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MOBILITY BARRIERS AND THE VALUE OF INCUMBENCY

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Abstract

This paper surveys developments in the theory of barriers to new competition for the forthcoming Handbook of Industrial Organization, R. Schmalensee and R. Willig (eds). Several definitions of entry barriers are considered and a definition is proposed that emphasizes rents to incumbency. Structural barriers, including economies of scale, product differentiation, and cost advantages are discussed and the conditions that determine their consequences for the mobility of capital are examined. Particular emphasis is placed on potential entrants' expectations of the behavior of incumbent firms.



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September 1988

## Table of Contents

I.	Introduction.....	3
II.	Determinants of the Conditions of Entry.....	10
A.	Scale Economies, Sunk Costs, and Limit Pricing.....	10
A.1.	The BSM Limit Pricing Model.....	11
A.2.	Behavior in the Theory of Limit Pricing.....	16
B.	Absolute Cost Advantages.....	25
B.1.	Opportunity Costs, Profits, and Rents.....	26
B.2.	Endogenous Cost Advantages.....	29
B.2.(a)	Experience-Related Cost Asymmetries.....	29
B.2.(b)	Network Economies.....	33
B.2.(c)	Raising Rivals' Costs.....	35
C.	Product Differentiation.....	41
C.1.	Switching Costs.....	47
III.	Fat Cats and Puppy Dogs.....	50
IV.	Entry, Dynamics and Industry Structure.....	53
A.	Dynamic Limit Pricing.....	54
B.	Multiple Incumbents and Entrants.....	61
V.	Exit Barriers and Asset Specificity.....	69
VI.	The Role of Information in Entry-Deterrence.....	74

VII. Contestable Markets.....	78
VIII. Mobility Barriers and Economic Performance.....	81
IX. Concluding Remarks.....	84

# Mobility Barriers and the Value of Incumbency

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## I. Introduction

The literature on the organization of markets is replete with definitions of barriers to entry. Bain defined the conditions of entry as "the extent to which, in the long run, established firms can elevate their selling prices above the minimal average costs of production and distribution (those costs associated with operation at optimal scales) without inducing potential entrants to enter the industry."<sup>1</sup> Bain's definition concentrates on the ability of established firms to earn excess profits. Stigler proposed a definition of barriers to entry that emphasizes the existence of relative cost advantages of established firms vis-a-vis new entrants. According to Stigler, "A barrier to entry may be defined as a cost of producing (at some or every rate of output) which must be borne by a firm which seeks to enter an industry but is not borne by firms already in the industry."<sup>2,3</sup> Baumol and Willig define an entry barrier as "anything that requires an expenditure by a new entrant into an industry, but that imposes no equivalent cost upon an incumbent."<sup>4</sup>

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Others have proposed definitions of entry barriers that directly address considerations of economic efficiency. Ferguson identifies barriers to entry as "factors that make entry unprofitable while permitting established firms to set prices above marginal cost, and to persistently earn monopoly return."<sup>5</sup> Ferguson's definition recognizes the divergence between price and marginal cost as an impairment to economic efficiency. Von Weizsacker also makes a direct connection between entry and economic welfare. Building on Stigler's definition, von Weizsacker defines a barrier to entry as: "A cost of producing which must be borne by a firm which seeks to enter an industry but is not borne by firms already in the industry and which implies a distortion in the allocation of resources from the social point of view."<sup>6</sup>

None of these definitions address the reasons why entry may be excluded. Consider a market large enough for a single firm to earn a profit, but not large enough for two or more firms to operate and both be profitable. The market is a natural monopoly, but that does not mean that entry is impossible. A new firm may be able to undercut the monopoly price of the established firm and force the firm to exit the market. If this could be accomplished with relative ease, barriers to entry in this market are arguably low. If not, the established firm could earn persistent monopoly profits while making entry unprofitable, in which case there would be a barrier to entry according to Bain and Ferguson. Stigler's definition would not assign an entry barrier to this industry if potential entrants have access to the same technology as the existing firm, and von Weizsacker would impose the additional requirement that entry should increase social surplus. The proposed definitions differ in their conclusions regarding the existence of entry barriers in this industry. Moreover, none of these definitions explain why an established firm

might, or might not, enjoy an advantage over other firms that could occupy the market.

