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by

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Abstract: This paper develops an analysis of markets in which sellers have significant sunk investments; it takes considerable time to enter; and buyers can make credible commitments to obtain alternative sources of supply. We show that in markets with these characteristics the market power of sellers is more attenuated than models with unsophisticated buyers would predict. In particular, current prices are critical to the decision whether or not to "enter," so that limit pricing is a likely form of equilibrium pricing, even in the presence of full information. The limit price is predicted to increase with the amount of time it takes to enter, the number of buyers, and with the level of buyers' switching costs, but to <u>fall</u> with the level of sunk investments. Thus, in such markets, sunk costs restrain, rather than increase, the ability of sellers to exert market power, and hence do not constitute entry barriers. Entry lags and switching costs, however, do enhance the ability of sellers to exert market power. This paper, then, questions the standard prediction of an inverse relationship between market performance and sunk investments.

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I. Introduction

Recent developments in the theory of industrial organization have shed much light on the structural conditions necessary for the exercise of market power. An important result is that in the presence of sunk costs pre-entry prices are irrelevant to entry decisions by informed potential entrants.[1] This result has spawned a burgeoning literature in which incumbents or first movers make strategic commitments to investments analogous to sunk costs.[2]

This literature paints a dark picture of the likely competitiveness of concentrated industries in which sunk costs are significant.[3] These theories, however, are largely derived from a framework with unsophisticated buyers -- in most cases buyers are modeled simply as a demand curve. That such modelling may in many cases be too simplistic seems clear once it is realized that most industries are intermediate good industries, i.e., they sell their products to other producers, who may be as equally able as their suppliers to engage in strategic behavior.[4]

There have been two main literatures that feature sophisticated buyers. One literature, largely ignored in recent years, dealt with "buyer power" or "countervailing powers."[5] Another literature, the transaction-cost approach to the theory of the firm and organization, highlights the role of buyers in the determination of the organization of firms and industries (for example, whether or not firms are vertically integrated).[6] In particular, Williamson, and Klein, Crawford and Alchian,[7] examine the implications of the possibility that sellers' sunk costs may be expropriated by a sophisticated buyer if the buyer can credibly threaten to vertically integrate, to contract for alternative sources of supply, or to switch to a different kind of input.[8] In these models sunk costs place the seller at risk to the threat of "entry" by a sophisticated buyer, and so vertical integration may be the only feasible solution to the threat of opportunistic behavior by buyers.

In many intermediate product industries buyers may be the most likely "entrants," either by vertical integration, by contracting with entrants, or by making investments that allow them to switch to alternative sources of supply.[9] For a buyer considering entry, the usual entry calculus of oligopoly theory is incorrect, since what is relevant to a buyer is whether his total profits if he "enters" are larger or smaller than his profits in the alternative of facing oligopoly pricing. In other words, pre-entry prices are directly relevant to the entry decision of a buyer, if those prices are expected to persist in the absence of entry.

In this paper we show that if buyers are credible potential entrants, the resulting equilibrium pricing will differ from that predicted by models featuring sunk costs as entry barriers (e.g. Spence (1977), Dixit (1980)). Thus, these models may not be appropriate for the analysis of industries, like many intermediate goods industries, where buyers can make credible "entry" threats. If sellers have significant sunk costs, if entry is observable and takes time, and if buyers can make credible "entry" commitments, then sunk costs and entry lags are countervailing forces that yield limit pricing equilibria. Even with a single seller, these equilibria have prices below the monopoly price, and no entry. The limit price will generally be an increasing function of the time it would take a buyer to "enter," and a declining function of the level of sellers' sunk costs. Thus, when buyers are sophisticated, models that predict that oligopoly prices will be sheltered from the threat of entry by sunk costs are incorrect.

Section II develops two basic models. Both models assume a sequential game in which a buyer purchases his needs at that period's price, and then decides whether or not to commit to "entry." In the first model, buyers are able to make credible long term commitments to entrants (equivalent to vertical integration). In the second model, buyers cannot credibly commit to long term contracts with entrants, but buyers can commit themselves to invest in "switching costs" that would allow them to switch to alternative sources of supply. Section III develops the implications of the general model for antitrust, and Section IV provides a concluding summary.

II. Sunk Costs, Entry Lags, and Market Power

Since we intend to highlight the role played by the ability of buyers to commit, the models are constructed so that if buyers were characterized simply as demand curves, then entry would be naturally blockaded by sunk costs and Bertrand competition. It is easiest to first develop the basic theory in the context of a market with one buyer and one seller. Later, we examine the conditions under which the results hold for the case of multiple buyers. Suppose that the single buyer, **B**, has an inelastic demand for one unit of the relevant input.[10] B can buy an acceptable input at a price, α, from a competitive industry. This input has other alternative uses, so that the input will be produced whether or not B purchases it. A seller, **S**, produces a substitute input, widgets. While widgets are good substitutes for B, they are not good substitutes for the other uses of the alternative input. Widgets are preferred by B as long as their price is not greater than α.

The assumptions about widget technology are as follows. Investment in an infinitely durable widget plant takes T periods, resulting in a total investment (at time T) of **I**. A portion of this investment is sunk, with γI being the salvage value of the plant ($\gamma<1$). Widgets are produced by this plant at constant average variable costs of **c**, where $c < \alpha$. Once S begins production, the technology is available to anyone. Assume that with more than one producer the conditions of competition in the widget industry result in Bertrand competition, with prices below long run average costs.[11] Finally, suppose that S has just started production, with no prior contractual arrangement with B.[12] Under these assumptions, if B is passive, S is protected from entry by sunk costs and post-entry Bertrand competition, and so S can sell widgets at the monopoly price, α, without stimulating entry.

A. The Effects on Competition of Potential Entry by Vertical Integration.[13]

The widget market is modelled as a sequential game that works as follows. We assume that a decision by B to vertically integrate is irreversible and known immediately by S. If such a decision is made, B will have an operational widget plant T periods hence. Each period B purchases a widget from S for a price that does not exceed α, and decides whether or not to vertically integrate after learning the price at which S is willing to sell the widget. B only buys from S because competition between S and the competitive industry producing the substitute input results in S selling to B at a price not exceeding α.

1. Infinite Horizon

Consider first infinite horizon games. Assume that in the absence of production by S, vertical integration by B into widgets would be profitable. That is,

$$-I\delta^T + (\alpha - c)\delta^T/(1-\delta) > 0,^{14} \tag{1}$$

where δ is the discount rate ($\delta = 1/(1+r)$, for interest rate r). In order to analyze potential equilibria, the structure of the game must first be specified. Consider, for example, an infinite horizon game with simultaneous moves by B and S. One equilibrium to this game has the seller charging the monopoly price, α, for T periods and then leaving the market, and the buyer vertically integrating during the first period. Given that the buyer is vertically integrating, the seller's best response is to charge the monopoly price in all future subgames. Similarly, if the buyer expects the seller to charge the monopoly price in all future periods then, from (1), his best response is to vertically integrate during the first period. This outcome is a Nash equilibrium in this game. It is also subgame perfect, because once B vertically integrates, all subsequent (T-1) subgames will feature a price of α. Because of the duplication of sunk investments, the equilibrium is inefficient.

