8

Commodity Bundling and Tie-In Sales

On November 5, 1999, Judge Thomas Penfield Jackson issued his "Findings of Fact" in the Microsoft antitrust trial—findings that served as the basis for Judge Jackson's guilty verdict in the trial five months later on April 3, 2000. Among other things, Judge Jackson concluded that Microsoft's Windows operating system and its *Internet Explorer* web browser constituted separate products that could, in principle, stand alone but that Microsoft had bundled together as one package. Judge Jackson's focus was on the use of such bundling as an illegal tying of the two products aimed at extending Microsoft's operating systems monopoly to the browser market. Any defense against this charge must offer an explanation for such bundling that is not related to extending monopoly power. The truth is that most firms —both those with market power and those without it—do sell more than one good and bundling or tying between a firm's different products is frequently observed. What are the possible gains to the firm from tying together the sale of its products apart from the anti-competitive effects that worried Judge Jackson? Does bundling raise both profit and efficiency, or does it earn profit at the expense of efficiency? Do consumers win or lose from these bundling and tying tactics? These are the questions we investigate in this chapter.

That consumers might actually gain from bundling seems possible when we examine the prices that Microsoft charges, not for its Windows operating system but for its software applications. The Microsoft Office suite is one of the most popular applications packages. Office XP Professional contains the Word, Excel, Outlook, PowerPoint and Access programs. In April, 2007 this package was priced at $400. You could also buy the individual components separately, Word, Excel, PowerPoint and Access selling for $200 each and Outlook for $95, a total of $695. In other words, there is a bundle discount of nearly $300. The question then becomes what incentive Microsoft has to engage in such bundling? How does offering the Office bundle help raise Microsoft's profit?

Before proceeding further it is helpful to make our discussion a bit more precise. In some cases, firms like Microsoft market two or more products as an explicit bundle comprised of fixed amounts of the individual components. Thus, the Office suite contains exactly one copy of each of the constituent programs just as a fixed-price menu at a restaurant contains one of each of the included courses. Similarly, a holiday travel package might specify one return flight to London, five nights' accommodation, and three West End plays.

There is though an alternative to bundling, more frequently known as tying. Under this strategy a firm *ties* the sale of one product to the purchase of another but does not control

the proportions in which the two products are consumed. Under a tying strategy the purchase of some amount of one good (the tying good) is conditional upon the purchase a second product (the tied good). For example, in the early days of business machines and computers IBM sold its machines only under the requirement that the buyer also use IBM-produced tabulating cards. In other words, the purchase of the machine was tied to the additional purchase of IBM cards.[1] We differentiate this from commodity bundling because IBM did not specify the number of cards that the consumer had to purchase.

More recent examples of tied sales are not difficult to find. Whenever you buy a computer printer, you are also committing yourself to buying the ink cartridges that fit into that printer. Hewlett-Packard cartridges do not fit Canon printers and vice versa. Similarly, Sony's Play Station games do not work on either a Nintendo Wii or a Microsoft Xbox system. What is tied in all these cases is just the brand of the associated product, not its quantity. You can always reduce your demand for Hewlett-Packard ink cartridges by being very strict with yourself on how many drafts of a term paper you actually print out! These modern examples of tie-in sales are *technology* based rather than *contractual* as in the IBM case. Yet, whether contractual or technical, the issues we wish to address are the motivations for and the implications of both tying and bundling practices. It is to a more formal analysis of these questions that we now turn.

8.1 COMMODITY BUNDLING AND PRICE DISCRIMINATION

We begin with a story told almost thirty years ago by Nobel laureate, George Stigler, who was one of the first to understand bundling as a mechanism for price discrimination.[2] At the time that he published his brief analysis he was responding to a recent Supreme Court case involving the movie industry. Throughout the 1950s and 1960s, airing older Hollywood films was a substantial part of television fare. Film distributors who owned the rights to the films would sell presentation rights for a fee to local television stations. However, they rarely sold films individually. Instead, they sold them in packages typically combining screen gems such as *Casablanca* and *Treasure of the Sierra Madre* with such "grade B" losers as *Gorilla Man* and *Tear Gas Squad*.[3] Stigler's insight was to recognize that while every television station would value the first two films (or others of similar quality) more than the last two films, the relative valuation of the two types of movies would vary from station to station. Such differences could provide a motive for the observed bundling.

A modified version of Stigler's example goes as follows. Suppose that there are two films, X and Y, and two stations (located in different cities), A and B. Each station's reservation prices for the two films are as follows:

	Maximum willingness to pay for film X	*Maximum willingness to pay for film Y*
Station A	$8,000	$2,500
Station B	$7,000	$3,000

[1] See *International Business Machines v. U.S.*, 298 U.S. 131 (1936). Similar charges arose repeatedly in the many private antitrust suits against IBM in the following decades.

[2] Stigler (1968).

[3] See *United States v. Loew's Inc.*, 371 U.S. 38 (1962).

Successful price discrimination must surmount the twin problems of identifying which station is which and then avoiding arbitrage between stations. If this is not possible and the distributor is forced to charge a uniform price for each film, its best bet is to charge \$7,000 for film X and \$2,500 for film Y. At these prices, both stations will buy both films, and the distributor's total revenue will be \$19,000.

Bundling, however, permits further revenues to be earned. Instead of selling the two films separately, suppose that the distributor offers the films in a bundle to the two stations for a combined price of \$10,000. Since both stations value the bundle at least this highly, the distributor will sell both films to both stations. Its revenue now rises to \$20,000.

The reason that bundling raises revenue is straightforward. Offering the films unbundled means that, if both stations are going to buy both films, the highest price that can be charged for any specific film is the minimum reservation price either station would pay for that film—\$7,000 for film X and \$2,500 for film Y. When the products are bundled, the highest bundle price that can be charged is the minimum of the sums of each station's reservation prices. This permits additional surplus extraction from both stations. Bundling extracts more from station A because it permits the distributor to circumvent the low value that station A places on film Y and to exploit its relatively high valuation of film X. Similarly, bundling avoids the need to charge a low price for film X in order to induce station B to buy it by exploiting that station's relatively high willingness to pay for film Y.

Stigler's insight into bundling as a way to price discriminate was surely valid. However, his analysis was incomplete on two fronts. First, his model included no discussion of production costs. The movie seller and television station example treats the distributor's costs as either sunk or nonexistent. The second limitation of Stigler's model was that it failed to consider the strategy of *mixed bundling*; that is, selling both products individually as well as in a bundle. Adams and Yellen (1976) address these issues and their paper has become the standard piece on commodity bundling. We now turn to a presentation of their paper.

Assume that there are two goods, labeled 1 and 2. Each of these goods is produced with constant marginal (and average) cost, denoted by c_1 and c_2, respectively. In other words, we assume that there are no cost advantages of multiproduct production. In particular, there are no scope economies of the type discussed in Chapter 4. Accordingly, the cost of producing a bundle or a package consisting of one unit of each good is $c_B = c_1 + c_2$.

We will also assume that a consumer buys exactly one unit of each good per unit of time provided that the price charged is less than his or her reservation price for that good. The consumer's reservation price or maximum willingness to pay for good 1 is R_1 and for good 2 is R_2. Finally, we assume that the consumer's reservation price for a commodity bundle consisting of one unit of each good is $R_B = R_1 + R_2$. This final assumption, that the reservation price for the bundle is the sum of the reservation prices for the individual goods, is a common one (and one made by Stigler as well). Yet the assumption is, at least in some circumstances, restrictive. If the two goods are complementary goods, such as nuts and bolts, the assumption is almost certainly false. We expect that the willingness to pay for bolts would be quite low in the absence of any nuts and vice versa. For complementary goods, the reservation price for the bundle would likely be higher than the sum of the separate reservation prices for each good consumed separately. Yet while the assumption that $R_B = R_1 + R_2$ is restrictive, it is also useful. It permits us to focus explicitly on the price discrimination motive for bundling. We return to the case of complementary goods in section 8.3.

Suppose that consumers differ in their separate valuations of the two goods—that is, the values of R_1, R_2, and R_B vary across consumers. Some consumers have a high R_1 and a low R_2; for others just the reverse is true. Some place a high value on both goods. For others,

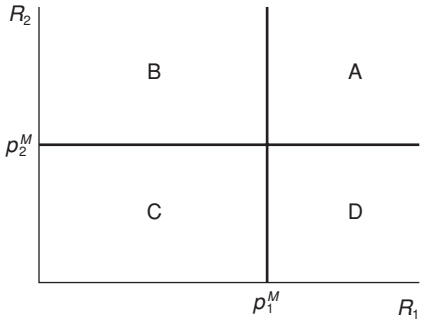

Figure 8.1 Consumers' reservation prices for goods 1 and 2 and simple monopoly pricing
At monopoly prices p_1^M and p_2^M, group A buys both goods; group B buys good 2; group D buys good 1; and group C buys neither good.

R_1 and R_2 are both quite low. If we draw a quadrant with R_1 on the horizontal axis and R_2 on the vertical axis as in Figure 8.1, then our assumptions allow us to describe each consumer's reservation prices by a point in the (R_1, R_2) quadrant.

It might be helpful to use a specific example, such as a restaurant menu. We are all familiar with restaurants that offer an à la carte menu from which we can pick individual items and a set menu that contains perhaps an appetizer and an entrée or an entrée and a dessert sold as a bundle. Figure 8.1 illustrates the simplest pricing strategy for the monopolist offering two goods. Sell the two products separately at their monopoly prices, p_1^M and p_2^M. (We leave aside for the moment just how these monopoly prices might be identified.) This could be a restaurant that sells soup at price p_1^M and a sandwich at price p_2^M. Buying both goods costs $p_1^M + p_2^M$. Facing these prices, consumers are partitioned into four groups. Consumers in group A have reservation prices for both goods that are greater than the prices being charged and therefore purchase one unit of each product. Consumers in group B have reservation prices for good 2 that are higher than its price, p_2^M and so buy good 2. However, their reservation prices for good 1 are lower than the price p_1^M and so they do not buy good 1. Similarly, consumers in group D have reservation prices for good 1 that are higher than its price, so they buy good 1. However, they do not buy good 2. Consumers in group C have reservation prices for both goods that are lower than the prices being charged and so do not purchase either product.