The height of entry barriers in this market depend on the factors that determine the ability of the incumbent firm to maintain its output in the face of entry, about which more will be said in the remainder of this Chapter. This example also illustrates that the mobility of capital into an industry may well depend on the mobility of capital out of an industry. Concerns about limitations on entry should not be divorced from concerns about barriers to exit. Market efficiency depends on the conditions that restrict the mobility of capital in all directions.

Bain's treatise on barriers to new competition (Bain [1949, 1956]) distinguished the conditions of entry from the determinants of barriers to entry. His definition can be defended as a means to measure the height of entry barriers, rather than as a means to identify the reasons why entry is easy or hard. Toward the latter end, Bain proposed economies of scale, product differentiation, and cost asymmetries as the main determinants of entry barriers. Bain's proposed determinants are discussed in Section II, which argues that while provocative they only touch on the reasons for limits to the mobility of capital into an industry.

The definitions proposed by Stigler, von Weizsacker, and Baumol and Willig strike at the heart of asymmetries that might favor an incumbent firm over a potential entrant. The central question in entry deterrence is the value that is attached to incumbency: Why is it that an established firm may lay claim to a profitable market while other (equally efficient) firms are excluded? However, these definitions concentrate on the relative costs of an incumbent



and a new entrant, which is unnecessarily confining. Suppose the established firm could commit itself to producing the monopoly output at all times, and this being the case, no other firm can enter at a profit. Entry would be excluded in this market, but it is difficult to see why the incumbent has a cost advantage over a new firm. One might argue that a new firm could enter and if it could not undermine the incumbent's commitment, (e.g., through bribing customers to change their allegiance), it is at a cost disadvantage. This type of argument would resurrect Stigler's cost asymmetry as the determinant of entry barriers, but at the risk of constructing a tautology.

According to von Weizsacker's definition, a cost asymmetry is a barrier to entry only if it implies "...a distortion from the social point of view". Consider a Chamberlin [1933] model of an industry with differentiated products and free entry. With identical firms there are no profits in the Chamberlin model and hence according to Bain, Ferguson and Stigler there are no barriers to entry. Incumbent firms may earn rents if entrants suffer a cost or price disadvantage. But Chamberlinian competition can result in an excessive number of products as measured by total economic surplus<sup>7</sup>, in which case von Weizsacker's approach would not assign a barrier to entry in this industry because economic welfare would be improved by making entry more difficult.

This Chapter distinguishes between determinants of barriers to the mobility of capital and the welfare implications of entry and exit. The first task is confined to identifying situations in which a firm that is established in an industry benefits by reason of its incumbency. An incumbency advantage does not necessarily imply that welfare would be improved by encouraging entry. In many of the examples discussed in this Chapter, quite the opposite is true. Consumers would be disadvantaged if forced to switch to another

supplier. Industry costs would increase if entry eroded the benefits of economies of scale or learning. Entry prevention may result in both lower prices and lower costs than would occur if entry were allowed.

What is a barrier to entry, and more generally, the mobility of capital? This Chapter takes the view that a capital mobility barrier is a rent that is derived from incumbency. It is the additional profit that a firm can earn as a sole consequence of being established in an industry. No attempt is made to collect an exhaustive list of the determinants of entry. This Chapter identifies factors that may limit capital mobility and support an incumbency advantage, but no factor stands alone as either necessary or sufficient. Crucial to the consequences for capital mobility is the combined incidence of structural factors that may impede entry or exit and industry behavior. For illustration, suppose all firms have the cost function  $C(x) = mx + F$ , where  $x$  is output and  $F$  is a sunk cost. If industry behavior is such that two or more established firms would act as perfect competitors, then entry would result in price equal to marginal cost and no firm would earn a profit. The only sustainable market structure would be a monopoly. Contrast this with a situation where incumbent firms always choose to keep their prices unchanged in response to entry. In the latter case, entry may be feasible even in an industry that is a natural monopoly.

A theory of barriers to entry cannot be constructed in isolation from a theory of oligopoly behavior. As the Chapter by Carl Shapiro shows, the scope for oligopolistic interactions is so wide that a predictive model of how firms behave may be no easier to construct than a model of the weather based on the formation of water droplets.

