, the United States does not fit outlets in, say, England. One can, however, purchase

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separately for $600. The power seat and CD-player were not available separately, but there was a $500 package that included both.

[48] In our model, Ford would only make air conditioner standard equipment on the Taurus if the average cost of producing a Taurus without an air conditioner literally exceeded the average cost of a Taurus with one. To get a more plausible, cost-based interpretation of the behavior, one needs to recognize how the facts of the case differ from the literal assumptions of the model. The Taurus is sold in a market in which substitutes are available. While the market is not perfectly competitive, it places limits on how much a company can charge for a given car. When the fixed cost of a product offering is taken into account, the average cost of a Taurus without an air conditioner would not necessarily be greater than the average cost of the Taurus with an air conditioner. It could, however, be sufficiently high that offering the Taurus without an air conditioner would be unprofitable at a price Ford could charge.

[49] See Evans and Salinger (2004) for a further discussion.

plug adapters that make it possible to use United States electrical equipment in England. We focus on a set of four plug adapters sold at RadioShack.

RadioShack is a retailer of electrical equipment. Part of its stated strategy is to offer otherwise hard-to-find electronic equipment at convenient locations.[50] In addition to selling electrical components, it sells electronic equipment such as televisions and computers. Compared to many other retailers of this latter type of electronic items, RadioShack's outlets are small. In addition to its traditional retail outlets, RadioShack sells items through a web site.

At the Radio Shack near the Boston University campus, one can purchase a package of four plug adapters for use in, roughly, England, Western Europe, Oceania, and North America. The store also sells the North American adapter separately. When we first observed these offerings on May 8, 2002, the prices were $9.99 for the package of four and $2.49 for the North American adapter. On March 1, 2004, the price for the package was $10.99 and the price for the North American adapter was $3.49. These same items are available for the same price (before shipping) at its web site. Also, at its web site, it offers the other three adapters under a different brand name. The price of the separate adapter for Great Britain is $4.99. The prices for the European and Oceania adapters were $2.49 each. The sum of the prices of the separate adapters on the web is $13.46.

This case raises the question of why RadioShack ties the foreign adapters together. The models of bundling as price discrimination do not provide a convincing explanation. Price discrimination is generally more compelling as an explanation for

mixed bundling than for tying. Stigler's (1968) seminal article on block booking presented a simple argument that tying could serve the same role as price discrimination. Subsequent analysis showed, though, that mixed bundling would generally dominate pure bundling as a price discrimination strategy.[51] We find it hard to even begin to tell a foreclosure story.

One can, however, make sense of RadioShack's adapter strategy within our model; and, indeed, the case illustrates one of the most surprising insights of the model about tying. In our model, tying can occur for one of two reasons. One is that a substantial fraction of customers want all the components of a bundle while the number of people who want just one of the components is too small to merit offering it separately. The other is that tying makes it possible to satisfy the needs of different groups of customers with a single offering.

We doubt that RadioShack offers the package because a substantial fraction of customers want all four adapters. Our skepticism rests primarily on two facts. First, we gathered data on travel statistics. The number of trips to Australia and New Zealand are much smaller than the number of trips to Europe and England. While those data are an admittedly crude indicator of demand, the numbers are so different that it seems likely that a relatively small fraction of the people who want the adapter for Europe and/or England also want the Oceania adapter. Second, the set includes the North American adapter, which would seem to be of little use to people from people in the United States who are planning to travel overseas.

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[50] It operates over 7,000 stores nationwide and claims that 94% of all people in the United States work or live within 5 minutes of a RadioShack.

[51] Adams and Yellen (1976) made this point with discrete examples. McAfee, McMillan, and Whinston (1989) made a similar point in a much more general model.

The cost-based model we presented predicts that tying can occur, even if no one wants all the components of the bundle, if fixed costs of product offerings are high. From the nature of RadioShack's business, the number of distinct items it can sell would seem to be a key constraint. Part of its strategy is to have small outlets. It typically stocks 3000 items at its stores, but it also offers a locater service based on a database of 100,000 items.[52] In addition, there are items available at its web site not available at its retail outlets.[53] The separate adapters are included in those items. While the fixed costs of additional product offerings at a web site are not zero, they are likely far less than the fixed costs of a product offering at a physical retail location.