We now will determine whether there are games with equilibria that do not involve vertical integration. Consider, first, what properties these equilibria must have. If there is an equilibrium without vertical integration, then the transaction price must be less than α in some periods. For example, consider a path in which as long as B is not vertically integrating, the price is $P^L<\alpha$ in all periods. Suppose the structure of the game is such that if B vertically integrates, then the price reverts to α. (We discuss below games that feature this structure.) For it not to be in B's interest to vertically integrate, P^L must be such that if this is the price forever, purchasing from S is no less profitable for B than vertically integrating. That is, P^L must satisfy

$$-I\delta^T + (\alpha-c)\delta^T/(1-\delta) \leq (\alpha-P^L)/(1-\delta), \tag{2a}$$

where the left hand side (LHS) of (2a) is the profitability of vertical integration, and the right hand side (RHS) is the profitability of paying P^L forever.[15] The P^L that makes (2a) an equality, $P^L{}_{max}$, leaves the buyer indifferent between vertically integrating and not. We might call P^L_{max} "the Bain limit price" in the sense of the traditional limit pricing models (e.g. Bain (1956), Modigliani (1958)), because it leaves the buyer indifferent between entering or not. Notice that P^L_{max} increases with average costs, the entry lag T, and the rate of time preference δ.

For it to be profitable for S to sell at a price P^L as long as B is not vertically integrating, this strategy must be no less profitable than charging the monopoly price α for T periods and then exiting. That is, P^L must satisfy

$$(P^L-c)/(1-\delta) \geq (\alpha-c)(1-\delta^T)/(1-\delta) + \gamma I\delta^T, \tag{2b}$$

where the left hand side (LHS) of (2b) is the profitability of charging P^L forever, and the RHS is the profitability of charging the monopoly price for T periods and then exiting. The P^L that solves (2b) with equality, P^L_{min}, leaves the seller indifferent between charging that price forever, and charging the monopoly price for T periods and then selling his assets. Observe that P^L_{min} falls with the amount of sunk investments, but increases with the entry lag. Thus, if sunk costs are so large relative to the entry lag that P^L_{min} is below long run average costs (LRAC), then if the equilibrium price was given by P^L_{min}, the original investment would have been unprofitable and it would have been undertaken only through vertical integration. This is the Klein-Crawford-Alchian result. However, if the entry lag is large enough so that P^L_{min}>LRAC, vertical integration is not the only feasible outcome, even if $P^L=P^L_{min}$.

For conditions (2a) and (2b) to hold, P^L must satisfy:

$$\alpha(1-\delta^T) + c\delta^T + \gamma(1-\delta)\delta^T I \leq P^L \leq \alpha(1-\delta^T) + c\delta^T + (1-\delta)\delta^T I. \tag{2c}$$

For any price P^L defined by (2c), there is a game in which P^L and no vertical integration is a subgame perfect equilibrium. To establish this result we first describe two games: one in which P^L_{max} is a subgame perfect equilibrium, and another in which P^L_{min} is a subgame perfect equilibrium. Both equilibria do not involve vertical integration. We will also show that bargaining games will support any price between P^L_{max} and $P^L{}_{min}$ as subgame perfect equilibria.

Consider first a game of Markovian strategies,[16] where the seller quotes a price P^L which is valid as long as the buyer does not vertical integrate during that period, and where no bargaining is possible between S and B. If B vertically integrates, then B pays a price of α to S, since once B vertically integrates S competes with the producers of the alternative input to supply one unit to B for this period. Conditioned on the price offer, B decides to vertically integrate or not. In essence, this is a game with S as a Stackelberg leader, with no bargaining allowed between S and B.

Since no bargaining is allowed, S's offer is credible, and by (2a), B's best response to any price at or below P^L_{max} is to not vertically integrate. Given B's optimal decision rule, S's optimal strategy is to offer a contract price of P^L_{max}. This game, then, in which S is a Stackelberg leader, yields the "Bain limit price" as a subgame perfect equilibrium.

Consider now a different game, where the buyer is the Stackelberg leader. In this game B offers to S not to vertically integrate if S supplies one unit at a price P^L. If the buyer does not accept this offer, then B vertically integrates and purchases from S, as in the previous game, at a price of α. Again, since no bargaining between S and B is allowed, B's offer is credible, and by (2b) S's best response to any contract price at or above P^L_{min} is to accept the contract. Given S's optimal decision rule, B's optimal strategy is to offer a contract price of P^L_{min}. Thus, this game, in which B is a Stackelberg leader, yields the "Klein-Crawford-Alchian price" as a subgame perfect equilibrium.

We have shown, then, that there are games that yield limit pricing and no vertical integration as subgame perfect equilibria. These are models in which either the seller or the buyer are given all the power of a Stackelberg leader, and no bargaining is permitted. The two games just described can be considered extreme forms of bargaining games, in which only one side has the ability to make all or nothing offers. In more general bargaining games, any P^L satisfying (2c) could arise as a subgame perfect equilibrium. One example is the Nash bargaining solution, which results in an equilibrium limit price that is the average of the two reservation prices,

$$P^L_{Nash} = \alpha - (\alpha-c)\delta^T + I\delta^T(1-\delta)(1+\gamma)/2.$$[17]

Notice that P^L_{Nash} increases with time to enter T, but falls with the extent of sunkness of the investment I, and with the rate of time preference δ.

Define limit pricing equilibria as those equilibria featuring a price below α and no vertical integration. Then, although limit pricing equilibria may involve prices above marginal costs, because of the inelastic demand assumption, there is no reduction in real welfare,[18] so, limit pricing equilibria are efficient. Equilibria with vertical integration are inefficient because of the duplication of sunk costs. In summary, we have the following proposition:

> **Proposition 1**: Assuming: (a) a single buyer, and (b) vertical integration is credible, then there are infinite horizon sequential games with subgame perfect limit pricing equilibria. Limit prices

are in the range specified by (2c). These equilibria are efficient.

Limit Pricing

The result presented in Proposition 1 is in sharp contrast to the equilibrium that would arise if the buyer was simply a demand curve. In that case, S would charge the monopoly price forever, since independent entry would not be profitable. Instead, when B can vertically integrate, all equilibria involve average long run prices below the monopoly price, either because of vertical integration following T periods of monopoly price, or because of limit pricing.