The value derived from incumbency begs the question of how incumbency is obtained. Firms may enjoy a positional advantage as a consequence of history, reputation, or sheer accident. For the most part, the discussion in this chapter will assume that one or more incumbent firms are already in the industry. Of course this obscures much that is interesting about strategic behavior with regard to capital mobility. If there is advantage to being an established firm, then unestablished firms will compete for the opportunity to become established. The process of this competition can involve investments and commitments that affect the ultimate value of the incumbent position.

The plan of this Chapter is as follows. Section II describes Bain's determinant's of barriers to entry and shows how they may be interpreted in the light of more recent contributions to the theory of strategic entry deterrence. This Section introduces the role of behavior in the determination of the conditions of entry, which is discussed further in Section III. An objective of this study of capital mobility is the development of a theory of endogenous industry structure. Progress that has been made in this direction is discussed in Section IV. Section V calls attention to the importance of exit barriers and specific assets in the theory of capital mobility.

Strategic entry deterrence is designed to influence the behavior of potential rivals. It is effective only to the extent that potential competitors look to current behavior as indicative of future market conditions. The role of information and its consequences for entry-detering behavior is the subject of Section VI.

If it is not possible to provide an exhaustive list of the determinants of barriers to entry, it is at least possible to describe a market in which barriers to capital mobility do not exist. This is the world of perfectly contestable markets, discussed in Section VII. Firms are equally efficient and each firm can imitate the products and services of any other firm. Cost functions need not be convex, but all expenditures are potentially reversible. The result is a market that performs as close as possible to the competitive ideal. Price equals marginal cost unless the industry is a natural monopoly, in which case price equals average cost. A key characteristic of a perfectly contestable market is that each firm acts as if it faces a perfectly horizontal demand function for any increase in price. This condition can serve as a definition for the absence of barriers to entry.

Section VIII is a brief discussion of the connections between barriers to entry and market performance. It is emphasized that the existence of barriers to the movement of capital does not imply a reduction in economic welfare. Mobility constraints may decrease welfare relative to a first-best allocation of economic resources, but we do not live in a first-best world. Mobility barriers arise for reasons of technology and consumer tastes and need not impair efficiency in an imperfectly competitive economy. Indeed, there are many circumstances where economic welfare is strictly improved by impeding entry into an industry.

This Chapter overlaps with others in this Handbook. It is impossible to divorce strategic entry deterrence from considerations of oligopoly behavior discussed by Carl Shapiro. The Chapter by Janusz Ordover and Garth Saloner on predation is closely related to issues discussed here. A distinction is that predation deals with strategies whose rationality depends on inducing

exit and preventing future entry, whereas entry deterrence is concerned with the conditions that impede capital mobility. The connections are nevertheless quite close and I encourage readers interested in this subject to consult these other sources.

With the large number of papers that have appeared in recent years dealing with strategic behavior and barriers to entry, there is not enough room to do complete justice even to this limited subject. In an attempt to confine my inquiry, I have limited the scope of this Chapter to the theory of mobility barriers. Empirical work on mobility barriers is surveyed in Geroski, Gilbert and Jacquemin [forthcoming].

## **II. Determinants of the Conditions of Entry**

As determinants of the conditions of entry, Bain [1949] identified economies of large scale, product differentiation, and absolute cost advantages of established firms. This list is neither a complete nor accurate enumeration of the factors that may limit capital mobility in an industry. Nonetheless, Bain's determinants of entry provide a convenient jumping-off point to discuss the structural determinants of mobility barriers. The sections that follow briefly describe Bain's arguments and show how they have been interpreted and extended in light of more recent developments.

### **A. Scale Economies, Sunk Costs, and Limit Pricing**

According to Bain, "The condition that there should be no significant economies to the large scale firm means of course that an entrant firm, even

if it enters at an optimal or lowest-cost scale, will add so little to industry output that its entry will have no perceptible effect on going prices in the industry".<sup>8</sup> In the absence of scale economies, entry is not limited by the size of the market. Bain and several of his contemporaries, notably Paulo Sylos-Labini [1962] and Modigliani [1958], investigated the consequences of market size for the conditions of entry when the production technology exhibits economies of scale. Their work led to the classic "limit-pricing" model of behavior by a dominant firm or cartel.

