

NBER WORKING PAPER SERIES

TYING, FORECLOSURE, AND EXCLUSION

Michael D. Whinston

Working Paper No. 2995

NATIONAL BUREAU OF ECONOMIC RESEARCH  
1050 Massachusetts Avenue  
Cambridge, MA 02138  
June 1989

Much of the work on this paper was done during the summers of 1986 and 1987. I would like to thank the Federal Trade Commission and the Graduate School of Business at Stanford University for their hospitality during that time. I would also like to thank Patrick Bolton, Franklin Fisher, Louis Kaplow, Richard Schmalensee, and Jean Tirole for their helpful comments. Financial support from the National Science Foundation through grant SES-8618775 is also gratefully acknowledged. This paper is part of NBER's research program in Productivity. Any opinions expressed are those of the author not those of the National Bureau of Economic Research.

NBER Working Paper #2995  
June 1989

TYING, FORECLOSURE, AND EXCLUSION

ABSTRACT

Tied sales have a long history of scrutiny under the antitrust laws of the United States. The primary basis for the condemnation of this practice has been the court's belief in what has come to be known as the "leverage theory" of tying: that is, that tying provides a mechanism whereby a firm with monopoly power in one market can use the leverage provided by this power to foreclose sales in, and thereby monopolize, a second market. In recent years, however, the leverage theory has come under heavy attack. In this paper, I reconsider the leverage hypothesis. I argue that, in an important sense, the models used by the critics of the leverage theory- which all assume that the tied good market has a competitive, constant returns-to-scale structure- are incapable of addressing the central concern of the leverage theory, that tying can be profitably used to change the market structure of the tied good market. I then demonstrate that when the tied good market has an oligopolistic structure, tying can indeed serve as a mechanism for leveraging market power through the foreclosure of tied market rivals' sales. The mechanism through which this foreclosure occurs, its profitability for the monopolist, and its welfare implications are discussed in detail.

Michael D. Whinston  
Department of Economics  
Littauer 314  
Harvard University  
Cambridge, MA 02138

## 1. Introduction

A firm engages in tying when it makes the sale (or price) of one of its products conditional upon the purchaser also buying some other product from it. Tying has a long history of scrutiny under the antitrust laws of the United States, and throughout this history it has been harshly treated by the courts.<sup>1</sup> A primary basis for this condemnation has been the courts' belief in what has come to be known as the "leverage theory" of tying: that is, that tying provides a mechanism whereby a firm with monopoly power in one market can use the leverage provided by this power to foreclose sales in, and thereby monopolize, a second market.

In recent years the leverage theory has come under heavy attack from a number of authors (see, for example, Director and Levi [1956], Bowman [1957], Posner [1976], and Bork [1978]) whose arguments are traceable to the University of Chicago oral tradition associated with Aaron Director. A typical rendition of their criticism goes along the following lines: Suppose that a firm is a monopolist of some good A that a consumer values at level  $v_A$  and that costs  $c_A$  to produce. The consumer also consumes some other product B that she values at level  $v_B$ , can be produced at a unit cost of  $c_B$ , and is competitively supplied. Now, the monopolist could require the consumer

.....  
<sup>1</sup>Tying doctrine was originally developed in patent cases [Motion Pictures Patents Co. v. Universal Film Manufacturing Co., 243 U.S. 502 (1917)]. Since then a long line of case law has developed both under Section 1 of the Sherman Act and Section 3 of the Clayton Act [See, for example, International Salt v. U.S., 332 U.S. 392 (1947) and Northern Pacific Railway Co. v. U.S., 356 U.S. 1 (1958)]. Similar ideas have also been developed under Section 2 of the Sherman Act [See, for example, U.S. v. Griffith, 334 U.S. 100 (1948) and U.S. v. United Shoe Machinery Corp., 110 F. Supp. 295 (D. Mass 1953)]. Two cases involving less harsh treatment are Times-Picayune Publishing Co. v. U.S., 345 U.S. 594 (1953) and U.S. v. Jerrold Electronics Corp., 365 U.S. 567 (1961).

to purchase good B from him if she wants good A, but what will he gain? The consumer will only purchase such a bundle if its price is no larger than  $v_A + c_B$  and so the monopolist can do no better than earning  $(v_A - c_A)$ , the level it earns selling good A independently. In short, there is only one monopoly profit that can be extracted.

Similar arguments are given for the case of complementary products.

Posner [1976], for example, comments that:

[A fatal] weakness of the leverage theory is its inability to explain why a firm with a monopoly of one product would want to monopolize complementary products as well. It may seem obvious... , but since the products are by hypothesis used in conjunction with one another... , it is not obvious at all. If the price of the tied product is higher than the purchaser would have to pay on the open market, the difference will represent an increase in the price of the final product or service to him, and he will demand less of it, and will therefore buy less of the tying product. To illustrate, let a purchaser of data processing be willing to pay up to \$1 per unit of computation, requiring the use of 1 second of machine time and 10 punch cards, each of which costs 10 cents to produce. The computer monopolist can rent the computer for 90 cents a second and allow the user to buy cards on the open market for 1 cent, or, if tying is permitted, he can require the user to buy cards from him at 10 cents a card- but in that case he must reduce his machine rental charge to nothing, so what has he gained?

As this example suggests, in the absence of price discrimination a monopolist will obtain no additional profits from monopolizing a complementary product.

Thus, the critics contend, if a monopolist does employ tying his motivation is not leverage but some other objective such as price discrimination (Bowman [1957]), achieving economies of joint sales, protection of goodwill, risk sharing, or cheating on a cartel price that has either socially beneficial, or at worst, ambiguous consequences. This view has also been reinforced by the more formal economics literature on tying by single product monopolists because of that literature's exclusive focus on price discrimination motivations for the practice (see, for example, Burstein [1960], Blair and Kaserman [1978], and Schmalensee [1982]). Thus, Posner

{1976} goes on to note that "the replacement of leverage by price discrimination in the theory of tie-ins has been part of the economic literature for almost twenty years", while Bork {1978} sums up his discussion of tying,

[the leverage] theory of tying arrangements is merely another example of the discredited transfer of power theory, and perhaps no other variety of that theory has been so thoroughly and repeatedly demolished in the legal and economic literature.

Though this conclusion may be worded a bit strongly, it is fair to say that these criticisms have had a tremendous impact in both legal and economic circles.<sup>2</sup>

In an important sense, however, the existing literature does not really address the central concern inherent in the leverage theory, namely, that tying may be an effective (and profitable) means for a monopolist to affect the market structure of the tied good market (i.e., "monopolize" it) by making continued operation unprofitable for tied good rivals. The reason lies in the literature's pervasive (and sometimes implicit) assumption that the tied good market has a competitive, constant returns-to-scale structure. With this assumption, the use of leverage to affect the market structure of the tied good market is actually impossible. Thus, in contrast to a concern over the effects of tying on market structure, the existing literature's focus is on a demand-side notion of "leverage": the idea that, taking the prices charged by tied good competitors as given, a firm might be able to extract greater

.....  
<sup>2</sup>In a recent antitrust textbook, for example, Blair and Kaserman [1985] comment that "according to this view, somehow the seller expands or levers his monopoly power from one market to another. This, of course, is not possible. A seller cannot get two monopoly profits from one monopoly .... Thus, the leverage theory of tying is unsatisfactory." The 1985 Department of Justice Vertical Restraints Guidelines state that "Tying arrangements often serve procompetitive or competitively neutral purposes.... [They] generally do not have a significant anticompetitive potential." For a recent rebuttal to this view in the legal literature, however, see Kaplow [1985].

profits from consumers by tying.<sup>3,4</sup>

In this paper, I reexamine the leverage hypothesis. In particular, I examine several simple models which depart from the competitive, constant returns-to-scale structure assumed in the existing literature. In contrast, here I assume that scale economies exist in the production process for the tied good, and as a result, the structure of that market is oligopolistic.

In these models I address three basic questions. First, can tying succeed in altering the market structure of the tied good market, and if so, how? Second, is it a profitable strategy? Third, what are the welfare consequences? As we shall see, tying can lead to a monopolization of the tied good market. Most interestingly, the mechanism through which this exclusion occurs is foreclosure; by tying, the monopolist reduces the sales of its tied good market competitor, thereby lowering his profits below the level that would justify continued operation.

Tying is frequently a profitable strategy for the monopolist in these models, and is often so precisely because of its potential for altering the market structure of the tied good market. The particular circumstances in which tying is a desirable strategy for the monopolist, however, depend in part on whether he is able to make a precommitment to tie. In many circumstances this is indeed possible. One of the primary ways in which this

.....  
<sup>3</sup>Indeed, this is exactly the sense in which the existing literature can be said to focus on price discrimination aspects of the practice; it analyzes whether tying is a profitable strategy given the prices of tied good competitors (which can be thought of as creating an induced demand structure for the monopolist). In contrast, here my focus is on the ability of tying to change those prices, in particular, by making continued operation unprofitable for competitors.

<sup>4</sup>Note that even in those existing models where the tying good is essential for the use of the tied good (as in Bowman [1957]), exit of the tied good producers from that market is actually irrelevant as far as the monopolist is concerned. For example, if a group of consumers exist who use the tied good alone and rival tied good manufacturers continue to sell their product to these consumers at the same competitive price, the monopolist's strategy is equally effective (by way of contrast, see Section 4C below).

can be accomplished is through product design and the setting of production processes, both of which may involve significant sunk costs. By bundling components of its system together, or by making interfaces between the separately sold components incompatible with their rivals' components, firms can precommit to their marketing strategy. IBM, for example, was accused of incorporating increased amounts of storage into its central processing units in order to prevent sales by plug compatible memory manufacturers and also of trying to achieve interface incompatibility for the same purpose (Fisher, McGowan, and Greenwood [1983], p. 332-3). Kodak was accused of designing its new film and camera in a format incompatible with rival manufacturers' products [Berkey Photo v. Eastman Kodak Co., 603 F.2d 263 (2d Cir., 1979)].

On the other hand, in a significant number of tying cases little more than an easily changed marketing decision seems to be involved. For example, in Times-Picayune Publishing Co. v. U.S. [345 U.S. 594 (1953)] the publisher of the only morning newspaper in New Orleans only sold an advertisement in his morning paper with an advertisement in that day's evening newspaper (which faced competition from another evening newspaper). In U.S. v. Griffith [334 U.S. 100 (1948)], a movie theatre chain refused to show films in its theatres in towns in which it possessed a monopoly if the distributor did not give it that film in towns where it faced competition. In United Shoe Machinery Corp. v. U.S. [110 F. Supp. 295 (D.Mass. 1953)], United Shoe bundled repair service with its shoe machinery leases.

Finally, when tying does lead to exclusion of rivals, the welfare effects both for consumers and for aggregate efficiency are in general ambiguous. The potential gain for consumers arises for the usual reasons associated with price discrimination. The loss, of course, arises because when tied market rivals exit prices may rise and the level of variety available in the market necessarily falls. Indeed, in the models studied here, tying that leads to the exit of the monopolist's tied market rival frequently leads to increases

in all prices, making consumers uniformly worse off. The effect on aggregate welfare, on the other hand, is uncertain due to the usual inefficiencies in the number of firms entering an industry in the presence of scale economies and oligopolistic pricing.

Though most tying cases involve products that are complements (particularly those where precommitment is involved), for expositional purposes I begin below by considering the case of independent products. In Section 2, I first analyze the simple case where all consumers have an identical valuation of the monopolized product, so that the monopolist, if he chooses to price his goods independently, can fully extract all of the surplus from his monopolized good. I first show that, absent precommitment, tying is not a useful strategy for the monopolist; any equilibrium outcome will be equivalent to one where only independent pricing is allowed. Despite this fact, however, a precommitment to tying can be a profitable strategy for the monopolist due to its potential for excluding his tied market rival. This exclusionary effect arises due to what I call "strategic foreclosure": tying represents a commitment to foreclose sales in the tied good market, which can drive its rival's profits below the point where remaining in the market is profitable. This strategic incentive to foreclose sales in the tied good market occurs because once the monopolist has committed to offering only tied sales, it can only reap its profit from its monopolized product by making a significant number of sales of the tied good. Thus, in this model, tying necessarily lowers the profits of the monopolist's tied good rival. I then discuss the implications of such a commitment to tying for the monopolist's profits, for consumers, and for aggregate efficiency, and present a simple example to illustrate these points.