Observe that the range of equilibrium limit prices is determined by the extent of sunk investments ($(1-\gamma)I$). If there are no sunk costs ($\gamma=1$), only $P^L=P^L_{max}$ solves (2c). This is because if the seller has no sunk costs, the buyer has no potential leverage over the seller. If $\gamma<1$, there is a range of equilibrium limit prices that satisfy (2c). In the "Bain limit pricing" model, P^L equals P^L_{max} and is independent of the level of sunk investments, but increases with long run average costs and the entry lag. If P^L is determined a-la Klein-Crawford-Alchian, P^L equals P^L_{min} and falls with the amount of sunk costs that the buyer can expropriate from the seller.

If P^L is determined by a bargaining process, then the particular characteristics of B and S affecting their relative bargaining power and the nature of the bargaining game will be critical. Since sunk costs provide what leverage the buyer has over the seller, and the entry lag is the leverage that the seller has over the buyer, we would expect that, in general, the limit price would be a decreasing function of sunk costs and an increasing function of the entry lag, as in the Nash bargaining solution.

Although the basic model here is simplistic, leaving for the time being the assumption of one buyer and seller, only two of the basic assumptions are critical to the basic results: that decisions are sequential, and that the buyer's decision to vertically integrate is irreversible and immediately observable.[19] Both of these assumptions appear quite reasonable. It is unlikely for it to be rational for the buyer to make a decision prior to knowing the price he has to pay. And a buyer can presumably make an irreversible decision by contract. The fact that the seller knows that the buyer can make an irreversible commitment is what gives the buyer leverage over the seller.

Variable Sunk Costs

So far we have assumed that technology determines the extent of sunkness of the incumbent's assets. One of the main results of the theory of the firm developed by Coase and Williamson is that technology and organizational form may be related. Sellers whose investments are at risk will have an incentive to choose a technology that reduces buyers' ability to disadvantage them, and as a consequence, the non-integrated equilibrium may not be efficient. For example, if there is a tradeoff between sunkness ($(1-\gamma)$ in our model) and marginal costs, c, so that $c=c(\gamma)$, $c'>0$, and S determines the value of γ unilaterally, S's decision may result in a level of sunkness that is lower, and a marginal production cost that is higher, than optimal.[20] A result of the unilateral choice of technology by S may be an equilibrium with vertical integration, in games in which for an exogenously given γ, the equilibrium would involve limit pricing.[21] If S has already entered with an inefficient technology, there may not be a limit price that satisfies (2c), and so the seller's profits are maximized by charging the monopoly price for T periods and exiting, forcing the buyer to vertically integrate.[22] If S has not yet entered, the inefficiency of independent production could be solved by the would-be monopolist selling his innovation to the buyer before he sinks his costs.[23]

2. Finite Horizon

In a perfect information finite horizon game, the usual game-theoretic result is that there are only prisoners'-dilemma-like subgame perfect equilibria. If that result would hold for the models considered here, all equilibria would involve vertical integration. In the type of games we have discussed, however, since the game is sequential and B's commitment decision is irreversible and observable, other outcomes are possible. In particular, in the finite horizon case, there are sequential games in which there are no subgame perfect equilibria involving vertical integration.

Let T+N be the length of the game and T+M be the minimum length of period necessary for vertical integration to be profitable in the absence of a widget producer. Assuming away the integer constraint, M solves

$$-I\delta^T + \delta^T(\alpha-c)(1-\delta^M)/(1-\delta) = 0.$$

If N<M, the unique equilibrium is for S to charge the monopoly price from the beginning, and B not to vertically integrate. If N>M, however, we show in the Appendix that there are finite horizon games with limit price equilibria. For example, P^L_{max} (P^L_{min}) is the unique subgame perfect equilibrium in games in which S (B) is allowed to give an offer that B (S) has to either accept or refuse. Other bargaining games yield prices between P^L_{max} and P^L_{min}. Thus, we can state:

Proposition 2: Assuming: (a) a single buyer, and (b) vertical integration is credible, then there are sequential games with finite horizon larger than T+M, with limit price subgame perfect equilibria. The range of limit prices is that given by (2c), except for the period T+M+1 before the last where the lower bound is below that in (2c). (See details in the Appendix.) During the last T+M periods, the price is α.

3. The Multiple Buyers Case.

In this section we show that most of the results of the single buyer case can still hold with multiple buyers, if buyers can contract, or if at least one buyer is large enough. Assume that there are n buyers, each demanding s_i units of the good, with $\Sigma_i s_i = 1$, and that vertically integration still requires a production capacity of 1 unit, enough to supply the whole market.[24]

Multiple Buyers with Commitment.

In this section we assume that buyers have the ability to write long term contracts with any supplier of the input (including a vertically integrating buyer). We also assume that a buyer who decides to vertically integrate can contract in advance to supply their product to the remaining, non-integrated, buyers.[25] We begin by analyzing the vertical integration subgame among the buyers. This subgame determines which buyer will vertically integrate and the contract price at which he will sell to the remaining non-integrated buyers. Buyers in this subgame make offers to each other consisting of a decision to vertically integrate and a long term contract price. These offers are contingent on all buyers signing the contract. Competition among buyers will result in the profitability for the buyer who vertically integrates equaling that for the buyers that do not, so that if buyer i integrates he will sell $(1-s_i)$ units to the remaining n-1 buyers at average cost, that is, at a unit price of $[c+(1-\delta)I]$. It is easily seen that there is a limit price equilibrium in which the price charged by S is specified by (2c).[26] Thus, we can state

> **Proposition 3:** Propositions 1 and 2 hold for the case of multiple buyers when all have the ability to write long term contracts.

Multiple Buyers without Contracting

In this section we show that when buyers cannot write long term contracts, as long as vertical integration is profitable at a minimum scale of I, there is a limit price equilibrium.

Assume first the case of identical buyers (i.e., $s_i=1/n$), and that in the absence of a widget producer, vertical integration is profitable for all. That is,

$$-I + (\alpha-c)/[n(1-\delta)] > 0.$$

If the seller has no recoverable assets, once a buyer vertically integrates,[27] both share the remaining (n-1)/n units, at a price of c. But there is a basic externality in the entry decision. The buyer that vertically integrates bears the cost of the investment but by driving the price down to marginal cost provides all other buyers with a windfall. This subgame is similar to that in Dixit and Shapiro (1985). The full game has multiple subgame perfect limit price equilibria. The upper bound to the equilibrium limit prices increases with the number of buyers, and exceeds that of the limit price when there is a single buyer.

If, the seller has recoverable assets, all equilibria in the buyers' vertical integration subgame involve more than one buyer vertically integrating. The rationale for this result is that since the seller has recoverable assets the seller prefers to exit rather than sell at marginal cost. Thus, if a single buyer vertically integrates he becomes a monopolist, generating incentives for further vertical integration. These results are presented in Proposition 4, and are proved in the Appendix.

