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REDUCING RIVALS' REVENUES

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Abstract

Vertical Integration as Strategic Behavior in a Spatial Setting:

Reducing Rivals Revenues

This paper provides a formal treatment of how vertical integration may deter entry "by reducing rivals' revenues". We examine a spatial market with the locations of firms fixed due to location-specific (sunk cost) investments at both the upstream and downstream level. We show that vertical integration restricts the potential entrant from selling to its most desirable customers, and thereby enables the upstream firm to expand its market and increase profits without attracting entry. Further, we show that integration is particularly beneficial in a growing and uncertain market, where the ability to integrate enables a firm to wait until future events unfold before any action is taken to deter entry.

I. Introduction

Courts have traditionally analyzed vertical integration in terms of "foreclosing" markets and "leveraging" market power.[1] Economists began challenging these notions as early as the fifties [see e.g., Bork (1951) or Peltzman (1977)]. They argue that vertical integration does not increase monopoly power, and does not increase the price paid by final consumers. Prices may even fall as a result of vertical integration.[2] The transactions cost analysis of Williamson and others has bolstered the view that integration enhances economic efficiency.

Krattenmaker and Salop (1986a and b) have recently revived the claim that vertical integration may increase monopoly power. They discuss how a downstream firm may integrate backwards to "foreclosure" input supplies and thereby raises rivals costs. This paper formalizes a different case in which the upstream firm vertically integrates with buyers in the downstream market in order to increase its total sales and the prices paid by at least some consumers. Integration may allow foreclosure in the sense of making entry unprofitable by "reducing rivals' revenues".

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[1] These arguments imply that vertical integration can increase monopoly power in a particular market or extend that power to other markets. See e.g., Scherer (1980, pp. 90-91, 303-6, 550, 582-90), or Fisher and Sciacca (1984).

Vertical integration in this paper is defined as the control of decisions at both stages, so that the firm acts as a single profit maximizing entity. The analysis may also apply to other types vertical control, such as exclusive dealing arrangements.

[2] Specifically, two cases are relevant when the stages are combined in fixed proportions. When both the upstream and downstream are monopolized (the successive monopoly case), vertical integration reduces the price of the final good. When one stage is monopolized and the other stage is competitive, vertical integration leaves the price unchanged. The primary qualification to these cases is when the upstream monopolist faces input substitution by downstream competitors, in which vertical integration may increase or decrease the final good price.

A typical objection raised against foreclosure arguments is that, if a firm were to vertically integrate downstream in order to deny entrants a buyer for their product, then the entrant would simply sell to other firms. The foreclosing firm would be required to integrate with all buyers in the downstream market in order to effectively foreclose entrants, but then the problem becomes horizontal at the downstream level rather than vertical. This objection to foreclosure arguments carries less weight if the foreclosing firm could isolate buyers that are particularly desirable to the entrant.

Our model has the property that certain buyers are more desirable to the entrant. In our model, both the upstream and downstream market are characterized by spatially differentiated goods, which are produced by firms with fixed locations due to sunk cost investments.[3] Eaton and Lipsey (1978) have shown that, in the presence of large enough location-specific investments and transportation costs, firms can locate in such a manner that non-zero profits can be earned without encouraging entry. We extend their analysis to show that integration may enable the upstream firm to further expand its market and increase profits without attracting entry. The analysis, however, demonstrates that restrictive conditions must be met before integration can successfully "foreclose" the market.

We also consider integration as an entry deterring strategy in the face of uncertainty about future growth. Eaton and Lipsey (1979) have shown it profitable, albeit costly, for firms in a growing market to

[3] Earlier papers by Dixit (1983) and by Mathewson and Winter (1984) also examine vertical integration in a spatial setting. Unlike our model, transportation costs are only incurred between the downstream firm and final customers and not between the upstream monopolist and downstream firms.

expand before the potential entrant makes a location-specific investment. We extend their analysis to consider uncertainty about future growth and an alternative strategy of vertical integration. If demand is revealed to exceed a certain level, entry would occur and substantially reduce the incumbent's profitability. By locating closer together in the first period, incumbents could preclude possible second period entry, but at the cost of foregoing first period profits. Vertical integration in the second period can prevent entry without sacrificing first period profits.

Section II provides the basic assumptions of the model. Section III demonstrates that vertical integration can prevent entry where it might otherwise occur. Section IV analyses the strategic role of integration in the context of uncertain future growth. Section V discusses the assumptions and possible extensions of the model, and implications for antitrust policy. While vertical integration may extend or maintain monopoly power, welfare implications of the strategy are ambiguous.

Section II. Upstream and Downstream Firms with Location-Specific Assets

Firms produce at an upstream or manufacturing stage, and a downstream or distributing stage. Manufacturers are assumed to be able to enter at both stages, but distributor are able to enter at only one stage.[4] Further, firms at <u>both</u> stages make location-specific investments and unintegrated firms operate from only one location on a circle.

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[4] Manufacturers may own multiple distributors. We assume that only manufacturers integrate in order to simplify the analysis. One justification might be that manufacturers are the larger geographic entities (i.e. due to larger fixed relative to variable costs).

Ultimate consumers are located uniformly on the circle.[5]

Manufacturers and distributors charge a uniform FOB price to all buyers, i.e., no price discrimination. The distributor's delivered price is equal to

$$P_m+Z_m t_m,$$

where P_m is the mill price set by the manufacturer, Z_m is the distance from the manufacturer to the distributor, and t_m is the per unit cost that the distributor incurs transporting to their location. Distributors purchase from the supplier that offers the good at the lowest delivered price. In figure I, A and B are the locations of two manufacturers setting the same mill price, and the delivered price to distributors at any point between A and B is on the line ACB[6]. Distributors a_1 through a_5 purchase from A, and distributors b_1 through b_5 purchase from B.

The ultimate consumers buy from the source with lowest distributor's mill price plus transportation costs. Define P_i as the price set by distributor i, and t_d as the common transportation charge per unit, Y_i as the distance between firm i and the location where its delivered price is the same as its closest rival on the right, and X_i analogously for firm i

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[5] Given the indivisibilities posited below, the assumption of a circular market may lead to an integer problem with respect to the number of firms. We assume that the circle is large enough so that the integer problem is inconsequential.

[6] For simplicity, figure I is drawn assuming a common per-unit markup by distributors of R. As shown below, for certain demand and conjectural variation conditions, R=1.