Now suppose that the monopolist adopts a *pure bundling* strategy in which the two goods can be purchased only as a bundle at a fixed price of p_B. In our restaurant setting, this would mean that the only deal on offer is soup plus a sandwich at a fixed price of p_B. The goods cannot be purchased separately at individual prices, p_1 and p_2.

The bundle price is illustrated in Figure 8.2 as a straight line with intercept on each axis of p_B and so with slope of minus one. Now consumers are partitioned into two groups. Each consumer in group E has reservation prices for the two goods the sum of which is greater than p_B and so will buy the package. By contrast, each consumer in group F has reservation prices for the two goods the sum of which is less than p_B and so will not buy the package.

Figure 8.2 illustrates an interesting feature of the pure bundling strategy. There are consumers who, as a result of the two goods being offered as a bundle, are able to buy one of the goods even though their reservation prices for that good are less than its marginal production cost. This is true in the case of good 1 for all consumers in group E whose

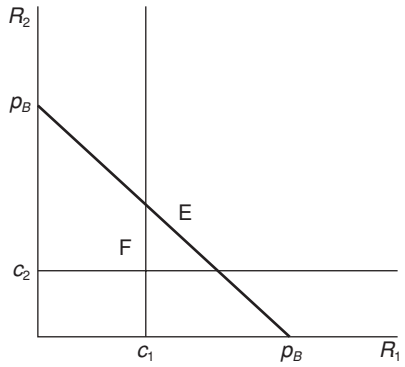

Figure 8.2 Monopoly pricing of a pure bundle of goods 1 and 2
At the bundle price p_B, consumers in group E buy the bundle.

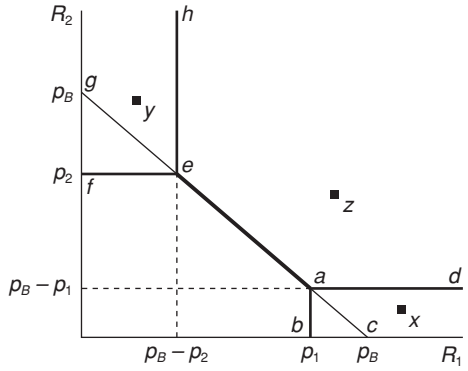

Figure 8.3 Monopoly pricing under mixed bundling of goods 1 and 2
The firm sets prices p_1 for good 1; p_2 for good 2; and $p_B < p_1 + p_2$ for the bundle.

reservation price for good 1 is less than c_1, and in the case of good 2 for all consumers in group E whose reservation prices for good 2 are less than c_2.

The third case is that of *mixed bundling*. Here, the monopolist offers to sell the two goods separately at specified prices, respectively, of p_1 and p_2 (which are not necessarily the monopoly prices) and also sells them as a bundle at price p_B (again not necessarily the pure bundle price). Of course, for this to make sense it must again be the case that $p_B < p_1 + p_2$. Figure 8.3 illustrates such a strategy. The restaurant offers the possibility of buying either soup or a sandwich individually at the stated prices or buying them as a set meal at price p_B.

Once again, we find that consumers are partitioned by this strategy into four groups. The determinants of these groups are, however, slightly different from those considered previously. What we need to do is to determine whether a consumer will prefer to buy only one of the two goods or the bundle or nothing.

Clearly, anyone who values good 1 at more than p_1 and good 2 at more than p_2, that is, anyone who is willing to buy both goods at the individual prices, will buy the bundle since its price is less than the sum of the individual prices. Consider now a consumer whose

reservation price for good 2 is less than p_2. If this consumer buys anything, she will buy either the bundle or only good 1. Of course, she will make the choice that gives her the greatest consumer surplus. Suppose then that her reservation prices are R_1 for good 1 and R_2 for good 2. If she buys the bundle, then she pays p_B and gets consumer surplus of $CS_B = R_1 + R_2 - p_B$. If she buys only good 1, she gets consumer surplus of $CS_1 = R_1 - p_1$.

This type of consumer will buy only good 1 if two conditions are satisfied. First, $CS_1 > CS_B$, which requires that $R_2 < p_B - p_1$. Second, $CS_1 > 0$, which requires that $R_1 > p_1$.

The difference $p_B - p_1$ is easily illustrated in Figure 8.3. Since the line $p_B p_B$ has a slope of minus one, the distance *ab* is equal to the distance *bc*, which is equal to $p_B - p_1$. So all points below the line *jad* represent consumers whose reservation prices for good 2 are such that $R_2 < p_B - p_1$ and, of course, all points to the right of *ab* represent consumers for whom $R_1 > p_1$. So all consumers with reservation prices in the region *dab*, such as consumer *x*, buy only good 1.

By exactly the same argument a consumer will buy only good 2 if two conditions are satisfied: first $R_1 < p_B - p_2$ and second $R_2 > p_2$. The difference $p_B - p_2$ is illustrated in Figure 8.3 by the line *jeh* and all points above *fe* represent consumers for whom $R_2 > p_2$. Therefore, all consumers with reservation prices in the region *feh*, such as consumer *y*, will buy only good 2.

Now consider a consumer for whom $R_2 > p_B - p_1$ and $R_1 > p_B - p_2$. This is a consumer whose reservation price for good 1 is to the right of *jeh* and for good 2 is above *jad*. If such a consumer buys anything at all she will buy the bundle since this gives more consumer surplus than either only good 1 or only good 2. For this consumer to buy the bundle it is then necessary that $R_1 + R_2 > p_B$, which means that her reservation prices must put her above the line *caeg* in Figure 8.3. In other words, all consumers in the region *daeh*, such as consumer *z*, will buy the bundle.

This leaves only the region *feab*. What will be the choice of these types of consumers? Their reservation prices are less than the individual prices of the two goods, so they will not buy either good individually. In addition, the sums of their reservation prices are less than the bundle price, so they will not buy the bundle. Consumers in *feab* do not buy anything.

When we compare either pure or mixed bundling with simple monopoly pricing, it is clear that mixed bundling always increases the monopolist's sales. What is less clear is whether bundling will increase the monopolist's profits. What we should expect is that the profit impact of commodity bundling will depend upon the distribution of consumer preferences for the goods being offered and the costs of making those goods. An example will serve to illustrate this and some of the other ideas introduced so far.

Assume that the monopolist knows that it has four consumers, A, B, C, and D, each interested in buying the two goods, 1 and 2. The marginal cost of good 1 is $c_1 = \$100$ and of good 2 is $c_2 = \$150$. Each consumer has reservation prices for these two goods as given in Table 8.1 and buys exactly one unit of either good in any period so long as its price is less than her reservation price for that good. Each consumer will consider buying the goods as a bundle provided that the bundle price is less than the sum of her reservation prices.

Suppose that the monopolist decides to sell the goods unbundled and adopt simple monopoly pricing. Table 8.2 allows us to identify the profit-maximizing monopoly prices for the two goods. Profit from good 1 is maximized at \$450 by setting a price of \$250 and selling to consumers B, C, and D. Profit from good 2 is maximized at \$300 by setting a price of \$450 and selling only to consumer A. Total profit from simple monopoly pricing is, therefore, \$750.

Table 8.1 Consumer reservation prices (U.S. dollars)

Consumer	*Reservation price for good 1*	*Reservation price for good 2*	*Sum of reservation prices*
A	50	450	500
B	250	275	525
C	300	220	520
D	450	50	500

Table 8.2 Determination of simple monopoly prices

Price	*Quantity demanded*	*Total revenue ($)*	*Profit ($)*	*Price*	*Quantity demanded*	*Total revenue ($)*	*Profit ($)*
450	1	450	350	450	1	450	300
300	2	600	400	275	2	550	250
250	3	750	450	220	3	660	210
50	4	200	–200	50	4	200	–400

Now consider the pure bundling strategy. The firm can: (1) choose a bundle price of $525, which will attract only consumer B; (2) choose a bundle price of $520, which will attract consumers B and C; or (3) choose a bundle price of $500, which will attract all four consumers. The third strategy is preferable because it yields a total profit of 4($500 – $100 – $150), or $1,000. Pure bundling is, in this case, preferable to simple monopoly pricing. However, under bundling, consumer A is able to consumer good 1 and consumer D is able to consume good 2 even though they each value the relevant good at less than its marginal production costs.

Can a mixed bundling strategy do better? Suppose for example that the monopolist merely combines the simple monopoly and pure bundling strategies. That is, the firm sets a price of $250 for good 1, $450 for good 2, and $500 for the bundle. How will consumers respond to this pricing and product offering? Consumer A will not buy just good 1, and is indifferent between buying the bundle or only good 2 because in either case, she earns zero surplus. However, the firm is definitely not indifferent. The firm makes a profit of $300 if consumer A buys just good 2 but only $250 if consumer A buys the bundle. Hence, the firm would like to find a way to encourage consumer A to opt only for good 2. Consumer B will not buy just good 2, earns no consumer surplus if she buys only good 1 and $25 consumer surplus if she buys the bundle so she will buy the bundle, giving the monopolist a profit of $250. Consumer C will not buy good 2, earns $50 consumer surplus if she buys only good 1 and $20 consumer surplus if she buys the bundle. She will buy only good 1 giving the monopolist profit of $150. Finally, consumer D earns the greatest surplus if she buys only good 1, in which case her consumer surplus is $200. Therefore, she will buy only good 1 and the profit to the monopolist from that sale will be $150. In this consumer's case, the monopolist would actually prefer that she buy the bundle at $500 from which the monopolist earns a profit of $250.

Adding up the sales and related profits, we find that the proposed mixed bundling strategy gives the monopolist a total profit of \$800 or \$850 depending upon whether consumer A buys the bundle or only good 2. This is certainly better than simple monopoly pricing profit derived earlier of \$750. However, it is not as good as the profit of \$1,000 earned in the pure bundling case of selling only the bundle at a price of \$500.

