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Abstract

This paper examines the nature of upstream rivalry in non-linear supply contracts with and without exclusive dealing. We find that foreclosure can occur without exclusive dealing, if economies of scale are sufficiently large, as well as with exclusive dealing. Surprisingly, however, it is the retailer and not the upstream firms who benefit. This formalizes the view that exclusive dealing will not be initiated by suppliers because retailer compensation is too steep. It also implies that anticompetitive foreclosure is more likely to occur when downstream firms have bargaining power.

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I Introduction

Exclusive dealing is a contractual restraint that prohibits a retailer from selling the brands of more than one competing manufacturer. Some view this restraint as an attempt by upstream firms either to exclude their competitors outright, or to raise their costs by forcing them to seek less efficient channels of distribution. Indeed, antitrust law has long been concerned with exclusive dealing as a means of market foreclosure. Section 3 of the Clayton Act expressly prohibits it when its effect is "substantially to lesson competition or to tend to create a monopoly".[1]

Nevertheless, it is puzzling why a retailer would voluntarily agree to limit her product selections. As Bork (1978) argues, a manufacturer would have to compensate the retailer to induce her to carry his product exclusively. He posits that she would agree to it only if the gain to consumers from the passed through lower retail price more than offsets the loss to consumers from the reduction in product variety. Hence, he concludes that if we see exclusive dealing, it must be for efficiency reasons.[2]

Recently, attempts have been made to formalize the foreclosure story. Mathewson and Winter (1987) consider an asymmetrically differentiated upstream duopoly selling to a local retail monopolist.[3] In the absence of exclusive dealing, the two manufacturers compete by playing a Nash game in wholesale prices. The retailer then acts as the agent for distribution. With exclusive dealing, the dominant manufacturer offers a wholesale price low enough to ensure the retailer at least as much profit as she could earn by buying from the excluded firm at cost. They find that exclusive dealing can be privately profitable for the dominant firm. Nevertheless, even in a model in which efficiency claims are conspicuously absent, their welfare analysis finds that foreclosure is not always anticompetitive. The two offsetting effects are the gain to welfare from the likely lower retail price of the included brand, and the loss to welfare from the reduction in product variety.

A different approach was taken by Aghion and Bolton (1987). They consider the incentives of a single seller and buyer to sign a contract that reduces the likelihood of entry into the seller's homogeneous product market. Surprisingly, they find that the incumbent seller and buyer will want to commit to an exclusive dealing contract with a penalty escape clause, requiring the buyer to pay damages to the incumbent if she switches to the entrant at some future date. The intuition is that the penalty clause increases the buyer's opportunity cost of purchasing from the entrant and hence permits greater surplus extraction. In the absence of uncertainty, the new firm enters with zero profit. With uncertainty, the penalty may be set too high ex ante and entry that would have increased welfare may be deterred.

One shortcoming of these papers is that neither allows for non-linear contracts to transfer surplus

[1] See Clayton Act, 15 U.S.C. 3, 14 (1970). Landmark cases include *Standard Fashion v. Magrane-Houston Co.* (258 U.S. 346 [1922]) and *Standard Oil Co. v. U.S.* (337 U.S. 293 [1949]).

[2] For example, Marvel (1982) points out that promotional activities undertaken by a manufacturer to increase demand for his product will be underprovided when they also generate customers for his rivals. Without exclusive dealing, the problem is exacerbated if retailers can influence consumers to purchase the brands of rival manufacturers from whom higher retail margins are earned.

[3] See Comanor and Frech (1985) for an earlier attempt to model foreclosure with exclusive dealing. However, Schwartz (1987) has criticized their work for failing to incorporate dealer rationality.

between firms. Aghion and Bolton sidestep the issue by supposing that the buyer purchases at most one unit from a single seller. But in general, with product differentiation and downward sloping demands, non-linear contracts (e.g., quantity discounts) can affect the buyer's opportunity cost of purchasing from the entrant in the same manner as a penalty escape clause. Yet if there is no need to include a penalty escape clause to transfer surplus, then it is not clear why exclusive dealing would be needed either.

In their conclusion, Mathewson and Winter acknowledge that if non-linear contracts were feasible, the dominant firm would not need to lower its wholesale price to obtain distribution. But if the wholesale price is not lowered, one is left to wonder whether exclusive dealing for market foreclosure purposes were always anticompetitive. Even if it were always anticompetitive, antitrust policy makers would not have to be concerned if foreclosure turns out never to be privately profitable. And if it is privately profitable, an open question is whether it can arise even in the absence of exclusive dealing, perhaps through an upstream firm offering generous quantity discounts or announcing a quantity forcing contract.

This paper examines market foreclosure when non-linear supply contracts are feasible. We first consider the nature of rivalry in the absence of exclusive dealing. Because we place few restrictions on the allowable set of supply contracts, it turns out that there exist multiple equilibria. However, in each instance the retailer buys the efficient amount in the sense that transfer prices equal production marginal cost at the equilibrium quantities. Equilibria differ as to whether foreclosure occurs and in the division of surplus among the contracting parties.

We find that foreclosure is possible through non-linear contracts alone, but only if economies of scale are large enough. By contrast, foreclosure through exclusive dealing can always arise in equilibrium. Hence exclusive dealing need not be superfluous.

Curiously, the impetus for exclusive dealing must necessarily come from the retailer. Every upstream firm is at least as well off in every equilibrium in which foreclosure does not occur as it is in every equilibrium in which foreclosure does occur. This is so regardless of the distribution of bargaining power among the participants. The intuition is that exclusive dealing or foreclosure through non-linear contracting decreases the bilateral surplus of the included firm and retailer (by lowering product variety) and also increases the retailer's disagreement point with each supplier. On the other hand, the retailer may or may not prefer *one-good* equilibria. Although her share of profit increases, this is offset by a shrinking overall surplus.

These findings do not support Bork's view that the retailer will serve as the consumer's agent, as the retailer may coerce suppliers into adopting exclusive dealing even though it may be socially undesirable. The model also lends credence to the view that retailers may purposely limit their shelf space to increase bargaining leverage vis-a-vis their suppliers.

On the other hand, our findings broadly support Bork's insight that suppliers will not find exclusive dealing for foreclosure purposes to be privately profitable because the cost of retailer compensation is steep. By contrast, a recent paper by Rasmusen et al. (1991) found that when economies of scale are important, exclusionary agreements can enable incumbent monopolists to exclude their potential rivals cheaply. If each buyer believes that enough other (noncompeting) buyers will sign an exclusive dealing contract with the incumbent, then each will also believe that entry will not be forthcoming. We differ from them by focusing on situations where buyers know that all sellers are active competitors. We also differ by allowing product differentiation, so that in the absence of exclusive dealing the retailer may wish to buy both products.

There is a small literature on non-linear contracting by multiple principals selling to a common agent. One paper, Bernheim and Whinston (1986), distinguishes between delegated and intrinsic agency. Under delegated agency, the agent can choose to sign contracts with a subset of principals. Under intrinsic agency, the agent either does not participate or it must sign contracts with all of the principals. Their analysis focuses on intrinsic agency. Bernheim and Whinston (1985) and Katz (1989) consider delegated agency. They are concerned with when principals will choose to sell through a common agent as opposed to selling through separate agents. Although they allow any one agent to reject a principal's contract, their models are constructed so that the principals will not be excluded from the market.[4] This assumption is plausible whenever the market for agents is competitive. However, in other contexts the assumption that upstream firms will not be excluded from the market is better derived as a consequence of equilibrium.

There is also some related literature on oligopoly price discrimination. Spulber (1979) establishes the existence of equilibrium in a model where competing firms take their inverse demand as given holding constant their rivals' prices. He does not model the buyer's optimization explicitly. Calem and Spulber (1984) and DeMeza (1986) model competing firms offering two-part tariffs to a representative consumer. The former derive equilibrium conditions without taking into account the possibility of foreclosure. DeMeza correctly conjectures the existence of a two-good equilibrium with two-part tariffs when the upstream firms have constant marginal costs. However, he does not allow for more general supply contracts, nor does he consider more general cost functions.