In Section 3, I investigate how the presence of heterogeneous preferences among consumers for the monopolized good affects these results. Two basic findings emerge. First, with heterogeneous preferences for the tying good,



tying no longer necessarily results in strategic foreclosure and the lowering of the monopolist's tied good rival's profits (though it still does in many circumstances). If, for example, a significant number of consumers in the tied market have low valuations of the tying good, tying (not surprisingly) will be not be a successful exclusionary device. In addition, a more subtle effect may prevent a commitment to tying from lowering the tied good rival's profits. This occurs when tying substantially decreases the responsiveness of the monopolist's demand to price changes relative to the level previously prevailing in the tied good market.

Second, with heterogeneous valuations, tying can now also be a profitable strategy in the absence of precommitment. There are two senses in which this is true. First, in a purely static sense, the monopolist may find tying to be a profitable strategy given its rival's price. This motivation for tying is analagous to that in the monopolistic bundling literature (e.g., Adams and Yellen [1976]; McAfee, McMillan, and Whinston [1987]), but here can have important competitive effects: tied product market rivals can find their sales foreclosed and continued operation unprofitable. Second, even when tying is not profitable in this static sense, it may be in a dynamic sense when the exclusion of rivals through predation is possible. In such cases, tying can be a profitable strategy for the monopolist precisely because it forecloses the sales of the monopolist's tied market rival.

In Section 4, I turn to the case of complementary products used in fixed proportions. I first consider a model of fixed proportions that is essentially an extension of the simple example quoted above from Posner [1976] to the case where the tied good market involves scale economies and oligopolistic behavior. Despite these differences, Posner's central contention continues to hold: a monopolist of one component never finds it worthwhile to tie in order to reduce the level of competition in the market for the other component. The reason lies in the fact that when the

monopolized product is essential for all uses of the products, the monopolist can always benefit from more competition in the market for other components through sales of its monopolized product. Nevertheless, I then show that in two natural extensions of this model where the monopolized product is no longer essential for all uses of the non-monopolized components, tying once again emerges as a profitable exclusionary strategy. In one case, the presence of an inferior, competitively supplied alternative to the monopolized component leads to results that parallel those for independent products. In the other case, the existence of a second use for the non-monopolized product (such as a replacement part market) can give the monopolist an incentive to tie in order to reduce competition in this other market.

Finally, I conclude in Section 6 with a brief discussion of the implications of these findings.

## 2. Independent Products

I begin by considering an extremely simple model with independent products. There are two markets, which I label A and B. Market A is monopolized by firm 1 (say, due to a patent). Market B, on the other hand, is potentially served by two firms, firm 1 and firm 2. The products of firms 1 and 2 in market B are differentiated. Production in market B involves fixed costs of  $K_i$  plus an expenditure of  $c_{Bi}$  per unit for firm  $i$ . Unit costs for good A are  $c_A$ .<sup>5</sup>

Consumers, who are indexed by  $d \in [0,1]$  with total measure 1, desire at most 1 unit of each good. All consumers have a reservation value of  $\gamma > c_A$  for good A, while a consumer of type  $d$  has a valuation of  $v_{Bi}(d)$  for a unit of firm  $i$ 's product B. Resale of products by consumers is

.....  
<sup>5</sup> For expositional simplicity, I ignore the possibility that there are fixed costs for product A.

assumed to be prohibitively costly. In the absence of tying by firm 1, consumers simply respond to individual product prices  $(P_A, P_{B1}, P_{B2})$ . Firm 1's sales of product  $B_i$  are then given by some function  $x^i(P_{B1}, P_{B2}) \leq 1$  which I assume to be everywhere differentiable and satisfy (subscripts denote partial derivatives):

$$x_j^i(P_{B1}, P_{B2}) = \begin{cases} \geq 0 & \text{if } j=i, > 0 & \text{if } x^i(\cdot, \cdot) \in (0,1) \\ \leq 0 & \text{if } j \neq i, < 0 & \text{if } x^i(\cdot, \cdot) \in (0,1); \end{cases}$$

that is, products  $B_1$  and  $B_2$  compete with one another for consumer purchases. When bundling is not permitted (which I will refer to below as an "independent pricing game"), it is easy to see that firm 1 will always set  $P_A = \gamma$ . It is also useful for what follows to define each firm 1's best response correspondence in market B by  $P_{B1}^*(P_{Bj})$  which solves:

$$\max_{P_{B1}} (P_{B1} - c_{B1}) x^1(P_{B1}, P_{B2}).$$

I assume that this correspondence is single-valued, continuous, and differentiable with  $P_{B1}^*(P_{Bj}) \in (0,1)$ .<sup>6</sup>

In the next two subsections I analyze the use of tying both for cases where firm 1 can precommit to tie and where it cannot. For the case without precommitment I analyze a simple two-stage game. In stage one, each firm simultaneously decides whether to be active in market B. If firm  $i$  decides to be active, it incurs the cost  $K_i$ . In stage 2, the firms pick prices (simultaneously if both are active). If firm 1 is active in market B, it can offer three different items for sale: good A at a price of  $P_A$ , good  $B_1$  at a

<sup>6</sup> Thus products are strategic complements in the sense of Bulow, Geanakoplos, and Klemperer [1985]. Also, note that under this assumption there is a unique static independent pricing equilibrium.

price of  $P_{B1}$ , and a bundle consisting of one unit of good A and one unit of good B1 at a price of  $\bar{P}$ . Throughout I assume that firm 1 is unable to monitor customer purchases; this assumption rules out the use of requirements contracts (where a consumer agrees as a condition of buying good A not to buy good B2) and also implies that a bundle will be purchased only if  $\bar{P} \leq P_A + P_{B1}$ .

To analyze the case where precommitment is possible, I extend this game to three stages. In the (new) first stage of the game, firm 1 commits to which subset of three possible products- good A, good B1, and a bundle- it will be able to produce. For example, firm 1 can commit itself to a position where it will only be able to produce a bundle. The second and third stages are then identical to the no commitment game, but with firm 1 only able to offer for sale those items that it is able to produce.<sup>7</sup> Thus, as discussed in the introduction, by setting its design and production process, firm 1 is able to commit to a tying strategy.

Finally, at various points below I make comparisons between the outcomes of these two games and those of a game where firm 1 only offers goods A and B1 independently (more precisely, a game that is the same as the no precommitment game but where bundling is prohibited). I refer to this game as the "independent pricing game."

#### A. Tying without Precommitment

Consider first the no commitment game. In the second stage of this game, if firm 1 is active in market B it selects three (non-negative) prices:  $[P_A, P_{B1}, \bar{P}]$ .<sup>8</sup> It is said to tie whenever it sets  $\bar{P} < P_A + P_{B1}$ , that is, whenever it offers product A on more advantageous terms to a consumer who also

<sup>7</sup>Note that as long as firm 1 can produce both goods A and B1 separately it can still offer a bundle for sale.

<sup>8</sup>Thus, taking firm 2's price as given, firm 1 picks these three prices acting as a monopolist on its residual demand structure.

purchases product B1. As the following proposition makes clear, however, tying is not a useful strategy in this game.

Proposition 1: Any subgame perfect equilibrium outcome of the no commitment game is economically equivalent to a subgame perfect equilibrium outcome in the independent pricing game.

Proof: The proposition is established by arguing that in the subgames of the no commitment game in which firm 1 is active in market B, any Nash equilibrium in prices is equivalent to a Nash equilibrium in the corresponding subgame of the independent pricing game. Then, given the equivalence of the equilibria in the pricing subgames, firms' decisions about whether to be active in market B must also be equivalent in the two games.

Consider the subgame where both firms are active in market B. The equivalence of equilibria is demonstrated by arguing that for any set of prices  $[(P_A^0, P_{B1}^0, \bar{P}^0); P_{B2}^0]$  that constitute a Nash equilibrium in the no commitment game there is a set of independent prices  $[\hat{P}_A, \hat{P}_{B1}]$  such that sales and profits are the same for both firms under prices  $[(\hat{P}_A, \hat{P}_{B1}); P_{B2}]$  as under prices  $[(P_A^0, P_{B1}^0, \bar{P}^0); P_{B2}]$  when  $P_{B2} = P_{B2}^0$  and are the same for firm 2 for any  $P_{B2}$ .<sup>9</sup> This implies that  $[(\hat{P}_A, \hat{P}_{B1}); P_{B2}^0]$  is a Nash equilibrium in the independent pricing game (note that firm 1 now has fewer possible deviations).

The equivalence clearly holds if firm 1's equilibrium strategy has  $\bar{P}^0 > P_A^0 + P_{B1}^0$ , so suppose that  $\bar{P}^0 \leq P_A^0 + P_{B1}^0$ . There are three cases to consider. First, suppose that  $P_A^0 > \gamma$ . If this is firm 1's best response then it must be that all consumers are buying firm 1's bundle since otherwise firm 1 could do better by setting  $P_A = \gamma$  while leaving all of its other prices unchanged: this

<sup>9</sup> While the text discusses economic equivalence in terms of identical sales and profits for the firms, it is in fact easy to see that all consumers also have identical consumption and expenditures in the two games.

price would make profitable sales of product A to those consumers not buying the bundle, while having no effect on firm 1's sales of either good B1 or the bundle (since consumers are indifferent about buying good A at this price).<sup>10</sup> In addition, since all consumers are purchasing the bundle (and therefore none are purchasing either A or B1 alone) it cannot be that  $\bar{P}^0 < \gamma$  since, if it were, firm 1 could do better by offering only the bundle at a price of  $\gamma$ . But if this is so then setting  $[\hat{P}_A - \gamma, \hat{P}_{B1} - \bar{P}^0 - \gamma]$  yields identical sales and profits to both firms given  $P_{B2}^0$  and identical profits to firm 2 for all  $P_{B2}^0$ . Second,  $\gamma \geq P_A^0 > \bar{P}^0$  cannot arise in an equilibrium: since all consumers would be buying firm 1's bundle (all consumers would be willing to buy good A individually and they can get good A cheaper by buying the bundle) firm 1 would increase its profits by offering only the bundle at a price of  $\gamma$ . Finally, if  $\gamma \geq P_A^0$  and  $P_A^0 \leq \bar{P}^0$ , then each consumer buys either good A alone or the bundle from firm 1. In this case, prices of  $[\hat{P}_A - P_A^0, \hat{P}_{B1} - \bar{P}^0 - P_A^0]$  yield identical sales and profits for both firms for all  $P_{B2}^0$ .

A similar argument establishes the equivalence for the subgame where only firm 1 is active.

□

The basic idea behind Proposition 1 is fairly straightforward. First, it is always worthwhile for firm 1 to make sure that all consumers purchase product A either alone or in the bundle. Given that all consumers are consuming good A, however, if firm 1 engages in tying then consumers choose between buying only good A or the bundle from firm 1. They do so by imputing an effective price (of either  $\bar{P}_1 - P_A$  or  $\bar{P}_1 - \gamma$  depending on the configuration of prices) to the product B1 portion of the bundle, which makes tying effectively

<sup>10</sup>I assume that all consumers will buy good A when  $P_A - \gamma$ . This assumption can be avoided through the use of limiting arguments, but is made in order to ease the exposition.

equivalent to an independent pricing strategy.

### B. Commitment and Strategic Foreclosure

The negative result of Proposition 1 changes dramatically if firm 1 is able to precommit to tying through its choice of which goods it will be able to produce. In the three stage game that I have described above, firm 1 can choose to produce seven different sets of goods: both goods individually, both goods individually and also a bundle, the bundle only, the bundle and product A, the bundle and product B1, A only, and B1 only. The argument in Proposition 1 implies that the first two options both yield outcomes equivalent to those in the independent pricing game and so they are strictly better for firm 1 than the last two (which yield lower profits to firm 1 in any subgame where it is active and at least as large profits to firm 2 when it is active). In fact, the following two lemmas indicate that firm 1's choice is essentially between producing independent goods and producing only the bundle.

Lemma 1: Any subgame perfect equilibrium outcome in the subgame of the commitment game where firm 1 can produce only the bundle and product A is equivalent to a subgame perfect equilibrium outcome of the independent pricing game.