We assume below that all distributors make the same profits, which requires that distributors further from manufacturers (and paying higher delivered prices) locate further apart to cover costs.

and its closest rival on the left.[7] Then,

$$P_i+t_dY_i \quad =P_{i+1}+t_dX_{i+1} = 1/2[P_i+P_{i+1}+t_d(X_{i+1}+Y_i)]$$

for firm i and neighboring firm i+1.[8] For notational convenience, this expression is denoted P_i^*. The effective price paid by consumers at any location is represented by the jagged line in Figure I.

The demand for final goods is the same at each point on the line and is described by $Q_i=f(P_i+t_dX_j)$. As in Eaton and Lipsey, we assume $f'<0$ and that the elasticity of demand approaches $-\infty$ as the delivered price approaches ∞.

As is standard in location models, the firm faces a fixed cost and a constant variable cost. Fixed costs at both stages are also sunk and specific to a particular location. The manufacturer's cost is:

$$G_m + C_mQ,$$

where G_m is the fixed cost, C_m is the per-unit cost, and Q is output. Similarly for distributor i, the cost function is:

$$G_d + (P_m + Z_mt_m + k_d)Q_i \equiv G_d' + c_iQ_i,$$

where Q is the distributors output, k_d is the per-unit distribution cost above and beyond the cost of the input purchased from the manufacturer, c_i is the full unit cost (which varies with transportation costs from the

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[7] We assume throughout that t_d is greater than t_m in order to avoid more than one manufacturer selling to each distributor. This assumption is natural when distributors are selling to individuals buying few units of the good. In contrast, distributors typically buy many units from the manufacturer, and may avail themselves of economies in transportation.

[8] We assume that both manufacturers and distributors have the lowest delivered price over some area, which Eaton and Lipsey (1978) refer to as "no mill price undercutting".

manufacturer), and G_d is the fixed costs to nonintegrated distributors.[9] For the integrated firm, distribution costs are

$$G_d' + (P_m' + Z_m t_m + k_d)Q_i \equiv G_d' + c_i' Q_i$$

where G_d' is the fixed cost of the integrated distributor. Price and cost are different from the nonintegrated firm since successive monopoly distortions can be avoided by setting the price to distributors equal to marginal cost.[10] We also assume that avoidance of the successive monopoly problem is not sufficient to overcome the higher fixed cost of the vertically integrated distributor, i.e.,

$$G_d^* \geq G_d,$$

where G_d^* is the fixed costs of vertical integration net of savings from avoiding the monopoly distortion loss.[11] This assumption assures that firms will not integrate other than to strategically deter entry.

III. Vertical Integration and Equilibrium

In this section, an equilibrium without vertical integration is compared to one in which manufacturers strategically purchases one or

[9] The input produced by the manufacturer is implicitly combined by the distributor in fixed proportions with other inputs. We examine the fixed proportions case, since previous studies show that price increases may occur with variable proportions but not with fixed proportions.

[10] Dixit (1983) shows how vertical integration eliminates the monopoly distortion in a spatial setting.

[11] The successive monopoly loss decreases with the distance between the manufacturer and each distributor, which implies that, if fixed costs are independent of location, then the upper bound on distributor's profits increases with distance. In what follows, we ignore this effect by assuming that G_d^*-G_d is constant across distributors. An alternative assumption is that the maximum profit a distributor can earn, as determined by G_d^*-G_d, increases as we move away from the manufacturer. The differential profit which results can be treated as a reward to the first mover without changing the equilibrium concept adopted below.

more distributors. The analysis illustrates the point that manufacturers may locate further apart and increase profits when they integrate. This approach is extended in the next section to an uncertain environment which provides insights into dynamic behavior, such as vertical mergers.

Equilibrium is determined after a sequence of moves. Manufacturers move first in a pre-arranged sequence and distributors follow. Firms can then make subsequent moves. Equilibrium attains when no firm can improve its position, based on the assumption that other firms act rationally following any action.[12] In order to obtain an explicit solution, equilibrium is determined in a backwards recursive manner; the distributor first determines its location and hence its pricing rule, which the manufacturer then takes as given in determining its price. The distributor's decision is rational in the sense that they locate "as if" they knew the location of manufacturers.

a) Equilibrium in distribution.

Distributors choose locations so as to maximize profits. Distributors, however, are constrained both by manufacturers' ability to vertically integrate and de novo entry by other distributors. If profits exceeded $G_d^*-G_d$,[13] manufacturers would find it in their interest to vertically integrate. Similarly, if the distance between distributors

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[12] I.e., Equilibrium is sub-game perfect in the sense of Selten (1975).

[13] We assume that distributors sell only one type of product (although not necessarily one "brand" of that product), and hence their locational decisions are based solely on selling that product. At the other extreme, distributors could sell a wide range of products, and, in the limit, the location of the manufacturers of any one product does not affect the location of distributors. This later approach leads to the same conclusions and simplifies the analysis, but seems at odds with the sorts of markets to which we envision applying this analysis.

was sufficiently great (and profits sufficiently high), then distributors could enter and reduce existing distributors' profits. In this paper, we assume that the binding constraint on distributors profits is the threat of vertical integration, so that in equilibrium distributors' profits equal $G_d^*-G_d$.[14]

As shown by Eaton and Lipsey (1978), the quantity demanded from firm i, Q_i, for integral F of demand f, is

$$Q_i=(1/t_d)\{F(P_i^*)+F(P_{i-1}^*)-2F(P_i)\} \quad (1)$$

and profits of firm i are

$$[(P_i-c_i)/t_d]\{F(P_i^*)+F(P_{i-1}^*)-2F(P_i)\}-G_d. \quad (2)$$

In particular, for demand[15] $Q_i=e^{-(P_i+t_dX_i)}$, profits are

$$[(P_i-c_i)/t_d]\{2e^{-P_i}-e^{-P_i^*}-e^{-(P_{i-1}^*)}\}, \quad (3)$$

and the first order condition with respect to price is

$$(P_i-c_i)\{(1/2)e^{-P_i^*}(1+\partial P_{i+1}/\partial P_i)+(1/2)e^{-P_{i-1}^*}(1+\partial P_{i-1}/\partial P_i)-2e^{-P_i}\}/$$
$$\{2e^{-P_i}-e^{-P_i^*}-e^{-P_{i-1}^*}\} = -1 \quad (4)$$

The solution of equation (4) with respect to price depends on each distributor's assumption about rivals' reaction to price changes. We assume that distributors conjecture that their rivals match their price cuts (i.e., $\partial P_{i+1}/\partial P_i=1$, $\partial P_{i-1}/\partial P_i=1$) or UPCV (unitary price conjectural variation). This assumption is plausible in the context of location-specific investments (see Archibald, Eaton and Lipsey (1986)), and yields the following result (from Eaton and Lipsey (1978)):

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[14] The equality also allows us to obtain an explicit expression for the distributor's equilibrium price.