The rest of this paper is organized as follows. Section ii presents the model and derives necessary and sufficient conditions for the existence of equilibrium. Section iii focuses on equilibria in which exclusion does not occur. Section iv analyzes alternative means of market foreclosure. We first consider exclusion through non-linear contracting. This is then contrasted with foreclosure through exclusive dealing. Finally, we consider the incentives for exclusion through vertical integration. Section v concludes the paper.

II The Model

Suppose there are two goods, X and Y, produced by firm X and firm Y respectively, which are partial substitutes in the sense that an increase in the retail price of one leads to an increase in consumer demand for the other. These goods are distributed to final consumers through local retail monopolists, and the technology of distribution is such that neither producer is willing to enter

[4] Rejected firms in Bernheim and Whinston "in effect take their marketing decisions with them: perhaps they hire another agent or make decisions independently." In Katz's model, two principals announce supply terms that each is willing to offer a common dealer. After observing their rivals terms, each principal then announces whether it is still willing to go with a common dealer. If not, then the principals simultaneously offer new supply terms to separate dealers.

the downstream market to sell only his good.[5] Thus, it is imperative that upstream firms secure retailer patronage.

A retailer will not sell good Y if her expected profit from doing so is negative. Incorporated into this calculation is what her foregone profit would be from reduced sales of good X. This foregone profit is determined by the exogenous degree of substitution between the goods, and by the cost of good X to the retailer. Notice that if the upstream firms are restricted to charging linear wholesale prices, then the retailer will sell both goods as long as retail prices can be found which equal or exceed the individual wholesale prices and for which demands are non-zero. Allowing the feasible supply contracts to include more general forms of quantity dependent pricing complicates the analysis in two ways. First, the additional flexibility allows the upstream firms to extract local retail surplus without distorting final goods prices. Second, both firms can choose their terms so as to disadvantage their rival, possibly foreclosing it from any sales. We are primarily concerned with this latter aspect of upstream rivalry. Hence, as in Mathewson and Winter, we purposely abstract from the recognized efficiency motives for exclusive dealing.

The formal game is as follows. In stage one, firms X and Y simultaneously and independently choose their supply contracts, $T_x(\cdot)$ and $T_y(\cdot)$.[6] We place three restrictions on these contracts. First, we assume that they are contingent only on own quantity.[7] Second, if the retailer decides not to purchase from a given firm, her payment to that firm is zero. Third, the payment asked for any given quantity must not be less than the total cost of producing that quantity.[8] In stage two, the downstream firm chooses how much of each good to purchase. These amounts are then sold to consumers. The equilibrium concept will be subgame perfection.

It is natural to ask in this setting why retailers who are local monopolists have no monopsony power. One justification commonly made in the literature is to assume that each retailer accounts for only a small fraction of the suppliers' wholesale market. Hence, the downstream firms are thought to be contract takers. This may have corresponded to the situation in *Standard Fashion v. Magrane-Houston Co.* where the Supreme Court concluded that the defendant sold to "hundreds, if not thousands of communities in which there is a single retailer for the product ...". On the other hand, this assumption is less plausible in the case when suppliers sell to a large supermarket chain. Clearly, such retailers have bargaining power and often earn positive rent. Although we assume the retailer is a contract taker, a surprising implication of our framework is that her profit will not be driven to zero. Because of this, and because all of our other qualitative results continue to hold in a Nash bargaining setting, we prefer to develop our insights with the more familiar take-it or leave-it assumption. A sketch of the bargaining analysis is given in the appendix B.

Let $R(X,Y)$ denote the downstream firm's revenue. The derived demand for good X is given

[5]This is descriptive of many consumer goods, where the degree of economies of scope achieved by spreading overhead costs over multiple products is too high to warrant opening a single product outlet.

[6]This is the crucial difference between our paper and Rasmusen et al. In their paper buyers must form beliefs about whether more than one seller will offer them a supply contract.

[7]Contracts contingent on the rival firms' quantity would arouse antitrust suspicion of collusion. Contracts contingent on retail prices is a form of resale price maintenance, which is currently per-se illegal.

[8]It is easy to show that any contract which violates this assumption can be ruled out by iteratively eliminating dominated strategies.

by $\partial R/\partial X$, and that for good Y is given by $\partial R/\partial Y$. We assume that both derived demands are decreasing in own quantity, i.e., $\partial^2 R/\partial X^2 < 0$ and $\partial^2 R/\partial Y^2 < 0$. Goods X and Y may be strategic substitutes or strategic complements. Formally, we define the goods as strategic substitutes if $\partial^2 R/\partial X \partial Y < 0$, and strategic complements if $\partial^2 R/\partial X \partial Y > 0$.[9] Distribution costs other than the payment made for goods X and Y are assumed to be zero for simplicity. Thus, the retailer's profit can be written as $R(X,Y) - T_x(X) - T_y(Y)$. Let $C_x(X)$ denote firm X's cost of producing X units.[10] We assume that $C_x(\cdot)$ is differentiable and increasing in X, and that $C_x(0) = 0$. Denote firm X's profit as $T_x(X) - C_x(X)$. Define similar notation for firm Y.[11]

We shall now derive necessary and sufficient conditions for subgame perfect equilibrium contracts. Define $\Omega(T_x(\cdot), T_y(\cdot)) = \{(X,Y) \in \arg\max_{x,y} R(X,Y) - T_x(X) - T_y(Y)\}$. For any vector of contracts, the retailer's optimal stage two quantity pair(s) is contained in the set Ω. In stage one firms X and Y simultaneously choose the terms of their supply contracts taking as given the retailer's optimal choices in Ω. Let $\left(T_x^e(\cdot), T_y^e(\cdot)\right)$ be a pair of supply contracts that induce the downstream firm to purchase $(X^e, Y^e) \in \Omega(T_x^e(\cdot), T_y^e(\cdot))$. This yields profit for firm X and firm Y of $T_x^e(X^e) - C_x(X^e)$ and $T_y^e(Y^e) - C_y(Y^e)$ respectively. Let the retailer's maximized profit be given by $\Pi_{x,y} = R(X^e, Y^e) - T_x^e(X^e) - T_y^e(Y^e)$. To examine the possibility of exclusion, it is convenient to introduce notation for the retailer's profit if she were to sell only one good. Let the retailer's profit be given by $\Pi_x = \max_x R(X,0) - T_x^e(X)$ and $\Pi_y = \max_y R(0,Y) - T_x^e(Y)$ when that good is X or Y respectively.

lemma 1 *$T_x^e(\cdot)$ and $T_y^e(\cdot)$ arise in a subgame perfect equilibrium if and only if the following conditions hold:*

$$\max_{x,y} R(X,Y) - C_x(X) - T_y^e(Y) = R(X^e, Y^e) - C_x(X^e) - T_y^e(Y^e) \tag{1}$$

$$\max_{x,y} R(X,Y) - C_y(Y) - T_x^e(X) = R(X^e, Y^e) - C_y(Y^e) - T_x^e(X^e) \tag{2}$$

$$\Pi_{x,y} = \Pi_x = \Pi_y \tag{3}$$

Although the formal proof has been deferred to Appendix A, these conditions are quite intuitive. Consider condition (1). The expression on the right hand side (RHS) of the equality represents the bilateral profit (i.e., the sum of the profits) of the retailer and firm X evaluated at the equilibrium quantities X^e, Y^e. The equality with the left hand side (LHS) means that the equilibrium quantities must maximize the bilateral profit of the retailer and firm X. Similarly, condition (2) means that the equilibrium quantities must maximize the bilateral profit of the retailer and firm Y. The intuition

[9]The usual notion of strategic substitutes and complements pertains to single product firms. However, by explicitly writing out the expression for revenue for our multi-product downstream monopolist, it is seen that strategic substitutes (complements) in the single product case imply strategic substitutes (complements) in the multi-product case. The former yields downward sloping best response functions and is usually taken to be the normal case in a quantity game. The latter yields upward sloping best response functions.