Proof: The argument is similar to that used to prove Proposition 1. Suppose that both firms are active. First, if  $P_A^0 > \gamma$  in an equilibrium, then all consumers must be buying the bundle,  $\bar{P}^0$  must be at least  $\gamma$ , and independent prices of  $[\hat{P}_A - \gamma, \hat{P}_{B1} - \bar{P}^0 - \gamma]$  yield identical sales and profits for both firms given  $P_{B2}^0$  and identical sales and profits for firm 2 for all  $P_{B2}$ . Second, setting  $\bar{P}^0 < P_A^0 \leq \gamma$  again cannot occur in an equilibrium. Finally, if  $P_A^0 \leq \gamma$  and  $P_A^0 \leq \bar{P}^0$ , then prices of  $[\hat{P}_A - P_A^0, P_{B1} - \bar{P}^0 - P_A^0]$  yield identical sales and profits for the two firms for all  $P_{B2}$ . The argument when only firm 1 is

active follows a similar line and the equivalence of the firms' decisions regarding activity in market B then follows.

□

**Lemma 2:** Any subgame perfect equilibrium outcome in the subgame of the commitment game where firm 1 can only produce the bundle and product B1 is equivalent to a subgame perfect equilibrium outcome that arises in the subgame of the commitment game where firm 1 can only produce a bundle.

**Proof:** Regardless of whether firm 2 is active, consumers prefer the bundle to buying only product B1 if and only if  $\bar{P} \leq P_{B1} + \gamma$ .<sup>11</sup> Thus, setting  $\bar{P} > P_{B1} + \gamma$  cannot be an optimal strategy for firm 1 if it results in a positive level of sales since by setting  $\bar{P} = P_{B1} + \gamma$  firm 1 makes exactly the same number of sales of the bundle as it did of product B1 only (for any  $P_{B2}$  if firm 2 is active), but at a larger margin (since  $\gamma > c_A$ ). Suppose first that firm 2 is active. In any equilibrium,  $[(P_{B1}^o, \bar{P}^o); P_{B2}^o]$ , either  $\bar{P}^o \leq P_{B1}^o + \gamma$  or  $\bar{P}^o > P_{B1}^o + \gamma$  and firm 1 makes no sales. If, instead, firm 1 sold only a bundle at a price of  $\bar{P}^o$  in the former case and at a price of  $P_{B1}^o + \gamma$  in the latter, then the outcome for both firms is the same when  $P_{B2} = P_{B2}^o$  and it is the same for firm 2 for all  $P_{B2}$ . A similar argument holds if firm 2 is not active. Therefore, any perfect equilibrium outcome (including decisions regarding activity in market B) is equivalent to one that arises after firm 1 has committed to producing only the bundle.

□

Given these results, firm 1 can restrict its attention to either producing goods A and B1 separately, which yields an outcome equivalent to

<sup>11</sup> Again, for expositional reasons, I assume here that consumers buy the bundle when they are indifferent.



that in the independent pricing game, or to committing to producing only a bundle. I now turn to an investigation of the competitive effects of this tying strategy. As the following result makes clear, such a commitment may make it unattractive for firm 2 to be active in the market:

Proposition 2: In the subgame of the commitment game where both firms are active and firm 1 has committed itself to producing only the bundle, firm 2 earns less than it does in the independent pricing game.

Proof: In Appendix A.

One might at first think that bundling in this context would have no effect at all: if firm 1 were charging independent prices of  $P_A - \gamma$  and  $P_{B1}$ , a switch to bundling at a total price of  $\gamma + P_{B1}$  would not change the demand for good B1 at all. The intuition for Proposition 2, however, centers on the way in which firm 1's pricing incentives change when it bundles. In an independent pricing game, firm 1's best response  $P_{B1}^*(P_{B2})$  satisfies,

$$(1) \quad [P_{B1}^*(P_{B2}) - c_{B1}] x_1^1(P_{B1}^*(P_{B2}), P_{B2}) + x_1^1(P_{B1}^*(P_{B2}), P_{B2}) = 0.$$

By contrast, when firm 1 bundles and sets price  $\bar{P}$  the demand for its bundle is given by  $x_1^1(\bar{P} - \gamma, P_{B2})$  and its best response to firm 2's price  $P_{B2}$  by  $\bar{P}^*(P_{B2})$  such that,

$$(2) \quad [\bar{P}^*(P_{B2}) - c_A - c_{B1}] x_1^1(\bar{P}^*(P_{B2}) - \gamma, P_{B2}) + x_1^1(\bar{P}^*(P_{B2}) - \gamma, P_{B2}) = 0.$$

Note first that if  $\gamma = c_A$ , then  $\bar{P}^*(P_{B2}) = P_{B1}^*(P_{B2}) + \gamma$ . However, if  $\gamma > c_A$ , then at

$\bar{P} = P_{B1}^*(P_{B2}) + \gamma$  the left hand side of (2) is strictly negative. Thus, it must be that  $\bar{P}^*(P_{B2}) < P_{B1}^*(P_{B2}) + \gamma$ : firm 1's optimal effective price for good B1 is lower under bundling than under independent good pricing. The reason is straightforward: when firm 1 is bundling, in order to make profitable sales of its monopolized product, good A, it must also make sales of good B1. This leads it to cut price in an effort to take sales away from firm 2, an effect I call "strategic foreclosure". The effect on the equilibrium can be seen in Figure 1, where the equilibrium effective price for B1 and actual price for B2 both fall as a result of firm 1's bundling, thereby lowering firm 2's profits. Thus, by committing to tie by producing only a bundle, firm 1 may make continued operation unprofitable for its tied good rival.<sup>12</sup> This point emerges particularly clearly in the following simple example, which is a limiting case of the above model.

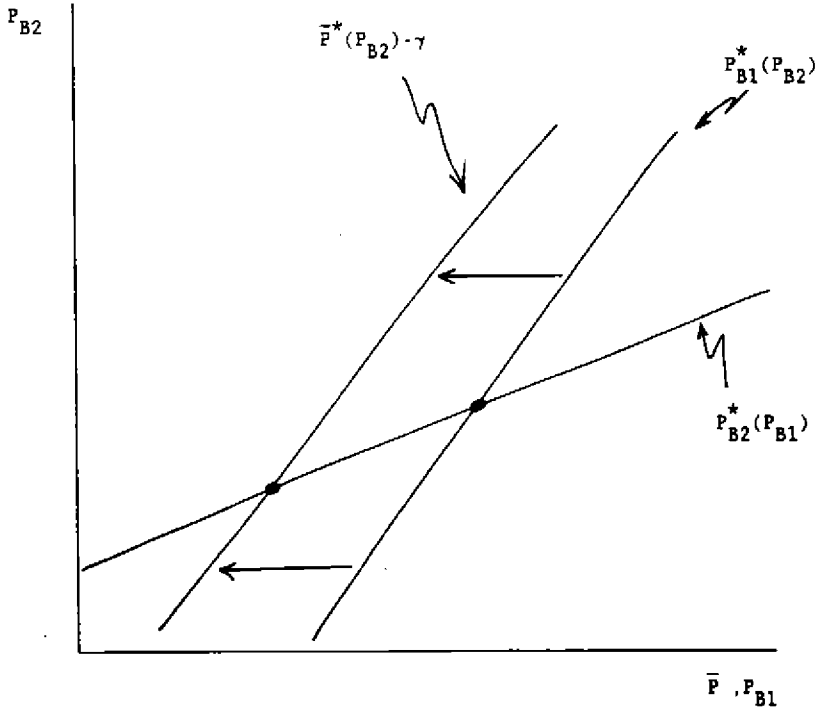
**Example 1:** Suppose that all consumers view products B1 and B2 as perfect substitutes with value  $v$ , that  $c_{B1} > c_{B2}$ , that  $(c_{B2} - c_{B1}) > K_2 > 0$ , and that  $K_1 = 0$ .<sup>13</sup> Then the subgame perfect equilibrium outcome of the independent pricing game has firm 2 being active in market B, making all

-----  
<sup>12</sup>Jean Tirole has pointed out a nice analogy to situations in which firm's can invest in cost reduction. Here, by bundling, firm 1 can incur an "investment cost" of  $(\gamma - c_A)$  [the lost good A sales] but thereby lowers its effective marginal cost in market B by  $(\gamma - c_A)$ .

This lowering of marginal cost makes firm 2 more aggressive in market B. As noted in Fudenberg and Tirole [1984] (see also Tirole [1988]), with price competition (strategic complements) and entry deterrence/exit inducement, firms overinvest in cost reduction relative to what they would do absent this strategic effect (a "top dog" strategy), a comparison analogous to my commitment versus no commitment games.

<sup>13</sup>I assume that  $K_1 = 0$  in order to focus attention on firm 2's decision of whether to be active in as simple a manner as possible. Note, though, that in situations of entry deterrence (where only firm 1 is currently active) it may be quite natural to think that firm 1 has already sunk its set-up costs, while the potential entrant (firm 2) has not.

Figure 1



sales in that market and earning profits of  $(c_{B1} - c_{B2}) - K_2 > 0$ .<sup>14</sup> By contrast, if  $(c_{B2} - c_{B1}) + (\gamma - c_A) > 0$ , then if firm 1 commits to bundling, firm 2 earns zero if it is active, and so the unique equilibrium outcome involves firm 2 being inactive and firm 1 extracting all of the consumers' surplus.



Note that, if both firms are active, firm 1's profits are also lower in the bundling regime than under independent pricing. This is true because bundling not only loses some profitable sales of good A, but also causes firm 2 to lower its price.<sup>15</sup> Thus, in this model, firm 1 would never commit to tying unless this would succeed in driving firm 2 out of the market.<sup>16</sup>

When tying would drive firm 2 out of the market, firm 1 may or may not find it profitable to do so. The advantage of tying in such an instance is the gain from converting market B from duopoly into a monopoly. The potential loss, however, comes from the fact that firm 1 will be a monopolist who can only offer a bundle. Thus, the presence of a large number of consumers who

-----  
<sup>14</sup>I am ignoring subgame perfect equilibria in which a firm prices below cost and makes no sales. These equilibria involve weakly dominated strategies and can be formally eliminated here through the use of Selten's [1975] notion of trembling-hand perfect equilibria (formally one examines discrete approximations to the game considered in the text where prices must be named in some discrete unit of account).

<sup>15</sup>Note that these lower profits can potentially force firm 1 to exit should it bundle since bundling may make it unprofitable for firm 1 to be active if it believes that firm 2 will be. If product A is very profitable, however, this effect is unlikely to occur. In fact, in situations in which market B can support only one firm under independent pricing, a commitment by firm 1 to bundling may also serve the strategic purpose of committing firm 1 to be active in market B.

<sup>16</sup>One special feature of this model, however, is that firm 2 can "concede" to firm 1 only by fully withdrawing from the market. In other models in which concession can be partial, this need not be true. For example, if market competition is of the form described in Kreps and Scheinkman [1983] (product production followed by output constrained price competition) then market interaction will take a strategic substitutes form in which firm 2 will respond to firm 1's more aggressive behavior by reducing its production level.

strongly dislike product B1 may make a commitment to bundling unprofitable, even when it leads to exclusion. It is worth stressing one point, however: if product B2 were supplied by a competitive industry under constant returns-to-scale, so that the price of product B2 could not be affected, firm 1 would never have an incentive to commit to bundling here (as the proof of Proposition 1 indicates).

At the same time, the welfare consequences of allowing tying in this circumstance are unclear both for consumers and for aggregate efficiency. First, consumers can lose both because of the price effects stemming from the exclusion, and also because there is less variety available in market B. The price effect, however, can potentially go either way. The reason is that the same incentive to lower the effective price of good B1 that drives firm 2 from the market is also present when firm 1 becomes a monopolist in market B. In general, though, one should expect that if the gains from monopoly in market B are large, the standard price movement should be upward, making consumers uniformly worse off. The effect on aggregate efficiency is still less certain. This is due to two different common welfare ambiguities. First, the biases associated with the free entry process (e.g., Spence [1976], Salop [1979], Mankiw and Whinston [1986]) imply that exclusion of firms does not necessarily reduce aggregate welfare. Second, it is known from the monopolistic bundling literature (e.g., Adams and Yellen [1976]) that bundling in a monopoly setting has ambiguous welfare consequences.

The following example illustrates these points more concretely, and also helps to set up the discussion in Section 3.