These results assume that in employing mixed bundling the monopolist uses the same price as for no bundling or pure bundling. There is no reason to believe that this is the best strategy. With a little thought, it is easy to see how the monopolist could alter the current mixed bundling strategy to raise profits further. The insight is to change the prices to sort customers into different purchase choices. We have already noted that Consumer A is indifferent between buying just good 2 or the bundle at the current prices. A slight rise in the bundle price say, to \$520 will definitely tilt this consumer to purchasing just good 2. Suppose that in addition the firm also raises the price of good 1 to \$450, so that the new price configuration is: p_B = \$520; p_1 = \$450; and p_2 = \$450. Consumer A will now buy good 2. Consumer D will continue to buy good 1 and Consumers B and C will continue to buy the bundle. However, the price increases for these good 1 and the bundle, respectively, will now let the monopolist earn an additional profit of \$200 on its sale of good 1 to Consumer D, and \$40 on its two bundle sales to Consumers B and C. Total profit is \$300 + \$270 + \$270 + \$350 = \$1,190, which *does* exceed our pure bundling maximum.

This is actually the best that the monopolist can do in this case. The monopolist has extracted the entire consumer surplus of consumers A, C, and D and all but \$5 of the consumer surplus of consumer B. In other words, the monopolist has done nearly as well as it would have done if it had been able to adopt first-degree price discrimination.

Mixed bundling (in which the bundle price is less than the price of buying each component separately) is always at least as profitable as pure bundling. The reason is simple enough to see. The worst that a mixed bundling strategy can do is to replicate the pure bundling strategy—by setting arbitrarily high individual prices and a bundle price equal to the pure bundle price. However, it will usually be possible to improve on this by setting individual component prices that are sufficiently low to attract those who really just want the one item but high enough to earn more profit than can be earned from the bundle.

We should note though that while mixed bundling must always improve profits relative to pure bundling, it is not always the case that some sort of bundling is more profitable than no bundling at all. A drawback to bundling—one illustrated in the previous example—is that it can lead to an outcome in which some of the consumers who buy the bundle actually have a reservation price for one of the goods that is less than marginal production cost. This is inefficient and so the firm would prefer a different pricing scheme. Our example also demonstrates that any bundling is likely to be profitable only when the variation in consumer valuations of the goods is significant. In our example, consumers A and D—who buy a single good—have very different valuations of the individual goods. In contrast, consumers B and C—who buy the bundled good—have very similar valuations. Adams and Yellen (1976) made clear that the gains from bundling arise from the differences in consumer valuations.

> Some people may value an appetizer relatively highly (soup on a cold day), others may value dessert relatively higher (Baked Alaska, unavailable at home), but all may wish to pay roughly the same amount for a complete dinner. The à la carte menu is designed to capture consumer surplus from those gastronomes with extremely high valuations of particular dishes, while the complete dinner is designed to retain those with lower variance. (p. 488)

We can see the same basic point in the context of the Stigler example above. If station A valued both movies at $8,000, and station B valued both at $3,500, the differences in the relative valuation of the products would vanish. In that case, bundling would no longer be a profitable strategy.

It is because the bundle price p_B is less than the sum of the individual prices $p_1 + p_2$ that commodity bundling may be viewed as discriminatory pricing. The lower bundle price serves to attract consumers who place a relatively low value on either of the two goods but are willing to pay a reasonable sum for the bundle. The two separate prices serve to extract surplus from those customers who have a great willingness to pay for only one of the products. We would therefore expect most multiproduct firms with monopoly power to engage in some sort of mixed bundling.

Mixed bundling is in fact a common practice. Restaurants serve combination platters and also offer items individually. Resorts often offer food and lodging both separately and as a package. Software companies sell individual products but also offer packages consisting of several applications, such as Microsoft's *Office* package. Some of this surely reflects price discrimination efforts.

Reality Checkpoint

All Bundled Up in the Vatican

These are hard times for traditional travel agents. Direct ticketing by airlines and the proliferation of discount Internet sites that permit customers to shop comparatively for the cheapest travel and lodging accommodations have taken their toll. But now the agents are fighting back with a new tool called "insider travel."

Many popular sites make it either difficult or impossible for tourists to get what they really want. Those who visit the Sistine Chapel will often stand in hours-long lines to get a glimpse of Michelangelo's masterpiece. Similarly, Queen Nefertari's tomb in Egypt can only be seen if one gets permission from the country's Supreme Council of Antiquities. Travel agents are increasingly doing the legwork to offer tourists these special features as part of a package. Select Italy will arrange a special, after-hours tour for tourists to see the Sistine Chapel artwork face-to-face. Los Angeles-based Destinations & Adventures International will likewise obtain the necessary permission to view the fabulous wall paintings in the tomb of the ancient Egyptian Queen Nefertari for an appropriate fee.

That fee can of course be intimidating. It can cost a fixed charge of $4,000 for a small group to take advantage of these opportunities and the fee rises if the group exceeds ten. However, by agreeing to stay at a hotel recommended by the agent or to use other agent-suggested services, tourists can often reduce these fees by anywhere from $400 to $1,000. In return, travelers get a personalized trip that can be truly memorable and for which they are willing to pay a lot. One of the larger tour operators, Abercrombie & Kent, claims that packaging a customized event with travel and lodging now makes up half of its business and earns some of the heftiest margins.

Source: C. Jackson, "VIP Travel on the Cheap," *Wall Street Journal*, May 17, 2006, p. D1.

Practice Problem 8.1

A cable company has two services. One service is the Basic Service channel. The other is the Walt Disney Movie channel. The potential subscribers for the services—students, families, hotels, schools, young adults, and pensioners—regard the two services as separate alternatives, that is, not as complementary products. So, the demands for the two services are completely unrelated for each and every consumer. Each buyer is characterized by a pair of reservation prices as shown in the following table:

Reservation prices for each cable service by type of subscriber

	Basic Service ($)	*Disney Channel ($)*
Students	5	15
Families	11	9
Hotels	14	6
Schools	4	16
Young adults	0	17
Pensioners	17	0

The marginal cost of each service is $3. Assume there are equal numbers of consumers in each category.

a. If the services are sold separately and not offered as a bundle, what price should the cable operator set for each service? What profits will she earn? Which consumers will subscribe to which service?
b. Suppose that the operator decides to pursue a mixed bundling strategy. What price should be set for the bundled service? What price should she set for each service if purchased individually? Which consumers buy which options, and what are the cable operator's profits?
c. How would your answers to the first two questions be changed if the marginal cost of producing each service had been $10 instead of $3?

8.2 REQUIRED TIE-IN SALES

Tie-in sale arrangements differ from bundling in that they tie together the purchase of two or more products without prescribing the amount that must be bought. A further difference commonly but not always observed is that the tied goods typically exhibit a complementary relationship with each other whereas bundled goods need not. We now turn to a somewhat magical example to illustrate why tying is often an effective marketing strategy.

Consider an imaginary product called a *Magicam* that is produced by only one firm, Rowling Corp. A *Magicam* is much like an ordinary camera with one exception—the figures in a *Magicam* photograph can actually move and even wave back at the picture viewer because of Rowling's patented, magical method of placing the images on film. In all other respects, however, the *Magicam* is essentially identical to a typical real world camera. In particular, both a *Magicam* and a regular camera can be used to make anywhere from one to a very large number of pictures per day or per month. It is up to the owner to decide how many pictures to take per period of time.

This fact does not mean that every consumer who has a *Magicam* will take a huge number of snapshots. After all, they have to pay for the film cartridge and spend time in taking snaps rather than doing other things. Presumably, consumers differ in this regard. Suppose that there are one thousand low-demand consumers each with a monthly demand for pictures described by $Q = 12 - P$, and one thousand high-demand consumers each with a monthly demand for pictures given by $Q = 16 - P$. In other words, if cartridges of film were free the first group of consumers would each take 12 pictures per month and the second group 16 pictures. Unfortunately, Rowling Corp. has no way, magical or otherwise, of identifying these different types.

Because of the sensitive nature of the technology incorporated in *Magicams* we assume that Rowling Corp. does not sell the cameras but rather uses its monopoly power to offer them on monthly lease agreements that include servicing the camera to maintain its magical properties.[4] Given that the lease fee is set such that each of the two thousand consumers will lease a *Magicam* the manufacturing costs of the cameras become effectively fixed costs for Rowling Corp. The same is not the true for the camera film. Suppose that film production takes place under competitive conditions and that the marginal cost of producing film is $2 per photograph that the film can take. This means, of course, that film will be priced at the competitive price of $2 per picture. Now consider Rowling Corp.'s potential strategies for leasing its cameras.

If a *Magicam* and camera film are all that is needed for producing the wonderful pictures, Rowling Corp. might find the situation somewhat frustrating. Because the firm cannot tell one type of consumer from another, the firm cannot easily lease its *Magicam*s at different prices to each type. About the best that Rowling Corp. can do is to charge a monthly rental rate of $50. Why? Because this is the consumer surplus earned by a low-demand consumer faced with a film price of $2 per picture and Rowling Corp. cannot price discriminate across the two consumer types. (You should check that this is indeed the consumer surplus for a low-demand consumer when film is priced at $2 per picture.)

Both types of consumer will lease the camera. High-demand consumers will use it to take 14 pictures per month while the low-demand consumers will take 10 pictures per month. Rowling earns a monthly profit of $50 on each of the 2000 cameras leased—one thousand to the low-demand and one thousand to the high-demand types—or $100,000 per month.

The situation is not desperate but like any good profit-maximizer, Rowling wonders if somehow the firm can do better. After thinking a bit, Rowling management realizes that with a bit of redesign of the camera and some clever marketing it can tie the lease of a *Magicam* to the use of its own *Magifilm*. This gives Rowling an idea. Why not implement a tying strategy and sell *Magifilm* cartridges at $4 per exposure?

Both low- and high-demand consumers now pay $4 at the margin for a picture. The low-demand consumers will therefore reduce their monthly demand for *Magicam* photos to just eight. And if low-demand consumers pay the $4 per picture price of *Magifilm*, they will enjoy a surplus of $32. So this surplus is the rental rate at which Rowling can lease the *Magicam*. (Notice the connection between this and our discussion of two-part pricing in Chapter 6.) As a result, Rowling earns $32 from each of the 1,000 low-demand consumers in camera rentals and $16 from each in cartridge sales, giving a total profit of $48,000 from the low-demand customers.