Proposition 4: Assuming: (a) multiple and identical buyers, (b) none able to write long term contracts, and (c) vertical integration is credible for all buyers, then there are infinite horizon sequential games with limit pricing as subgame perfect equilibria. When the limit pricing equilibria exist, the upper bound to the equilibrium limit prices increases in n and exceeds that given by (2c). The lower bound is no lower than that in (2c).

Consider now the case when buyers are of different sizes. In particular, suppose there is only one buyer, demanding $z<1$ units, for whom, in the absence of a market for widgets, it is profitable to vertically integrate, while vertical integration is not profitable for the remaining n-1 buyers, each demanding a share $s_i<z$. That is

$$-I\delta^T + z(\alpha-c)\delta^T/(1-\delta) \geq 0 > -I\delta^T + s_i(\alpha-c)\delta^T/(1-\delta), \text{ for } s_i<z.$$

Thus, there is a critical value for the market share of the large buyer that makes vertical integration profitable. Denoting that market share by, z^*, we have $z^* = I(1-\delta)/(\alpha-c)$. Now, the large buyer will prefer to pay a price P^L forever instead of vertically integrating only if

$$0 \leq -I\delta^T + z(\alpha-c)\delta^T/(1-\delta) \leq z(\alpha-P^L)/(1-\delta). \tag{3a}$$

Similarly, for a seller with no recoverable assets to prefer to charge a price below α that precludes vertical integration, his profits must exceed those from charging a monopoly price. That is,

$$(\alpha-c)(1-\delta^T)/(1-\delta) \leq (\alpha-P^L)/(1-\delta). \tag{3b}$$

Thus, for a limit price to be possible,

$$\alpha - (\alpha-c)(1-\delta^T) \leq P^L \leq \alpha - (\alpha-c)(1-\delta^T) + I(1-\delta)\delta^T/z. \qquad (3c)$$

Assume, for the moment, that P^L takes the value given by its upper bound in (3a). For $z<z^*$ limit pricing will not develop, since the large buyer will obtain a negative surplus from vertical integration. At $z=z^*$, P^L is exactly α. For values larger than z^*, P^L is a decreasing function of z. Furthermore, as z converges to 1, P^L converges to the limit price specified in (2c) for the case of a single buyer.[28]

When the seller has recoverable assets, however, he will leave the market following entry, thus providing the large buyer with a monopoly. In this case, the vertical integration calculus for the large buyer is different from (3a). Now the large buyer's profits from vertical integration are larger, and are given by his own surplus plus the surplus of all the small buyers. Hence, he will require a lower price so as not to vertically integrate. That is, he will choose not to vertically integrate only if

$$-I\delta^T + (\alpha-c)\delta^T/(1-\delta) \leq (\alpha-P^L)/(1-\delta),$$

which is exactly the condition in the single buyer case given by (2a), since, as in the single buyer case, the vertically integrating buyer captures all the surplus. Thus, the limit price is lower than if S had no recoverable assets. In a sense, the seller must compensate the large buyer for not vertically integrating by providing him with the profits that the buyer could extract from the small firms if he were to integrate.

So far we have assumed that the seller cannot discriminate. If the seller could discriminate, then he will charge α to all small buyers, but a lower limit price to the large buyer.[29] In particular, the lower bound for the limit price is given by

$$(\alpha-c)(1-z)/(1-\delta) + (P^L-c)z/(1-\delta) \geq (\alpha-c)(1-\delta^T)/(1-\delta) + \gamma I\delta^T(1-\delta)$$

implying that

$$P^L_{min} = \alpha - (\alpha-c)\delta^T/z + \gamma I\delta^T(1-\delta)/z < \alpha - (\alpha-c)\delta^T + \gamma I\delta^T(1-\delta),$$

where the right side of the inequality is the lower bound for the limit price when the seller cannot price discriminate. Thus, if the seller could price discriminate, the seller would prefer to transfer to the large buyer up to all the profits from the small buyers that he can capture rather than have the buyer vertically integrate. Thus, the lower bound for the limit price with price discrimination is below its value when the seller cannot price discriminate. Thus, we can state

> **Proposition 5**: Assuming: (a) multiple buyers, (b) none able to write long term contracts, (c) vertical integration is credible only for the unique largest buyer,[30] and (d) the seller cannot price discriminate, then there are infinite horizon sequential games with limit pricing as subgame perfect equilibria. If there are recoverable assets (i.e., $\gamma=0$), then the upper bound for the limit price falls with the market share of the large buyer. If, however, $\gamma>0$, the upper bound to the limit price is that given in (2c). If the seller can price discriminate, then the lower bound for the limit price is below that given in (2c).

B. **Switching Costs and Entry by Independent Producers.**

In this section we assume that buyers cannot vertically integrate or sign long term contracts. We will show that, nonetheless, buyers may have sufficient leverage over sellers to generate a limit price equilibrium if they are able to make credible commitments to purchase alternative inputs, or to purchase the same input from new suppliers. Switching to a new supplier or input may require modifications in the production process, which are likely to involve costs and may take time. We show in this section that if buyers can make credible commitments to switch, and if switching is costly and takes time, limit pricing is an equilibrium, independent of the number of buyers.[31]

We assume that: (i) buyers' expenditures on switching costs (σ) are known to the seller; (ii) that the alternative supplier's technology is the same as that of the original monopoly supplier;[32] and that (iii) the alternative supplier and the incumbent firm produce somewhat different products, so that after bearing switching costs, buyers prefer buying from the alternative supplier as long as the price differential does not exceed β. That is, given that the buyer has invested in switching costs of σ, β represents the premium that the buyer is willing to pay to use the alternative supplier's product.[33] As above, we also assume that the post-entry game is Bertrand, implying a post-entry price of c for the incumbent and of $c+\beta$ for the entrant. At that price the alternative supplier serves the whole market. If the new supplier is a single entrant, for this to be an equilibrium, the incumbent's assets must all be sunk (i.e. $\gamma=0$), otherwise it would leave the market.[34] Given that buyers have incurred switching costs, an independent entrant will enter as long as

$$-I+\beta/(1-\delta) \geq 0.^{35}$$

Alternatively, the buyer could be thought as switching to an input currently produced by a competitive industry at a price of $c+\beta$. In this case, whether S has any recoverable assets is immaterial to the structure of the game.