Example 2: Suppose that a consumer of type  $d$  has a valuation for good B1 of  $v_{B1} = w - \alpha_1 d$ , and that  $d$  is uniformly distributed on  $[0,1]$ . Assuming that we have all consumers purchasing from some firm and both firms making sales (so that our earlier assumptions hold in the relevant range), it is

straightforward to show that equilibrium prices and profits (gross of fixed costs) in an independent pricing game are given by:

$$P_A^0 = \gamma$$

$$P_{B1}^0 = c_{B1} + (1/3)[3\alpha_j + (\alpha_1 - \alpha_j) + (c_{Bj} - c_{B1})]$$

$$\Pi_1^0 = (\gamma - c_A) + [1/9(\alpha_1 + \alpha_2)][3\alpha_2 + (\alpha_1 - \alpha_2) + (c_{B2} - c_{B1})]^2$$

$$\Pi_2^0 = [1/9(\alpha_1 + \alpha_2)][3\alpha_1 - (\alpha_1 - \alpha_2) - (c_{B2} - c_{B1})]^2$$

In contrast, profits (gross of fixed costs) for firm 2 when firm 1 bundles are given by,

$$\Pi_2^0 = [1/9(\alpha_1 + \alpha_2)][3\alpha_1 - (\alpha_1 - \alpha_2) - (c_{B2} - c_{B1}) - (\gamma - c_A)]^2.$$

which is lower than in the independent pricing case. Note also that firm 2's profits fall as the surplus associated with good A,  $(\gamma - c_A)$ , rises. In order to illustrate the other points made above, I consider three special cases of this model in turn:  $\alpha_1=0$ ,  $\alpha_1=\alpha_2$ , and  $\alpha_2=0$ .

Consider first the case where  $\alpha_1=0$ . In this case, firm 1 always increases its profits by excluding firm 2 (that is, monopoly profits with bundling are greater than duopoly profits with independent good pricing). This is because as a monopolist firm 1 suffers no loss from bundling. Furthermore, the monopoly bundle price of  $(w + \gamma)$  necessarily represents an increase in the effective price of good B1, and in fact, leaves all consumers with zero surplus. While all consumers are made worse off, aggregate welfare may rise or fall: if  $c_{B2} > c_{B1}$  aggregate welfare must rise since all consumers are still served, and production costs fall. When  $c_{B2} < c_{B1}$ , the change in aggregate efficiency is given by  $\Delta W = K_2 - \alpha_2(c_{B1} - c_{B2})^2$ .

For simplicity, assume now that  $c_{B1} = c_B$ . When  $\alpha_1 = \alpha_2 = \alpha$ , the independent pricing equilibrium has full coverage of market B whenever  $w > c_B + (3/2)\alpha$ . For simplicity, I also assume that  $(\alpha/2) < (\gamma - c_A)$ , which implies that

the firm 1 will always sell its bundle to all consumers when it is a monopolist.<sup>17</sup> In that case firm 1's price and profits are given by:

$$\bar{P}^0 = w + \gamma - \alpha$$

$$\pi_1^0 = w + \gamma - \alpha - c_A - c_B.$$

Comparison of these expressions with those for the independent pricing game (setting  $\alpha_1 = \alpha_2$ ), reveals that firm 1 always gains from exclusion. The effective price of good B1 ( $\bar{P} - \gamma$ ), however, falls whenever  $[c_B + (3/2)\alpha] \leq w \leq [c_B + 2\alpha]$ , so that some consumers (e.g., those who were already buying B1) are made better off in these cases. Aggregate consumer surplus, however, never rises here:

$$CS^{\text{IndependentDuop}} = w - c_B - (5/4)\alpha$$

$$CS^{\text{BundlingMonop}} = (\alpha/2).$$

Finally, when  $\alpha_2 = 0$ , firm 1 profits in an independent goods pricing duopoly are given by  $\pi_1^0 = (\gamma - c_A) + (1/3)\alpha_1$  (an interior solution arises whenever  $w > c_B + (2/3)\alpha_1$ ). Then, assuming again that  $(\alpha_1/2) < (\gamma - c_A)$ , we have that firm 1's profits rise from this exclusion if and only if  $w > c_B + (4/3)\alpha_1$ . Notice that exclusion is more likely to be profitable as the value of monopolizing market B rises [increases in  $(w - c_B)$  and decreases in  $\alpha_1$ ] and as the competitive constraint that firm 2 imposes when it is in the market becomes more severe [decreases in  $\alpha_1$ ].

■

.....  
<sup>17</sup>The qualitative results in the other case are similar.

### 3. Heterogeneous Consumer Preferences for Good A

The results of Section 2 provide two important lessons. First, tying can be profitably used as an exclusionary device. Second, there may be important differences in the likelihood of its use depending on whether a commitment to tying is possible. Indeed, in the model of that section: (i) tying is only used when commitment is possible, (ii) a commitment to tying always lowers the profitability of tied market rivals, and (iii) tying is only used when it leads to exclusion.

An important feature of that model, however, was the strong assumption that all consumers have the same valuation of the tying good. In this section, I investigate the effects of relaxing that assumption. Two important points emerge. First, a commitment to tying need not always result in foreclosure as it did in the model of Section 2. Second, when consumer valuations for the tying good differ, tying can be a profitable strategy for firm 1 even in the absence of an ability to commit, and when it is, it may lower firm 2's profitability in a similar manner to that observed earlier. In the following two subsections I consider first the case of commitment and then that of no commitment.

#### A. Commitment

Recall that in the model of Section 2, if firm 1 moved from its optimal independent prices of  $[P_A = \gamma, P_{B1} = P_{B1}^*(P_{B2})]$  to offering only a bundle at a price of  $\bar{P} = \gamma + P_{B1}^*(P_{B2})$ , then firm 2's sales and profits would be unaffected; that is, tying had no direct foreclosure effect. Rather, firm 1's commitment to offering only a bundle lowered firm 2's sales because it created an incentive for firm 1 to price more aggressively (strategic foreclosure). When consumers have heterogeneous preferences, however, both direct and strategic effects are generally present and a commitment to bundling by firm 1



need not lower firm 2's profits. The net impact can be determined by asking whether, at the bundle price  $\bar{P}'$  such that firm 2's sales equal its independent pricing level (i.e.,  $\bar{P}'$  such that  $x^2(\bar{P}', \gamma, P_{B2}) - x^2(P_{B1}^*, P_{B2})$ ), firm 1 has an incentive to lower its price further.<sup>18</sup> This will be true when

$$(3) \quad (\bar{P}' - c_A - c_B) \frac{d \text{ Bundle Sales}}{d\bar{P}} + x^1(P_{B1}^*, P_{B2}) < 0.$$

With homogeneous preferences for good A, for example, the inequality in condition (3) was satisfied because  $(\bar{P}' - c_A - c_B) > P_{B1}^*(P_{B2}) + \gamma$  and  $(d \text{ Bundle Sales} / d\bar{P}) - x^1(P_{B1}^*, P_{B2})$ .

Condition (3) indicates that, with heterogeneous valuations for good A, a commitment to only offering a bundle may fail to lower firm 2's profits for two distinct reasons. First, enough consumers may find good A unattractive (may have valuations below the cost of production) that firm 1 may have a lower, rather than a higher, margin at a bundle price of  $\bar{P}'$ . In such a case, firm 1's monopoly of good A is too weak for bundling to be an effective exclusionary threat in market B; bundling would help rather than hurt firm 2. This effect, of course, is exactly what one should expect a priori.

The second reason is a bit more subtle. As I noted above, with homogeneous valuations the derivative of demand at bundle price  $\bar{P}'$  is identical to that arising in market B with independent goods pricing. With heterogeneous valuations, however, this demand derivative can change when firm 1 bundles, potentially counteracting the price-cost margin effect. The

<sup>18</sup> Here, unlike in Section 2, firm 1 may prefer to commit to producing the bundle plus one of the two goods independently as part of an exclusionary strategy (i.e., Lemmas 1 and 2 do not hold here). I focus on the case of a commitment to pure bundling here to provide a comparison with the result in Section 2. These other strategies may also lower firm 2's equilibrium profits. If they do so sufficiently to exclude firm 2 from the market, then they will actually be preferred by firm 1 to pure bundling, since they restrict its pricing to a lesser degree when firm 2 is out of the market.

clearest example of this occurs in the limiting case where products B1 and B2 are nearly homogeneous.<sup>19</sup> Then bundling essentially transforms the competitive interaction from a nearly homogeneous market B into a setting with vertical differentiation (since all consumers value the bundle more than B2, but they differ in how large this valuation difference is-- see, for example, Shaked and Sutton [1982]) and can thereby raise firm 2's profits.

The following example, which is an extension of Example 2, illustrates these points.

Example 3: The model I consider here is identical to that in Example 2 except that I now allow there to be different possible levels of consumer valuations for product A. I assume that the distribution of  $\gamma$  in the population is described by  $F(\gamma)$  and that for all  $d$ ,  $\text{Prob}(\gamma \leq s | d) = F(s)$  (i.e., types are independently distributed across the two markets). In the discussion that follows, I assume that  $w$  is large enough so that (in the relevant range) all consumers purchase product B from one of the firms.

Suppose that firm 1 commits to tying by only producing a bundle. To see how the distribution of tastes for good A can effect the exclusionary effect of tying, it is useful to first assume that for any level of  $\gamma$  some consumers of that type are buying from each of the firms ("interior" equilibria). It is straightforward to show that, for interior equilibria, equilibrium profits for the two firms are given by,

$$\Pi_1^0 = [1/9(\alpha_1 + \alpha_2)] [3\alpha_2 + (\alpha_1 - \alpha_2) + (c_{B2} - c_{B1}) + (E\gamma - c_A)]^2$$

-----  
<sup>19</sup>Note that this requires that the  $K_1$ 's are close to zero if independent pricing would result in a duopoly.

$$\pi_2^0 = [1/9(\alpha_1 + \alpha_2)] [3\alpha_1 - (\alpha_1 - \alpha_2) - (c_{B2} - c_{B1}) - (E_\gamma - c_A)]^2$$

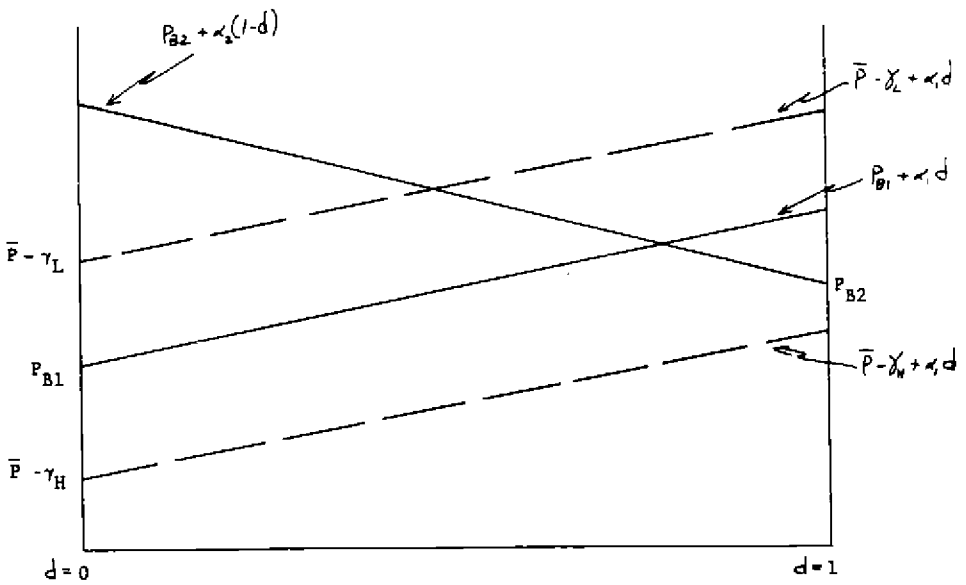
where  $E_\gamma = \int s \, dF(s)$ . Comparing firm 2's profits to its level under independent goods pricing (derived in Section 2), we see that firm 2's profits are lower in the bundling equilibrium as long as  $E_\gamma > c_A$ . Thus, as one would expect, if there are enough consumers who dislike product A, bundling raises rather than lowers firm 2's profits.