[4] This is actually the strategy that IBM, Kodak, and Xerox used initially with their machines.

High-demand consumers will also lease the *Magicam* at $32. However, at $4 per picture in film costs, these consumers will shoot 12 photos per month. Hence, Rowling earns a profit of $32 on cameras and $24 on film cartridges from each of the one thousand high-demand customers, giving a total profit from this group of $56,000. In total, Rowling now earns a combined profit of $104,000—greater than the $100,000 it earned without the tie-in. It has achieved this profit increase by exploiting its ability to *tie* the use of its camera to the use of its film.

To understand the way that tying helps Rowling, first note that high-demand consumers receive a quantity discount under either of the two regimes. When the *Magicam* is leased for $50 and the film is purchased competitively at $2 per photo, high-demand consumers take 14 photos and pay only $5.57 per shot, while low-demand consumers take 10 pictures and pay $7 for each. Under the tied film arrangement, high-demand consumers pay a total charge of $80 for 12 pictures or $6.67 per photo. By contrast, low-demand consumers pay a total of $64 and take only eight pictures per month or $8 per photo. Thus, the tied sale is not attractive solely because it permits a quantity discount.

What tying does accomplish is to permit Rowling to solve the identification and arbitrage problems by exploiting its post-lease position as the monopoly seller of *Magifilm*. Now, the high-demand consumers are revealed by their film purchases to Rowling and the quantity discount is put to work in a profit-increasing way. Nor is arbitrage capable of undoing the discrimination. After all, both the camera and the film are readily available to all consumers at the same prices. Given that a single *Magicam* can serve either a low-demand consumer or a high-demand consumer equally well, solving the identification and arbitrage problems can only be achieved by tying its use to another product whose volume does change depending on the consumer's type. No consumer will ever lease more than one *Magicam*, but they will differ in terms of how much *Magifilm* they purchase.

Now let's take Rowling's case one step further. The low and high-demand functions we have used may look familiar to you. They are the same ones we used in Chapter 6 in our discussion of quantity discounts with second-degree price discrimination. In fact if you want to look back at that earlier example you may get an idea of how Rowling can redesign and package the camera to do even better. For example, suppose that Rowling redesigns the *Magicam* so that the cartridge of *Magifilm* becomes an integral part of the camera that only Rowling's film developers can take out without destroying the camera.

Rowling can then design two varieties of its new, integrated *Magicam*, one of which has a 10-shot capacity and the other a 14-shot capacity.[5] The firm can offer to lease the 10-shot *Magicam* for $70 per month and the 14-shot *Magicam* for $88 per month. In both cases, the lease agreement also offers free developing as well as the free replacement of the cartridge. From our analysis in Chapter 6, we know what will happen in this case. Low-demand consumers will lease the 10-shot *Magicam* while high-demand consumers will lease the 14-shot *Magicam*. Rowling will then earn an even greater profit of $50,000 + $58,000 = $108,000. We also know from Chapter 6 that Rowling can do even better. If she designs a 14-shot and a 6-shot camera she can lease the 14-shot camera for $102 per month and the 6-shot camera for $54 per month, increasing her profit to $116,000. This technological integration plus the monthly leasing agreement has enabled Rowling to identify and separate the different customers even more profitably.

[5] With marginal film costs of $2, these are the socially efficient quantities to offer.

8.2 Practice Problem

Consider the *Magicam* story in the text. Again, let there be 1,000 high-demand and 1,000 low-demand consumers and let them have inverse demand functions of $P = 16 - Q$ and $P = 12 - Q$, respectively. Show that the price of \$4 per photo is, indeed, the profit-maximizing price for Magifilm when the film is sold separately from the camera. Now suppose that Rowling Corp. produces the integrated camera plus film cartridge in 8-shot and 14-shot varieties. What rental rates will be charged for the 2 varieties? What are Rowling Corp.'s profits? Finally, suppose that there are 1,000 low-demand consumers and N_h high-demand consumers. How many high-demand consumers would there have to be for Rowling to wish to manufacture only the 14-shot variety of integrated Magicam given that the other variety is

a. 10-shot;
b. 8-shot.

We have seen that, like bundling, tie-ins can be used to implement price discrimination schemes. This is no doubt one reason that tie-ins are frequently used, especially in situations where one of the components, like our fictitious *Magicam*, is capable of different intensities of use covering a very large range. Some tying is contractual, as in the case of IBM requiring the use of its punch cards for users of its punch card machines in the early days of computing. Some tying is technologically forced as in the *Magicam* and *Magifilm* example, or in the real-world case where Polaroid instant picture cameras used only Polaroid film. Nintendo's Wii uses only Nintendo or Nintendo-licensed games. The leading maker of computer printers, Hewlett-Packard, designs its printers so that they use only Hewlett-Packard cartridges. Again, these can be very useful product design strategies for extracting surplus from the market.

Price discrimination is not the only reason, however, that we may observe bundling and tying practices. As Judge Stevens made clear, an additional reason is that such practices may enhance monopoly power. At the same time, we also need to recognize that bundling and tying based on actual cost considerations will be observed in relatively competitive markets where they have little to do with discriminatory practices. We turn to these issues shortly, after first considering some aspects of complementary goods pricing.

8.3 COMPLEMENTARY GOODS, NETWORK EXTERNALITIES, AND MONOPOLY PRICING

The *Magicam* and *Magifilm* are, like real-life cameras and film, complementary goods. There is no point in buying a camera—magical or otherwise—unless one also buys some film (at least until the advent of digital cameras). Likewise, there is little point in owning a CD player without also purchasing CDs; or a PC without also buying some software applications; or in buying bolts without buying nuts. In passenger airline manufacture it is necessary to have both engines and avionics equipment.

Sometimes the market for at least one of the complementary goods is reasonably competitive. Other times, the same firm may control both goods. However, there is a third possibility. This is that each of the complementary goods is produced by a different monopolist. There might be just one camera corporation and one, separate film company. As the French

mathematical economist, Augustin Cournot, recognized over a hundred and fifty years ago, this last situation may have particularly bad implications for both profit and efficiency.

Cournot's basic argument can be demonstrated fairly simply. For this purpose, let us assume that the two complementary goods in question are nuts and bolts. A separate monopoly firm produces each and, to keep things simple, marginal production cost for each firm is zero. (We provide in the inset an alternative solution in which we allow the two firms to have different marginal costs.) The two goods are perfect complements. A consumer who wants to purchase 100 bolts also wishes to buy 100 nuts. In other words, the two goods are always consumed in the fixed proportion of one-to-one. For this reason, consumers care only about the combined price, $P_B + P_N$, in determining their demand. As you can see, the demands for the two products are clearly interrelated. The price of bolts will affect the demand for nuts and vice versa.

Suppose that the demand for nut and bolt pairs is given by the demand function

$$Q = 12 - (P_B + P_N) \tag{8.1}$$

Since consumers always buy the two goods together—one nut for every bolt—equation (8.1) also describes the separate demand facing each monopolist. That is, the bolt producer and the nut producer each face demand curves

$$\begin{aligned} Q_B &= 12 - (P_B + P_N) \quad \text{Bolt demand curve} \\ Q_N &= 12 - (P_B + P_N) \quad \text{Nut demand curve} \end{aligned} \tag{8.2}$$

The problem with separate production is easy to see. The nut producer's pricing decision affects the bolt producer's demand curve, and vice versa. A change in the price of nuts not only changes the quantity demanded in the nut market but also in the bolt market. This implies that any one firm's pricing decision has profit implications not just for itself but for the other firm as well. In other words, the pricing policy of either of the two firms imposes an externality on the other firm. In this situation, we might reasonably expect that a merger or creation of a business network to coordinate the pricing decisions of the two firms will offer significant advantages for them by at least partially correcting the market failure associated with the externality. Less obviously but, as we shall see nonetheless true, it is also possible that consumers will gain from such coordination.

Let's calculate the profit-maximizing decisions of the two firms, first without and then with coordination between them. We can rewrite the demand curves of equation (8.2) in inverse form.

$$\begin{aligned} P_B &= (12 - P_N) - Q_B \quad \text{Inverse demand curve for bolts} \\ P_N &= (12 - P_B) - Q_N \quad \text{Inverse demand curve for nuts} \end{aligned} \tag{8.3}$$

From this we know that the marginal revenue curve facing each firm is

$$\begin{aligned} MR_B &= (12 - P_N) - 2Q_B \quad \text{Bolt marginal revenue} \\ MR_N &= (12 - P_B) - 2Q_N \quad \text{Nut marginal revenue} \end{aligned} \tag{8.4}$$

Not surprisingly, just as each firm's demand curve depends on the other firm's price, so each firm's marginal revenue is affected by the other firm's price decision. When each firm

Derivation Checkpoint

Firms with Complementary Goods and Nonzero Marginal Costs

Assume that demand for nuts and bolts is given respectively by: $Q_N = Q_B = A - P_N - P_B$. Suppose now that the marginal cost of the nut producer is c_N, while that of the bolt producer is c_B. Then, with separate production, profit of the nut producer is: $\pi_N = (P_N - c_N)Q_N = (P_N - c_N)(A - P_N - P_B)$. Differentiate this with respect to P_N to obtain the necessary first-order condition for profit maximization:

$$\frac{\partial \pi_N}{\partial P_N} = (A - P_B - 2P_N + c_N) = 0$$

This gives the nut-pricing rule as:

$$P_N = (A + c_N - P_B)/2$$

By symmetry, it follows immediately that the profit-maximizing bolt-pricing rule is:

$$P_B = (A + c_B - P_N)/2$$

Solving these two equations for P_N gives:

$$P_N = \frac{1}{2}\left[A + c_N - \frac{1}{2}(A + c_B - P_N)\right];$$

This then simplifies to: $P_N = \dfrac{A + 2c_N - c_B}{3}$. In turn, this implies: $P_B = \dfrac{A + 2c_B - c_N}{3}$.