Consider first an infinitely repeated game with a single buyer. If B incurs switching costs, then S will charge the monopoly price for T periods. There is a price P^L, however, such that if the incumbent firm charges it forever, the buyer will prefer not to incur the switching costs σ. P^L is given by

$$-\sigma\delta^T + (\alpha-c)\delta^T/(1-\delta) \leq (\alpha-P^L)/(1-\delta).^{36} \tag{4a}$$

The incumbent will prefer to charge P^L only if

$$(P^L-c)/(1-\delta) \geq (\alpha-c)(1-\delta^T)/(1-\delta). \tag{4b}$$

Thus, for P^L to be an equilibrium it must satisfy simultaneously (4a) and (4b). That is, P^L must satisfy

$$\alpha(1-\delta^T) + c\delta^T \leq P^L \leq \alpha(1-\delta^T) + c\delta^T + (1-\delta)\delta^T\sigma. \tag{4c}$$

If the entrant has the same costs as the incumbent, and there is a single buyer, then as long as $\sigma>0$, a limit price equilibrium will always exist. If the entrant's costs are significantly below the incumbent's, then there may not be a P^L that satisfies (4c) unless switching costs were sufficiently large. The upper bound of the limit price is an increasing function of switching costs, but if switching costs are sufficiently large,[37] then the upper bound is given by the monopoly price.[38] Thus we can state:

> **Proposition 6**: Assuming: (a) a single buyer, (b) switching is credible, and (c) switching is costly and takes time, then there are infinite horizon sequential switching costs games with limit pricing as subgame perfect equilibria if $\sigma<(\alpha-c)/(1-\delta)$.

We will now show that Proposition 6 holds for the case of multiple buyers. Assume, first, that buyers with a combined market share of ζ^* (<1) are enough to make entry by a potential entrant profitable, i.e. $-I+\zeta^*\beta/(1-\delta)=0$, and that switching provides a non-negative return, i.e. $\sigma < (\alpha-c)/[(1-\delta)]$. Switching costs now are rescaled to σ/n.

Assume, now, that, for some reason, the incumbent firm charges the monopoly price α, and that buyers with combined market share of ς^* have already invested in switching costs so that the independent producer is already in place. If the seller is able to price discriminate, buyers that have not spent the switching costs yet will still be charged α, while those that have already switched will be charged the competitive price. Thus, for a buyer to be able to pay c (or $c+\beta$), he must pay the switching costs. It is clear then, that if the seller charges the monopoly price, all buyers will find it optimal to pay the switching cost.

The seller, then, will have the same calculus as in the case of a single buyer, and a limit price, determined by (4c), will be the equilibrium with multiple buyers. Thus, we can state:

> **Corollary**: The results of Proposition 6 hold also for the case of multiple buyers.

III. Implications for Antitrust Analysis under the Merger Guidelines

The Department of Justice's 1982 Merger Guidelines introduced a new approach to the antitrust analysis of entry barriers. The barriers test in the Guidelines appears to be based on whether entry or its threat would prevent a merger-to-monopoly from profitably exercising significant market power for a period of more than two years.

The underlying intuition seems to be as follows. Suppose a merger-to-monopoly, and that entry takes two years. Then price could be raised to the monopoly level for two years before entry could occur. But such a scenario is unlikely to occur. First, models featuring sunk costs as entry barriers show that if incumbents have sufficient sunk costs, entry may never occur, independent of the amount of time it would take to enter. So, for example, proof that it is possible to enter in one year does not imply that monopoly pricing could only last for one year. The second problem with the intuition is made clear by the results we have derived. If sellers have significant sunk costs, and entry, if it occurs, is likely to be by buyers vertically integrating, contracting with entrants, or investing in switching costs, a merger-to-monopoly is not likely to lead to monopoly pricing followed by entry. Nonetheless, if this is the relevant model of the market, the scenario in which there is monopoly pricing for the duration of the entry lag provides an upper bound to the consumer welfare costs of a merger-to-monopoly. In general, however, the Guidelines overestimate the welfare or consumer costs of a merger-to-monopoly.

To see the reason for this bound, recall that by (2a), P^L_{max} makes the buyer indifferent between paying the limit price in perpetuity and vertically integrating and paying the monopoly price for T periods. Assuming, as in (2a), that the buyer would be equally efficient, the maximum the seller can extract is equivalent to what is extracted by charging the monopoly price for T periods. Thus a merger-to-monopoly could extract <u>at most</u> the equivalent of monopoly pricing for the period it would take to enter. Formally, using (2a), the discounted value of the limit price minus average cost (AC), is

$$\begin{aligned}(P^L_{max}-AC)/(1-\delta) &= [P^L{}_{max} - (c + I(1-\delta))]/(1-\delta) \\ &= (1-\delta^T)(\alpha-c-I(1-\delta))/(1-\delta),\end{aligned} \tag{5a}$$

where the RHS of (5a) is the present discounted value of the loss in buyer's surplus (relative to the benchmark, AC) from charging the monopoly price for T periods.

Now, consider the lower bound of the possible limit prices, P^L_{min}. The seller is indifferent between charging this limit price, P^L_{min}, in perpetuity, or charging the monopoly price for T periods and exiting. It is easily seen that the present discounted value of the overcharge arising from a price of P^L_{min} is equal to the value of monopoly overcharge for T periods minus the sunk costs of the seller. Formally, using (2b),

$$\begin{aligned}(P^L_{min}\text{-}AC)/(1\text{-}\delta) &= [P^L{}_{min} - (c + I(1\text{-}\delta))]/(1\text{-}\delta) \\ &= (1\text{-}\delta^T)(\alpha\text{-}c\text{-}I(1\text{-}\delta))/(1\text{-}\delta) - (1\text{-}\gamma)\delta^T I.\end{aligned} \tag{5b}$$

The actual value of the limit price depends on the relative bargaining strengths of the buyers and the seller, and the structure of the game, but we would expect that the limit price would generally be below P^L_{max}.[39]

To sum up, the length of the entry lag is critical in calculating the potential welfare costs of an anticompetitive merger. Not because a merger-to-monopoly will raise price to the monopoly level during the time it takes to enter, but rather, because limit pricing results in a monopoly overcharge that is at most the equivalent of monopoly pricing until entry.

Equations (5a) and (5b) also provide the boundaries for the potential (percentage) price increase from a merger to monopoly. From (5a) we observe that

$$(P^L_{max}\text{-}AC)/AC = (1\text{-}\delta^T)[(\alpha/AC)\text{-}1], \tag{6}$$

where the RHS of (7) is the monopoly mark-up over average cost times a factor less than one. For example, if the annual rate of discount is 10% and if it takes two years to enter (T=2), then the price increase will be less than .17 times the monopoly mark-up. Consequently, if antitrust enforcement deters mergers that could result in a potential monopoly price increase of 5%, then, in fact, antitrust deters mergers that would bring a permanent price increase of less than .9%.