[10]This should be interpreted as the cost to X of supplying a particular local market, taking as given production and sales in all other markets.

[11]This model could also be set up with the upstream firms selling directly to final consumers. What is crucial is the common buyer assumption. Thus an equally good alternative specification involves a representative consumer who has utility $U(X,Y) + z$, where z is the numeraire good. All of our results carry through.

is that if bilateral profits were not maximized, then at least one of the suppliers could offer an alternative contract that would increase his bilateral profit with the retailer, allowing both of their profits to increase. Condition (3) will be interpreted below.

Notice that condition (1) implies $X^e = \arg\max_x R(X, Y^e) - C_x(X)$; therefore, either $X^e = 0$ or the derived demand for X equals X's marginal cost when evaluated at (X^e, Y^e). Symmetrically, condition (2) implies that either $Y^e = 0$ or the derived demand for Y equals Y's marginal cost. In other words, each producer endeavors to maximize the total surplus available from sales of his good, taking the sales of the other good as fixed. We refer to (1) and (2) as the *efficiency* conditions.

Proposition 1 *In any equilibrium, a supplier who succeeds in obtaining patronage will have induced the retailer to purchase out to the quantity where her marginal revenue is equal to his production marginal cost.*

Let $(X^I, Y^I) \in \Omega(C_x(\cdot), C_y(\cdot))$ be the level of inputs that would be chosen by a vertically integrated firm that could produce both goods at cost. The implication of the preceding paragraph is that in any equilibrium where both goods are bought, $X^e = X^I$ and $Y^e = Y^I$, and the joint profits of the vertical structure are maximized. Similarly, let $X^m = \arg\max R(X, 0) - C_x(X)$ and $Y^m = \arg\max R(0, Y) - C_y(Y)$. Then in any equilibrium where only good X is purchased, $X^e = X^m$ and $Y^e = 0$, while in any equilibrium where only good Y is purchased, $Y^e = Y^m$ and $X^e = 0$. Thus, in any one good equilibrium, the joint profits of the retailer and included firm are maximized.

These results can be compared with the well known bilateral monopoly case in which non-linear contracts are sufficient to avoid a double markup by the downstream firm. We have shown that when an upstream duopoly sells to a single retailer, it is still the case that non-linear contracts avoid double markups. This is true whether or not both goods are bought in equilibrium.

Condition (3) embodies two *surplus extraction* conditions. It says that in equilibrium the retailer must be indifferent between buying both goods, good X only, or good Y only. In other words, each supplier will extract his good's incremental contribution to the retailer's profit. If he attempts to extract more, the retailer will not buy from him; if he were extracting less, he could offer a new supply contract with a higher fixed component that would increase his profit.

Proposition 2 *In any equilibrium, the retailer will necessarily earn positive profit.*

This is surprising, yet if it were not true, then $\Pi_{x,y} = \Pi_x = \Pi_y = 0 \Longrightarrow \Pi_x + \Pi_y - \Pi_{x,y} = 0$, which can easily be shown to contradict the definition of substitute goods.[12]

Although the buyer's demand is known with certainty by both upstream firms, and fully extractive non-linear supply contracts are feasible, they do not arise. This is because the retailer's opportunity cost of selling each good—viz., the reduction in demand for her substitute good—is non-negative. This contrasts with the case of bilateral monopoly, where it is well known that a

[12] This finding has also been derived in similar contexts by Calem and Spulber (1984), who consider a duopoly charging two-part tariffs to a representative consumer, and by Shaffer (1991), who considers a multi-product upstream monopolist charging two- part tariffs to a retail monopolist.

take-it or leave-it supplier can employ a fixed fee to extract all of the buyer's surplus. The case of multiple substitute goods differs because the price that consumers are willing to pay for a given amount of one good will be less if another good is available than if one were not available. When more than one good is sold, total revenue from the product class will be less than the sum of the revenues if the same amount of each good were sold alone. Even if the retailer sells just one good in equilibrium, she will still earn positive profit. Her bargaining strength is derived from her opportunity cost of selling either good when the other good is available.

III Supply Contract Two-good Equilibria

The analysis in the previous section proved that the retailer will purchase the vertically integrated quantities X^I and Y^I in any equilibrium in which both goods are bought. By lemma 1, the necessary and sufficient conditions for (T_x^e, T_y^e) to be a two-good equilibrium pair of supply contracts are given by conditions (1) - (3) with (X^I, Y^I) substituted for (X^e, Y^e). The *surplus extraction* conditions determine the payment that firms X and Y will receive from the retailer. Although they can easily be satisfied by supply contracts which specify a fixed fee or equivalent, the amount that firm X can collect will depend on the terms of firm Y's supply contract and vice versa. Intuitively, the more advantageous are firm Y's supply terms to the retailer, the less inclined she will be to promote sales of good X, and hence the less surplus there will be for firm X to extract.

The *efficiency* conditions can also be easily satisfied. If it is assumed that positive amounts of both goods will be bought, then there are a variety of ways for both suppliers to design their contracts to induce the retailer to purchase X^I and Y^I respectively. One possibility is to ensure that marginal transfers to the retailer are made at production marginal cost. A second possibility is for firm X (Y) to write a quantity forcing contract which stipulates that the retailer must purchase X^I (Y^I). Variants of the latter include minimum or maximum purchase requirements.

However, one must also check that both goods will, in fact, be purchased. That is, in a two-good equilibrium, the LHS of the *efficiency* conditions must not be maximized at a corner solution. Notice that condition (1) can be interpreted as saying that in any two-good equilibrium, a coalition of firm X and the retailer will not wish to foreclose firm Y from the market. Therefore, the maximum surplus available from selling good X only must be less than or equal to the surplus that the coalition would earn from selling X and Y. Mathematically, it must be true that

$$R(X^m, 0) - C_x(X^m) \leq R(X^I, Y^I) - C_x(X^I) - T_y^e(Y^I). \tag{4}$$

Additional insight is gained by explicitly writing out firm Y's *surplus extraction* condition, $\Pi_{x,y} = \Pi_x \implies T_y^e(Y^I) = R(X^I, Y^I) - T_x^e(X^I) - \Pi_x$, and then substituting it into (4) to get

$$\Delta_x = T_x^e(X^I) - C_x(X^I) + \Pi_x - (R(X^m, 0) - C_x(X^m)) \geq 0. \tag{5}$$

We refer to (5) as one of the *non-foreclosure* conditions.[13] If it were violated (and hence (4) were violated) at a proposed equilibrium pair of contracts, firm X could simply offer to sell at cost plus a

[13] In addition to its analogue, the other two *non-foreclosure* conditions are that a coalition of firm X and the retailer

fixed fee. This would induce the retailer to drop Y and choose the quantity X^m. Bilateral surplus would increase, so a fixed fee could be chosen to make both firm X and the retailer better off.

Using (5) and firm Y's *surplus extraction* condition, Y's profit in any two-good equilibrium can be written as

$$\text{Y's profit} = R(X^I, Y^I) - C_x(X^I) - C_y(Y^I) - (R(X^m, 0) - C_x(X^m)) - \Delta_x.$$

Since $\Delta_x \geq 0$, we know that firm Y's profit is less than or equal to the total profit in the system minus the profit that a coalition of firm X and the retailer could make if good Y were dropped. This upper bound on profit is positive whenever a vertically integrated firm would choose $Y^I > 0$. Whether or not firm Y can achieve this bound will depend on Δ_x, which in turn depends on the contract that firm X offers the retailer.

Symmetrically, firm X's profit in a two-good equilibrium can be written as

$$\text{X's profit} = R(X^I, Y^I) - C_x(X^I) - C_y(Y^I) - (R(0, Y^m) - C_y(Y^m)) - \Delta_y.$$

The upper bound on profit will be positive whenever a vertically integrated firm would choose $X^I > 0$. Whether this bound is reached will depend on the contract that firm Y offers the retailer.