If the two firms merger, their joint profit is:

$$\pi_M = (P - c_B - c_N)(A - P).$$

The first-order condition necessary for profit maximization is:

$$\frac{\partial \pi_M}{\partial P} = A - 2P + c_B + c_N = 0.$$

Hence, the coordinated price for the nut-and-bolt combination after merger is:

$$P = \frac{A + c_B + c_N}{2}.$$

Comparison of this price with the sum of the nut and bolt prices under separate firms makes it clear that this price is lower by an amount $\dfrac{A - c_B - c_N}{6}$. Prices are lower as a result of the merger, while profits are higher. Both consumers and producers gain from coordinating the prices of these two complementary goods.

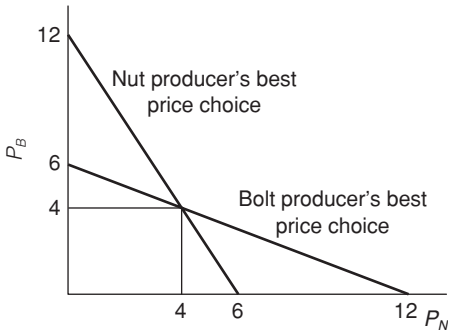

Figure 8.4 Pricing of complementary goods: the nuts and bolts case

independently maximizes its profit then each firm will choose an output where marginal revenue equals marginal cost, here assumed to be zero. So, setting each of the equations in (8.4) to zero and solving for Q_B and Q_N gives

$$\begin{aligned} Q_B &= (12 - P_N)/2 \qquad \text{Bolt production} \\ Q_N &= (12 - P_B)/2 \qquad \text{Nut production} \end{aligned} \tag{8.5}$$

If we now substitute these outputs into the individual demand curves we obtain each firm's optimal price as a function of the other firm's price, as follows:

$$\begin{aligned} P_B &= (12 - P_N)/2 \qquad \text{Bolt price rule} \\ P_N &= (12 - P_B)/2 \qquad \text{Nut price rule} \end{aligned} \tag{8.6}$$

These equations show that each producer's profit-maximizing price depends on the price set by the other firm. Alternatively, the equations identify what is the firm's best or profit-maximizing choice of price given the price of the other firm's good. Whatever price is being charged by the nut firm is communicated to the bolt firm through the effect on the demand curve facing the bolt producer. If nut prices are high, the demand curve will be low. On the other hand, if nut prices are low, bolt demand will be strong. Taking the demand curve as given, the bolt producer simply picks the price–quantity combination that maximizes profits using the familiar profit-maximizing $MR = MC$ rule.

We can identify what the price equilibrium in the two markets will be by graphing equations (8.6) in a diagram with the two prices P_B and P_N on the axes. This is done in Figure 8.4. The more gently sloped line gives the bolt company's best choice of P_B for every alternate nut price, P_N. For example, if the nuts were given away free or the nut price were zero the profit-maximizing bolt price would be \$6. If the nut price rises to somewhere near \$12, the profit-maximizing bolt price falls to near zero. Higher nut prices reduce bolt demand and lower the bolt firm's profit-maximizing price. The more steeply sloped line describes the same strategic choices from the perspective of the nut company. This line describes the profit-maximizing choice of P_N for every choice of P_B.

Equilibrium occurs at the intersection. At this point, each firm has selected a price that is best given the price choice of the other firm. Accordingly, neither has an incentive to change.

In order to identify this equilibrium, we substitute the equation for the nut price, for example, into the equation for the bolt price. This gives

$$P_B = \frac{1}{2}(12 - P_N) = \frac{1}{2}\left(12 - \frac{1}{2}(12 - P_B)\right) = \frac{12}{4} + \frac{P_B}{4} \text{ so that } \frac{3P_B}{4} = 3 \text{ or } P_B = 4 \qquad (8.7)$$

This tells us that the profit-maximizing bolt price is $P_B = \$4$. Substituting into equation (8.6) also gives the profit-maximizing nut price as $P_N = \$4$. As a result, the combined nut/bolt price is $P_B + P_N = \$8$, and from the demand equation (8.1), the number of bolt and nut pairs sold is 4. The bolt firm makes profits of $P_B Q_B = \$16$, as does the nut producer.

Now consider what happens if the two firms merge and the newly combined firm markets a single, bundled "nut-and-bolt" product. Such a firm faces the joint demand curve of equation (8.1) and so recognizes that the relevant price to customers is the sum of individual bolt and nut prices, or the total price paid for the bundled nut-and-bolt product. The marginal revenue curve associated with the demand curve of equation (8.1) is $MR = 12 - 2Q$, where Q is the number of nut-and-bolt pairs sold. Equating marginal revenue with marginal cost identifies the optimal quantity of nut-and-bolt pairs to sell. Since we have assumed that marginal cost is zero, it is easy to see that the optimal quantity of nut-and-bolt pairs that the merged monopolist should offer for sale is $Q^* = 6$. The demand function then tells us that each pair can be sold at a combined price of $P^* = \$6$ (or separate prices of \$3 each). The merged firm's total profit is $P^*Q^* = \$36$.

Comparing these values with those obtained when the firms set their prices independently of each other shows that a merger of the two firms leads to lower prices and more output than when the two firms act separately. This is because the merged firm understands the interaction of demands between the two products. As a result of coordinating nut and bolt production and pricing, consumers are made better off by this merger. Moreover, the profit of the combined firm exceeds the sum of profits earned by the two separate firms. This was Cournot's basic point.[6] By internalizing the interdependence of the two firms, both consumers and producers gain.

Merger is not the only way to achieve this outcome. Alternative means of coordinating the separate decisions of the two firms exist. For example, they could decide to form a product network. Examples include automatic teller machine (ATM) networks, airline computerized reservation systems (CRS), real estate multiple-listing services (MLS), markets for interactive components such as computer CPUs and peripherals, and long-distance and local telephone services. Where they exist, such networks have been created by the joint action of many firms with the aim of taking better account of the interactions between the demands for the firms' complementary products.

Alternatively, we might hope for one or both markets to become competitive. If this happened in only one of the two markets, say bolts, then the bolt price would fall to marginal cost, which in this case was assumed equal to zero. Each firm in the bolt market would be so small that it could not possibly impose any external effects on the nut-producing monopoly. Given a zero price for bolts, equations (8.6) imply that the profit maximizing price for nuts —and therefore of a nut-and-bolt combination—would be \$6. Accordingly, this outcome would duplicate that which occurs under merger. If both markets were to become competitive, then

[6] Allen (1938) made the same point with regard to the price-reducing effects of merging two complementary-goods monopolies. A calculus-based presentation of our analysis is provided in the Appendix.

bolt price and the nut price would each fall to marginal cost. This, of course, would yield the maximum total surplus and all of that surplus would accrue to consumers.

There is a factor that can work against the emergence of competition in markets for complementary goods. This is the presence of network externalities. For some goods and services, there is a scale economy effect that operates on the demand side of the market. For example, the more consumers that are connected to a phone system, the more valuable the phone system is to existing and new consumers. Each consumer who connects to the phone system generates an external benefit to all those already connected and makes the system more attractive to potential consumers. Sometimes this feature is described as a positive feedback.

Product complementarities of the sort we have been discussing here can also give rise to a positive feedback. Consider the Microsoft case. Microsoft's operating system Windows serves as the platform from which software applications such as word-processing packages, computer games, and graphic arts programs can be launched. A technical aspect of this relationship is that the code for a particular application must include an applications program interface (API) in order to work with the operating system. Typically, the API that works with one operating system will not work with another. In other words, applications such as Harvard Graphics or Mathematica are usually written to work on a specific operating system such as Windows. The two products, the applications and the operating system, are therefore complements.

Two additional features of the design and production of applications programs are also important. First, such production exhibits substantial scale economies. The cost is almost entirely in the design phase. Once the underlying source code is written, the program can be put on CD-ROMs (or websites) and sold (or downloaded) to millions of consumers almost costlessly. Second, there is a network externality in that the more people who use the application, the more consumers will want to use it. It is convenient to know that I can put my presentation graphics on a memory stick or in an e-mail attachment and have it read by a colleague miles away because we both use the same graphics software. For both of these reasons, firms that make these software applications have an incentive to design them to work with the most widely used operating system because this permits the firms to exploit these supply-side and demand-side scale economies more effectively.

By exactly the same reasoning, the operating system that consumers will want the most is the one for which there are the most applications. The complementary relationship between applications and operating system has resulted in a very favorable positive feedback for Microsoft's Windows. As Windows has become the dominant operating system, applications are increasingly written to run on it. In turn, this ever-expanding menu of applications has greatly fortified the position of Windows as the dominant system. This interaction is sometimes called the *applications barrier to entry*. The idea is that any would-be rival operating system will have a great deal of difficulty entering the market. Applications producers will not have an incentive to design their products to run on the alternative system until it has a significant market share. Yet the system will never get any sizable market share unless applications are written for it.

We have a countervailing force to the benefits from closer coordination in the production and marketing of complementary products. Although it is generally true that coordination is profitable, and as our nut and bolt example indicates, is beneficial for consumers when there is monopoly power in the production of the complementary goods, the network effects and the positive feedback that they generate means that monopoly power can be enhanced. This is one way in which monopoly power in one product line could be extended or leveraged to others.

8.4 ANTITRUST, BUNDLING, AND TIE-IN SALES

We are now in a better position to consider the antitrust issues raised by bundling and tie-ins. The main question is whether such practices may be used by firms with significant market power either to sustain or to extend that power against competitors or potential competitors. We illustrate these issues first with a review of the Microsoft case with which we opened this chapter. We then briefly discuss other cases and legal developments in this area.

8.4.1 Bundling and the Microsoft Case

A central issue in the government's case against Microsoft was the claim that Microsoft had integrated or bundled its browser, Internet Explorer, directly into its operating system Windows as a means to eliminate the rival browser, Netscape's Navigator, from the market. The argument was that since Microsoft had monopoly power in the operating systems market, every consumer of Windows would now find Internet Explorer as her default browser thereby eliminating or greatly reducing Netscape's market share. To prove its claim and demonstrate a violation of the antitrust laws, the government would have to show: (1) that Microsoft did possess monopoly power: (2) that an operating system and a browser were two related but distinct products that did not need to be tightly bundled; and (3) that Microsoft's practices constituted an abuse of its power motivated by the firm's desire to maintain or extend its dominant position.