[15] This demand curve was adopted by Eaton and Lipsey (1978) due to its attractive computational properties, but see also Greenhut, Norman and Hung (1987) for an extension to linear demand.

Lemma 1: Assuming UPCV, each distributors optimal price is $1+c_i$.

Proof: By the UPCV assumption, equation (4 can be re-written as

$$(P_i-c_i)\{e^{-P_i^{*}+1}+e^{-P_{i+1}^{*}}-2e^{-P_i}\}/\{2e^{-P_i}-e^{-P_i^{*}}-e^{-P_{i-1}^{*}}\} = -1. \qquad (5)$$

Since $P_i^*=P_i+t_dY_i$ (and similarly for $P_{i-1}=P_i+t_dX_i$), equation (5) simplifies to $P_i=1+c_i$. Consequently, the profits of firm i equal

$$e^{-(c_i+1)}[2-e^{-t_dX_i}-e^{-t_dY_i}]/t_d - G_d, \qquad (6)$$

and, by virtue of the fact that profits equal $G_d^*-G_d$, then X_i and Y_i can be obtained from the following[16]

$$[e^{-(c_i+1)}[2-e^{-(t_dX_i)}-e^{-(t_dY_i)}]/t_d= G_d^*. \qquad (7)$$

Several aspects of equilibrium at the distribution stage should be noted. First, because distributors further from manufacturers face transportation costs, P_i, X_i and Y_i must increase as c_i rises in order to keep profits constant and equal to $G_d^*-G_d$. Further, assuming that a distributor locates exactly at the manufacturer's site (i.e., $Z_m=0$), distributors locate symmetrically around each manufacturer.

b) Equilibrium in manufacturing.

For distributor demand as specified above, the manufacturers' profits in the absence of vertical integration are

$$2(P_m-C_m)/t_d\{\Sigma_{i=1}^{n} e^{-(c_i+1)}[2-e^{-t_dX_i}-e^{-t_dY_i}]+e^{-(c_0+1)}[1-e^{-Y_0t_d}]\}-G_m, \qquad (8)$$

where n is half the number of distributors between any manufacturer and his closest rival, and distributor zero is the distributor for which $Z_m=0$. Since all distributors earn the same profits and the difference between price and cost is the same for all distributors [by equation (5)], the quantity sold by all distributors must be the same and equation

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[16] A necessary condition for equation (7 to have a solution is that $(G_d-\Delta)t_d\exp(C_m+k_d+2+t_m(\Sigma X_i+Y_{i-1})) < 2-\exp(-X_it_d)$.

(8) simplifies to the following equation for profits:

$$[2(P_m-C_m)/t_d][ne^{-(c_i+1)}[2-e^{-t_dX_i}-e^{-t_dY_i}+e^{-(c_0+1)}][1-e^{-Y_0t_d}]-G_m. \qquad (9)$$

The manufacturer's first-order condition resembles that of the distributor and hence Lemma 2 follows.

Lemma 2: Assuming UPCV, each manufacturer's optimal price is $1+C_m$.

Proof: Follows the same reasoning as Lemma 1.

c) Vertical Integration

For the purposes of examining the effects of vertical integration, it is useful to define the following:

1) N is the smallest number of distributors for which the profits of a manufacturer (π_m) ≥ 0, and ϵ is the value of π_m consistent with N.

2) X' is $2[\Sigma_{i=1}^{N}(X_i+Y_{i-1})]$, twice the smallest market area consistent with nonnegative profits for a manufacturer.

Then, it follows:

Lemma 3: For every ϵ, there is a δ such that if existing manufacturers A and B located $X'-\delta$ apart, then entry will not occur.

Proof: It can be shown that for a uniform distribution of customers and common pricing by incumbents, entrants will always locate exactly half way between existing firms, and by Lemma 1, charge $1+C_m$. Hence, if the distance between A and B allows for 2N distributors, an entrant would be the lowest cost seller to N of these, and entry would occur. Conversely, if only 2N-2 distributors could be located in that space, the entrant will sell to only N-1 of them and entry will not be profitable. Denote X' the distance between A and B sufficient to allow 2N distributors and X the distance sufficient to allow 2N-2. Then, it follows that there is some δ, $0<\delta\leq(X'-X)$, such that entry is not profitable when firms are $X-\delta$

apart, but would be profitable if A and B were any further apart.

Our basic result, Theorem 1, states that A and B can profitably locate further apart by vertically integrating. To prove this theorem, we define S-1 to be the distributor buying from A who is located furthest from A (i.e., n = S-1 in equation (8) above, when the distance between A and B is $X'-\delta$).

Theorem 1: If $t_m[\Sigma^S_{i=1}(Y_{i-1}+X_i)] < 1$ and ϵ (the entrants profitability at minimum profitable scale) is sufficiently small, integrated manufacturers can locate further apart than nonintegrated firms and still deter entry. Further, vertical integration will increase the manufacturer's profits.

Proof: i) To show that the vertically integrated firm can locate further apart than the non-integrated firm, we show that entry can be unprofitable even though the manufacturer locates sufficiently far from its nearest rival so that entry would occur without integration. Faced with a situation in which distributor S is owned by an integrated manufacturer, an entrant has four options.[17]

1) <u>Entry without selling to the vertically integrated distributor or a substitute independent distributor</u>. From Lemma 3, it is clear that entry by a manufacturer is not profitable if the entrant were not able to sell to the integrated distributor, S, or an alternative unintegrated distributor at a nearby location.

2) <u>Entry by a manufacturer selling to an independent unintegrated distributor</u>. Note that the integrated firm sets a delivered price to its

[17] It can be shown that the entrant's optimal location is always half-way between incumbent manufacturers (see Lemma A.1 below).

distributor equal to its marginal cost while the nonintegrated manufacturer's profit-maximizing price is $1+C_m$. Consequently, the integrated firm will be able to supply its integrated distributor (including the additional transportation costs) at less than $1+C_m$, if

$$C_m+t_m[\Sigma^S_{i=1}(Y_{i-1}+X_i)] < 1+C_m,$$

or, simplifying,

$$t_m[\Sigma^S_{i=1}(Y_{i-1}+X_i)] < 1. \qquad (10)$$

For the independent distributor to enter and replace the integrated distributor, its costs must be at least as low, and, hence, the entering manufacturer would be required to commit to a below-optimal price. Even with such a commitment, if price discrimination is not feasible, the entrant's profits on sales to every distributor is less at the lower (sub-optimal) price. Hence, if, ϵ is sufficiently small, the reduction in profits resulting from the sub-optimal price will make entry unprofitable (nonsustainable), and entry will be prevented.