We have assumed, thus far, that there are no efficiencies arising from the merger. Assume now that following a merger the incumbents' costs are $c-\Delta$ (with $\Delta>0$), while a potential entrant's costs remain c.[40] If merger policy is only concerned with monopoly overcharge, efficiencies are important only if they result in lower prices. If total surplus is the criterion however, then the social costs of the merger are reduced by the total efficiency gain, which equals $\Delta/(1-\delta)$. If the limit price is determined by the upper bound in (2a), the monopoly overcharge calculation in (5a) remains the same. However, (5b) now becomes

$$(P^L_{min}-AC)/(1-\delta) = (1-\delta^T)(\alpha-c-I(1-\delta))/(1-\delta) - (1-\gamma)\delta^T I - (1-\delta^T)\Delta/(1-\delta), \tag{7}$$

i.e., P^L_{min} is reduced by the present discounted value for T periods of the efficiency gains.

We can then state:

Proposition 7: The maximum present discounted value of the monopoly overcharge is equivalent to that which would arise if the monopoly price was charged for T periods. In the absence of any efficiency gain from the merger, the minimum overcharge is equal to the maximum minus the sunk costs of the seller. If there are efficiencies, the minimum overcharge is reduced by the present discounted value for T periods of the efficiency gains.

IV. Final Comments.

This paper has developed an analysis of markets in which: (1) sellers have significant sunk investments; (2) it takes considerable time to enter; and (3) buyers can make credible commitments to obtain alternative sources of supply. Markets with property (3) are probably not unusual, since most markets are intermediate product markets in which buyers may be the most likely "entrants."

We have shown that in markets with these three characteristics the market power of sellers is significantly less than what models with unsophisticated buyers would predict. Current prices are critical to the decision whether or not to "enter," so that limit pricing is a likely form of equilibrium pricing, even in the presence of full information. The limit price is predicted to increase with the amount of time it takes to enter, the number of buyers, and with the level of buyers' switching costs, but to <u>fall</u> with the level of sunk investments. Sunk costs, although representing a potential barrier to entry by independent entrants, are not a barrier to buyers making commitments to alternative sources of supply. Thus, if buyers can make credible commitments to switch to alternative sources of supply, sunk costs restrain, rather than increase, the ability of sellers to exert market power. Entry lags and switching costs, however, do enhance the ability of sellers to exert market power. This paper, then, questions the standard prediction of an inverse relationship between market performance and sunk investments.[41]

APPENDIX

A. Proof of Proposition 2.

To prove the Proposition first observe that there is not a subgame perfect equilibrium of the sequential game discussed in the text that involves vertical integration. Assume that period T+M before the last has arrived and the buyer is not vertically integrated. Then, the only equilibrium involves monopoly price from that period on. It is straightforward to show that if the seller has not vertically integrated up to period T+M+1 before the last, a price P will arise at that period that will make the buyer prefer not to vertically integrate. Such a price will arise independently of whether the seller or the buyer is the one to quote the price. Thus, given that the price for the period T+M+1 before the last is P, the buyer will not vertically integrate if

$$- I\delta^T + (\alpha-c)\delta^T(1-\delta^{M+1})/(1-\delta) \leq (\alpha-P),$$

or,

$$P^{\tau+1}_{max} = \alpha - (\alpha-c)\delta^T + (1-\delta)I\delta^T = \alpha - (\alpha-c)\delta^{T+M} \geq P, \qquad (A1)$$

where τ=T+M, and where the equality uses the definition of T+M given by

$$(\alpha-c)\delta^T-I(1-\delta)\delta^T=(\alpha-c)\delta^{T+M}. \qquad (A2)$$

On the other hand, the seller would prefer to sell at a price P below the monopoly price, if so doing the buyer would not vertical integrate, only if

$$(P-c) + (\alpha-c)(1-\delta^{T+M})\delta/(1-\delta) \geq (\alpha-c)(1-\delta^T)/(1-\delta) + \gamma I\delta^T$$

or,

$$P^{\tau+1}_{min} = \alpha - (\alpha-c)\delta^T + (\gamma-\delta)I\delta^T = \alpha - (\alpha-c)\delta^{T+M} - (1-\gamma)\delta^T \leq P, \qquad (A3)$$

where the equality uses again the definition of T+M.

Thus, for P to be profitable for both the buyer and the seller, it has to satisfy (A1) and (A3) simultaneously. Since γ<1, there always exists a P such that (A1) and (A3) hold. If the seller is the one that gives the price offer, then it will offer P_{max} as long as the buyer does not vertically integrate. If, instead, the buyer is the one that gives price offers, it would offer to pay not to vertically integrate if the price does not exceed P_{min}.

Similarly, it can be shown that if the buyer did not vertical integrate at period T+M+2 before the last, then there exists a price less than α that will deter the buyer from vertically integrating at that time. To determine the range of prices that can arise, assume first that if the buyer does not vertical integrate, then next period's price will be such that the buyer will remain indifferent between integrating and not (i.e. the boundary in (A1)). Then prices are given by

$$P_{max}^{\tau+2} = \alpha - (\alpha-c)\delta^{T+M} = \alpha - (\alpha-c)\delta^{T} + I(1-\delta)\delta^{T}. \tag{A4a}$$

If, instead, the next period's price is expected to be such that the seller will remain indifferent between charging the monopoly price or a limit price, then $P^{\tau+2}$ is given by

$$P_{min}^{\tau+2} = \alpha - (\alpha-c)\delta^{T} + I\delta^{T}\gamma(1-\delta). \tag{A4b}$$

Thus, if the limit price is such that the buyer is indifferent between vertically integrating and not, then $P_{max}^{T+2}=P_{max}^{T+1}$. And, similarly, it can be shown that $P_{max}^{\tau+k}=P_{max}^{\tau+1}$ for all k. That is, the limit price is a constant and equals the upper bound in (2c). If, instead, the limit price is set at the reservation level of the seller, then it can be shown that for k>2, the limit price is given by

$$P_{min}^{\tau+k} = P_{min}^{\tau+2} = c + (\alpha-c)(1-\delta^{T}) + I\delta^{T}\gamma(1-\delta). \tag{A5}$$

To show (A5), solve first for P_{min}^{T+3}. While tedious, it can be shown that $P_{min}^{\tau+3}=P_{min}^{\tau+2}$ using a method similar to the derivation of (A3). Thus, for k=3, (A5) holds. Assume now, that at T+M+k periods before the last the seller expects the future limit prices to remain constant until T+M+1 periods before the last when the price will be given by the lower bound in (A3). Thus, the limit price P that leaves the seller indifferent between charging P for k periods or the monopoly price α for T periods is given by

$$(\alpha-c)(1-\delta^T)/(1-\delta) + I\gamma\delta^T = (P-c)(1-\delta^{k-1})/(1-\delta)$$
$$+ \delta^{k-1}(P^{T+M+1}-c) + \delta^k(\alpha-c)(1-\delta^{T+M})/(1-\delta),$$

which after solving for P confirms (A5). Thus, if the bargaining game between the buyer and the seller is such that the seller is always left indifferent between charging the monopoly or the limit price, then the limit price is a constant (equal to the lower bound in (2c)) until T+M+1 periods before the last. At T+M+1 periods before the last the price falls to the lower bound of (A3), and from T+M periods before the last to the end the price is the monopoly price, α.