Consider the following proposed pair of equilibrium supply contracts for X and Y. Suppose both upstream firms charged fixed fees (lump sum payments made at the time of ordering) and then sold their good at cost. Let X's supply contract be such that

$$T_x^e(X) = \begin{cases} 0 & \text{if } X = 0 \\ T_x^e(X^I) - C_x(X^I) + C_x(X) & \text{if } X > 0 \end{cases} \tag{6}$$

Similarly, let Y's contract take the same form, where $T_x^e(X^I)$ and $T_y^e(Y^I)$ simultaneously satisfy the *surplus extraction* conditions. Substituting these supply contracts into the *efficiency* conditions, it is easily verified that if there is an interior solution to the maximizations, then X^I and Y^I will be the retailer's choice of inputs. Intuitively, once the downstream firm pays a franchise fee of $T_x^e(X^I) - C_x(X^I)$ to firm X and $T_y^e(Y^I) - C_y(Y^I)$ to firm Y, she becomes the residual claimant to profits. Her choices will be identical to a vertically integrated firm. It remains to check, however, that the efficiency conditions are not maximized at the boundaries, i.e., that the *non-foreclosure* condition (5) and its analogue are satisfied. Clearly, this depends on the size of the franchise fees.

Given the supply contract in (6), it is possible to compute the retailer's maximized profit if she were to drop good Y. We have

$$\begin{aligned} \Pi_x &= \max R(X,0) - T_x^e(X) \\ &= \max R(X,0) - C_x(X) - \left(T_x^e(X^I) - C_x(X^I)\right) \\ &= R(X^m,0) - C_x(X^m) - \left(T_x^e(X^I) - C_x(X^I)\right) \end{aligned}$$

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will not foreclose firm X from the market, and that a coalition of firm Y and the retailer will not foreclose firm Y from the market. One can show that both of these conditions will be satisfied provided that firm X and firm Y earn non-negative profit in equilibrium. This is true by assumption since we assumed that the payment asked for any given quantity must not be less than the total cost of producing that quantity.

The first equality follows from the definition of Π_x. The second equality is obtained by substituting in for the supply contract in (6). The third equality follows from by the definition of X^m. When the last expression for Π_x is substituted into the *non-foreclosure* condition (5) the LHS becomes zero. Similarly, given firm Y's supply contract, the analogous *non-foreclosure* condition is also satisfied with equality. This means that both upstream firms achieve their upper profit bounds.

Proposition 3 *Two-good equilibria always exist when supply contracts specify fixed fees with the option to buy at cost. Furthermore, the upstream firms obtain their upper bounds on profits.*

Since the total profit pie is fixed in any two-good equilibrium, it is clear that the retailer is better off when suppliers do not achieve their upper bounds on profit. This suggests that the retailer will have strong preferences over the nature of the supply contracts she receives. For example, suppose firm Y's contract remained unchanged, but firm X offered a two-part tariff contract of the form

$$T_x^e(X) = \begin{cases} 0 & \text{if } X = 0 \\ T_x^e(X^I) - w_x^I + w_x & \forall X > 0 \end{cases} \tag{7}$$

where $T_x^e(X^I)$ and $T_y^e(Y^I)$ are chosen to simultaneously satisfy the *surplus extraction* conditions, and the wholesale price w_x is equal to firm X's production marginal cost when evaluated at X^I. The fixed fee is $T_x^e(X^I) - w_x X^I$.[14] Substituting these supply contracts into the *efficiency* conditions, it is easily verified that if there is an interior solution to the maximizations, then X^I and Y^I will be the retailer's choice of inputs. It remains to check for boundary solutions.

Let $X^t \in \arg\max R(X,0) - T_x^e(X)$. Then the *non- foreclosure* condition (5) is satisfied if and only if $T_x^e(X^I) - C_x(X^I) + R(X^t,0) - T_x^e(X^t) - (R(X^m,0) - C_x(X^m)) \geq 0$. Substituting in the two-part tariff contract in (7) and rearranging gives the *non-foreclosure* condition as

$$\Delta_x = \int_{X^m}^{X^t} \left(\frac{\partial R(s,0)}{\partial X} - w_x \right) ds + \int_{X^I}^{X^m} \left(\frac{\partial C_x(s)}{\partial X} - w_x \right) ds \geq 0. \tag{8}$$

The easiest case to consider is when firm X's production marginal cost is constant. Then $X^t = X^m$, $w_x = \partial C_x / \partial X$, and (8) is satisfied with equality. Firm Y achieves its upper profit bound.

Next, consider the cases where production marginal costs are not constant. This can be illustrated with the help of figures 1–2. Figure 1 (2) depicts increasing (decreasing) production marginal costs. Both illustrate strategic substitutes, which are represented graphically as a shifting out of derived demand as Y falls from Y^I to 0.[15] The initial starting point has been labeled "A" in each figure. Here, the retailer's derived demand for X is equal to X's production marginal cost.

[Insert figures 1 and 2]

When production marginal costs are increasing and the goods are strategic substitutes (see Figure 1), the left hand side of (8) is strictly positive and is given by the area ABC. This means

[14] Notice that at $X = X^I$, firm X is indifferent between this contract and the one in (6).

[15] The analysis with strategic complements is similar and does not yield any insights beyond figures 1 and 2.

that if firm X offers a two-part tariff contract, $\Delta_x = ABC > 0$, and hence firm Y will not achieve its upper profit bound.

For any given supply contract by firm Y, firm X's profit is determinate. Thus, firm X is indifferent between a variety of contract forms. However, the retailer does have a preference. Her threat to foreclose good Y is more credible when she can purchase additional units beyond X^I at a linear wholesale price as opposed to an increasing tariff that reflects rising marginal cost. Hence, in order to secure the buyer's patronage, firm Y will not be able to extract as much surplus under X's two-part tariff as it would if firm X were selling its units at cost.

It is easy to see that under more generous quantity discounts the retailer's opportunity cost of selling both goods as opposed to one good would be even greater, and thus her equilibrium profit would be higher. Let X's supply contract be such that

$$T_x^e(X) = \begin{cases} 0 & \text{if } X = 0 \\ T_x^e(X^I) - f_x(X^I) + f_x(X) & \forall X > 0 \end{cases} \tag{9}$$

where the discount function f_x has the properties $\partial R(X, Y^I)/\partial X < \partial f_x(X)/\partial X < 0 \; \forall X > 0$, and $f_x(X)$ induces the retailer to purchase X^I when Y^I is also chosen. Let X^d be the amount the retailer would purchase if she dropped good Y when offered the quantity discount in (9). Then referring to figure 1, the left hand side of (5) is strictly positive and is given by the area ABD. Since this area exceeds ABC, firm Y will necessarily be extracting even less surplus from the retailer given firm X's quantity discount schedule than it would extract if firm X were to specify the two-part tariff contract in (7).[16] This is so because firm X's discount makes the option of dropping good Y more valuable to the retailer, thus strengthening her threat vis- a-vis firm Y. Obviously, the greater the discount that firm X offers, the worse off firm Y will be, and vice versa. The retailer stands to gain from this type of competitive rivalry.

Now consider figure 2. With a two-part tariff the non-foreclosure condition (8) is strictly negative and is given by area ABC. But this cannot be an equilibrium because a coalition of firm X and the retailer will be able to find a profitable deviation that excludes good Y from the market and permits both to earn higher profit. Intuitively, the retailer's option to foreclose good Y is less valuable under a two- part tariff contract with decreasing production marginal costs than is actually the case from the coalition's standpoint. Thus, two-good equilibria will not exist with two-part tariffs when marginal costs are decreasing. On the other hand, a more generous quantity discount schedule, which induces $X^d \geq X^m$, does yield an equilibrium because the *non-foreclosure* condition (5) is non-negative and is given by area ABD. When firm X offers a contract such that $X^d > X^m$, firm Y will not achieve his upper bound on profit.

The main insights of this section are that two-good equilibria always exist and that the division of surplus will vary depending on the retailer's opportunity cost of selling each good. In particular, profit is transferred from the upstream firms to the retailer according to the following proposition.

[16]This is true even though the quantity discounts are unused in the sense that in equilibrium the retailer purchases too little of good X to benefit directly from firm X's increasingly generous quantity discount.