3) Entry selling to the vertically integrated distributor. Once the manufacturer enters the market, it may be profitable for the integrated distributor to buy from the entrant, since it can reduce its costs. For the equilibrium to be sub-game perfect, this strategy cannot be feasible. If condition (10) holds, it would not be in the interests of the integrated distributor to buy from an entrant charging $1+C_m$ (regardless of whether sunk costs have been incurred). Just as in case 2) above, the entrant must offer a lower price than the incumbent's cost of serving the integrated distributor. Hence, as above, integration may reduce the entrant's profits, particularly if price discrimination is not possible.

4) Entry by a vertically integrated firm. A final possibility is entry

at both levels. This is similar to case 3), except that the integrated firm will set the internal price at marginal cost. This is equivalent to selectively setting a lower price to its integrated distributor without lowering the price to all other distributors. Nevertheless, as long as condition (10) holds, this price will be below the optimal price and the entrant's profits will be lower by virtue of the incumbent's vertical integration. For sufficiently small values of the integrated entrant's profits (ϵ), entry can be deterred.

Therefore, in all four cases, the existence of the integrated incumbent reduces entrant profitability. Hence, if condition (10) holds and ϵ is sufficiently small, entry can be prevented.

ii) When the integrated incumbent owns only one distributor, it can still sell to the same number of nonintegrated customers (as in the absence of integration) at a price of $1+C_m$ and earn the same profits from them. To see that sales to the integrated distributor are also profitable, recall that an independent distributor in the same location as the integrated firm would earn profits of $G_d^*-G_d$. By construction, the additional fixed costs of integration (net of savings from eliminating the successive monopoly distortion) of $G_d^*-G_d$, so that economic profits from distribution are zero. Meanwhile, the manufacturer still earns the same profits from sales to the integrated distributor as it would have if it were selling to an independent distributor.[18] Hence, integration is profitable because the incumbent is able to increase its profits by

[18] Recalling equation (9), these profits simplify to $(1/t_d)\exp(-P_i)[2-\exp(-t_dX_{i+1})-\exp(-t_dY_{i+1})]$.

selling to an additional distributor S.

Theorem I examined the feasibility of preventing entry by acquiring the distributor located closest to the entrant's location (distributor S). The assumption $t_m[\Sigma^S_{i=1}(Y_{i-1}+X_i)]<1$ insures that the potential entrant faces a credible threat that the distributor will not buy from the upstream entrant unless the entrant charges a price below its optimal price. In general, the entrant may have to sell to distributors S-1, S-2, etc., in addition to distributors S in order to achieve non-negative profits. Then, if condition (10) does not hold but if $t_m[\Sigma^{S-1}_{i=1}(Y_{i1}+X_i)]< 1+t_m[Y_{s-1}+X_s)]$, integration with a distributor at location S-1 may still deter entry. Or, if this condition is not satisfied but $t_m[\Sigma^{S-2}_{i=1}(Y_{i-1}+X_i)] <t_m[\Sigma^S_{i=S-1}(Y_{i-1}+X_i)]$, then integration with the next distributor may still be a feasible entry deterring strategy. In fact, for larger values of profits to the integrated entrant, the incumbent may need to integrate with more than one distributor, since each such acquisition lowers the integrated entrant's profitability at no cost to the incumbent.

IV. Extension to Uncertainty

In this section, we incorporate uncertainty about future demand growth. We show that, under specific conditions, the incumbent manufacturer can outbid the entrant for independent distributors and vertical integration can, thereby, deter entry.

A two-period model is employed. Growth takes place in the second period, but the firm's fixed and sunk cost investment is infinitely durable and incurred only once. We assume that all agents are risk neutral, and demand in the second period is $\theta e^{-P_i+t_d x_i}$, where θ is a random variable on the interval $(1,\overline{\theta})$, with a continuous and symmetric distribution $f(\theta)$. The first period equilibrium will reflect the possibility of higher profits in the absence of second-period entry, and also the fact that entry may occur for high enough values of θ. Firms take both of these effects into account when choosing location.

The timing of the player's movements resembles that in the basic model. Prior to period one, manufacturers and distributors sequentially choose locations. The initial equilibrium concept is the same as above. After the first period ends, θ is revealed; the incumbent may vertically integrate and/or manufacturers and distributors may enter the market.

A. Equilibrium in Distribution

Extending the analysis in section III, distributors locate with the expectation of profits $G_d^*-G_d$. In so doing, distributors take into account that, for certain values of θ, entry occurs at the distribution level. For a fixed set of locations, expected profits are a linear function of θ, so that for large enough θ, entry occurs between each existing pair of distributors. Therefore, realized second-period profits are again uniform across distributors, although the common level of profits depends on θ in a rather complicated way. Profits increase with demand until entry occurs, and then falls to a certain level and begins increasing at a slower rate. Figure 2 portrays the profitability of distributors as a function of θ, based on an arbitrary initial set of locations, X_0 and Y_0. The slope of each line is $e^{-P_d}(2-e^{t_d X_0^i}-e^{t_d Y_0^i})$, where the superscript indicates that the slope will change each time entry occurs and the distributor's market shrinks.

Despite the odd shape of the profit function, expected profits are a continuous function of the distance between distributors. As shown in appendix A, there is some set of locations such that the expected profit of distributors selling in both periods is $G_d^* - G_d$.

B. Equilibrium in Manufacturing.

Manufacturers, like distributors, take the second period into account. In first period equilibrium, expected first plus second period profits of manufacturers not selling in the first period are negative. However, for high enough θ, second period profits may be sufficient to allow a firm to enter once θ is revealed.[19]

For each value of θ, there is an n, denoted $2\eta(\theta)$[20], which is the minimum number of distributors between manufacturers required for an entering manufacturer to achieve non-negative profits, $\epsilon(\theta)$. Let $X(\theta)$ denote the total length of that market. The following Lemma proceeds as Lemma 2, and establishes the distance between incumbent manufacturers.

Lemma 4: For each $\tilde{\theta}$ and the corresponding $\epsilon(\tilde{\theta})$, there is a $\delta(\tilde{\theta})$, such that if existing manufacturers locate $X(\tilde{\theta})-\delta(\tilde{\theta})$ apart, entry does not occur.