Therefore, the range of feasible limit prices in the finite horizon model is the same as in the infinite horizon one, except for the period T+M+1 before the last, proving the proposition.

B. Proof of Proposition 4:

Let us first analyze the case of γ=0. We show first that the upper bound to the limit price is given by

$$0 < -I\delta^T + (\alpha-c)\delta^T/[(1-\delta)n] \leq (\alpha-P^L)/[n(1-\delta)],$$

or

$$P^L \leq \alpha - (\alpha-c)\delta^T + nI\delta^T(1-\delta). \tag{B1}$$

Consider the game that develops between buyers when facing monopoly pricing. If a buyer expects someone else to vertically integrate his profits from not vertically integrating are simply

$$\delta^T(\alpha-c)/[(1-\delta)n]$$

which exceed those if he would vertically integrate. Thus, every buyer prefers someone else to vertical integrate. This game has N equilibria involving pure strategies, and one symmetric mixed strategy equilibrium. The pure strategies equilibria consist of any of the N buyers vertically integrating. The mixed strategy equilibrium is such that all buyers are indifferent between vertically integrating and not, and where each chooses a probability **p** of integration such that the others will be indifferent between vertically integrating and not. In either type of equilibrium, all buyers prefer not to vertically integrate if the price charged satisfies (B1). Observe that the upper bound to the limit price is substantially above the upper bound given by (2a).

The condition for the seller to prefer to charge P^L, rather than α, depends on the nature of buyers' strategies. If buyers play mixed strategies, then the probability of each vertically integrating (p) is determined by

$$-I\delta^T + (\alpha-c)\delta^T/[n(1-\delta)] =$$

$$p\delta^T(\alpha-c)/[n(1-\delta)] + (1-p)\delta^{T+1}\{-I+(\alpha-c)/[n(1-\delta)]\},$$

or

$$p = 1 - 1/\{(\alpha-c)/(In) + \delta\}. \tag{B2}$$

and S prefers to charge P^L only if

$$(P^L-c)/(1-\delta) \geq (\alpha-c)[1-\delta^T\pi/(1-\delta+\delta\pi)]/(1-\delta),$$

or

$$P^L \geq c + (\alpha-c)[1-\delta^T\pi/(1-\delta+\delta\pi)], \tag{B3}$$

where $\pi = \Sigma_{i=1}^{n} ({}^{n}{}_{i})p^i(1-p)^{n-i}$ is the probability of at least one firm vertically integrating. Thus, in the mixed strategy equilibrium, P^L has to satisfy

$$c + (\alpha-c)[1-\delta^T\pi/(1-\delta+\delta\pi)] \leq P^L \leq c + (\alpha-c)(1-\delta^T) + (1-\delta)\delta^T In. \tag{B4}$$

Since $\pi/(1-\delta+\delta\pi)<1$, the LHS of (B4) exceeds the lower bound of the limit price for the single buyer case when $\gamma=0$. Thus, since there is a positive probability that no buyers will vertically integrate, (B4) implies that there many not be an equilibrium with limit pricing. This result, however, does not follow if buyers play pure strategies. In this case the seller will prefer to charge a limit price of P^L only if

$$(P^L-c)/(1-\delta) \geq (\alpha-c)(1-\delta^T)/(1-\delta),$$

which is exactly equation (2b) when $\gamma=0$. Thus, P^L is given by

$$(1-\delta^T)\alpha + c\delta^T \leq P^L \leq \alpha(1-\delta^T) + c\delta^T + (1-\delta)\delta^T In. \tag{B5}$$

Comparing (B4) and (B5), observe that the upper bound to the limit price is the same, and it increases with n. The lower bound in (B4) is above that in (B5) which equals the lower bound in the single buyer case, showing the proposition when the seller has no recoverable assets.

When the seller has recoverable assets ($\gamma>0$) the set of equilibria in the buyers' subgame is expanded. There are now $\binom{n}{2}$ pure strategy equilibria, and n symmetric mixed strategy equilibria. The pure strategy equilibria differ in which two firms vertically integrating. Since a single firm vertically integrating obtains a monopoly, such a configuration cannot be an equilibrium to the subgame. But, if two firms are vertically integrating, no other firm will like to do so. Each of the mixed strategy equilibria now involves one firm choosing to vertically integrate with probability 1, and the remaining n-1 choosing to vertically integrate with probability given by (B2). Since now the probability of one firm vertically integrating is one, the calculus for the seller is the same as for the case of a single buyer. Thus, the lower bound for the limit price is given by (2b). The upper bound is still given by (B1) which exceeds (2a). Thus, proving the proposition.

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FOOTNOTES

1. In the presence of informational asymmetries, this result may not hold. See Milgrom and Roberts (1982).

2. For surveys of this strategic literature see Gilbert (1987), Shapiro (1987), Ordover and Saloner (1987), and Holt and Scheffman (1987).

3. In this framework, the only limitation on supra-competitive pricing is the incumbent firms' coordination ability.

4. In many intermediate product markets, sales are effected essentially by bargaining between the sellers and buyers. For this reason alone, it is clear that modelling buyers as passive demand curves may be inappropriate, since buyers will make calculations with respect to their surplus in a bargaining situation.

5. See Scherer (1980), Chapter 10, for a summary of some of the literature.

6. See, Coase (1937) and (1987), and Williamson (1975), (1979), (1983) and (1985).

7. See Williamson (1979), and Klein, Crawford and Alchian (1978).

8. Thus, in the absence of countervailing factors, such as inefficiencies of alternative production technologies, or specific investments by the buyer, significant sunk costs may preclude market arrangements from developing, and vertical integration may arise as the organizational mode. See Williamson (1983).

9. In the rest of this paper when we talk about "entry" by the buyer we mean entry by vertical integration, writing binding long term contracts with entrants, or making irreversible investments that allow switching to an alternative input.

10. The basic results derived from this formulation would hold for a more general demand function as well (i.e. a continuous and differentiable demand function). Since in the current formulation there are no inefficiencies associated with a price above marginal cost, there is no need for vertical integration or for multiple part tariffs to either extract monopoly rents or solve a successive-monopoly problem. This allows us to focus on the use of vertical integration as a credible entry threat. (See also footnote 4).

11. The model could easily incorporate any post-entry equilibrium concept that makes independent entry unprofitable.

12. Our analysis could easily be modified to model a situation where S and B bargain ex-ante over the purchase by B of the widget technology.

13. In this section we will concentrate on vertical integration, but it should be clear that vertical integration has exactly the same features as a long term contract with a potential entrant.