Proposition 4 *The retailer's equilibrium profit will be increasing in the size of the quantity discounts offered by firm X and Y.*

The results of this section will be used in comparing two- good equilibria with one-good equilibria from the perspective of each firm.

IV Market Foreclosure and One-good Equilibria

In this section we begin by considering whether non-linear supply contracts can give rise to equilibria in which the retailer purchases only one good. Without loss of generality, we assume that firm Y is the excluded firm. We then consider equilibria that arise when the contract set is expanded to include exclusive dealing provisions. Finally, we address whether firm X would want to foreclose firm Y by vertically integrating with the retailer.

IV.1 Foreclosure through Non-linear Supply Contracts

The analysis in section ii proved that the retailer will purchase X^m and 0 in any equilibrium in which only good X is bought. By lemma 1, this gives the following three conditions as necessary and sufficient for $\left(T_x^e, T_y^e\right)$ to be an equilibrium pair of supply contracts:

$$\max_{x,y} R(X,Y) - C_x(X) - T_y^e(Y) = R(X^m, 0) - C_x(X^m) \tag{10}$$

$$\max_{x,y} R(X,Y) - C_y(Y) - T_x^e(X) = R(X^m, 0) - T_x^e(X^m) \tag{11}$$

$$R(X^m, 0) - T_x^e(X^m) = \max_{y} R(0,Y) - T_y^e(Y) \tag{12}$$

From (11), it must be the case that a coalition of firm Y and the retailer will not foreclose firm X from the market. Mathematically, $R(0,Y^m) - C_y(Y^m) \leq R(X^m, 0) - T_x^e(X^m)$. Hence, firm X will necessarily be the more profitable stand alone brand.

Proposition 5 *With asymmetry of cost and demand, only the stronger brand, i.e., the most profitable, can emerge as the included firm in a one-good equilibrium. Only with symmetry would it be possible to have one good-equilibria in which either good is purchased.*

Profit for the included firm X can be found from rearranging condition (12). It is equal to the maximized coalition profit $R(X^m, 0) - C_x(X^m)$ minus the amount the retailer would earn by selling good Y only. It can be easily verified that firm Y must specify a contract that allows the retailer to buy Y^m at cost, and hence this latter amount is equal to $R(0, Y^m) - C_y(Y^m)$. Intuitively, if this were not true, then firm X would be induced to extract too much surplus. By reoptimizing, a coalition between firm Y and the retailer would find it profitable to drop good X.

Proposition 6 *In any equilibrium in which only good X is purchased, profits for firm X, firm Y, and the retailer are given by*

$$\begin{aligned} \textit{X's profit} &= R(X^m,0) - C_x(X^m) - (R(0,Y^m) - C_y(Y^m)) \\ \textit{Y's profit} &= 0 \\ \textit{Retailer's profit} &= R(0,Y^m) - C_y(Y^m). \end{aligned}$$

This division of surplus is unique for any one-good equilibrium regardless of the supporting supply contracts. Firm X obtains exclusive distribution at substantial cost because the retailer must earn at least as much profit as she would earn by selling good Y only. The more symmetric are goods X and Y, the lower firm X's profit will be. The retailer always earns the monopoly profit on the excluded good.

It remains to show that a pair of supply contracts can be constructed which satisfy the necessary and sufficient conditions above. From (11), it must be the case that the value of Y which maximizes $R(X^m, Y) - C_y(Y)$ is equal to zero. Clearly, this will depend on the parameters of cost and demand. If this is satisfied, then one-good equilibria will exist, since $T_x^e(\cdot)$ can always be chosen to be a quantity forcing contract.[17]

Proposition 7 *Foreclosure through non-linear supply contracts is feasible if and only if the derived demand for good Y, when evaluated at X^m, is everywhere below Y's average cost.*

This condition is more likely to be satisfied when scale economies are large. It will not be satisfied, for example, if marginal costs are constant and there are no fixed costs associated with selling to the retailer, or if fixed costs are sufficiently low and variable costs are convex. Thus, for a wide range of cases, foreclosure can only occur through other means of contracting. We consider exclusive dealing and vertical mergers below.

IV.2 Exclusive Dealing

Up to now, we have considered supply contracts that depend only on quantity. In practice, firms can choose to foreclose a rival directly through exclusive dealing. That is, if the retailer sells good X, and firm X has an exclusive dealing provision, then the retailer would be legally prohibited from also selling good Y. This subsection compares explicit foreclosure through exclusive dealing to the one and two-good equilibria in non-linear supply contracts.

We consider two ways to model the incorporation of exclusive dealing contractual provisions: these decisions can be made prior to the choice of payment terms, or simultaneously with the rest of the contract terms. Beginning with the former, the game is played as follows. In stage one, the upstream firms simultaneously, but independently, decide whether to adopt exclusive dealing. In stage two, the upstream firms offer supply contracts, and in stage three, the retailer chooses

[17] Let $T_x^e(X) = R(X^m,0) - R(0,Y^m) - C_y(Y^m)$ if $X = X^m$, 0 if $X = 0$, and ∞ otherwise. Let $T_y^e(Y^m) = C_y(Y^m)$ if $Y = Y^m$, 0 if $Y = 0$, and ∞ otherwise. It can be verified that these conditions satisfy the necessary and sufficient conditions.

how much of each good to purchase. At each stage, all information is common knowledge. The equilibrium concept is subgame perfection.

There are four possible subgames after stage 1. One subgame extends from the decision by both firms to forego exclusive dealing. This has already been analyzed. The other three subgames are equivalent and arise regardless of whom adopts the restraint. Without loss of generality, let firm X be the stronger brand in the sense that its stand-alone maximum profit exceeds that of firm Y. We now consider under what conditions, if any, firm X or firm Y will choose to initiate an exclusive dealing subgame.

Consider the exclusive dealing subgames. Many of the results found in the preceding subsection on foreclosure through non-linear supply contracts extend trivially. For example, it will still be true that in any equilibrium, surplus will be extracted until the retailer is just indifferent between buying good X or good Y. Therefore, $\Pi_x = \Pi_y$. Although conditions (10) and (11), which were necessary and sufficient for a one- good equilibrium without exclusive dealing, have to be modified, the replacement condition, $R(0,Y^m) - C_y(Y^m) \leq R(X^m,0) - T_x^e(X^m)$, has already been considered.[18] Recall that this inequality must hold if good Y is to be excluded from the market. In equilibrium, we know that firm Y must offer a contract that allows the retailer to buy Y^m at cost; hence firm profits are given as in proposition 6.

The next step is to compare the upstream firms' profits with and without exclusive dealing. Clearly, firm Y will be at least as well off in any two-good equilibria as it would be if it were foreclosed. Surprisingly, firm X would also prefer to be in a two-good equilibrium. To see this, let firm X's equilibrium profit with exclusive dealing be denoted by Π_x^{ED}. Then, from proposition 6,

$$\Pi_x^{ED} = R(X^m,0) - C_x(X^m) - (R(0,Y^m) - C_y(Y^m)).$$

Let firm X's profit without exclusive dealing be denoted by Π_x^{NED}. Then, from firm X's *surplus extraction* condition, profit in a two-good equilibrium can be written as

$$\Pi_x^{NED} = R(X^I,Y^I) - C_x(X^I) - T_y^e(Y^I) - \Pi_y.$$

Subtracting Π_x^{ED} from Π_x^{NED} yields

$$\left[R(X^I,Y^I) - C_x(X^I) - T_y^e(Y^I) - (R(X^m,0) - C_x(X^m))\right] + [R(0,Y^m) - C_y(Y^m) - \Pi_y] \geq 0$$

Although the profit that firm X obtains in any two-good equilibrium can vary substantially, it will always be at least as much as what it would obtain in a one-good equilibrium. There are two reasons. The first set of terms in brackets represents the increase in surplus to the coalition of firm X and the retailer when good Y is sold in addition to good X. It is non-negative. The second set of terms in brackets represents the increase in the opportunity cost of the retailer when she is committed to sell at most one brand as opposed to when she can only threaten to sell just one brand. It is also non-negative. Both effects serve to make firm X better off in a two-good equilibrium.