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[19] It can be shown that in order for θ to induce second period entry, it must exceed μ_θ, its expectation.

[20] The number of distributors which buy from the entrant is increasing in n. The notation here is somewhat different from Lemma 2 in that here $2\eta(\theta)$ represents the total number of distributors between incumbent manufacturers A and B, rather than (twice) the number of distributors to which the entrant must sell. The difference is a result of the fact that distributors are already in place because of location decisions made in period 1, while the entry decision occurs in period 2.

Proof: This result is an extension of Lemma 3, with the modification that η is a function of θ, rather than being predetermined. Given a specific θ, the reasoning is identical.

Lemma 4 can be restated as the following:

Corollary: Given a distance between existing manufacturers of $X(\check{\theta})-\delta(\check{\theta})$, if $\theta>\check{\theta}$ and no vertical integration, entry occurs in the space between existing manufacturers.

In what follows we assume that manufacturers do not choose to locate $X(\bar{\theta})-\delta(\bar{\theta})$ apart. That is, we assume that it is not optimal in the first period to locate sufficiently close together to prevent entry for all values of θ. As shown in appendix B, a sufficient condition for incumbent manufacturers to locate more than $X(\bar{\theta})-\delta(\bar{\theta})$ apart is

$$[1+(\theta+1)/2]/\int_{\bar{\theta}-\tau}^{\bar{\theta}} \theta f(\theta)d(\theta) > 2n,$$

where $X(\bar{\theta}-\tau)-\delta(\bar{\theta}-\tau)$ is the distance which would allow one more distributor than $X(\bar{\theta})-\delta(\bar{\theta})$, and n is the number of distributors where the entrant displaces the incumbent.

Theorem 2 states that vertical integration prevents entry under specific conditions.

Theorem 2: Let θ be the value of θ required for entry when manufacturers sell to $\eta(\theta)$ distributors. As long as $t_m[\Sigma_{i=1}^{\eta(\theta)}(Y_{i-1}+X_i)]<1$, incumbent manufacturers integrating into distribution can prevent entry for some values of θ between $\tilde{\theta}$ and $\bar{\theta}$. (We assume for notational simplicity that θ_e, the θ at which entry occurs in distribution, is less than $\tilde{\theta}$).

Proof: The minimum number of distributors necessary for entry with $\theta > \tilde{\theta}$ is no larger than $2\eta(\check{\theta})$, while at least $2\eta(\check{\theta})$ distributors exist between manufacturers A and B. In particular, suppose θ is such that exactly

$2\eta(\tilde{\hat{\theta}})$ distributors are the minimum required for the profitable entry and that manufacturer A can buy the distributor located (closest to) half the distance between A and B (distributor η). For $t_m[\Sigma_{i=1}^{\eta(\theta)}(Y_{i-1}+X_i)]<1$, this strategy can prevent entry. The logic is the same as that in Theorem 1. Again the entrant has four options available, and if $t_m[\Sigma_{i=1}^{\eta(\theta)}(Y_{i-1}+X_i)]<1$ and $\epsilon(\tilde{\hat{\theta}})$ is sufficient small, entry can be prevented.

Remark: In the certainty case, vertical integration increases incumbent sales by the sales of the integrated distributor(s). When demand is uncertain, integration not only increases sales by the amount to the integrated distributor, but also retains sales to those distributors who may have been customers of the entrant. This can be nearly half the entire sales of the manufacturer. An illustration of this is the following corollary to Theorem 2.

Corollary: Suppose that it is not possible to establish a distributor in the second period, and that $\theta>\tilde{\hat{\theta}}$, but sufficiently small that the entrant cannot make a profit without selling to distributor η. Then, for <u>any</u> value of ϵ, incumbents can prevent entry by purchasing distributor η. Further, the two incumbents will always be able to outbid the entrant in acquiring a distributor as long as the entrant must sell to at least three distributors to earn positive profits, and $t_m\Sigma_{i=1}^{\eta}(X_i+Y_{i-1})<1$.

Proof: The loss to the two incumbents if entry occurs (and hence their reservation value) is at least

$$3e^{-[c_m+k_d+2+t_m\Sigma_{i=1}^{\eta}(X_i+Y_{i-1})]}[2-e^{-t_dX_\eta}-e^{-t_dY_\eta}],$$

while the value to the entrant is

$$0\leq \epsilon \leq 2e^{-(c_m+k+2)}[2-e^{-t_dX_\eta}-e^{-t_dY_\eta}].$$

The difference between the value to the incumbent and the entrant is at least $e^{-(c_m+k+2)}[3e^{-t_m\Sigma_{i=1}^{n}(X_i+Y_{i-1})}-1][2-e^{-t_dX_\eta}-e^{-t_dY_\eta}]$ which is greater than 0 for $t_m\Sigma_{i=1}^{n}(X_i+Y_{i-1})\leq 1$. Therefore, the incumbent can outbid the entrant is purchasing the distributor. Since the value to the distributor is exactly $2e^{-c_m+k_d+2}[2-e^{-t_dX_\eta})-e^{-t_dY_\eta}]$, the incumbent can cover the distributor's opportunity cost as well.

Theorem 2 establishes that, for certain values of θ, the incumbent can increase its market size by more than the size of the acquired distributor. Compared to the one-period certainty result, the gains to vertical integration can be substantial. In addition to this direct effect of vertical integration, profits increase because firms may locate further apart in the first period for the same probability of entry. This follows because the manufacturer can earn greater first period profits for any given probability of second period entry.

V. Conclusion

When firms are differentiated by location, vertical integration may extend the incumbent's spatial market in a way that precludes entry and increases profits. Due to first mover advantages, acquisition of the downstream entity by an upstream firm may "foreclose" customers from the entrant. In the context of uncertainty about future market growth, an incumbent firm may wait until future states unfold and then vertically integrate, when necessary, to deter entry. The analysis has been applied to integration of the downstream firm by the upstream manufacturer, but could just as easily be applied in a straightforward manner to integration by the downstream firm.[21]

The spatial setting is conducive to the integration strategy because certain customers are more desirable to the entrant due to their location. Nevertheless, a number of assumptions are still required for the foreclosure solution to hold. Significant location-specific investments must be made at each stage of production. Otherwise, an entrant at either stage can expect entrants at the other stage to replace the "foreclosed" market, and lower overall cost. This assumption implies downward sloping demand curves in the absence of vertical integration. Related to sunk costs is the assumption that firms face downward-sloping average cost schedules. As a consequence, a minimum quantity of sales are required for non-negative profits with any given price-cost margin. Another key assumption is that the differential transportation costs associated with transferring within the integrated firm (relative to the entrant's transportation costs) must not be larger than the entrant's mark-up, in order that foreclosure of the market is sustainable once the entrant has already made a location-specific investment. Further, while the costs of vertical integration cannot be so high that the strategy is nonviable, vertical integration must cost something, or firms would be integrated independent of the ability to foreclose. In sum, the vertical integration strategy is in many ways fragile, and requires specific conditions on the extent of transportation costs, sunk costs at both levels, and the costs of vertical integration.