14. Recall that the investment expense, I, is incurred at the time the plant is completed, T periods after the commitment to vertical integration.

15. The buyer's calculus is made assuming that he can buy the alternative input at a price of α, so that α can be thought as his maximum willingness to pay for widgets.

16. This type of strategies relate current actions only to last period outcomes, implying that the optimal decision depends only on the node being played. When the strategy space is not restricted to Markovian strategies, then non-constant price strategies may arise. For example, the seller may choose a strategy that consists on charging α for, say, two periods, and some price below α for the next, say, five periods. If this pricing pattern is preferred by the buyer to vertical integration, it may also arise as an equilibrium. This pattern also involves limit pricing, since the average price, over time, will be below α.

17. Since payoffs are linear in prices, the bargaining frontier is linear with a slope of -1. Observe that the no agreement outcome is given by vertical integration and monopoly pricing for T periods, implying a profit level for the buyer similar to that obtained from P^L_{max}, and a profit level for the seller similar to that obtained from P^L_{min}.

18. In a model with a more general demand function, multiple part tariffs may arise, and the relevant limit price may take the form of a surcharge on inframarginal units.

19. This decision, instead of physical vertical integration, could be interpreted as a long term contract with an entrant.

20. In the current model, this could be incorporated by assuming that the marginal cost of operations, c, is itself a function of γ, with γ^* representing the level of sunkness that minimizes operating costs (i.e., $c'(\gamma^*)=0$, with $c''(\gamma^*)<0$). Suppose that P^L is determined as the solution of a simple bargaining process that results in P^L being the average of the upper and lower bounds given in (2a) and (2b), i.e., $P^L = (1-\delta^T)\alpha + [c(\gamma^*)+c(\gamma)]\delta^T/2 + (1-d)\delta^T I(1+\gamma)/2$. Then total expected profits of the would-be monopolist are given by $V = [\alpha-(c+c^*)/2](1-\delta^T)/(1-\delta) + I[\delta^T(1+\gamma)/2 - 1]$, and the first order condition, $V_\gamma=0$, is $c_\gamma = \delta^T I(1-\delta)/(1-\delta^T) > 0$. If c is monotone in γ, the equilibrium values of c and γ exceed c^* and γ^* respectively.

21. The incentives to vertically integrate discussed here are analogous to those discussed in Klein, Crawford and Alchian (1978).

22. For the limit price P^L to be an equilibrium, (2c) requires that $c(\gamma)<c(\gamma^*)+(1-\delta)I(1-\gamma)$, which may be violated by S's choice of technology.

23. The transaction price should at least equal the profits that independent production would provide the seller. There is, however, a joint gain equal to $[c(\gamma)-c(\gamma^*)]/(1-\delta)$ which will be shared by both the buyer and the seller.

24. The assumption of buyers' inelastic demands avoids potential raising rivals' costs' considerations for vertical integration, as discussed in Salop and Scheffman (1983), (1987) and Katz (1987). (See, also, footnote 4).

25. In this section, vertical integration can be interpreted as writing a long term contract with an independent entrant.

26. For vertical integration not to be a profitable strategy for any buyer, the price charged by S (P^L) has to satisfy $0 \leq -I\delta^T/n + (\alpha-c)\delta^T/[n(1-\delta)] \leq (\alpha-P^L)/[n(1-\delta)]$, which is exactly condition (2a) developed for the case of a single buyer. P^L has to provide S with no lower profits than charging a price of α for T periods and then exiting. That is, $(\alpha-c)(1-\delta^T)/(1-\delta) + \gamma I\delta^T \leq (P^L-c)/(1-\delta)$, which is exactly condition (2b) developed for the case of a single buyer.

27. Because of the Bertrand assumption, which implies marginal cost pricing, the incumbent obtains zero net operating profits following entry. Thus, if $\gamma>0$ the incumbent will leave the market following entry. The incumbent's exit, however, implies that the entrant replaces the incumbent as the monopolist. Thus, to assure that the incumbent remains in the market we assume that $\gamma=0$. However, if the post-entry game provided the entrant with a positive net revenue in excess of its non-sunk investments, the assumption of $\gamma=0$ would not be needed.

28. As long as the actual limit price is some function of its upper bound, this result will hold. However, at $z=z^*$, P^L may be less than α.

29. See Katz (1987) for an analysis of the welfare effects of third-degree price discrimination in intermediate goods industries.

30. His market share must be at least $I(1-\delta)/(\alpha-c)$.

31. For an analysis of optimal switching strategies in the presence of informational asymmetries, see Demski, Sappington and Spiller (1987).

32. Here, however, "entry" may involve buying from an already existing supplier of a somewhat different product, e.g., a foreign supplier not currently in the market. In this case T will reflect the time it takes for the buyer to learn to use, or to qualify the supplier of the new input.

33. Alternatively, the buyers' surplus from buying from the entrant is now $\alpha+\beta$, while their surplus from buying from the incumbent remains at α. The rationale for this assumption is based on the idea that once B has switched, its facilities are more efficient when using the entrant's input. Thus, using the incumbent input results in a per-unit cost disadvantage, once the switching investments have been made.

34. See footnote 27 for a discussion of this assumption.

35. If the post entry game was Cournot, then the assumption that buyers are willing to pay a premium of β to purchase from the entrant will not be necessary to generate an incentive for the entrant to come in. For the model

at hand (with inelastic demand) the Cournot solution concept implies monopoly pricing. Buyers, then, will see no gain from promoting entry and will not invest in switching costs, and monopoly pricing will not promote entry. If, however, demand was downward sloping, there could be an equilibrium where monopoly pricing would trigger entry. When the post-entry game is Bertrand, because of positive fixed costs, unless the entrant can charge a price above its marginal cost it will not enter.

36. Observe that since the buyer is indifferent between buying from the incumbent or from the entrant, his surplus after entry is given by α-c, that is, it is independent of β.

37. Larger than the present value of uncontested monopoly profits, $\sigma>(\alpha-c)/(1-\delta)$).

38. In many circumstances switching may simply involve changing to an already existing alternative input, that can be readily purchased from competitive suppliers. If it takes no time or investment for the buyer to switch, then the limit price is simply the differential that the buyer is willing to pay over the alternative source of supply. But switching is likely to take time, and switching costs may be required. In this case the differential that the buyer is willing to pay over the price of the alternative source of supply will be larger.

39. For example, if buyers are large, and they buy other products from the merged-to-monopoly entity besides the product affected by the merger, the buyers may have considerable leverage over the merged entity, and the limit price may be close to P^L_{min}.

40. That is, the efficiencies are realized exclusively by the merging firms.

41. See Gilbert (1987) for a discussion of the welfare implications of specific assets in the framework of the modern theory of market structure.