Another insight of our model is that while marginal cost savings from bundling can be a factor that contributes to tying, they are not necessary for tying to occur. In this case, the price of the bundled item is approximately $2.50 less than the sum of the prices of the individual adapters on the web. If we interpret that as a cost savings within the context of our model, it represents both bundling efficiencies and a savings of average fixed costs. The packaged product does entail one package rather than four, so some marginal cost savings from bundling may well be present, but they appear to be at most a small piece of the explanation for why we observe tying in this case.

Measured by the amount of commerce at stake, this case may well be minor. It does, though, provide a clear illustration of the distinction between marginal and fixed cost savings from bundling. Retailing provides a natural setting to examine the effects of fixed costs of product offerings because shelf space is an obvious source of those fixed costs.

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[52] See "Radio Shack Looks Like a Palace Now," *Business Week*, May 13, 1996, p. 153.

IV. Conclusions

In this paper, we have presented a cost-based framework for analyzing tying and bundling and shown how the framework can help us understand tying and bundling in three quite different cases. We believe that the model is a powerful lens through which we can view the cases. In the pharmaceutical case, it helps us understand the sources of the substantial price savings that consumers get from bundled products. In the adapter case, it explains why we might observe tying even if very few customers want all the components of a bundle that is offered (even if the components themselves have substantial marginal costs). In the automobile case, it helps explain why tying can occur even if there are no marginal cost savings.

Our analysis suggests that the factors that give rise to mixed bundling are distinct from the factors that give rise to tying. In the presence of product-specific fixed costs, marginal cost savings from bundling can contribute to tying. But these marginal cost savings are neither necessary nor sufficient for tying to occur.

Of course the model has highly stylized assumptions which should be relaxed in future research. More general assumptions about demand[54] and costs are needed. Replacing the contestability assumption with a tractable model of bundling in the "almost competitive" markets that we observe in the real world would also be useful That said, the model yields interesting insights even with its stylized assumptions, and an awareness

[53] In 1999, it stocked 5,000 items at its web site. See Malik (1999).

[54] Salinger (1995) showed that the demand conditions that consideration of bundling efficiencies dramatically alters the demand conditions that give rise to pure bundling. However, that analysis ruled out mixed bundling by assumption and did not distinguish between marginal cost savings and fixed cost effects. A natural extension of that literature is to allow for both kinds of cost effects.

of the results with these assumptions should make it easier to solve and understand the model under more general conditions.

We have presented our theory in conjunction with a set of cases. Doing so is challenging because the facts of the cases and the assumptions of the theory never coincide. Still, a striking feature of the economics literature on bundling and tying is that it rests on stylized assumptions that are hard to match to real markets. We believe that one of our most important contributions is exploring the implications of our model in light of actual cases.

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Appendix

Conditions for Sustainable Configurations

In this appendix, we establish the conditions for sustainable product offerings.

A scenario implies an allocation of customer types to products. For example, under mixed bundling, the "group B" buys the bundle, "group 1" buys good 1 and "group 2" buys good 2. Under components selling, groups 1 and B by good 1 and groups 2 and B buy good 2. The allocation of customer types to goods then determines a price. For example, under components selling, $p_1 = c_1 + F/X_1$ whereas under components selling, $p_1 = c_1 + F/(X_1 + X_B)$. As noted in the text, a set of offerings is sustainable if it is impossible either to sell an existing offering at a lower price or enter with a good not being offered in a way that attracts all the customers needed to break even at that price. In what follows, let P(i,s) be the price of good i under scenario j, with i ∈ (1, 2, B) and s ∈ (M, C, T1, T2, B)

1. Pure Bundling

Under pure bundling,

(A1) $$P(B,B) = c_B + \frac{F}{X_1 + X_2 + X_B}$$

Pure bundling is potentially subject to entry by a single component priced to attract the group that wants just that component or by the simultaneous entry of both components with the price of good i priced to attract groups i and B.

The first of these cannot occur if:

(A2) $$c_i + \frac{F}{X_i} > c_B + \frac{F}{X_1 + X_2 + X_B} \qquad i = 1 \text{ and } 2$$

Under the assumption that $c_B \leq c_1 + c_2$, the second type of entry cannot occur. Thus, (A2) is the only additional condition needed for pure bundling to be sustainable.

Equation (A2) says that the strong stand-alone condition does not hold for either good 1 or good 2. Note that in both panels of Table 2, pure bundling is sustainable except in the right-hand column, which says that the strong stand-alone condition for good 1 holds, and the bottom row, which says that the strong stand-alone condition for good 2 holds.