### A.1 The Bain-Sylos-Modigliani Limit Pricing Model

The essential assumptions of the Bain-Sylos-Modigliani (BSM) limit pricing model are:

1. There are two periods: pre-entry ( $t=0$ ) and post-entry ( $t=1$ ). Entry may occur only in period 1.
2. There is a single established firm or a coordinated cartel, "the incumbent" (labelled  $i$ ), and a single potential entrant ( $e$ ).
3. Consumers are indifferent between purchases from the incumbent or the entrant and have no costs of switching suppliers.
4. Demand does not change over time.
5. In period  $t=0$ , the incumbent can commit to an output level  $x_i$  which the entrant believes it will maintain in period 1.

The last assumption implies that the incumbent can act as a Stackelberg leader in output. The entrant acts as a Cournot follower, believing that the established firm will continue to produce at its pre-entry output level regardless of the entrant's actions or the final price that prevails in the market.

The market price is  $P(x_i)$  in the first period and  $P(x_i + x_e)$  in the second period, where  $x_e$  is the entrant's production. Suppressing factor prices, the entrant's profit is

$$\pi_e(x, x_i) = P(x_i + x)x - C_e(x) \quad (1)$$

where  $C_e(x)$  is the entrant's cost function. Let  $x_e$  be the entrant's profit-maximizing output taking  $x_i$  as given. The firm should enter if its maximum profits are positive and should stay out otherwise. The limit output,  $Y$ , is the smallest  $x_i$  for which  $x_e$  is zero (no entry). The associated limit price is  $P_L$ .

The elements of the limit pricing model come together in Figure 1. The incumbent and the potential entrant have the same average cost curve, AC. The potential entrant expects the incumbent's output to remain fixed and maximizes its profit given the residual demand curve  $D(P) - x_i$ . This is shown by using  $x_i$  rather than the original axis as the ordinate for the entrant's demand and cost curves. As shown in Figure 1, given  $x_i$ , there is no output at which the entrant can earn a positive profit. The incumbent's output shown in Figure 1 is the smallest output that yields everywhere negative profits for the entrant, hence  $x_i = Y$ . The associated price is the limit price,  $P_L$ .

All else equal, the limit price is lower the flatter is the residual demand curve (in the sense that a rotation about the point  $(x_i, P_L)$  makes entry more profitable.) Also, entry is easier if the entrant's minimum efficient scale is small and if the average cost falls quickly to its lowest level.

In the BSM model the entrant behaves as a Cournot competitor. For the special (but simple) case of linear demand

$$P = a - bX \quad (2)$$

and the cost function

$$C(x) = mx + F \quad (3)$$

the entrant's reaction function is

$$x_e = \begin{cases} (a-m-bx_i)/2b & \text{if } x_i \leq Y \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

where

$$Y = (a-m)/b - 2(F/b)^{1/2} \quad (5a)$$

and the corresponding limit price is

$$P_L = m + 2(F/b)^{1/2} \quad (5b)$$

Bain used the term blockaded entry to refer to a situation where the output of established firm(s) exceeds the limit output when the possibility of entry is ignored. For example, a monopolist blockades entry if the monopoly output is larger than the limit output. If entry is not blockaded, established firm(s) have to compare the benefit of entry prevention against the cost. If the conditions of entry are such that the established firm(s) can prevent entry with a limit output that is not too large, the benefits from preventing



entry exceed the cost. This is the condition Bain referred to as effectively impeded entry. When entry is very easy, the limit price may be so low that incumbent firm(s) are better off allowing entry to occur. Bain called this ineffectively impeded entry.

Figure 2a shows the entrant's reaction function for the case where  $Y$  is relatively small (entry is difficult). Also shown are two isoprofit curves. The curve labelled  $\pi^L$  goes through the point  $(x_i=Y, x_e=0)$ , and corresponds to the profit earned when entry is prevented. The curve labelled  $\pi^A$  is the locus of outputs that yield an incumbent profit equal to the maximum profit that the incumbent could earn if entry is allowed. This is the Stackelberg optimum for the incumbent when entry is allowed and corresponds to the profit earned at the point  $(x_i=S, x_e=E)$ . Incumbent profits are a maximum at the monopoly point  $(x_i=(a-m)/2b, x_e=0)$  and higher isoprofit curves imply lower profits. In Figure 2a, the incumbent is better off when entry is prevented and entry is "effectively impeded". Note that if  $Y$  were to the left of the monopoly output,  $(a-m)/2b$ , entry would be blockaded.