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[21] We expect that the analysis could be extended to a model with products and inputs differentiated by their characteristics.

An interesting implication of the analysis is that manufacturers will tend to integrate with distributors that are desirable to entrants. Normally, it might be expected that manufacturers in a spatial setting would integrate with distributors who are located closest to them, since location-specific investments would create the largest potential for opportunistic behavior (see Klein, Crawford and Alchian (1978)).[22] In contrast, the analysis above suggests that distributors farther away, which would be more desirable customers of the entrants, are the target of firms attempting to foreclose.

In conclusion, we have yet to address the welfare implications of the "foreclosure" strategy. Although our analysis suggests that vertical integration may increase market size and profits in a spatial setting, there are also offsetting efficiencies to consider. One implication of extending the upstream firm's market is that fixed costs are spread over more units, thereby lowering costs of production. In addition, the effect on the delivered prices must be considered in a complete welfare analysis. In our model, transportation costs increase for some customers, but the mill price stays constant as the firm's market expands. The latter is true because of the functional form assumed for final demand. However, under some forms of demand (e.g. linear final demand), the optimal mill price may fall as the market of the upstream firm expands. Then, the effective price is relevant, since the benefits of any decrease in mill price must be weighed against the increase in transportation costs born by some downstream

[22] It can also be shown in the context of the above model that successive monopoly distortions considerations would create greater incentives for integration with the closer downstream entities.

firms as the market expands. A final consideration in a more general framework is that vertical integration may produce net benefits in terms of cost reduction (reduced bargaining problems, sharing of information, etc.) and avoidance of successive monopoly distortion. Consequently, it is not clear that vertical integration should be discouraged by antitrust authorities, even if it can be determined that "foreclosure" was the primary motivating strategy.

Appendix A

Lemma A.3 shows that, given the profit function, there will be some initial set of locations such that expected profits, $E[\pi]=G_d^*-G_d$. Lemmas A.1 and A.2 provide intermediate results necessary to show this result.

Lemma A.1: When θ is large enough for entry to be profitable, the entrant will locate at the point where the delivered prices from the existing distributors are equal. Furthermore, the entrant's market area will be symmetric about this point.

Proof: WLOG, consider entry between distributors 0 and 1, so that the entrant sells in the area between the point where his price is equal to that of firm 0 and the point where his price is equal to that of firm 1. That is, the entrants market area is between b_0 and b_1, where b_0 and b_1 are defined as follows:

$P_0+b_0t_d = P_e+t_d(z-b_0)$, and

$P_1+t_d(A-b_1) = P_e+t_d(b_1-z)$,

where A is the location of firm 1 and z is the location of the entrant.

For any price, the entrant will attempt to maximize sales through his choice of location, where total sales are

$Q = 1/t_d\{2^{-P_e}-e^{-1/2(P_e+P_0+t_dz)}-e^{-1/2[P_e+P_0+t_d(A-z)]}\}$

Taking a partial derivative with respect to z yields

$e^{-P_e}/t_d\{(-1/2)e^{-1/2[P_e+P_0+t_dz]}+(1/2)e^{-1/2[P_e+P_0+t_d(A-z)]}.$

This expression implies that entrants locate such that

$P_0+t_dz = P_1+t_d(A-z)$ or,

$$z = (1/2t_d)(P_1-P_0+t_dA), \qquad (A.1)$$

i.e., where delivered price from distributors 0 and 1 are equal.

Further, the entrant's market area is symmetric about this point since $b_1 - z = z - b_0$ as shown below:

$b_1 + b_0 = 1/2t_d[P_e - P_0 + t_d z + P_1 - P_e + t_d(A - z)] =$

$1/2t_d[P_1 - P_0 + tA] + z = 2z$,

which holds by equation (A.1) above.

Lemma A.2. The θ required for entry is a continuous function of Y_0 for $Y_0 > 0$ and $t_d > t_m$ (and by extension a continuous function of the entire set of locations).

Proof: Let Y_0' be half the post-entry market size of distributor 0. Then using Lemma A.1, $Y_0' t_d = t_d(Y_0 - Y_0') + Y_0 t_m \iff Y_0' = [(t_m + t_d)/2t_d]Y_0$, so that the entrant's market area is $Y_0 - Y_0' = [(t_m - t_d)/2t_d]Y_0$, and the entrant's profits are $\pi_e = 2\theta/t_d[e^{-(c_e+1)}][1 - e^{-Y_0(t_d - t_m)/2}] - G_d$. Define θ_e as the θ which equates this equation to zero, i.e.,

$\theta_e = G_d\{t_d e^{c_e+1}/2[1 - e^{-Y_0(t_d - t_m)/2}]\}$.

The first derivative of this expression exists (and in fact is negative) if both $Y_0 \neq 0$ and $t_d \neq t_m$. Hence, for the cases in which we are interested, θ_e is a continuous function of Y_0.

Lemma A.3: There exists some X_0 (and by extension, some set of locations) such that the expected profit to distributors is equal to $G_d^* - G_d$.

Proof: WLOG, assume that $\bar{\theta} < G_d(t_d/2)e^{-(C_e+1)}[1 - e^{-Y_0(t_d - t_m)} \ (t_d + t_m)/4)$ so that there will only be one potential entrant between each pair of existing distributors). Then profits of distributor 0 (which sells in both periods) is

$\pi = [2/t_d] \ e^{-P_i}[\theta(1 - e^{-Y_0 t_d}) + \int_1^{\theta_e} \theta(1 - e^{-Y_0 t_d}) f(\theta) d\theta + \int_{\theta_e}^{\bar{\theta}} \theta(1 - e^{-Y_0 t_d} f(\theta) d\theta] =$

$[2/t_d]e^{-P_i}[\theta[1 - e^{-Y_0 t_d}][\int_1^{\theta_e} \theta f(\theta) d\theta + 1] + (1 - e^{-Y_0' t_d}) \int_{\theta_e}^{\bar{\theta}} f(\theta) d\theta]$, which is a continuous function of θ (using the result in Lemma A.2). We know that, if Y_0 were large enough so that $e^{-(c_0+1)}[1-e^{-t_d Y_0}]=G_d^*-G_d$, distributors would earn profits above $G_d^*-G_d$, (because fixed costs were covered in the first period). Similarly, if Y_0 were such that $(1+\mu_\theta)e^{-(c_0+1)}[1-e^{-t_d Y_i}]=G_d^*-G_d$ (i.e. distributors earn zero profits when $\theta=Y_\theta$), distributor 0 will earn less than $G_d^*-G_d$ (because entry would occur for large enough θ). By Rolle's Theorem, there exists an Y_{0f} such that $E[\pi]=G_d^*-G_d$.