Relating this finding to condition (3), we see that bundling has no effect on the demand derivative, but that  $\bar{P}'$  is now given by  $\bar{P}' - P_{B1}^*(P_{B2}) + E_\gamma$  so that the inequality in (3) holds if and only if  $E_\gamma > c_A$ . It is worth noting, however, that the lack of any effect on the demand derivative term in (3) now relies heavily on the linearity of the demand structure assumed here. With this structure, the average of the demand derivatives across consumers with various levels of  $\gamma$  at the bundled sales levels is identical to the average of the demand derivatives at the sales levels that occur with independent pricing. If, instead, bundling were to lower this average derivative (in absolute value) this would work against the incentive for more aggressive pricing that arises in this linear model.

In fact, this is why inferiority of the equilibrium is important for the characterization above. Figure 2 depicts an example with two types of valuations for good A,  $\{\gamma_L, \gamma_H\}$ , in which bundling causes all type  $\gamma_H$ 's to buy from firm 1 (at the bundle price that keeps firm 2's sales unchanged). As is clear, this causes the derivative of firm 1's demand function to fall, which tends to make firm 1 less aggressive. Note that this effect intuitively seems more likely to occur when the dispersion of valuations for good A increases, and the differentiation between products B1 and B2 decreases.

In order to investigate this effect further, consider the special case where  $\gamma$  is uniformly distributed on the interval  $[\gamma - \beta, \gamma + \beta]$  where  $\beta \leq \gamma$

Figure 2



$c_{B1} = c_{B2} = 0$ , and  $\alpha_1 = \alpha_2 = \alpha > 0$ .<sup>20</sup> In this example, the issue addressed above, that some consumers may value good A at less than its production cost, does not arise (here  $E\gamma > c_A$ ). Rather, the focus here is on the effects of the level of valuation dispersion for good A and the level of product differentiation in market B. Tedious calculations (an example of which is provided in Appendix B) reveal that the effect of a commitment by firm 1 to offering only a bundle on firm 2's profits can be summarized in the following way:

	$\beta \geq \alpha$	$\beta < \alpha$
$\gamma \geq 3 \beta - \alpha $	$\pi_2^{\text{BUND}} < \pi_2^{\text{IND}}$	$\pi_2^{\text{BUND}} < \pi_2^{\text{IND}}$
$\gamma \leq 3 \beta - \alpha $	$\pi_2^{\text{BUND}} < \pi_2^{\text{IND}}$ if and only if: $\left(\frac{3\beta - \gamma}{3}\right)^2 < \alpha\beta$	$\pi_2^{\text{BUND}} < \pi_2^{\text{IND}}$

Examination of the condition in the lower left hand box (the only case where firm 2's profits are not necessarily lowered by firm 1's bundling) confirms that high levels of dispersion of valuations for good A and low levels of differentiation in market B are necessary for firm 2's profits to rise when firm 1 bundles. Interestingly, though, even when  $\alpha$  is close to zero, we need  $\gamma$  not to be too large for this to occur (so that the incentive to make sales

.....  
<sup>20</sup> My investigation of this example is motivated in part by the example analyzed in independent work by Carbajo, DeMeza, and Seidmann [1987]. They illustrate the differentiation effect in an example with homogeneous goods in market B and valuations for goods A and B that are perfectly correlated and uniformly distributed across consumers. Earlier versions of this paper pointed out the implications of noninteriority for the derivative of demand in the context of a two-type (of  $\gamma$ ) example.

of A does not outweigh the differentiation effect).<sup>21</sup> Note also that firm 1's profits may now rise with bundling even if bundling does not drive firm 2 from the market. In fact, in this example, whenever bundling causes firm 2's profits to rise, firm 1's profits rise as well and, further, firm 1's rise in some cases where firm 2's profits fall (this is shown in Appendix B).<sup>22</sup>



### B. No Commitment

The presence of heterogeneous valuations of product A can also cause tying to be firm 1's optimal strategy even in the absence of an ability to commit to this strategy. To see this more clearly, consider first the no commitment game analyzed in Section 2. In that game, when both firms are active in market B, firm 1 selects its prices taking firm 2's price as given and acting as a monopolist on the residual demand structure. Given the literature on bundling by multiproduct monopolists, which has found bundling to be a profitable strategy quite generally, it should not be surprising that firm 1 may now find some form of bundling to be its best-response to firm 2's

-----  
<sup>21</sup>The reader may be puzzled by this point since it seems that when  $\alpha=0$  firm 2's profits would always rise with bundling. In fact, when  $\alpha=0$  the upper left box would have  $\Pi_2^{\text{BUND}} - \Pi_2^{\text{IND}}$  and firm 1 making all sales when it bundles.

<sup>22</sup>It is worth contrasting this result to that in Schmalensee [1982]. There he shows that if market B has a constant returns to scale competitive structure (and homogeneous goods), then pure bundling must lower firm 1 profits. Here firm 1's profits may rise even though firm 2's price falls as a result of this bundling. The reason is that in Schmalensee's model when firm 1 bundles it necessarily sacrifices sales in market A where sales margins are positive while any changes in sales in market B are worthless since margins are zero there (due to competition). Here, however, the sales gained in market B are valuable because price-cost margins are positive (as in the multiproduct monopoly bundling literature).

price choice.<sup>23</sup> What is interesting from our perspective, however, is that this tying strategy by firm 1 may have detrimental effects on firm 2's profits since, when firm 1 does decide to bundle, it may have an incentive to foreclose sales in market B in a manner similar to that discussed in Section 2.

In Whinston [1987], for example, I considered the structure described in Example 3 where there are two types of valuations for good A,  $\gamma_L$  and  $\gamma_H$  with  $\gamma_H > c_A$  and  $\text{Prob}(\gamma_H) = \lambda$ . For this case I showed that any equilibrium of the no precommitment game is equivalent to an equilibrium of a game where firm 1 is allowed to either sell A and B1 independently or to offer only the bundle and product A at price  $P_A \in (\gamma_L, \gamma_H)$ .<sup>24</sup> In addition, the equilibrium may involve firm 1 pursuing the latter (bundling) strategy, though a necessary condition for this is that  $\gamma_L > c_A$  (see Whinston [1987] for details). When the equilibrium does involve bundling and is "interior" in the sense discussed above, firm 2's profits are easily seen to be:<sup>25</sup>

$$\Pi_2^0 = [1/9(\alpha_1 + \alpha_2)] [3\alpha_1 - (\alpha_1 - \alpha_2) - (c_{B2} - c_{B1}) - (1-\lambda)(\gamma_L - c_A)]^2$$

Thus, when firm 1 does tie here it forecloses firm 2's sales in a similar

.....  
<sup>23</sup>The models of bundling by a multiproduct monopolist most relevant for the model here are Adams and Yellen [1976] and McAfee, McMillan, and Whinston [1987].

<sup>24</sup>That is, we can without loss of generality restrict firm 1's pricing strategy choices to one of these two forms. This equivalence actually holds for any market B structure that satisfies the assumptions made in Section 2 (a proof of this fact is available from the author upon request). It is worth noting that a bundling strategy of this sort may not appear to be tying at all since firm 1 does offer to sell product A at a price that some consumers are willing to pay. For type L consumers, however, this offer is unattractive, putting them in exactly the same situation as when firm 1 offers only a bundle.

<sup>25</sup>In fact, this follows for any given level of  $P_A \in (\gamma_L, \gamma_H)$  from requiring that the prices of B2 and the bundle are best responses.

manner to that observed earlier. Note, though, that firm 2's equilibrium profits are larger here than when firm 1 commits to only offering a bundle. The reason is that when firm 1 also offers product A independently, it is assured of making sales of product A to all type H consumers regardless of whether they buy product B1; thus, here the incentive for foreclosure arises only from the L types and firm 2's profits fall only if  $\gamma_L > c_A$ . When this condition holds, however, even without the ability to precommit, firm 1 may find tying to be a profitable strategy, and by employing it may exclude firm 2 from the market.

Though the effect of firm 1's tying here may be exclusionary (firm 2, anticipating that firm 1 will tie, may choose to be inactive), one might argue that its motives are in some sense "innocent" since its decision to tie is never affected by the possibility that firm 2 might be excluded from the market. Such dynamic considerations, however, may be important even when firm 1 cannot precommit to tying. For example, if firm 2 faces a financial constraint that it must meet in order to remain active in the market (as in the work of Benoit [1984] and Fudenberg and Tirole [1986]), firm 1 may be led to use tying in order to lower firm 2's profits and increase the likelihood that firm 2 will be forced to exit the market, even when tying is not profit-maximizing in a static sense.

To formalize this idea, consider a simple extension of the earlier no commitment model in which there are two production periods. If firm 2 decides to be active and incurs the set up cost  $K_2$  prior to period 1, it may face a financial constraint that it must meet after period 1 in order to be able to remain in the market in period 2. In particular, suppose that with probability  $1-\theta$  firm 2 will not face a financial constraint, while with probability  $\theta f(\Pi)$  firm 2 will face a constraint that prohibits continued participation if first period profits were less than  $\Pi$  and assume that  $f'(\Pi) \geq 0$  (there is a diminishing marginal return to predation).



In this setting, what is the effect of an increase in  $\theta$  on the attractiveness of tying for firm 1? It is not difficult to see that for the two type example, if  $\gamma_L > c_A$  (and outcomes are "interior") then increases in  $\theta$  make tying a relatively more attractive policy for firm 1 in period 1 for any given level of  $P_{B2}$ . The central (and very general) idea is that increases in  $\theta$  make firm 1 care more about foreclosure relative to current profits.

To see this more formally, let  $G$  denote the benefit to firm 1 if firm 2 does not meet its financial constraint and fix some initial level of  $\theta$  and  $P_{B2}$ . Suppose, first, that firm 1 pursues its best independent pricing policy and that this results in a profit level for firm 2 of  $\Pi_2^I$ . Then, firm 1's price choices are equal to the level that it would choose in the simple one period model if its marginal costs of production for B1 were  $c_{B1} - \theta GF(\Pi_2^I)(P_{B2} - c_{B2})$  instead of  $c_{B1}$ . Likewise, if firm 1 pursues its optimal bundling strategy and thereby gives firm 2 profits of  $\Pi_2^B$  then its prices are equal to those it would pick in the static game if its marginal cost was  $c_{B1} - \theta GF(\Pi_2^B)(P_{B2} - c_{B2})$ . Then since we have seen that the optimal bundling strategy in the one period no precommitment game results in lower profits for firm 2 than does the optimal independent pricing policy for any given level of the marginal cost of B1 (since  $\gamma_L > c_A$ ), it must be that  $\Pi_2^B < \Pi_2^I$  (that is, bundling leads to foreclosure). But the envelope theorem then implies that a small increase in  $\theta$  raises the profits from the optimal bundling best response by more than it raises the profits from the optimal independent pricing best response (since the derivative of firm 1 profits with respect to  $\theta$  is  $GF(\Pi_2)$ ). Thus, in this example, increases in  $\theta$  strictly increase the likelihood that firm 1 will find bundling to be its best response (since bundling is never optimal if  $\gamma_L < c_A$ ).<sup>26</sup>

<sup>26</sup> Note that in many environments some form of bundling is always firm 1's best response in the one period no precommitment game (see McAfee, McMillan, and Whinston [1987]). In such cases, one would have to examine how increases in  $\theta$  affected the degree of bundling.

#### 4. Complementary Products

I now turn to the case of complementary products used in fixed proportions.<sup>27</sup> I first consider a model of fixed proportions that is essentially an extension of the simple example quoted above from Posner [1976] to the case where the tied good market involves differentiated products with scale economies in production and an oligopolistic, rather than a competitive, market structure. Despite these differences, I show that Posner's central contention continues to hold: a monopolist of one component never finds it worthwhile to tie in order to reduce the level of competition in the market for the other component. The key point is that with complementary products used in fixed proportions, the monopolist can actually derive greater profits when its rival is in the market than when it is not because it can benefit through sales of its monopolized product from the additional surplus that its rival's presence generates (due to product differentiation).

Nevertheless, I then show that in two natural extensions of this model in which the monopolized product is no longer essential for all uses of other components, tying once again emerges as a profitable exclusionary strategy. In one case, the presence of an inferior, competitively supplied alternative to the "monopolized" component leads to results that parallel those of the independent products case. In the other case, the existence of a second use for the non-monopolized product (such as a replacement part market) can give the monopolist an incentive to tie in order to eliminate competition in this other market.

The discussion in the text focuses on the case of precommitment. In fact, for each of the models considered here, any no precommitment outcome is .....