In light of the foregoing, it is worthwhile recalling Judge Jackson's three key findings of fact. First, the judge found that Microsoft is indeed a monopoly in the sense of the Sherman Act. The evidence for this finding appears reasonably strong. At the time of the trial, Windows had over 90 percent of the operating systems market and had maintained that share of the market for well over a decade. Additionally, Microsoft's use of mixed bundling and other price discriminatory practices provided further evidence of something less than a competitive market. Both the structural and behavioral evidence provided some support to Judge Jackson's finding that Microsoft possessed monopoly power.

The judge's second finding was that an operating system and an Internet browser are two separate albeit complementary products. Microsoft had argued that a browser was really just an integrated part of a modern operating system. Just as flash bulbs that used to be sold separately had become technologically embedded in cameras, Microsoft claimed that similar technological developments had led it to make its browser, Internet Explorer, an integral part of its Windows operating system. Microsoft further alleged that separation of the two could not be achieved without damaging at least one of them. However, the fact remained that Netscape still marketed its Navigator browser independently suggesting that consumers did not demand an integrated operating system and browsing experience. In addition, evidence was presented at the trial showing that it was relatively easy to separate Internet Explorer from the operating system with which Microsoft had bundled it, without harming either product. So, Judge Jackson's finding that Windows and Internet Explorer are separate products could also be justified.

In light of these first two findings, Microsoft's only remaining defense is that even though it possesses monopoly power, its practice of bundling its distinct operating system and browser products did not amount to "acting badly." In other words, arguing that its integration of Windows and Internet Explorer was not done with a view to hurt competition but instead to help consumers might avoid a finding that it had violated the antitrust laws. One way to

make such a defense would be to pursue the coordination argument that we discussed above. That is, Microsoft might argue that the complementarity between an operating system and a browser requires coordination of the marketing of the two products in order to insure that consumers receive both goods at low prices. Microsoft could then make a case that its behavior was in fact pro consumer.

As we saw in the previous section, the existence of a complementary relationship between two products can lead to serious inefficiencies if each product is produced by a separate monopoly. This was arguably the case in the software industry. Microsoft's Windows controlled the lion's share of the operating systems market and Netscape's *Navigator* dominated the complementary browser market. There was a good case to be made that some mechanism for coordinating the marketing of these two products was desirable. One way to achieve this coordination is by means of a merger of the two firms.[7] What happens, however, if one of the firms does not want to merge?

For example, suppose that Netscape feels that, as a much smaller company, any merger would amount to its being swallowed up by Microsoft and losing all its managerial independence. Its management might then decide to reject a merger proposal and to continue the separate marketing of its browser. In these circumstances we can imagine that Microsoft might decide to create its own browser and bundle it with its operating system.

We can illustrate how the market outcome might evolve, again using our simple nut/bolt example. Suppose that the demand by consumers who want both an operating system and a web browser is given by

$$Q = 12 - (P_O + P_B). \tag{8.8}$$

where the subscripts "O" and "B" now indicate operating system and browser, respectively. Again, let us simplify by assuming that marginal costs for both products are zero. (We noted earlier that for software, this assumption is actually quite realistic.)

Our nut-bolt example above tells us that, when operating independently, Microsoft will sell its operating systems at $P_O = \$4$ and Netscape will sell its browser at $P_B = \$4$, so that the price of a combined operating system and browser service is \$8. We also know that this is an inefficient outcome. If the two firms coordinate or become one firm, the price of a combined system falls to \$6. Total profit of the two firms would simultaneously rise.

If a merger with Netscape is rejected, Microsoft might then develop its own browser, which we also assume can be produced at a marginal cost of zero. It would then appear that Microsoft could offer the operating system at \$3 and the browser at \$3, or a package price of \$6. However, this ignores the competition from Netscape. If Microsoft proceeds with this plan, Netscape can no longer offer its browser at a price of \$4. It could, however, offer to sell its browser at a price of \$2. After all, this is still well above marginal cost. Moreover, this price is sufficiently low that consumers would then be attracted to the Netscape browser while still buying Microsoft's operating system at the price of \$3. Of course, Microsoft would then want to reduce the price of its browser, perhaps to \$1.95. Netscape would then respond by selling its browser at perhaps \$1.80 and so on.

What we have just described is an outbreak of price competition in the browser market. The ultimate effect of this price competition will be to drive the browser price to marginal

[7] In June of 1995, Microsoft did in fact offer to work cooperatively with Netscape in the browser market and, allegedly, even suggested a merger—a proposal that was rejected by Netscape.

cost—in this case to zero. This is certainly bad news for Netscape. What about Microsoft? A review of its optimal pricing strategy as given by equations (8.6) implies that when the browser price falls to zero, Microsoft's optimal price for operating systems rises to $6. Further, a browser price of zero implies that $6 is also the best price for a combined operating system and browser package—exactly as would occur if the two firms merged. Moreover, the profit increase that a merger would bring is also realized, although it now goes entirely to Microsoft. In other words, a merger is not the only way to solve the coordination problem. Competition in one of the markets will remove the inefficiency that would otherwise result when each market is monopolized and the monopolists fail to coordinate their pricing. Prices are lower and both consumer and producer surplus have increased.

It is insightful to note that the outcome of the "browser war" just described involves a final browser price of zero. That is, in equilibrium Microsoft sells its operating system for $6 and then throws in its browser for free. This looks very much like bundling, the only complicating factor being that Netscape is also offering a free browser and so can be expected to retain a share of the browser market.

Review of the foregoing scenario should make clear that the accusation that Microsoft bundled its browser with its operating system to exploit its monopoly power and harm competitors can be challenged. Microsoft could legitimately argue that it has simply acted in a way that promotes price competition and that the lower browser prices are just a reflection of this fact. In this view, Microsoft's actions have been pro-competitive not anti-competitive.

There is, however, an additional aspect to the case that we must consider. This involves the interaction between complementary products and network externalities. The complementarity between operating systems and the applications written for them has created a substantial positive feedback loop for Microsoft. Because Windows has a monopoly in operating systems, the majority of applications are written to run on Windows. In turn, because most applications are written for Windows, no other operating system can challenge the Windows dominance. Internet browsers, however, offer a potential way around this problem. The advent of the JAVA programming language developed by Sun Microsystems and other technical advances make it possible to run applications on an Internet browser. The browser itself therefore can serve as a platform from which to launch applications.

If Navigator can serve as an applications platform, then even after the development of Internet Explorer Navigator would be expected to retain a reasonable share of the browser market. In turn, the existence of this alternative platform with a substantial market share means that design firms could begin to write their applications to run on an alternative to Windows. As this happened, Navigator would benefit from the same positive feedback that Windows enjoyed. As more applications could be run from the browser, the browser would become more popular and still more applications would be written for it. Clearly, such a development would strike at the core of Microsoft's success by leading to fierce competition in the platform market. Testimony at the trial revealed that Microsoft management was both aware and fearful of this development.

In light of the foregoing, Microsoft's explicit bundling of Internet Explorer with its Windows operating system takes on a different light. Instead of a competitive act that reduces a coordination inefficiency between complementary products, Microsoft's bundling can also be viewed as a deliberate effort to reduce Netscape's share of the browser market so that the Netscape browser becomes an unattractive alternative to applications designers. In turn, this would eliminate Netscape as a threat to Microsoft's operating system monopoly. Indeed, Microsoft initially required that PC manufacturers such as Compaq and Dell, who installed Windows as their operating system also install Internet Explorer as the default browser appearing on

the Windows desktop. They did this presumably on the supposition that most consumers want only one browser even if a second can be obtained for free. The subsequent integration of Internet Explorer into the Windows software could be viewed as an attempt to replace contractual bundling with technological bundling.

Whatever the type of bundling, however, the foregoing analysis sees the motive as the same—namely the prevention of Netscape developing a viable competitor to Microsoft. This alternative interpretation of Microsoft's behavior does imply a violation of the antitrust laws because it alleges that Microsoft abused its power primarily to sustain its monopoly, i.e., to hurt competition. In support of this argument, the Justice Department offered much suggestive evidence only a portion of which we can summarize here.

First, there were internal Microsoft documents revealing management's concern over the potential threat that Netscape might pose to the dominance of Windows as the applications platform. Second, some additional evidence of malicious intent was that in addition to its bundling strategy that effectively required Windows users to acquire Internet Explorer as their default browser, Microsoft also pressured Macintosh to support Internet Explorer as its default browser. It did so by refusing to develop applications, such as its Office products, for the Macintosh computers unless Macintosh complied. Since Macintosh computers do not use the Windows operating system, this action was hard to justify as reflecting a technical improvement to Windows in the way that an internal flash device was an improvement to cameras. Finally, and perhaps even more damaging was the fact that Microsoft actually paid internet service providers such as America-On-Line (AOL) to adopt its browser and even gave AOL a space on the Windows desktop. Since AOL competes directly with Microsoft's own Internet service, this action is again hard to understand except as a way to foreclose the AOL market to Netscape.

Ultimately, Judge Jackson found the evidence compelling that Microsoft had abused its market power to bundle separate goods as a means to extend its dominance to the browser market. To some extent, it is what the appellate court later found as well. However, that court differed strongly with Judge Jackson that the appropriate remedy for violation was to break up Microsoft into separate companies much as John D. Rockefeller's Standard Oil was broken up 90 years earlier. Instead, the court remanded the case to Judge Colleen Kollar-Kotelly to work out a less drastic remedy that would be based on restrictions on Microsoft's actions and on monitoring to insure that those restrictions are enforced.[8] These arrangements appear to have been worked out and the case is over as a legal matter (at least in the U.S.). As we noted in Chapter 1, however, Microsoft has continued to be sanctioned and fined in Europe for anticompetitive bundling practices, most notably, in connection with its audio-visual software, Media Player. This is simply further evidence that in an age of complementarities and "interconnectedness," such issues unlikely to disappear.