Appendix B - Necessary and Sufficient Conditions for Entry in Period 2.

Period 2 entry occurs if and when θ exceeds $\tilde{\theta}$, the level for which manufacturers 'planned'. A direct implication is that if manufacturers locate consistent with $\tilde{\theta} = \bar{\theta}$, entry will never occur. In this appendix, we derive the conditions necessary for $\tilde{\theta}<\bar{\theta}$, and examine the extent to which we can draw some inference about whether or or not those conditions are likely to be met.

Define $d(\bar{\theta})$ as the distance between adjacent manufacturers which would preclude entry for all values of θ, and let S-1 be the number of distributors between manufacturers A and B corresponding to that distance. Further, let $d(\bar{\theta}-\tau)>d(\bar{\theta})$ be the distance consistent with S distributors. By this definition, τ is the difference between the θ at which entry never occurs (and there will be S-1 distributors) and the θ necessary before entry occur with S distributors.

The change in manufacturer's profits resulting from locating $d(\bar{\theta}-\tau)$ rather than $d(\bar{\theta})$ away from his nearest rivals is the sum of increased first-period profits, $2e^{-P_i}[2-e^{-Y_s t_d}-e^{-X_s t_d}]$, plus the gain in the second period if entry doesn't occur, $2\int_1^{\theta_e} \theta e^{-P_i}[2-e^{-Y_s t_d}-e^{-X_s t_d}]f(\theta)d(\theta)$ $+4\int_{\theta_e}^{\bar{\theta}-\tau}\theta e^{-P_i}[2-e^{-(Y_s' t_d)}-e^{-(X'_s t_d)}]f(\theta)d(\theta)$ minus the loss if entry does occur, $4(n-1)\int_{\bar{\theta}-\tau}^{\bar{\theta}} \theta e^{-P_i}[2-e^{-Y_s' t_d}-e^{-X_s' t_d}]f(\theta)d(\theta)$, where n is the number of distributors in which the incumbent is displaced.

The gain to the incumbent of moving far enough away to have an additional distributor will be positive if

$$2e^{-P_i}(2-e^{-Y_s t_d}-e^{-X_s t_d}+2\int_1^{\theta_e}\theta e^{-P_i}(2-e^{-Y_s t_d}-e^{-X_s t_d})f(\theta)d(\theta)]+4\int_{\theta_e}^{\bar{\theta}-\tau}\theta e^{-P_i}(2-e^{-Y_s' t_d} -e^{-X_s' t_d})f(\theta)d(\theta) > 4(n-1)\int_{\bar{\theta}-\tau}^{\bar{\theta}}\theta e^{-P_i}(2-e^{-Y_s' t_d}-e^{-X_s' t_d}f(\theta)d(\theta). \quad \text{(B.1)}$$

Let

$$R = \frac{2(2-e^{-Y_s' t_d}-e^{-X_s' t_d})}{2\ (2-e^{-Y_s t_d}-e^{-X_s t_d})} < 1$$

and $Q = 2e^{-P_i}(2-e^{-Y_s t_d}-e^{-X_s t_d})$.

Then we can re-write the inequality in (B.1) as

$$Q+Q\int_{1}^{\bar{\theta}} \theta f(\theta)d(\theta)+2QR\int_{\theta-\tau}^{\bar{\theta}} \theta f(\theta)d(\theta) > 2QR(n-1)\int_{\theta-\tau}^{\bar{\theta}} \theta f(\theta)d(\theta) \qquad \text{(B.2)}$$

The left hand side of (B.2) is greater than

$$Q[1+\int_{1}^{\bar{\theta}} \theta f(\theta)d(\theta)-\int_{\theta-\tau}^{\bar{\theta}} \theta f(\theta)d(\theta)] = Q[1+(\theta+1)/2]-\int_{\theta-\tau}^{\bar{\theta}} \theta f(\theta)d(\theta)].$$

The last equality holds by virtue of the fact the $f(\theta)$ is symmetric, so that B.2 will hold as long as

$$1+(\theta+1)/2 > 2R(n)\int_{\bar{\theta}-\tau}^{\bar{\theta}} \theta f(\theta)d(\theta) \qquad \text{(B.3)}$$

Whether this condition is satisfied will largely depend on θ, τ, and $f(\theta)$. If either $\int_{\bar{\theta}-\tau}^{\bar{\theta}} f(\theta)$ or τ is sufficiently small or $\bar{\theta}$ is sufficiently large, the inequality will hold. There is little in the model which justifies a priori restrictions on any of these magnitudes. Consequently, manufacturers may locate sufficiently close together to preclude entry for all θ, but it is also possible that they will locate such that entry will occur for some θ.