<sup>27</sup>Whinston [1987] provided a brief discussion of the case of variable proportions where there is a required base product and an optional add-on component.

equivalent to an equilibrium of the independent pricing game.<sup>28</sup> Of course, this is therefore also true when firm 1 produces A and B1 independently in the commitment game. In order to simplify the exposition, in Subsections 4B and 4C below I will use this fact and simply compare bundling outcomes to the independent pricing game equilibria when investigating whether firm 1 would find a commitment to bundling to be a profitable exclusionary device.

#### A. The Basic Model

Consider the following simple model. There are two components needed to comprise a system, A and B: a system consists of one unit of each. As before, firm 1 is a monopolist of component A, and two different versions of component B could potentially be available, B1 and B2. The production technology for these products is as before.

The set of consumers is also the same as before. Each consumer demands at most one unit of the system. A consumer of type  $d$ 's valuation of a system with product B1 is  $v_{A/B1}(d)$ . When goods A, B1, and B2 are independently priced, consumers' demand for an A/B1 system is given by some function  $x^i(P_A + P_{B1}, P_A + P_{B2})$ , where  $x_j^i(\cdot, \cdot) \geq 0$  if  $i=j$  and is  $\leq 0$  if  $i \neq j$  with strict inequalities whenever  $x^i(\cdot, \cdot) \in (0, 1)$  and where  $\{x_1^1(\cdot, \cdot) + x_1^2(\cdot, \cdot)\} \leq 0$

In the case of independent products we implicitly assumed that production of a bundled unit did not interfere with the independent use of either of the products.<sup>29</sup> Though natural in the case of independent products, this assumption is less so when products must be used together. For example, the

28. The proofs of this fact for the three models presented in this section are available from the author upon request. For the model of subsection 4C, the result requires the use of Selten's [1975] notion of trembling-hand perfection in order to eliminate the use of weakly dominated strategies. It should also be noted that in Sections 4B and 4C this equivalence does not have to do with product complementarity, but rather is a consequence of the homogeneity of valuations assumed there (as in Section 2).

29. The proof of Lemma 1, for example, used this fact.

bundling of a stereo tuner and a stereo amplifier into a stereo receiver may not allow the buyer to use just the amplifier in conjunction with another manufacturer's tuner. Thus, here I assume that production of a bundled good does not allow the user to use only part of the bundle.

In this model, since component A is essential to any system, firm 1 is trivially able to exclude firm 2 by committing to produce only a bundle. Nevertheless, as the following proposition indicates, firm 1 never finds it worthwhile to tie in order to exclude firm 2.

Proposition 3: If a commitment to tying causes firm 2 to be inactive, firm 1 can do no worse- and possibly better- by committing to producing only independent components.

Proof: Suppose that firm 1's precommitment to tying (by not producing one or both of the components individually) causes firm 2 to be inactive. In this case, since only firm 1's bundle price is relevant once firm 2 is inactive, firm 1's profits given its optimal bundle price of  $\bar{P}^*$  are:

$$(\bar{P}^* - c_A - c_{B1}) x^1(\bar{P}^*, \infty).$$

Suppose that firm 1 instead commits to only producing components A and B1 independently. One pricing policy that it can always follow, regardless of whether firm 2 is active, is to set individual component prices of  $\hat{P}_{B1} = c_{B1} - \epsilon$  (where  $\epsilon > 0$ ) and  $\hat{P}_A = \bar{P}^* - \hat{P}_{B1}$ . If firm 2 is inactive, this pricing scheme leads to exactly the same level of profits as did the bundling outcome. If firm 2 is active, however, firm 1's profits will be at least as large as those in the bundling outcome since they are given by

$$(\bar{P}^* - c_A - c_{B1}) [x^1(\bar{P}^*, \hat{P}_A + P_{B2}) + x^2(\bar{P}^*, \hat{P}_A + P_{B2})] + \epsilon x^2(\bar{P}^*, \hat{P}_A + P_{B2})$$

when firm 2 names price  $P_{B2}$  (since  $x^1+x^2$  weakly increases when prices fall, and  $x^2$  is non-negative).

□

Thus, as in the arguments of the leverage critics, when firm 1's good is essential and components are used in fixed proportions, firm 1 does not find it profitable to use tying to reduce competition in market B. The basic idea behind this result is fairly simple to see. If firm 2 did not exist, firm 1 could do as well as it does through bundling by setting independent prices that had component B1 priced at or below cost and component A's price set at a high level; it would simply earn all of its profits on sales of component A (consumers purchases depend only on the sum of the prices). But, if pricing in this manner leads firm 2 to be active, this can only raise firm 1's profits since firm 1 would then sell more component A's (on which it makes profits) and fewer component B's (on which it has a negative margin). Intuitively, firm 1 is able to benefit through sales of its product A from the increase in surplus generated by firm 2's presence.

While firm 1 never gains from committing to tying here if this forces firm 2 to be inactive, firm 1 may commit to tying in order to price discriminate. For example, suppose that some set of consumers get positive benefits only out of an A/B1 system, while the remainder get positive benefits only out of an A/B2 system, and that the latter group's valuation of its desired system is much higher. Then firm 1 will want to set a very high price for good A in order to extract surplus from this latter group, and a very low price for good B1 in order to get an optimal A/B1 system price for the former group. If this attempt hits the non-negativity constraint on  $P_{B1}$ , however, then firm 1 will find it worthwhile to tie by offering a bundle with

price  $\bar{P} < P_A$ .<sup>30,31</sup>

Firm 1's lack of desire to use tying as an exclusionary device can change dramatically, however, when firm 1's monopolized component is not essential for all uses of product B2. I now consider two natural extensions of the above model in which tying can prove to be not only an effective exclusionary device, but also a profitable one.

B. An Inferior, Competitively Supplied, Component A: Strategic Foreclosure

Suppose that there exists a uniformly inferior, competitively supplied alternative to firm 1's product A, denoted as product A2 (henceforth, firm 1's product A will be denoted by A1). The cost of component A2 is also  $c_A$ , but compared with the valuations described above for A1/B1 and A1/B2 systems, a consumer's valuation for a system that has product A2 in it rather than A1 is  $(\gamma - c_A)$  lower [i.e.,  $v_{A2/B1}(d) = v_{A1/B1}(d) - (\gamma - c_A)$ ] where  $\gamma > c_A$ .

Consider, first, the independent pricing game (which, as I noted above, yields an outcome identical to that which occurs if firm 1 produces A and B1 only independently). In this game, firm 1 always sets  $P_{A1} \leq \gamma$  and makes all component A sales. When firm 1 sets  $P_{A1} < \gamma$  in this equilibrium, the inferior alternative (product A2) is irrelevant for pricing and profits. In the case where  $P_{A1} = \gamma$ , however, the presence of the inferior product A2 constrains firm

<sup>30</sup>This point is analogous to the observation that an upstream monopolist may wish to vertically integrate forward into one of the industries that uses its product in order to achieve price discrimination across users (see, for example, Tirole [1988, p. 141]). Note that precommitment is essential for this purpose since otherwise the second set of consumers would buy the bundle to get their component A when the bundle price is lower than the price of good A alone (resulting in an outcome that is identical to that which would occur with independent prices of  $P$  for component A and zero for component B1).

<sup>31</sup>In fact, offering a bundle plus good A individually is always an optimal policy for firm 1. However, when the optimal bundle price exceeds the price for good A alone, the same outcome is achievable by offering goods A and B1 independently.

1's equilibrium pricing and profits. This could mean that, contrary to Proposition 3, firm 1 would prefer to have firm 2 out of the market (firm 1 can no longer necessarily benefit through its component A1 sales from the surplus created by the presence of firm 2).<sup>32</sup> Example 4 illustrates this point and shows how the presence of component A2 can make competitive interaction here look very much like the independent products case considered earlier.

Example 4: Suppose that  $v_{A1/B1}(d) = w - \alpha d$ ,  $c_A > 0$ , and  $c_{B1} - c_{B2} = c_B > 0$ , and that  $w \geq 2\alpha + c_A + c_B$  (to insure that all consumers buy a system; note the parallel to Example 2). Ignoring the constraint imposed by the presence of product A2, the independent pricing equilibrium level of  $P_{A1}$  is increasing in  $w$ .<sup>33</sup> When  $w > \gamma + c_B + (3/2)\alpha$ , the unique equilibrium involves prices of:

$$P_A^0 = \gamma$$

$$P_{B1}^0 = P_{B2}^0 = c_B + \alpha.$$

and all consumers receiving positive surplus (see Figure 3). Profits (gross of fixed costs) are given by:

$$\Pi_1^0 = (\gamma - c_A) + (\alpha/2)$$

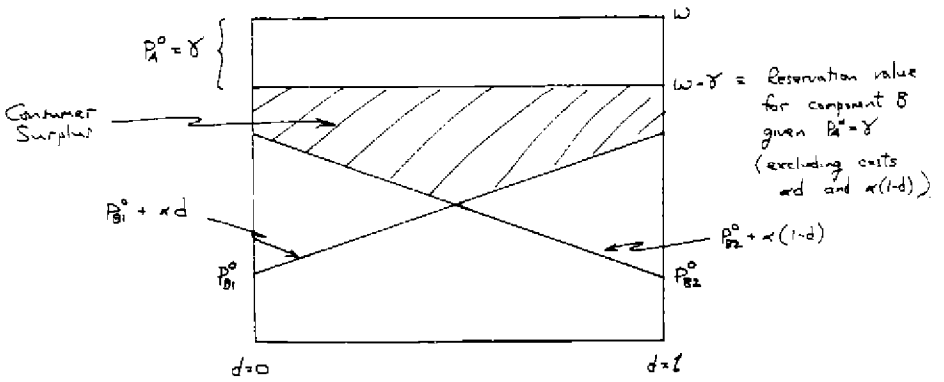
$$\Pi_2^0 = (\alpha/2).$$

Note that this equilibrium essentially replicates the independent goods outcome from Section 2 (Example 2 with  $\alpha_1 = \alpha_2$  and  $c_{B1} = c_{B2}$ ). That is, the presence of a competitive constraint from product A2 serves to "uncouple" the

<sup>32</sup>The fact that the presence of an inferior competitively supplied product A can potentially prevent firm A from deriving maximal (two product monopoly) profits has also been noted in Ordober, Sykes and Willig [1985].

<sup>33</sup>More precisely, though multiple equilibria exist in the game when component A2 does not exist which correspond to a range of values for  $P_{B1}$  and  $P_{B2}$  which is independent of  $w$ , in any such equilibrium, the level of  $P_A$  is given by  $P_A^* = w - (1/2)[\alpha + c_B - 3P_{B1}^*]$ .