8.4.2 Antitrust Policy, Bundling, and Tying: Additional Developments

The issues raised in the Microsoft case are not new. The fear that large, established firms could abuse their market power and prevent or eliminate competition is what lies at the heart of antitrust policy. As noted in Chapter 1, Section 1 of the Sherman Act explicitly proscribes

[8] For the legal record, see *U.S. v. Microsoft*, 253 F.3d 34 (D.C. Cir., 2001) and *U.S. v. Microsoft*, 231 F. Supp. 2d 144 (D.D.C. 2002). For further discussion see Economides and Salop (1992), Shapiro and Varian (1999), and Rubinfeld (2003).

monopoly power whenever its exercise weakens competition. Moreover, the subsequent Clayton Act speaks rather directly to the issue of bundling or tying: "It shall be unlawful . . . to lease (or sell) goods . . . on the condition, agreement, or understanding that the lessee or purchaser thereof shall not use or deal in the goods . . . of a competitor or competitors of the lessor or seller, where the effect . . . may be *to substantially lessen competition or tend to create a monopoly in any line of comme*rce [emphasis added]." We defer until Chapters 12 and 13 for a detailed formal discussion of anti-competitive or predatory practices. However, now is a good time to examine further the evolution of antitrust policy towards bundling and more specifically, tying.

Two key cases established a very clear legal presumption against tie-in requirements. The first was the *United Shoe* case of 1922. As a result of over fifty mergers, the United Shoe company had emerged as the dominant maker of shoe-manufacturing machinery in the early twentieth century with a market share on the order of 80 to 90 percent. Shoe-making uses a number of machines, however, and United Shoe faced competition in at least some of these lines. In leasing its machines to shoe manufacturers it stipulated that the manufacturers could not use any United Shoe machines in combination with those of other rival manufacturers and also that the shoe manufacturers had to buy certain supplies exclusively from United Shoe. Twenty-five years later, the court confronted a similar case with the International Salt Company. That company refused to lease its salt processing machines unless the lessee also agreed to purchase all its salt from International Salt. In this case, the court inferred International Salt's monopoly power largely from the fact that the company had a patent on its machines. The court found that both the United Shoe and International Salt tying requirements violated the antitrust statutes.[9] In these cases and others (including one involving IBM), the court emphasized the defendant firm's monopoly power in the tying good. As a result, the conventional legal wisdom was that tying requirements imposed by large, dominant firms would almost constitute a *per se* violation of the antitrust laws.

Over the years, the court's views on tying mellowed. In part, this was the result of an important insight of the Chicago School. This insight was that tying contracts as a means of leveraging a firm's power in one market to power in another would make little sense in a wide class of cases. Recall our nut-and-bolt example. Assume that bolts are monopolized but nuts are competitive. As we showed earlier, the bolt monopolist would then set a price of $6 and earn a profit of $36. Suppose now that this monopoly bolt firm uses a tying clause to require the use of its own nuts and thereby extends its monopoly power to this second market, as well. We know that this would allow the firm to raise the price of nuts to say, $2. However, if it does this, the firm will need to lower the bolt price to $4 because what consumers really want is the nut-and-bolt combination and the profit-maximizing price for that combination is still $6, and the maximum profit earned is still $36. The point of this Chicago School argument is that there is a potential maximum monopoly profit in these two markets and the monopolist can get all of the profit in the bolt market if the nut market is competitive, thereby removing any incentive to extend its monopoly to nuts via a tying requirement.

As the Microsoft case shows, however, there is a qualification to this argument. Generally speaking, when the market for the tied good involves substantial scale or scope economies, tying (and bundling) and leveraging power from one market into another can be profitable.

[9] *United Shoe Machinery Corp. v. United States*, 258 U.S. 451; *International Salt Co. v. United States*, 332 U.S. 392 (1947). Peterman (1979) argues that the fact that firms were allowed to use salt from producers other than International Salt if it was cheaper suggests that the real purpose of the tying was to reveal to International Salt the pricing practices of its rivals.

The volume of profit in these cases depends positively on the scale of operations. By requiring tied purchases, the monopolist in say operating systems can deny those scale economies to rivals in web browsers—thereby making them unprofitable—and enhance its own profits by reaping those scale economies for itself.

Recognition that the leverage of market power may sometimes be anticompetitive has led the court to move cautiously in relaxing its earlier strict rules against tying and bundling. In 1960, the Supreme Court accepted the use of a tied-sales clause in a case involving Jerrold Electronics Corporation, a pioneer in cable television systems and the community antenna television (CATV) industry, because it felt that this was a legitimate way of guaranteeing quality performance of a service in the early, developmental stage of an industry.[10] More recently, in the 1984 *Jefferson Parish* case, the Supreme Court attempted to articulate a clear set of guidelines under which any such arrangement would be *per se* illegal. The case involved a requirement by the Jefferson Parish Hospital that to use its surgical services it was necessary to use the group of anesthesiologists with whom the hospital had an exclusive contract. In its decision, which found for the hospital, the court stated three conditions, all of which would have to be met for the tie-in to violate antitrust laws.[11] These are:

1. the existence of two distinct products, the tying product and the tied one;
2. the firm tying the products must have sufficient monopoly power in the tying market to force the purchase of the tied good; and
3. the tying arrangement must foreclose, or have the potential to foreclose, a substantial volume of trade.

The logic behind these conditions is clear enough. It would be wrong, for example, to consider a computer and its power cord as two separate products and then claim illegal tying. Likewise, the anticompetitive abuse of market power is only plausible if a firm has such power in the first place, and must be substantial to constitute a violation of the antitrust laws. Yet the result of these efforts in practice has been a curious mixture of *per se* and rule of reason standards. On the one hand, the *Jefferson Parish* conditions are meant to establish conditions under which bundling and tying are *per se* illegal. On the other hand, the interpretation of those standards is open to enough variation that a sort of rule of reason has emerged about whether they apply.

One troubling feature of the foregoing judicial history is that so little attention has been paid to cost-based reasons for bundling and tying. Yet there can be little doubt that such cost-efficiencies are present. This is because we see bundling and tying requirements in many competitive situations where neither price discrimination nor the extension of monopoly power can be the motive. This point has been particularly emphasized in a series of recent papers by Evans and Salinger (2005) and Evans (2006).

To understand the intuition of the Evans and Salinger (2005) argument, consider the case of head cold remedies. Some cold sufferers primarily endure headaches and sore throats. For these consumers, the main treatment they want is pain relief. Others, however, find sinus congestion and irritation to be the main aggravating symptom. These consumers want a decongestant in their cold remedy. Of course, there is also a third group that wants both a pain reliever and a decongestant.

[10] *United States v. Jerrold Corporation*, 187 F. Supp. 545 (1960), affirmed *per curiam* at 363 U.S. 567 (1961).

[11] *Hyde v. Jefferson Parish Hospital District No. 2, et al.*, 466 U.S. 2, 15–18 (1984).

Table 8.3 Pure bundling as the sustainable equilibrium

Demand volume	*Product*		
	Pain relief 50	*Decongestant* 50	*Bundle* 100
Costs			
Fixed cost	$300	$300	$300
Marginal cost	$4	$4	$7
Possible prices under:			
Separate goods	$6	$6	—
Pure bundling	—	—	$8.5
Mixed bundling	$10	$10	$10
Bundle and good 1	$10	—	$9
Bundle and good 2	—	$10	$9

As a specific example, let us assume that there are 50 people in each of the first two groups and 100 in the third. Members of each group have a sufficiently high reservation price that they will always buy the product. Let us also assume that to produce, package, and market each cold remedy drug for this market incurs a fixed cost of $300. Further, assume that the marginal cost of producing and packaging either bottle of pain relief medicine or a package of decongestants is $4, but that there are some marginal cost savings in putting the two in one pill so that the marginal cost of a combined, pain reliever and decongestant product is just $7. Finally, rather than assume a perfectly competitive market, we will assume that there is just one firm. However, we will also assume that entry is easy and costless so that that firm is constrained to offer products at prices that just permit it to break even. Table 8.3 shows the possible product offerings and the associated zero-profit prices.

Let's first think about our firm just offering the pain reliever and the decongestant separately. The first group of consumers will buy the pain reliever, the second will buy the decongestant and the third group will want to buy both products. So, demand for each product is 150 implying an average fixed cost for each drug of $300/150 = $2. When added to the marginal cost of $4, the break-even price is $6. However, this outcome is not an equilibrium. Any firm could enter the market and sell just the bundle for $10.00. This would attract all of the 100 consumers who want a combined medication, since they currently pay $6 + $6 = $12 to get both types of relief. In turn, the loss of these customers would make the continued offering of the two separate products at a price of $6 impossible as the average cost of each of these would now rise to $10. Indeed, since this price is the same as the bundle price, we might imagine that some of these consumers will actually buy the bundle as it gives them the relief they want plus a little something extra. As this happens, however, the bundle price falls further due to additional fixed cost savings while the individual prices must rise further. This will push all 200 customers to buy the bundle at which point the break-even price for the bundle drops to $8.50. This is, in fact, the only sustainable price and product combination. It is therefore the equilibrium in this imperfectly competitive but contestable market.[12]

[12] A review of Table 8.3 will make it clear why either mixed bundling or offering a bundle and one good separately also cannot be an equilibrium

The scenario just described is worth some reflection. Competitive pressures police the market and force prices to equal costs. Even so, the firm in the market offers only the two goods, pain reliever and decongestant, together in one package. No consumer can buy this firm's pain relief medicine without also buying its decongestant. This is definitely a case of tying. Yet the tying is not done either to price discriminate or to extend monopoly power. It is simply another result of the competitive pressure to offer low-cost medication.

The idea that competition underlies much of the tying and bundling we observe is precisely the point that Evans and Salinger (2005) and Evans (2006) make. In their view, these practices are far too common to be explained either by price discrimination or monopolization motives. They note as well that even when price discrimination is the cause, the market outcome does not merit policy intervention. Hence, the only time that tying or bundling is definitely harmful is when it is used for leveraging market power. Given that some large scale and possibly scope economies are required to make the leveraging argument powerful, these authors and others have argued that all attempts at a *per se* illegal rule is misguided. Instead, they call for an explicit use of a rule of reason with a general presumption that the tying is legal unless the intent and ability to extend market power is explicitly shown.