Figure 2b shows a situation with easy entry. Now the positions of the  $\pi^L$  and  $\pi^A$  isoprofit contours are reversed. The incumbent is better off allowing entry and entry is "ineffectively impeded".

The BSM limit output is determined by demand and the entrant's technology. Figure 3 shows the incumbents' optimal output as a function of the limit output,  $Y$ .<sup>9</sup> The figure illustrates the following conclusions, which follow directly from the limit pricing model.

(i) Let  $x_0$  be the incumbents' optimal output ignoring entry. If  $x_0$  exceeds  $Y$ , entry is blockaded.

(ii) The smallest limit output for which incumbents maximize profits by allowing entry strictly exceeds  $x_0$ .

(iii) At the limit output for which the incumbent is indifferent between preventing and allowing entry, total output is strictly lower and price is strictly higher when entry is allowed.

Result (i) is just the definition of blockaded entry. Results (ii) and (iii) follow from the discontinuity of the entrant's reaction function. If the firm enters the market, it produces an output bounded away from zero. Consider the incumbents' incentive to prevent entry when  $Y$  is near  $x_0$ , which is indicated in Figure 3 by  $Z_0$ . If  $Y = x_0$ , the incumbents' total profit when entry is ignored is the same as when entry is prevented. If  $Y$  is slightly larger than  $x_0$ , the incumbents can earn almost the same amount by preventing entry. But if entry is allowed, the new firm produces a strictly positive amount and therefore the total profits of the incumbent firms must fall by a discrete amount. Thus the incumbents are better off preventing entry when  $Y$  is only slightly larger than  $x_0$ .

In Figure 3,  $Z_1$  is the limit output at which incumbents are indifferent between allowing and preventing entry. Incumbents produce  $Z_1$  if entry is prevented, but if entry is allowed, incumbents produce a total output  $S < Z_1$ . (See the Stackelberg solutions in Figures 2a,b.) To be indifferent, given the lower incumbent output with entry, the post-entry price must be higher than the limit price.

## A.2. Behavior in the Theory of Limit Pricing

The BSM model assumes that the incumbent firms can convince potential entrants that they will continue to produce at the pre-entry output level regardless of whether or not entry occurs. This assumption was recognized as crucial early in the development of the theory of limit pricing. One can easily see how alternative theories of firm behavior would upset the limit pricing result.

Suppose the potential entrant conjectures that if it were to enter the market, it would compete with established firms as a Cournot oligopolist. For the case of a single established firm, the resulting post-entry equilibrium would appear as in Figure 4. The entrant cares only about profits in the post entry game. It will choose to enter if the Cournot equilibrium output is to the left of the limit output,  $Y$  (as indicated in Figure 4), and will stay out of the market otherwise. The established firm's pre-entry price and output have no bearing on the equilibrium of the post-entry game and will properly be disregarded by the potential entrant. There is no scope for limit pricing in this model. The incumbent might as well set the monopoly price in the pre-entry period. Any other choice would sacrifice profits in the pre-entry period with no consequences for the likelihood of entry.

Cournot competition is not the only plausible conjecture for the nature of competition in the post-entry game. Spence [1977] examined a model of entry deterrence in which he assumed that the post-entry game would be perfectly competitive, which implies that the post-entry price equals marginal cost. Again, pre-entry output is no longer an indication of post-entry profitability and the BSM limit pricing model breaks down. Spence argued that the incumbent

firms may invest in additional production capacity in order to lower their post-entry marginal cost and therefore lower the post-entry price and profitability for the entrant. Because the pre-entry price is no longer a signal of post-entry profitability, the incumbents can choose the monopoly price in the pre-entry stage, given their production costs.