Figure 2





two component markets. As in the independent products case, if  $w$  is large, firm 1's profits are increased by firm 2 being inactive (firm 1 then acts as a systems monopolist setting an A1/B1 system price of  $w$ ).<sup>34</sup>

■

Now consider the commitment game. When firm 1 would prefer firm 2 to be out of the market, but under independent pricing firm 2 would want to be active, can a commitment to tying by firm 1 force firm 2 out of the market (note that firm 1's component A1 is not essential). The answer is "yes", and for the same basic reason as in Section 2: when it is only able to sell a bundle, firm 1 can only gain its profits from component A1 if it also sells component B1; this causes firm 1 to foreclose sales in the component B market. To see this formally, suppose that firm 1 can only produce a bundle. When the presence of product A2 constrains firm 1's pricing (so that  $P_{A1} = \gamma$ ) in an independent pricing game, firm 1's price for component B1 given firm 2's price  $P_{B2}$  is given by  $P_{B1}^*(P_{B2})$  such that,

$$(3) \left\{ [P_{B1}^*(P_{B2}) - c_{B1}] x_1^1(\gamma + P_{B1}^*, \gamma + P_{B2}) + x_1^1(\gamma + P_{B1}^*, \gamma + P_{B2}) \right\} \\ + (\gamma - c_A) [x_1^1(\gamma + P_{B1}^*, \gamma + P_{B2}) + x_1^2(\gamma + P_{B1}^*, \gamma + P_{B2})] = 0.$$

The first term of this expression represents the effect on sales of component B1 of marginally changing  $P_{B1}$ , while the second is the effect on sales of component A1. Note that this second change is due solely to the total change in system sales. In contrast, when firm 1 commits to

.....  
<sup>34</sup>Unlike the independent products case, firm 1 suffers no loss from being restricted to bundle when it is a monopolist. Rather, here the cost of exclusion of firm 2 is that firm 1 is unable to capture any of the surplus created by firm 2 (through firm 1's sales of component A1).

bundling, its optimal bundle price given firm 2's price,  $P_{B2}$ , is given by  $\bar{P}^*(P_{B2})$  such that,

$$(4) \quad [\bar{P}^*(P_{B2}) - c_A - c_{B1}] x_1^1(\bar{P}^*, \gamma + P_{B2}) + x_1^1(\bar{P}^*, \gamma + P_{B2}) = 0.$$

However, at  $\bar{P} = P_{B1}^*(P_{B2}) + \gamma$ , this expression becomes,

$$(5) \quad \left\{ [P_{B1}^*(P_{B2}) - c_{B1}] x_1^1(\gamma + P_{B1}^*, \gamma + P_{B2}) + x_1^1(\gamma + P_{B1}^*, \gamma + P_{B2}) \right\} \\ + (\gamma - c_A) x_1^1(\gamma + P_{B1}^*, \gamma + P_{B2})$$

Note that  $x_1^2(\cdot, \cdot)$  does not appear in the second term of (5). This represents the fact that when firm 1 bundles, only by increasing sales of A1/B1 systems does firm 1 increase the sales of component A1: firm 1 is therefore led to foreclose sales in market B. Indeed, comparing (3) and (5), it must be that (5) is strictly negative (since  $\gamma > c_A$  and  $x_1^2(\cdot, \cdot) > 0$ ) and therefore,  $\bar{P}^*(P_{B2}) < P_{B1}^*(P_{B2}) + \gamma$ . As in the independent product case, this lowering of firm 1's effective price for component B1 lowers firm 2's profits.<sup>35</sup> Thus, by committing firm 1 to "strategic foreclosure", tying can be an effective device for excluding firm 2 and thereby raising firm 1's

-----  
<sup>35</sup> This incentive for foreclosure is similar to the effects studied in Matutes and Regibeau [1986]. They study product compatibility in a symmetric duopoly and identify a collusive incentive to have compatibility. This corresponds to the "puppy dog" strategy in the Fudenberg and Tirole [1984] taxonomy for the case of accommodation under price competition, in contrast to the "top dog" strategy that I focus on here (see footnote 12).

profits.<sup>36,37</sup>

Example 4- cont'd: If firm 1 commits to only producing a bundle, firm 2's equilibrium profit when both firms are active is given by,

$$\Pi_2^0 = \max \left\{ 0, (1/2\alpha) \left[ \alpha \cdot \frac{\gamma - c_A}{3} \right]^2 \right\}$$

which is lower than its profit under independent pricing. Note that if firm 1 bundles and forces firm 2 to be inactive, all consumers receive zero surplus here (although, as usual, aggregate welfare may either fall or rise).

■

#### C. An Alternative Use for Product B: Direct Foreclosure

Next, consider an alternative variation in the basic model. Suppose that there exists an alternative use for component B that does not rely on the simultaneous purchase of component A. One example of such a use is a replacement parts market for existing owners of a system who need to replace only component B. Because component A is not essential for the use of product B in that market, firm 1 is not able to benefit from firm 2's presence in this

<sup>36</sup>The discussion in the text has only compared producing A and B1 independently with committing to produce only a bundle. One might wonder about other alternatives. It turns out that as long as the sort of price discrimination motivation discussed in the previous subsection is not present, any of the other alternatives are either equivalent to independent pricing (Bundle and A1; Bundle, A1, and B1), equivalent to producing only a bundle (Bundle and B1), or clearly inferior to these options (A1 only; B1 only).

<sup>37</sup>A longstanding issue in the legal treatment of tying is when to treat the tying and tied products as distinct products. One argument sometimes made is that the tied product must be one which consumers might want to purchase separately, without also purchasing the tying product (see, for example, Justice O'Connor's concurrence in Jefferson Parish Hospital District No. 2 v. Hyde, 466 U.S. 2 (1984) where she argues this position because "When the tied product has no use other than in conjunction with the tying product, a seller of the tying product can acquire no additional market power by selling the two products together."). Note though, that in the model analyzed here, this statement is incorrect unless one defines "other uses", contrary to Justice O'Connor's meaning, to include use with other producers' component A.

market through sales of good A and the logic of Proposition 3 therefore breaks down.<sup>38</sup> Firm 1 may now find it worthwhile to exclude firm 2, if it can, in order to monopolize this other market for product B. Furthermore, because component A is still essential for certain uses of product B, firm 1 may have the means to accomplish this end: by offering to sell component A only in a bundle with component B1, firm 1 directly forecloses firm 2's sales in the joint use market (foreclosure of these sales is complete regardless of firm 1's bundle price), which may drive firm 2's profits below the level that justifies its continued operation. The following simple example illustrates these points.

Example 5: Suppose that there are two types of consumers. Type I consumers desire a system. There are a continuum of type I consumers indexed by the uniformly distributed variable  $d \in [0,1]$  with total measure 1. Consumer  $d$  has valuations for the two possible systems of:

$$v_{A/B1}(d) = w \cdot d$$

$$v_{A/B2}(d) = w \cdot d + \gamma_1.$$

Type II consumers, of which there are a total measure of  $\theta$ , only desire product B. Each type II consumer has valuations for products B1 and B2 of:

$$v_{B1} = \varphi$$

$$v_{B2} = \varphi + \gamma_2.$$

The firms are unable to discriminate across these consumers in their pricing. The cost structure has  $c_A > 0$ ,  $c_{B1} = c_{B2} = c_B > 0$ ,  $K_2 > 0$ , and  $K_1 = 0$ .

<sup>38</sup> In the replacement parts market example, component A is, in a sense, essential for the use of these replacement parts as well. One may therefore wonder why firm 1 cannot benefit from firm 2's presence through the initial price of component A. While this is true for future purchasers of systems, it is not true for those consumers already owning a system (which may have been purchased before firm 2 even existed).

Finally, in what follows, I make two further assumptions: (A.1)  $(1+\theta)\gamma_2 > \gamma_1 > \gamma_2$  and (A.2)  $w > \max\{4\gamma_2 - \gamma_1 + c_A + c_B, \gamma_1 + c_A + c_B\}$ .

Consider, first, the outcome of the independent pricing game. Under our assumptions, the unique equilibrium outcome when both firms are active involves prices of:<sup>39,40</sup>

$$\begin{aligned} P_{B1}^0 &= c_B \\ P_{B2}^0 &= c_B + \gamma_2 \\ P_A^0 &= [w + (\gamma_1 - \gamma_2) + c_A - c_B] / 2 \end{aligned}$$

In this equilibrium, all consumers buying a component B buy product B2 and profits for the two firms are given by:

$$\begin{aligned} \Pi_1^0 &= [w + (\gamma_1 - \gamma_2) - c_A - c_B]^2 / 4w \\ \Pi_2^0 &= \gamma_2 \cdot \left[ \theta + \frac{w + (\gamma_1 - \gamma_2) - c_A - c_B}{2w} \right] - K_2 \end{aligned}$$

Suppose, instead, that firm 1 commits to producing only a bundle and product B1 alone. In this case the unique equilibrium prices when firm 2 is active are given by:

$$\begin{aligned} P_{B1}^0 &= c_B \\ P_{B2}^0 &= c_B + \gamma_2 \\ \bar{P}^0 &= (w + c_A + c_B) / 2, \end{aligned}$$

and profits are:

$$\Pi_1^0 = (w - c_A - c_B)^2 / 4w$$

<sup>39</sup>I am ignoring equilibria here that involve firm 1 pricing its component B1 below cost and making no sales. As earlier, these equilibria involve the use of a weakly dominated strategy by firm 1 and can be eliminated through the use of Selten's [1975] notion of trembling-hand perfection.

<sup>40</sup>Assumption (A.2) ensures that the optimal price for B2 is not less than  $\gamma_2$ .

$$\Pi_2^0 = \gamma_2 \cdot \theta - K_2.$$

Thus, by committing to tie, firm 1 denies firm 2 its profitable sales to type I consumers, lowering firm 2's profits, and possibly forcing firm 2 to be inactive. Furthermore, if tying does force firm 2 to be inactive, firm 1's profit is  $[(w - c_A - c_B)^2 / 4w] + \theta(\varphi - c_B)$ , which is larger than its independent pricing profits if  $\varphi$  - the gain from monopolizing the type II market - is large.<sup>41</sup> Finally, if firm 1 does exclude firm 2 in this manner, all consumers are made worse off here, although aggregate welfare may either fall or rise.

## 5. Conclusion

The above results demonstrate, in my view, that the leverage hypothesis can be formally modelled in a coherent and appealing way. Once one allows for scale economies and strategic interaction, tying-- by leading to the foreclosure of tied good sales-- can make continued operation by a monopolist's tied market rival unprofitable. As the models above have indicated, such a strategy can be a profitable one for a monopolist, often

<sup>41</sup>The reader may be wondering about other alternatives available to firm 1. A commitment to producing A only, B1 only, or just a bundle is worse as an exclusionary strategy for firm 1 than committing to produce the bundle and B1 since firm 2's profits are higher when it is active under these strategies than when firm 1 commits to produce the bundle and B1, and firm 1's profits are lower under these options if firm 2 is inactive. They also are less attractive as an accommodation strategy for firm 1 than independent production of A and B1. Producing A, B1, and a bundle yields an outcome equivalent to the independent production outcome (restricting attention to trembling-hand perfect equilibria). Finally, producing a bundle and A is less effective as an exclusionary strategy than producing a bundle and B1 (it gives firm 2 higher profits if it is active and firm 1 lower profits when firm 2 is not active). Also, when firm 2 is active, no pure strategy (trembling-hand perfect) equilibrium can give firm 1 higher profits than when it produces A and B1 independently. However, a pure strategy equilibrium may not exist here. A sufficient condition for a pure strategy equilibrium to exist is that  $\gamma_2 < (\varphi - c_B)$ . Thus, when this condition holds, firm 1 can effectively limit itself to the two options considered in the text.

precisely because of this exclusionary effect on market structure.

While the analysis vindicates the leverage hypothesis on a positive level, its normative implications are less clear. Even in the simple models considered here, which ignore a number of other possible motivations for the practice, the impact of this exclusion on welfare is uncertain.<sup>42</sup> This fact, combined with the difficulty of sorting out the leverage-based instances of tying from other cases, makes the specification of a practical legal standard extremely difficult.

Finally, it should be noted that the leverage issue is not limited to the practice of tying, but rather is widespread in antitrust analysis. With the practice of reciprocity, for example, a monopsonistic buyer of some product refuses to buy from its suppliers unless they also buy a product from him (in which he may face competition). Alternatively, when a vertically integrated monopolistic input supplier can sell its input to both its own downstream manufacturer and to a rival manufacturer, a refusal to supply this rival manufacturer is similar to the tying of complementary goods. The models analyzed above can frequently be reinterpreted to apply to these other settings as well.<sup>43</sup>

.....  
<sup>42</sup>It should be noted that this is not a problem limited to tying, but is pervasive in the area of anticompetitive exclusion (see, for example, Ordovery and Saloner [1987] and Schmalensee [1982b]). If one puts relatively more weight on consumer welfare, however, these ambiguities become somewhat less severe as exclusion typically does hurt consumers.

<sup>43</sup>The extent to which commitment is possible, however, may well vary by practice. In addition, in some instances additional contracting possibilities may be available. For instance, in the example of vertical integration described above, the monopolist may be able to use more elaborate contracts with the downstream rival than contracts that just specify a linear wholesale price (which would yield results similar to those above).