[18] Condition (10) is trivially true under exclusive dealing, since a coalition of firm X and the retailer does not have the option of selling both good X and good Y. Similarly, condition (11) reduces to the inequality in the text, because a coalition of firm Y and the retailer does not have the option of selling both goods.

On the other hand, the retailer's profit in any equilibrium is determined by her opportunity cost of selling good X, and since this is highest when firm Y offers her a supply contract at cost, the retailer will prefer one-good equilibria. This yields the following proposition from which it follows that neither upstream firm will initiate exclusive dealing in the three stage game.[19]

Proposition 8 *Both suppliers are at least as well off in all two-good equilibria as they are in all one-good equilibria. The retailer is always better off in a one-good equilibrium than it is in any two-good equilibrium.*

It should be pointed out that the retailer's preference for one-good equilibria is not robust to the take-it or leave- it offer assumption. More generally, if the retailer has some bargaining power, her profit will depend both on the total surplus available as well as on her disagreement point vis a vis each supplier, i.e. her opportunity cost of selling each good. When comparing one-good equilibria with two-good equilibria, we know that the overall surplus is higher in the latter, but that her disagreement points are lower. In the polar case where the retailer has all of the bargaining power, only the size of the total surplus matters; the retailer would prefer two- good equilibria. At the other extreme, when the upstream firms can make take-it or leave-it offers, only the disagreement points matter and the proposition holds.

The second way to model exclusive dealing is to assume that these decisions are made simultaneously with the rest of the contract terms. The formal game is as follows. In stage one, the upstream firms simultaneously choose their supply contracts, which includes their non-linear payment terms and their exclusive dealing decisions. The retailer purchases X and Y in stage two.

Because the contract set has been expanded to include exclusive dealing, the first task is to consider whether the two-good equilibria found in the previous section are robust. Without loss of generality, let firm X deviate from a proposed two-good equilibrium by offering a new supply contract with exclusive dealing.

Holding firm Y's supply contract constant at T_y^e, any alternative supply contract by firm X must give the retailer at least Π_y. Thus, the maximum profit that firm X can earn under an alternative contract with exclusive dealing is $\Pi_x^* = R(X^m, 0) - C_x(X^m) - \Pi_y$. Comparing profits gives $\Pi_x^{NED} \geq \Pi_x^*$. Therefore, firm X cannot deviate so as to earn strictly higher profit and hence two-good equilibria are robust to the modification of the game.

The second task is to consider whether the one-good equilibria found in the previous subsection are robust. However, this is trivially so. Market foreclosure that arises through non-linear contracting is unaffected by whether firm X or Y decides to adopt exclusive dealing in addition to their other terms. On the other hand, exclusive dealing allows one-good equilibria to be supported even when firm Y's derived demand is everywhere above Y's average cost.

The analysis in this section has shown that there is a role for exclusive dealing even when non-linear supply contracts are feasible. This is because explicit foreclosure is always possible whereas foreclosure through non-linear supply contracts is not, and because the division of surplus is the same in all one-good equilibria. However, we have shown that the manufacturers themselves do

[19] It is weakly dominated for either firm to announce exclusive dealing.

not have incentives to foreclose their rivals, and that it is the retailers who may sometimes prefer the one-good equilibria because of the added bargaining strength it gives them.

IV.3 Vertical Mergers

Market foreclosure can also occur when an upstream firm merges with a downstream firm and refuses to carry the products of its competitors. This solution to the problem is drastic and would seem to be unnecessary if contractual foreclosure is possible. Nevertheless, vertical mergers can easily be accommodated in our framework.

Consider the bilateral profit of firm X and the retailer in the absence of a merger. In any two-good equilibrium, this profit is given by $R(X^I, Y^I) - T_x^e(Y^I) - C_x(X^I)$. On the other hand, the maximized bilateral profit of firm X and the retailer after a merger is $R(X^m, 0) - C_x(X^m)$ if firm Y is excluded. Clearly, market foreclosure is not profitable. Furthermore, in the context of our model, vertical separation is a weak best response by a coalition of firm X and the retailer. A vertical merger is undesirable because firm Y would then be able to achieve its upper profit bound. By remaining separated, the retailer may be able to negotiate a quantity discount with firm X that can extract additional surplus from Y, without making firm X any worse off.

V Conclusion

An important issue when suppliers sell to commercial buyers is how the surplus from sales to final consumers will be shared. Many authors resolve this by focusing their attention on supply contracts with linear wholesale prices. Such a restriction is, however, inefficient. It leads to the well known double marginalization problem whereby both upstream and downstream firms markup over cost. The end result is a retail price which is too high in the sense that joint profits are not maximized. Non-linear contracting can avoid this problem, and moreover, is frequently observed in intermediate goods markets.

Nevertheless, nearly all of the formal exclusive dealing literature takes linear wholesale pricing as the benchmark.[20] It then considers whether the restraint can arise for anticompetitive reasons. The difficulty with this approach is that it mixes the foreclosure motives of suppliers with their desire to extract additional surplus from retailers. It also does not consider the possibility that foreclosure can arise through non-linear contracting directly without the need to specify exclusivity in the contract. We believe that policy informed by these models can be misguided.

This paper places few restrictions on the type of non-linear supply contracts that are allowed. We do find that foreclosure can occur without exclusive dealing, but only if economies of scale are sufficiently large. Hence exclusive dealing is necessary for foreclosure to occur in many cases.

A surprising result is that when the foreclosure and surplus extraction motives of suppliers are disentangled, suppliers never want to foreclose their rivals. The intuition is that the restraint

[20] Lin (1990) considers two-part tariffs. However, in the absence of exclusive dealing, the retailer in his model is necessarily assumed to carry both brands. This leads him to conclude, in violation of our propositions 1 and 2, that transfer prices will not equal marginal cost and that the retailer's surplus will be zero.

decreases the total surplus available (by lowering product variety) and serves to raise the retailer's bargaining power by increasing her opportunity cost of buying each good. By contrast, we find that it is the retailer who may desire exclusive dealing. Her share of profit increases in a one-good equilibrium, but this must be balanced against a shrinking overall surplus. In the polar case where she has all of the bargaining power, the total size of the surplus dominates. She prefers two-good equilibria. When her bargaining power is determined solely by her opportunity cost of selling each brand, the size of the total surplus is irrelevant to her. Although she prefers exclusive dealing, it is not likely that suppliers will acquiesce. Thus, we expect to see exclusive dealing for foreclosure purposes only when bargaining power is more even and only at the initiation of the retailer.

Some comments should be made on the welfare effects of foreclosure in our model. Fortunately, this can be done by analogy to the literature on monopoly and product diversity. There, it is known that a monopolist may have too much or too little social incentive to introduce a second product.[21] Here, the problem is isomorphic because the retailer's product choice in the absence of foreclosure is the same as a vertically integrated monopolist. Hence, it cannot be determined apriori whether welfare is higher or lower with one good or two good equilibria. By analogy with the product diversity literature, we know that it is likely to be higher when demand can be represented spatially, and likely to be lower when demand is derived from a representative consumer.

Much work remains to be done, and so our policy conclusions are necessarily tentative. We agree with Mathewson and Winter that foreclosure can arise but that its welfare implications are ambiguous. However, we do not see an easy way to distinguish when more product variety is desirable. For this reason, we would find against exclusive dealing if the restraint is adopted to foreclose markets. The difficulty, of course, is in determining when exclusive dealing is used for efficiency reasons and when it is used for foreclosure purposes. In our view we have provided a formal justification for why policy makers should not jump to the conclusion that exclusionary agreements are for anticompetitive foreclosure. The cost of retailer compensation is simply too steep. On the other hand we would be concerned when exclusive dealing arises in markets where the retailer has some bargaining power.[22]

One direction for future research is to extend the Aghion and Bolton model to differentiated products with downward sloping demands. We conjecture, based on the results of this paper, that an optimal contract between the incumbent seller and buyer would specify quantity discounts without an exclusive dealing clause. This would suffice to extract extra surplus from the potential entrant without necessarily foreclosing it from the market. A second direction for research is to allow for competing downstream firms. Here, a crucial distinction needs to be made regarding contract observability. If the downstream firms cannot observe each other's supply contracts, then the qualitative results of this paper are unchanged. However, the nature of competition when multiple principals sell to multiple agents and non-linear contracts are observable and feasible is an open question.