The BSM, Cournot, and perfectly competitive models differ only in their assumptions about the behavior of the firms in the industry. Structural factors play an important role in the profitability of entry and in its effect on market performance, but behavior is crucial. For example, suppose incumbents could deliver a message to all potential entrants that says "if you enter, we will produce enough to force the price down to zero." Call this the "tough" strategy. It contrasts with a "soft" strategy, in which incumbents play their Cournot-Nash best responses. The payoff matrix corresponding to these strategies is shown in Table 1, below.

Table 1

Payoff Matrix

		Incumbent Firms	
		tough	soft
Potential Entrant	entry	[-1,-1]	[0,1]
	no entry	[1,0]	[1,0]

The payoffs are listed for the incumbents first and the entrant second. The potential entrant receives zero if it doesn't enter. Its preferred outcome is to enter and have the incumbents play soft. Entry against tough opponents is a disaster. The incumbents prefer no entry, in which case whether they are "tough" or "soft" is irrelevant. They earn a return of "1" in either case.

There are two Nash equilibria of this game: [tough, no entry] and [soft, entry]. Taking the incumbent's threat as a serious proposition, the entrant's best response is to remain out of the industry. Given the entrant's strategy, the incumbent's best choice is to threaten an aggressive response if entry should occur. But the problem with the incumbent's threat (specifically, the equilibrium [tough, no entry]) is why would a potential entrant take it seriously? If the firm actually entered, the incumbent's best response is to play "soft". The entry game in Table 1 has two Nash equilibria, but only one of them is an equilibrium of a sequential game in which the entrant could forecast how an incumbent firm would respond if it tested the market by entering. In the language of Selten [1975], [soft, enter] is a "subgame perfect Nash equilibrium" of the sequential game. The equilibrium [tough, no entry] is not perfect: it is not robust to the experiment in which the firm tests the market by entering. (See Chapter by Drew Fudenberg and Jean Tirole and Chapter by Carl Shapiro in this Handbook for definitions of subgame perfect Nash equilibrium.)

The concept of perfection eliminates threats that are not "credible". But what is "credible" depends on the micro-structure of the game and perhaps on expectations of the entrant about the behavior that can be expected from incumbent firms.<sup>10</sup>

Avinash Dixit [1981] posed the problem of an entrant's rational conjecture about post-entry competition in the following way. Suppose there is one incumbent, one potential competitor and two periods: "before" and "after" entry. Entry can occur only in the second period. If entry occurs, Dixit supposes that the two firms behave as Cournot competitors. Agents have perfect foresight about the consequences of actions taken in the first period for equilibrium outcomes in the second period. The incumbent uses this "look-ahead" to determine its best first-period actions.

Let the vector  $z_t$  summarize the incumbent's actions in period  $t = 1, 2$ . The entrant's optimal output is  $r(z_1, z_2)$ . By solving for the entrant's optimal response conditional on the incumbent's choice of  $z_1$ , Dixit ensures that all equilibria of the entry game have the property of being perfect Nash equilibria, as defined by Selten [1975] and Kreps and Wilson [1982b]. The incumbent's total profit is

$$\pi(z_1) + \beta\pi(z_1, z_2, r(z_1, z_2)) \quad (6)$$

The incumbent has an incentive to act strategically in the first period only if the entry decision or entrants' subsequent production decisions depend on  $z_1$ . If not, the incumbent should maximize first-period profits without regard to entry. Strategic entry deterrence requires an intertemporal linkage between actions that the incumbent may take prior to entry and the probability or extent of subsequent entry.

This intertemporal linkage can arise in many ways. An incumbent may attempt to influence rivals' future demand through advertising or building a reputation for quality and service. An incumbent may locate retail branches

in preferred locations or acquire key resources in an attempt to disadvantage future potential entrants. None of these strategies guarantee successful entry deterrence, but they establish the feasibility of strategic behavior by providing a connection between pre-entry behavior and post-entry outcomes.

Dixit achieves an intertemporal linkage by allowing for capital expenditures that, once made, become irreversible or "sunk" in the next period. This allows an established firm to commit to an output that it could not sustain as an equilibrium if its first period expenditure were reversible. The incumbent is able to turn a liability (irreversibility of capital investment) into a key asset that makes entry deterrence feasible. This is a striking feature in Dixit's model, but one that follows directly from the logic of game theory (see e.g. Schelling [1960]).