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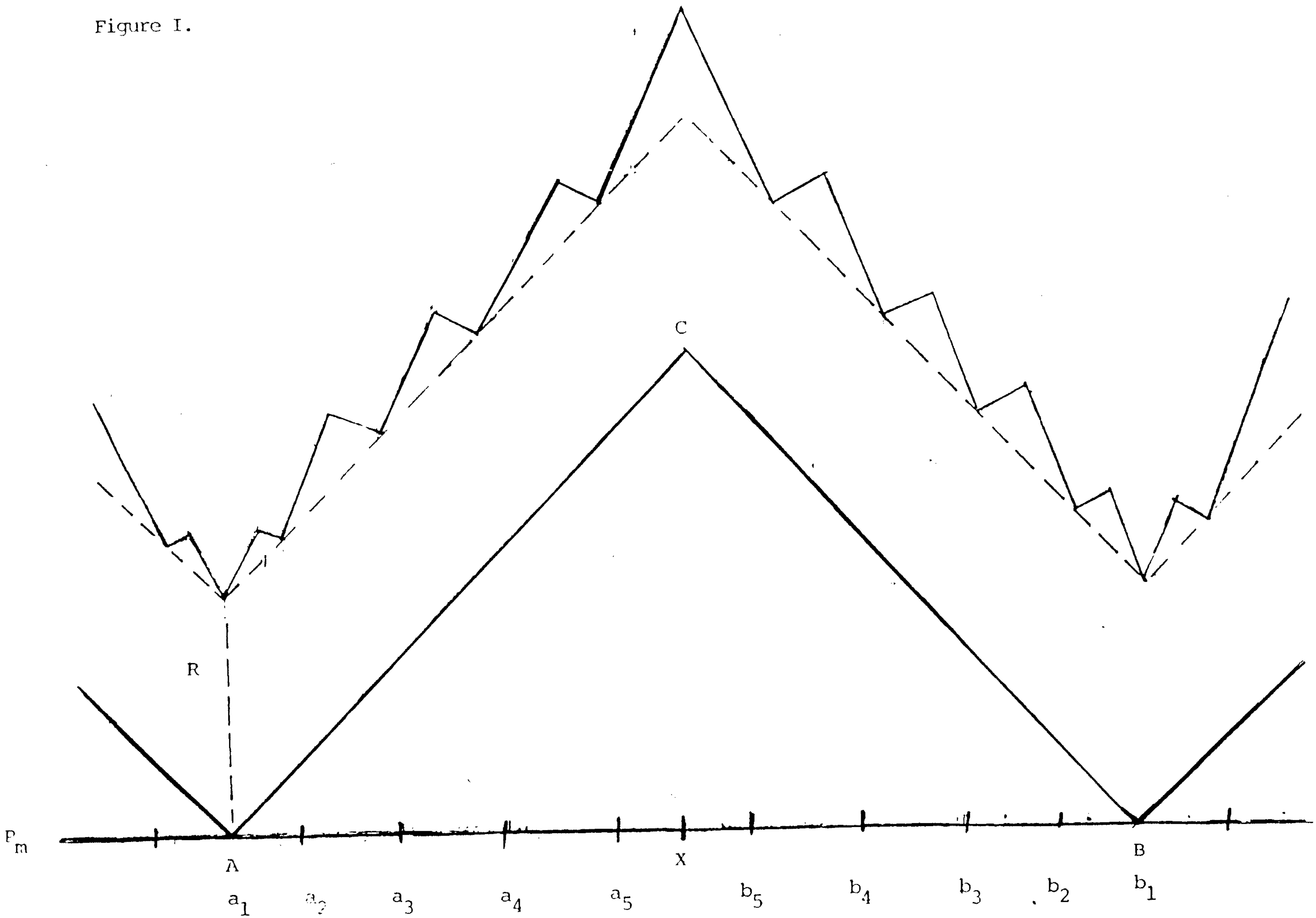
Figure I.



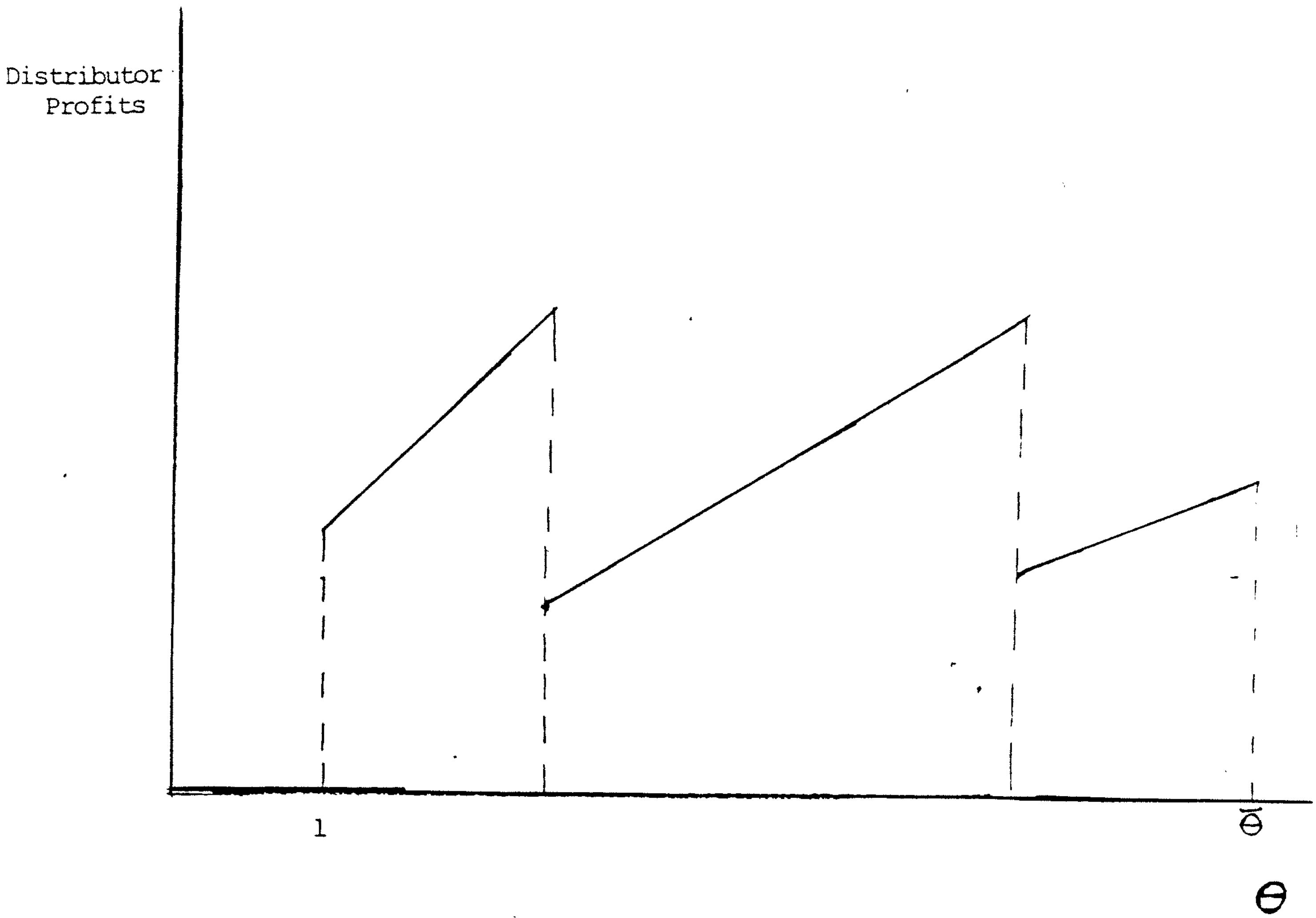


Figure II. Profits as a function of uncertain demand parameter Θ