[21]The opposing factors are the inability to capture all of the consumer surplus generated by the second product versus the more effective segmentation of consumers. See de Meza and Ungern-Sternberg (1982).

[22]In private conversation we have learned that a retail chain in the northeast may have pressured suppliers of some products into an implicit exclusive arrangement.

Figure 1: Strategic Substitutes with Increasing Marginal Cost

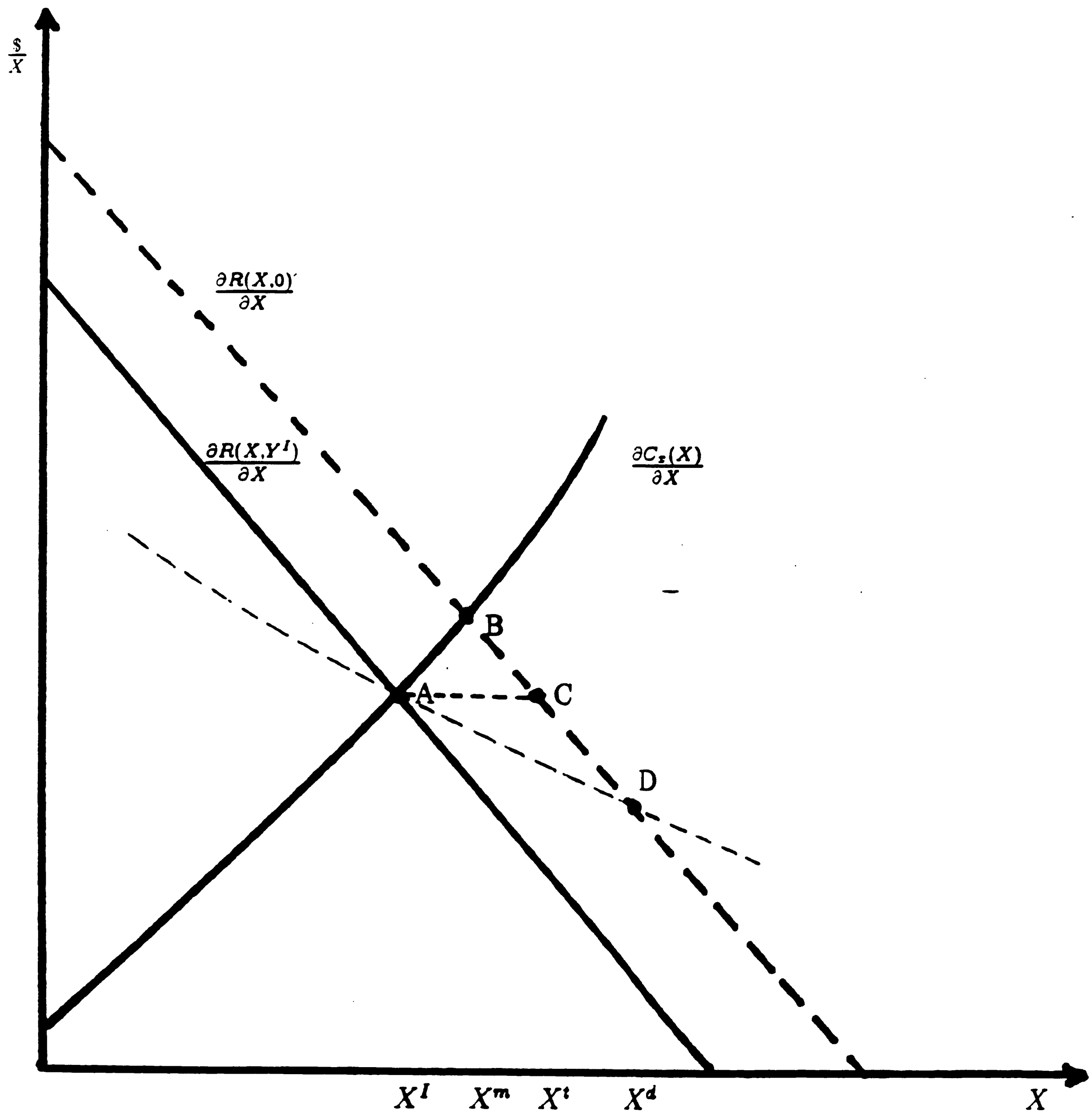
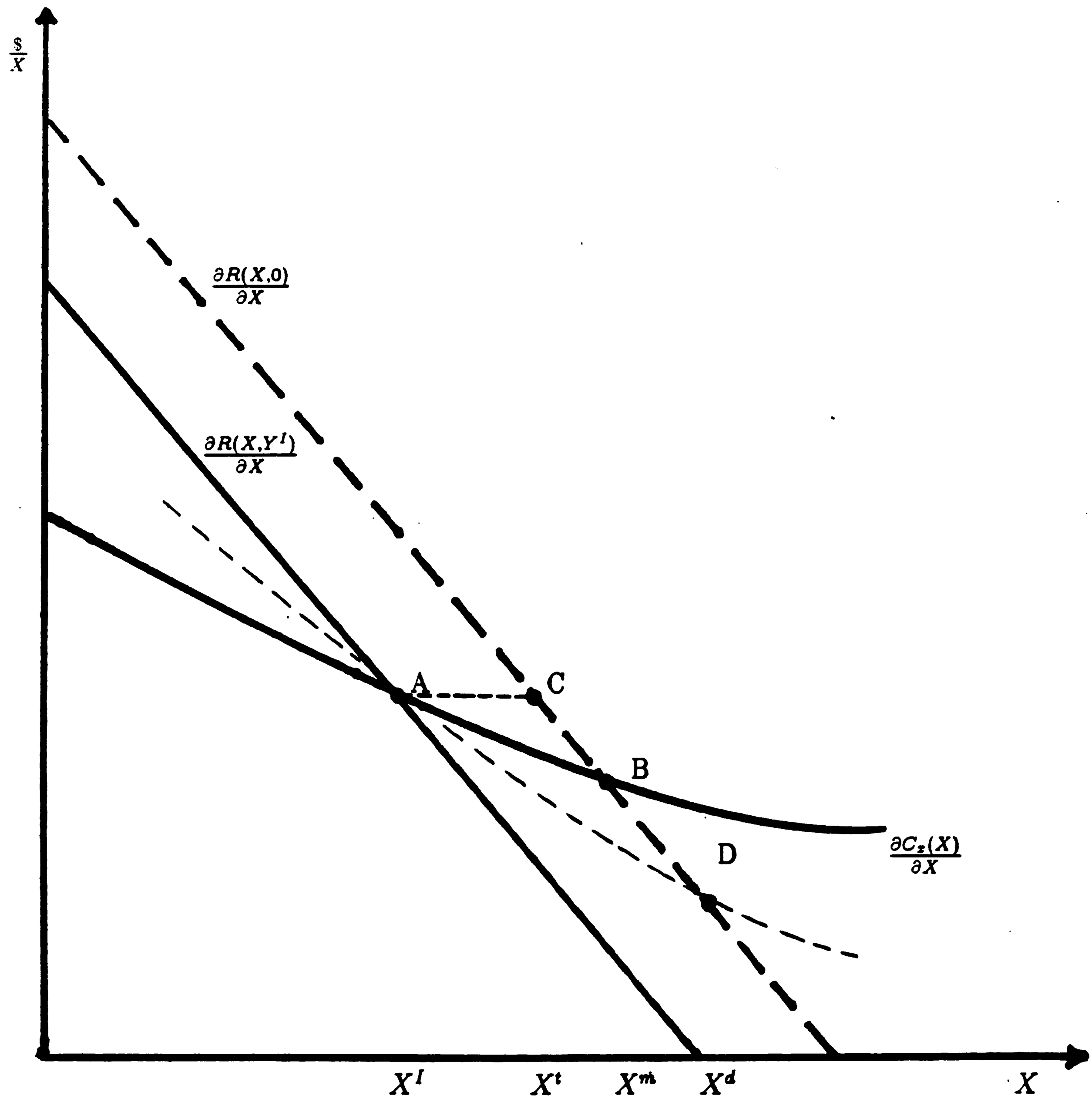