Consider the case of linear demand,  $P = a - bX$ , and identical firms with constant marginal costs. If investment is perfectly reversible, the cost structure is simply

$$C(x) = mx + F \quad (7)$$

where  $F$  is a fixed cost that can be recovered upon exit from the industry.

The reaction functions of the incumbent and the potential entrant are shown in Figure 4. There is a single Nash equilibrium with both firms operating. Entry is profitable in the second period if (as shown) the Cournot equilibrium output is less than  $Y$ . Dixit introduces a simple, yet very important extra dimension to this example. He allows production cost to depend on installed capacity,  $K$ , in addition to output. Both are measured in the same units (e.g.

tons/yr of output and tons/yr of capacity). Capacity has a cost of  $s$  per unit and, once installed, has no alternative use. The cost function is

$$\begin{aligned} C_j(x,K) &= vx + sK + F \quad \text{for } x < K \\ &= (v+s)x + F \quad \text{for } x = K \end{aligned} \quad (8)$$

The marginal cost function is shown in Figure 5. The marginal cost is  $v$  whenever there is excess capacity and  $v+s$  when capacity and output are equal.  $F$  remains as a reversible fixed cost.

The incumbent has sunk costs in the amount of  $sK$ , where  $K$  is the incumbent's installed capacity. A potential entrant has no sunk costs, because it has not yet invested in capacity. The entrant's cost function is simply

$$C_e(x) = (v+s)x + F \quad (9)$$

The reaction functions corresponding to the cost functions in (8) for the incumbent and (9) for the potential entrant are shown in Figure 6. The reaction function labelled  $R^i(x_e | m)$  is the incumbent's reaction function when the firm has no excess capacity (that is, when  $K = x_i$ ), so that its marginal cost is  $v+s = m$ . If  $K > x_i$ , the incumbent's marginal cost is only  $v$  and its reaction curve is  $R^i(x_e | v)$ , which is to the right of the reaction function with no excess capacity. The reaction function that the incumbent is "on" depends upon the installed capacity and its output  $x_i$ . The entrant has no installed capacity. Therefore, with respect to the entry decision, the entrant faces a marginal cost of  $v+s$ , which includes the cost of capacity. The entrant's reaction function is shown as  $R^e(x_i | m)$  in Figure 6.



If the incumbent has no installed capacity, its reaction function is  $R^i(x_e | m)$  and the Cournot equilibrium occurs at the point  $E(m,m)$ . If the incumbent holds excess capacity, its reaction function is  $R^i(x_e | v)$  and the Cournot equilibrium occurs at  $E(v,m)$ . Depending on the incumbent's choice of capacity,  $K$ , the post-entry equilibrium can be at any point between A and B on the entrant's reaction function. The point A corresponds to the incumbent's equilibrium output at  $E(m,m)$ . This is the incumbent's smallest output that can be sustained as a Cournot equilibrium. The point B corresponds to the incumbent's output at  $E(v,m)$  and is the incumbent's largest output that can be sustained as a Cournot equilibrium. Outputs intermediate between A and B are equilibria for corresponding capacity investments,  $K$ . If, given an investment in capacity,  $K$ , the equilibrium output that results if a firm entered the market is such that the entrant would not break even, a rational firm would choose to stay out of the market. Thus the incumbent's capacity investment is a way to make a BSM limit output "credible".

Although sunk costs in the Dixit model allow an established firm to prevent entry, sunk costs are actually a barrier to exit, not entry. The fact that some of the incumbent's costs are sunk means that the incumbent cannot leave the market and recover its costs. If it could costlessly exit, the incumbent would have the same reaction function as the entrant and strategic entry deterrence would be impossible. The possibility that the entrant may incur sunk costs is irrelevant because the entrant never makes a mistake in the Dixit model. The entrant has perfect foresight and there is no "third period" in which new information may arise. Sunk costs are an exit barrier for the incumbent that permit the firm to act strategically and capitalize on the entrant's need to operate at a large scale in order to make a profit. Sunk costs are not themselves an entry barrier. Sunk costs allow an established

firm to commit to a preferred output, much as a Stackelberg leader. If the entrant's cost function is non-convex, this output commitment can succeed in preventing entry.