2. Pure Components Selling

Under pure components selling, the prices are:

(A3) $$P(i,C) = c_i + \frac{F}{X_i + X_B} \qquad i = 1,2$$

Pure components selling is potentially subject to entry by the bundle priced just to attract group B, by the bundle priced to attract group B and either group 1 or group 2, or by the bundle priced to attractt all three groups. Given the assumption that $c_i \leq c_B$, the middle form of entry cannot occur as the fixed cost for the fixed cost of the bundle would be spread out over the same number of customers as with components selling. Group i would then prefer to buy good i because of the lower marginal cost. Thus, the conditions for components selling to be sustainable are:

(A4) $$c_B + \frac{F}{X_B} > c_1 + c_2 + \frac{F}{X_1 + X_B} + \frac{F}{X_2 + X_B}$$

and

(A5) $$c_B + \frac{F}{X_1 + X_2 + X_B} > c_i + \frac{F}{X_i + X_B} \qquad i = 1 or 2$$

Equation (A4) means that the bundle stand-alone condition does not hold. Since Panel A of Table 2 covers the case when the bundle stand-alone condition does hold, components selling is not sustainable in the cases covered by Panel A. Equation (A5) says that the pure bundling sufficiency condition does not hold. Since Panel B covers the cases when neither the bundle stand-alone condition nor the pure bundling sufficiency condition holds, components selling is sustainable in all the cases covered in that panel.

3. Tying

When good i is available separately and good j is available only in bundled form, then the prices are:

(A6) $$P(B,Ti) = c_B + \frac{F}{X_B + X_j} \qquad i = 1,2;\ j \neq i$$

(A7) $$P(i,Ti) = c_B + \frac{F}{X_i} \qquad i = 1,2$$

This scenario could conceivably be threatened in a variety of ways. There could be entry by good j alone. Alternatively, entry by good j could be accompanied by a price reduction in good i that would attract group B. Finally, a price reduction in the bundle could attract group i. Given the assumption that $c_1 + c_2 \geq c_B$, however, the second of these threats cannot occur.[55] The conditions, then, under which it is sustainable to have good i available separately and good j available only as part of a bundle are:

(A8) $$c_j + \frac{F}{X_j} > c_B + \frac{F}{X_B + X_j}$$

and

(A9) $$c_B + \frac{F}{X_1 + X_2 + X_B} > c_i + \frac{F}{X_i}$$

Equation (A8) says that the weak stand-alone condition for good j does not hold, while equation (A9) says that the strong stand-alone condition for good i does. These are the cases covered by the upper right-hand corner and lower left-hand corners of both panels in Table 2.

4. Mixed Bundling

Under mixed bundling, the prices are:

(A10) $$P(B, M) = c_B + \frac{F}{X_B}$$

(A11) $$P(i, M) = c_i + \frac{F}{X_i} \qquad i = 1, 2$$

Under mixed bundling, all the possible products exist, so entry cannot occur. However, mixed bundling is potentially subject to price cuts in the components that attract group B or price cuts in the bundle that attract group 1 and/or 2. Thus, the conditions for mixed bundling to be sustainable are:

(A12) $$c_B + \frac{F}{X_1 + X_2 + X_B} > c_i + \frac{F}{X_i} \qquad i = 1 \, or \, 2$$

and

(A13) $$c_B + \frac{F}{X_i + X_B} > c_i + \frac{F}{X_i} \qquad i = 1 \, and \, 2$$

[55] With tying, group B gets one of the other groups to share the fixed cost of the bundle. As a result, group B's expenditure on fixed costs would increase if it purchased the components separately and, by assumption, its expenditure on marginal costs would as well.

and

(A14) $$c_1 + c_2 + \frac{F}{X_1 + X_B} + \frac{F}{X_2 + X_B} > c_B + \frac{F}{X_B}$$

Equation (A12) says that the strong stand-alone condition must hold for one of the components while equation (A13) says that the weak stand-alone condition must hold for both. Equation (A14) says that the bundle stand-alone condition must hold. Panel B in Table 2 covers the cases in which (A14) does not hold, so mixed bundling is not sustainable in Panel B. In Panel A, it appears in the bottom right-hand corner, which is where both stand-alone conditions hold. It also appears in the third column of the second row and the second column of the third row, which are where one strong and one weak stand-alone condition hold. It does not appear in the middle cell of Panel A because neither strong stand-alone condition holds there.