Figure 2: Strategic Substitutes with Decreasing Marginal Cost



Appendix A

Necessity. The proof is by contradiction. Consider first the necessity of condition (3). By definition, $\Pi_{x,y} \geq \Pi_x, \Pi_y$. Suppose one of the inequalities were strict. Then the supplier who is not extracting all his incremental profit could increase his profit by raising the fixed component of his supply contract. Next, consider the necessity of (1). Suppose $T_x^e(\cdot)$ and $T_y^e(\cdot)$ arise in a subgame perfect equilibrium, but that $\max_{x,y} R(X,Y) - C_x(X) - T_y^e(Y) \neq R(X^e, Y^e) - C_x(X^e) - T_y^e(Y^e)$. Using the fact that $\Pi_{x,y} = \Pi_y$, this can be written as

$$\max_{X,Y} R(X,Y) - C_x(X) - T_y^e(Y) - T_x^e(X^e) + C_x(X^e) \neq \Pi_y. \tag{13}$$

If the left hand side of (13) were less than the right hand side, the retailer would earn less by buying X^e and Y^e than by buying only good Y, a contradiction. Suppose the left hand side were greater than the right hand side. Then for some arbitrarily small ω,

$$\max_{X,Y} R(X,Y) - C_x(X) - T_y^e(Y) - T_x^e(X^e) + C_x(X^e) - \omega > \Pi_y. \tag{14}$$

But consider the supply contract

$$T_x^*(X) = \begin{cases} 0 & \text{if } X = 0, \\ T_x^e(X^e) + C_x(X) - C_x(X^e) + \omega & \text{otherwise.} \end{cases}$$

Substituting this contract into (14) gives

$$\max_{X,Y} R(X,Y) - T_x^*(X) - T_y^e(Y) > \Pi_y,$$

which means that under T_x^* the retailer would purchase a positive amount. Hence, supplier X would earn ω more in profit under $T_x^*(\cdot)$ than under $T_x^e(\cdot)$, contradicting the hypothesis that $T_x^e(\cdot)$ was a best response to $T_y^e(\cdot)$. The necessity of condition (2) is established symmetrically.

Sufficiency. Suppose that conditions (1) through (3) hold, but that $T_x^e(\cdot)$ and $T_y^e(\cdot)$ do not arise in a subgame perfect equilibrium. Then at least one of the suppliers can offer a contract that would increase his profit. Without loss of generality, suppose $\exists\ \hat{T}_x(\cdot)$ that would induce the retailer to choose $X > 0$ and would make firm X better off. That is,

$$\max_{X,Y} R(X,Y) - \hat{T}_x(X) - T_y^e(Y) > \Pi_y, \tag{15}$$

and $\hat{T}_x(X) > T_x^e(X^e) - C_x(X^e) + C_x(X)\ \forall(X,Y) \in \Omega(\hat{T}_x(\cdot), T_y^e(\cdot))$. Without loss of generality, let $(\hat{X},\hat{Y}) \in \Omega(\hat{T}_x(\cdot), T_y^e(\cdot))$ be the retailer's choice of (X,Y). There exists some $\hat{w} > 0$ such that $\hat{T}_x(\hat{X}) = T_x^e(X^e) - C_x(X^e) + C_x(\hat{X}) + \hat{w}$. Substituting this expression into (1), and using the fact that $\Pi_{x,y} = \Pi_y$, yields

$$\max_{X,Y} R(X,Y) - C_x(X) - T_y^e(Y) - \hat{T}_x(\hat{X}) + C_x(\hat{X}) + \hat{\omega} = \Pi_y. \tag{16}$$

Evaluating the left hand side of (16) at $(\hat{X},\hat{Y})$, we have

$$R(\hat{X},\hat{Y}) - T_y^e(\hat{Y}) - \hat{T}_x(\hat{X}) + \hat{\omega} \leq \Pi_y,$$

which means that

$$R(\hat{X},\hat{Y}) - T_y^e(\hat{Y}) - \hat{T}_x(\hat{X}) < \Pi_y. \tag{17}$$

But by the definition of $(\hat{X},\hat{Y})$, condition (17) contradicts condition (15). **Q.E.D.**

Appendix B

This appendix shows that the qualitative results of the paper are unchanged when the retailer bargains with the upstream firms. Following Harsanyi (1977) and Horn and Wolinsky (1988), suppose the retailer is simultaneously engaged in bilateral monopoly relations with each supplier. A *bargaining equilibrium* is defined as a set of asymmetric Nash bargaining solutions between the retailer and each supplier. Let the profits of the retailer and supplier X be given by $\phi_r = R(X,Y) - T_x(X) - T_y(Y)$ and $\phi_x = T_x(X) - C_x(X)$ where $(X,Y) \in \Omega(T_x(\cdot), T_y(\cdot))$. Their bargaining problem is defined by the disagreement points $(\Pi_y, 0)$ and the convex set of payoff pairs $\Phi_x = \{\phi_r, \phi_x \mid (X,Y) \in \Omega(T_x(\cdot), T_y(\cdot))\}$. A set of asymmetric Nash bargaining solutions is a vector of contracts that maximize the Nash products, $(\phi_r - \Pi_j)^{(1-\alpha_i)}(\phi_i)^{\alpha_i}(i = X, Y; i \neq j)$, where $\alpha_i \in (0,1)$ is a measure of the bargaining power of supplier i in negotiations with the retailer. Let $T_y^e(\cdot)$ be the bargaining equilibrium contract between the retailer and supplier Y. Then notice that the Nash product between the retailer and supplier X can be rewritten as

$$\Big(R(X,Y) - C_x(X) - T_y^e(Y) - \text{X's profit} - \Pi_y\Big)^{1-\alpha_x} (\text{X's profit})^{\alpha_x}.$$

Without loss of generality, we may assume that $T_x(\cdot)$ consists of a non-linear payment schedule $\tilde{T}_x(\cdot)$ and a fixed fee F_x. Given component $\tilde{T}_x$, choosing F_x is equivalent to choosing X's profit. From the first order condition we have

$$\text{X's profit} = \alpha_x \Big(R(X,Y) - C_x(X) - T_y^e(Y) - \Pi_y\Big). \tag{18}$$

Substituting this into the Nash product, yields

$$(1-\alpha_x)^{1-\alpha_x}(\alpha_x)^{\alpha_x} \Big(R(X,Y) - C_x(X) - T_y^e(Y) - \Pi_y\Big).$$

Since Y^e maximizes $R(X^e, Y) - T_y^e(Y)$, and since the supplier and retailer X can always write a forcing contract that induces the retailer to choose any X, the remaining part of their problem is equivalent to

$$\max_{X,Y} R(X,Y) - C_x(X) - T_y^e(Y) = R(X^e, Y^e) - C_x(X^e) - T_y(Y^e). \tag{19}$$

A similar maximization problem determines the Nash bargaining solution between the retailer and supplier Y. Conditions (18) and (19) and their analogues are necessary and sufficient for $(X^e, Y^e, T_x^e(\cdot), T_y^e(\cdot))$ to arise in a bargaining equilibrium.

Notice that (18), (19), and their analogues are qualitatively similar to the conditions in proposition 1. The only difference is that supplier profits under bargaining differ from supplier profits in the text by a factor of α_i. It is easy to see that with the exception of proposition 8, all of our previous results continue to hold. Proposition 8 differs because under bargaining the retailer may or may not earn higher profit under exclusive dealing. The intuition was discussed in the text.

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