Summary

In this chapter we have shown that a firm with monopoly power in more than one product line may have additional opportunities to price discriminate. By bundling its two goods together as a package or, more generally, by tying the sale of one good to the purchase of the other, the firm can induce customers to sort themselves out by their purchase decisions and ex post identify who is who. This permits charging a higher net price to those consumers with a greater willingness to pay.

In the case of two complementary products for which a fall in the price of one good raises the quantity demanded of both, sales coordination may occur for reasons other than price discrimination. In the absence of such coordination through a merger or a business network, for example, the separate production and marketing of two complementary products will typically raise prices, reduce output, and reduce profits. By taking account of the interrelationship between the demands for each product, coordination potentially offers benefits to both consumers and firms alike.

There can, however, be a downside to both bundling and tie-in sales. In cases in which large scale economies are present, these strategies may enable a firm to extend its market power in one product to another product line. This was the charge against Microsoft, and it is the central issue in antitrust cases involving tie-in requirements. However, it is worthwhile recognizing that some fairly strong market conditions have to be met for this outcome to prevail. It is equally worthwhile to remember that much of the tying and bundling occurs in fairly competitive markets. In such cases, there is some presumption that the practices are cost efficient. It follows that when we observe firms with market power using the same tactics, the goal of cost minimization may again be the reason.

So far, our analysis has focused on the strategic choices of a monopoly firm either acting alone or interacting in a second market that is also monopolized. The next step is to consider firms' strategies in the context of imperfect competition where neither one nor many firms but just a few firms interact. In such a setting, a firm can no longer simply address the issue of how to extract greater surplus from consumers. Each firm must now also consider how its production and pricing strategies affect not just consumers but the other, rival firms. This is the stuff of game theory and it is to this topic that we turn next.

Problems

1. A university has determined that its students fall into two categories when it comes to room and board demand. University planners call these two types, Sleepers and Eaters. The reservation prices for a dormitory room and the basic meal plan of the two types are as follows:

	Sleepers	*Eaters*
Dorm room	\$5,500	\$3,000
Meal plan	\$2,500	\$6,000

   Currently, the university offers students the option of selecting just the dorm room at \$3,000, just the meal plan at \$2,500, or both for a total price of \$5,500. An economic consultant advises the university to stop offering the two goods separately and, instead, to sell them only as a single, combined room and board package. Explain the consultant's strategy and determine what price the university should set for the combined product.

2. Bundling is not always superior to nonbundling. To see this, consider a telecommunications firm that offers both phone service and a high-speed modem service. It has two types of consumers who differ in their willingness to pay a monthly rental fee for either service.

	Talkers	*Hackers*
Phone service	\$30	\$*a*
High-speed connection	\$16	\$24

   Determine for what values of a bundling would be more profitable than not bundling.

3. Many years ago, the major alternative to xerography in copying was the Electrofax copying process. Electrofax machines used a special paper coated with a heavy wax film. Like Xerox, the Electrofax companies charged a low price for the use of the machine but set a paper price per page of 4 cents. The actual and marginal cost of manufacturing the paper was, in fact, only 1 cent per page.
   a. Explain the pricing policy of the Electrofax producers.
   b. The high markup on Electrofax paper soon attracted new firms offering to supply the paper at a much lower price than the Electrofax producers. How do you think Electrofax will respond to this competition?

4. Computer software, S, and hardware, H, are complementary products used to produce computer services. Customers make a one-time purchase of hardware, but buy various amounts of software. That is, once the hardware is purchased, the price of additional computer services is P_S, the price of a unit of software. The software market is competitive. However, the hardware market is monopolized by the firm, HAL, Inc. The cost of producing software and hardware is c_S and c_H, respectively:
   a. Assume that all users of computer services are alike, that is, have the same demand curve for computer services. Use a graph to describe the profit-maximizing price HAL can charge.
   b. Would HAL gain anything by buying software at the competitive price, branding it as its own, and then selling its hardware only to customers who use the HAL-brand software?

5. LRW runs a railroad line from New York to Philadelphia, the LRW line. At present, fixed costs are reasonably large making it difficult for others to enter the market. Later, Nat Skape discovers that there is a market for travel from Philadelphia to Washington that is sufficiently large to permit offering passenger service between these two cities. His service is called the NSRR. Over time, both the LRW Line and the NSRR learn that many, though not all, of the customers riding from Philadelphia to Washington are actually passengers who originated in New York.
   a. What pricing issues arise between the LRW Line and the NSRR?
   b. Imagine that once it has incurred the sunk costs of setting up the Philadelphia to Washington line, it is possible that with a little experience, NSRR may be able to enter successfully the New York to Philadelphia market. Imagine further that before such entry occurs, the LRW Line builds an extension to Washington and offers riders from New York the advantage of service to Washington without the need to change trains. How should antitrust policy makers respond to this development?

6. Return to Table 8.3. What would be the equilibrium product offering and associate prices if:
   a. All values were unchanged except that there are now 100 consumers in each of the first two groups and only 50 in the group that wants both a pain reliever and a decongestant?
   b. All values were unchanged except that there are now 100 consumers who want pain relief, and 100 who want both pain relief and a decongestant, but only 50 who want only a decongestant?

References

Adams, W. J., and J. Yellen. 1976. "Commodity Bundling and the Burden of Monopoly." *Quarterly Journal of Economics* 475 (May): 475–98.

Allen, R. G. D. 1938. *Mathematical Analysis for Economists*. New York: St. Martin's Press.

Economides, N. and S. Salop. 1992. "Competition and Integration among Complements, and Network Market Structure." *Journal of Industrial Economics* 40 (March): 105–23.

Evans, D. 2006. "Tying: The Poster Child for Antitrust Modernization." In R. Hahn, ed., *Antitrust Policy and Vertical Restraints*. Washington, DC: Brookings Institution Press, 65–88.

Evans, D. and M. Salinger. 2005. "Why Do Firms Bundle and Tie? Evidence from Competitive Markets and Implications For Tying Law." *Yale Journal on Regulation* 22 (Winter): 38–89.

Peterman, J. 1979. "The International Salt Case." *Journal of Law and Economics* 22 (October): 351–64.

Rubinfeld, Daniel. 2003. "Maintenance of Monopoly: *U.S. v. Microsoft* (2001)." In J. E. Kwoka, Jr. and L. J. White, eds., *The Antitrust Revolution: Economics, Competition, and Policy*. 4th edition. Oxford, Oxford University Press.

Stigler, G. 1968. "A Note on Block Booking." In *The Organization of Industry*. Homewood, IL: Irwin.

Shapiro, C. and H. R. Varian. 1999. *Information Rules*. Boston: Harvard Business School Press.

Appendix

Formal Proof of the Inefficiency Induced by the Marketing of Complementary Goods by Separate Monopolists

Assume that the products of two monopolists, A and B, are complementary goods. Consumers require one unit of good B for every unit of good *A* consumed. The price charged by each firm will be denoted as P_A and P_B, respectively. However, since consumers only buy the two goods together in a one-to-one proportion, the price of concern to either firm's customers is the sum of P_A and P_B, denoted here as S.

Total demand Q for the composite product or *AB* pair is described as:

$$Q = D(S); \text{ where } D' = \partial Q/\partial S < 0; \text{ and } S = P_A + P_B \tag{8A.1}$$

We simplify further by assuming that each firm has a constant marginal cost of production equal to zero. Hence, revenue maximization is equivalent to profit maximization. Firm A's profit and Firm B's profit Π^A and Π^B, respectively, are therefore given by:

$$\begin{aligned} \Pi^A (P_A, P_B) &= P_A D(S) \\ \Pi^B (P_A, P_B) &= P_B D(S) \end{aligned} \tag{8A.2}$$

Individual profit maximization at each firm implies choosing a price such that the derivative of its profit, $\Pi^A(P_A, P_B)$ or $\Pi^B(P_A, P_B)$, with respect to its own price is zero. That is:

$$\frac{\partial \Pi^A(P_A, P_B)}{\partial P_A} = P_A D'(S) + D(S) = 0$$
$$\frac{\partial \Pi^B(P_A, P_B)}{\partial P_B} = P_B D'(S) + D(S) = 0 \tag{8A.3}$$

Since each firm will always set its price so as to maximize profits, equations (8A.3) must always hold. Denote the resultant equilibrium value of S as S^e. We obtain some insight into the value of S^e by first summing the two equations in (8A.3) to obtain:

$$S^e D'(S^e) + 2D(S^e) = 0 \tag{8A.4}$$

where we have made use of the fact that $S^e = P_A^e + P_B^e$. Subtracting $D(S')$ from each side of equation (8A.4) then yields:

$$S^e D'(S^e) + D(S^e) = -D(S^e) < 0 \tag{8A.5}$$

Now consider the strategy of a firm M that markets both goods as a single, composite product selling at the price S^M. Its profit Π^M is given by:

$$\Pi^M(S^M) = S^M D(S^M) \tag{8A.6}$$

Profit maximization for this firm therefore requires:

$$\frac{\partial \Pi^M(S^M)}{\partial S^M} = S^M D'(S^M) + D(S^M) = 0 \tag{8A.7}$$

If instead of choosing the optimal price S^M, firm M chose the price S^e chosen by the two separate firms A and B, it clearly would not be at a point where the derivative in equation (8A.7) is zero. Indeed, we can determine precisely what the sign of that derivative evaluated at S^e would be.

$$\frac{\partial \Pi^M(S^e)}{\partial S^e} = S^e D'(S^e) + D(S^e) \tag{8A.8}$$

It is clear from comparison with equation (8A.5) that the value of the derivative in equation (8A.8) must be negative. That is, if the single, two-product firm priced at the aggregate level that the two rival firms did individually, an increase in that total price would tend to reduce its profit while a decrease would tend to raise it. The two rival firms thus set prices P^A and P^B that exceed the optimal price of a single firm marketing both products. Starting from that price, the single, two-product firm could raise profit by lowering the price further. Such a price reduction would not only raise producer surplus. It would also raise consumer surplus.