Appendix A

Proof of Proposition 2: The argument is a simple comparative statics exercise. Letting  $\phi = \bar{P}_1 - \gamma$ , firm 1's problem, given  $P_{B2}$ , can be written:

$$\max_{\phi} [(\phi - c_{B1}) + (\gamma - c_A)] \cdot x^1(\phi, P_{B2}).$$

The bundling equilibrium is then characterized by the following two equations which have a unique solution (with positive sales by both firms) under our assumptions.

$$[(\phi^{**} - c_{B1}) + (\gamma - c_A)] x_1^1(\phi^{**}, P_{B2}^{**}) + x^1(\phi^{**}, P_{B2}^{**}) = 0$$

$$(P_{B2}^{**} - c_{B2}) x_2^2(\phi^{**}, P_{B2}^{**}) + x^2(\phi^{**}, P_{B2}^{**}) = 0.$$

Note that if  $\gamma = c_A$ , then  $(\phi^{**}, P_{B2}^{**}) = (P_{B1}^*, P_{B2}^*)$ , the independent pricing equilibrium. Now define (omitting arguments of functions):

$$A = 2 x_1^1 + [(\phi^{**} - c_{B1}) + (\gamma - c_A)] x_{11}^1$$

$$B = 2 x_2^2 + (P_{B2}^{**} - c_{B2}) x_{22}^2$$

$$C = x_2^1 + x_{12}^1 [(\phi^{**} - c_{B1}) + (\gamma - c_A)]$$

$$D = x_1^2 + x_{21}^2 (P_{B2}^{**} - c_{B2}).$$

The assumption that  $P_{Bi}^* \in (0, 1)$  implies that  $(A, B) \ll (-C, -D) \ll 0$ .

This then implies that,

$$\text{sign } \frac{d\phi^{**}}{d\gamma} = \text{sign } (-Bx_1^1) < 0$$

$$\text{sign } \frac{dP_{B2}^{**}}{d\gamma} = \text{sign } (Dx_1^1) < 0.$$

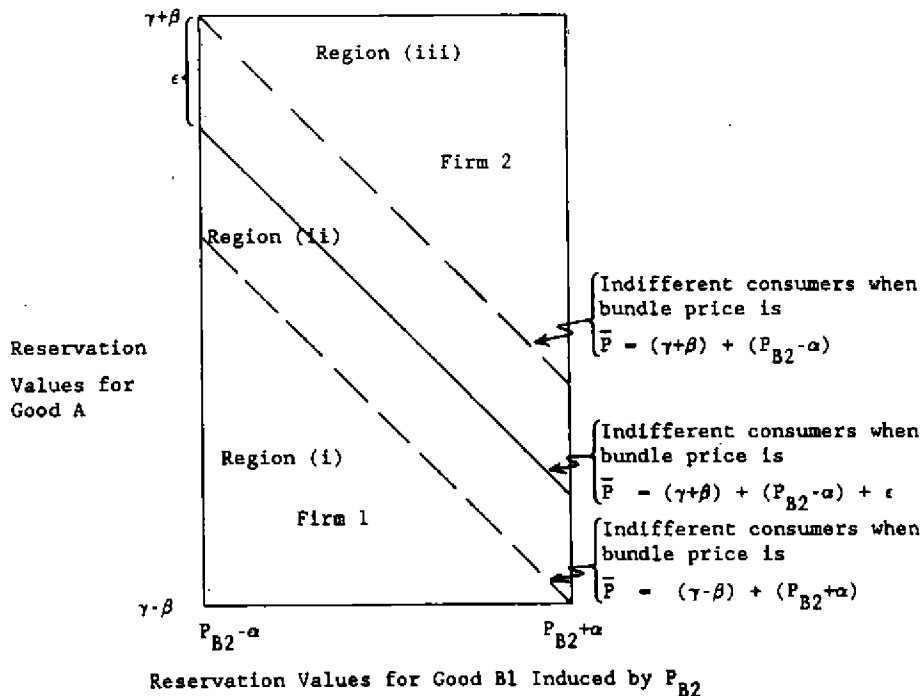
so that both firms' profits fall relative to the independent pricing equilibrium.

□



Appendix B

Here I work out the example for the cases where  $\beta \geq \alpha$ . In this class of cases, the division of consumers between the two firms can be represented diagrammatically as follows:



Consider first equilibria that are in Region (i), i.e., that satisfy  $\bar{P} \leq (\gamma-\beta) + (P_{B2} + \alpha)$ . In this region, the first-order conditions for the two firms are:<sup>1</sup>

Firm 1:  $4\alpha\beta - (1/2)[\bar{P} - (\gamma-\beta) \cdot (P_{B2} - \alpha)]^2 - \bar{P} [\bar{P} - (\gamma-\beta) - (P_{B2} - \alpha)] = 0$

<sup>1</sup>It can easily be shown that these are sufficient for a global maximum; at any point where the first-order condition holds, the firms' profit functions are concave.

Firm 2:  $[\bar{P} - (\gamma - \beta) - (P_{B2} - \alpha)] \cdot 2P_{B2} = 0.$

From firm 2's first-order condition we see that we are in Region (i) if and only if  $P_{B2} \leq \alpha$ . Solving the two first-order conditions for  $P_{B2}$  yields the following expression:

$$-8(P_{B2})^2 + 2[\alpha - (\gamma - \beta)] P_{B2} + 4\alpha\beta = 0.$$

This expression is strictly concave and is non-negative at  $P_{B2} = 0$ . Hence,  $P_{B2} \leq \alpha$  if and only if the value of this expression is non-positive at  $P_{B2} = \alpha$ . Substituting yields the requirement that  $\gamma \geq 3(\beta - \alpha)$ . Firm 2's profits in this region under bundling are  $(1/2\alpha\beta)(P_{B2})^3$  compared with its profits of  $(\alpha/2)$  under independent goods pricing. Since  $P_{B2} \leq \alpha$  in this region, firm 2's profits must fall.

Consider now bundling equilibria that fall in region (ii), i.e., where  $\bar{P} \in [(\gamma - \beta) + (P_{B2} + \alpha), (\gamma + \beta) + (P_{B2} - \alpha)]$ . Straightforward analysis of the firms' first-order conditions reveals that in equilibrium we must have  $3P_{B2} = 3\beta - \gamma$ . In addition, to be in region (ii),  $P_{B2}$  must satisfy  $2\beta - \alpha \geq P_{B2} \geq \alpha$ , or substituting for  $P_{B2}$ :  $3(\beta - \alpha) \geq \gamma \geq 3(\alpha - \beta)$ . The first of these inequalities is just the reverse of our region (i) condition, while the second, which assures that we are not in region (iii) is always satisfied since  $\beta \geq \alpha$  (in fact, the bundling equilibrium can never be in region (iii)). Firm 2's profits under bundling in this region are given by  $(1/2\beta)(P_{B2})^2$  compared with  $(\alpha/2)$  under independent goods pricing. Substituting for  $P_{B2}$  yields the condition in the text. Firm 1's profits under bundling in this region are given by:

$$\begin{aligned} \Pi_1 &= \bar{P} \left( 1 - (1/2\beta) [\bar{P} - (\gamma - \beta) - P_{B2}] \right) \\ &= \left( \frac{3\beta + \gamma}{3} \right) \left( \frac{1}{2} + \frac{\gamma}{6\beta} \right) . \end{aligned}$$

while under the parameter values of this region its independent goods pricing profits are given by  $(\alpha/2) + \left( \frac{\gamma + \beta}{2} \right)^2 (1/2\beta)$ . Bundling then yields firm 1 larger profits than independent pricing (assuming that firm 2 remains active) if and only if:

$$\left( \frac{9\beta + 5\gamma}{6} \right) \left( \frac{3\beta - \gamma}{6} \right) \geq \alpha\beta .$$

But, the expression on the left side of this inequality is strictly larger than  $\left( \frac{3\beta - \gamma}{3} \right)^2$ , which implies that whenever firm 2's profits are higher under bundling, so are firm 1's. There is also clearly an area of the parameter space where firm 1 is better off while firm 2 is worse off under bundling compared to independent goods pricing.

The analysis of cases where  $\alpha > \beta$  proceeds in a similar manner.

## References

- Adams, W.J. and J.L. Yellen [1976], "Commodity Bundling and the Burden of Monopoly," Quarterly Journal of Economics (90), pp. 475-98.
- Benoit, J.P. [1984], "Financially Constrained Entry in a Game with Incomplete Information", Rand Journal of Economics (15), Winter, pp. 490-99.
- Blair, R.D., and D.L. Kaserman [1978], "Vertical Integration, Tying and Antitrust Policy," American Economic Review (68), June, pp. 397-402.
- \_\_\_\_\_ [1985], Antitrust Economics, Richard D. Irwin, Inc., Homewood, Illinois.
- Bork, R.H. [1978], The Antitrust Paradox, Basic Books, New York.
- Bowman, W.S. [1957], "Tying Arrangements and the Leverage Problem," Yale Law Review (67), November, pp. 19-36.
- Bulow, J.I., J.D. Geanakoplos, and P.D. Klemperer [1985], "Multimarket Oligopoly; Strategic Substitutes and Complements," Journal of Political Economy (93), June, pp. 488-511.
- Burstein, M.L. [1960], "The Economics of Tie-in Sales," Review of Economics and Statistics (42), February, pp. 68-73.
- Carbajo, J., D. DeMeza, and D.J. Seidmann [1987], "A Strategic Motivation for Commodity Bundling," London School of Economics, mimeo.
- Director, A. and E. Levi [1956], "Law and the Future: Trade Regulation," Northwestern University Law Review (51), pp. 281-96.
- Fisher, F.M., J.J. McGowan, and J.E. Greenwood, Folded, Spindled Mutilated: Economic Analysis and U.S. v. IBM, MIT Press, Cambridge.
- Fudenberg, D., and J. Tirole [1984], "The Fat-Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look," American Economic Review (74), May, pp. 361-66.
- \_\_\_\_\_ [1986], "A Signal-Jamming Theory of Predation," Rand Journal of Economics (17), Autumn, pp. 366-77.
- Gelman, J.R. [1983], "Tie-ins Involving Bundles with Fixed Proportions Demand," Federal Trade Commission Working Paper No. 97.
- Kaplow, L. [1985], "Extension of Monopoly Power Through Leverage," Columbia Law Review (85), April, pp. 515-54.

- Krattenmaker, T.G., and S. Salop [1986], "Anticompetitive Exclusion: Raising Rivals' Costs to Achieve Power Over Price," Yale Law Journal (96), December, pp. 209-93.
- Kreps, D.M. and J.A. Scheinkman [1983], "Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes," Bell Journal of Economics (14), Autumn, pp. 326-37.
- Mankiw, N.G. and M.D. Whinston [1986], "Free Entry and Social Inefficiency," Rand Journal of Economics (17), Spring, pp. 48-58.
- Matutes, C., and P. Regibeau [1986], "Mix and Match: Product Compatibility without Network Externalities," mimeo.
- McAfee, R.P., J. McMillan, and M.D. Whinston [1987], "Multiproduct Monopoly, Commodity Bundling, and Correlation of Values," forthcoming in The Quarterly Journal of Economics.
- Ordover, J.A., and G. Saloner [1987], "Predation, Monopolization, and Antitrust," forthcoming in R. Schmalensee and R.D. Willig, eds., The Handbook of Industrial Organization, North Holland, Amsterdam.
- \_\_\_\_\_, A.O. Sykes, and R.D. Willig [1985], "Nonprice Anticompetitive Behavior by Dominant Firms toward the Producers of Complementary Products," in F.M. Fisher, ed., Antitrust and Regulation: Essays in Memory of John J. McGowan, MIT Press, Cambridge.
- Posner, R.A. [1976], Antitrust Law: An Economic Perspective, University of Chicago Press, Chicago.
- Salop, S. [1979], "Monopolistic Competition with Outside Goods," Bell Journal of Economics (10), Spring, pp. 141-56.
- Schmalensee, R. [1982], "Commodity Bundling by Single-Product Monopolies," Journal of Law and Economics (25), April, pp. 67-71.
- \_\_\_\_\_, [1982b], "Antitrust and the New Industrial Economics," American Economic Review (72), May, pp. 24-28.
- Selten, R. [1975], "A Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games," International Journal of Game Theory (4), pp. 25-55.
- Shaked, A. and J. Sutton [1982], "Relaxing Price Competition Through Product Differentiation," Review of Economic Studies (49), January pp. 3-13.
- Spence, A.M. [1976], "Product Selection, Fixed Costs, and Monopolistic Competition," Review of Economic Studies (43), pp. 217-35.

Tirole, J. [1988], The Theory of Industrial Organization,  
MIT Press, Cambridge, MA.

U.S. Department of Justice [1985], "Vertical Restraints Guidelines,"  
Antitrust and Trade Regulation Report, Bureau of National  
Affairs, Washington, DC.

Warren-Boulton, F.R. [1978], Vertical Control of Markets: Business  
and Labor Practices, Ballinger, Cambridge.

Whinston, M.D. [1987], "Tying, Foreclosure, and Exclusion,"  
Harvard Institute of Economic Research Discussion Paper No.  
1343.