Capital investment in the Dixit model can be an effective entry deterrent even if the potential entrant has the same cost function as the incumbent (or even if it has lower costs). This seems to be in contrast with Stigler's definition of a barrier to entry, which relies on asymmetric costs of established and new firms. In the Dixit example there is room in the industry for more than one firm, both the entrant and the incumbent have the same ex-ante cost function, and entry can be deterred. Yet there is no Stiglerian barrier to entry based on ex-ante costs. One can interpret Stigler's definition to exclude costs that are sunk, but this is not the apparent intention of his definition. Also, in the Dixit model, the amount of costs that are sunk do not correspond to the height of the barrier to entry as measured by the cost advantage the entrant must have to successfully enter the industry. (see Schmalensee [1981]).

The result in Dixit's model is incumbent behavior that is similar to the limit-pricing behavior in the BSM model. The incumbent invests in (sunk) capacity which allows the firm to commit to a fixed output in excess of  $A$  in Figure 6. This commitment is larger than the incumbent's post-entry equilibrium output that would result if its capital costs were not sunk. The output commitment reduces the demand available to the entrant and allows the incumbent firm to exploit economies of scale in the entrant's production technology.

Entry deterrence in the Dixit model is the result of both scale economies for the entrant and behavior by the incumbent that enforces a limit output. The limit output is made credible by the sunk cost technology of the incumbent firm. Although sunk costs imply economies of scale in the short run (when capital is sunk), the incumbent's production technology need not display economies of scale in new investment for successful entry deterrence.

Dixit's example yields predictions that are consistent with the BSM model of limit pricing, in that the entrant can correctly forecast that the incumbent will not change its output in response to entry. But the comparative statics of the models can be very different. For example, in the BSM model, a ceteris paribus decrease in the elasticity of demand makes entry more difficult. Not so in the Dixit model. Entry prevention requires the ability to commit to an entry-detering output. If demand is less elastic, the incumbent may not have an incentive to produce the quantity required for entry-prevention. The incumbent may be better off preventing entry, but the incumbent may not be able to commit to the necessary limit output. (see Gilbert [1986]).

The logical lesson from the Dixit model is that strategic incentives for entry deterrence depend on the correlation between actions which the incumbent can take prior to entry and competition in the post-entry game. By investing in sunk capital, the incumbent can lower its marginal cost and increase its post-entry equilibrium output. Actions which make the post-entry game more(less) competitive for the incumbent would increase(decrease) the scope for feasible entry deterrence. Figure 7 illustrates how an action that lowers the incumbent's marginal cost by a greater amount would affect the post-entry game. With a marginal cost  $v_1$ , the incumbent's maximum equilibrium output is  $B_1$ . With a marginal cost  $v_2 < v_1$ , the incumbent's maximum output increases

to  $B_2$ . If the limit output were between  $B_1$  and  $B_2$  (as shown), entry could be prevented with marginal cost  $v_2$ , but not with  $v_1$ .

The incumbent never holds excess capacity in the Dixit model because the post-entry equilibrium output never exceeds the incumbent's pre-entry output. Any pre-entry excess capacity would remain unused after entry and therefore could not serve as an entry deterrent. Bulow, Geanakoplos and Klemperer [1985] argue that this result depends on the slopes of the firms' reaction functions. Dixit assumed that firm's reaction functions are everywhere downward sloping. Therefore, post-entry equilibria are always to the left of the incumbent's pre-entry output and pre-entry excess capacity would never be used post-entry. If reaction functions slope up, this result could be reversed and excess capacity may be desirable. The incentive for strategic entry deterrence and its relation to the slopes of reaction functions is discussed in more detail in Section III below.

## B. Absolute Cost Advantages

Bain defined the absence of absolute cost advantages of an established firm by the following conditions. "...For a given product, potential entrant firms should be able to secure just as low a minimal average cost of production after entry as established firms had prior to this entry. This in turn implies (a) that established firms should have no price or other advantages over entrants in purchasing or securing any productive factor (including investible funds); (b) that the entry of an added firm should have no perceptible effect on the going level of any factor price; and (c) that established firms have no preferred access to productive techniques."<sup>11</sup>

## B.1 Opportunity Costs, Profits, and Rents

Absolute cost advantages appear to be the simplest of Bain's determinants of the condition of entry. If a potential entrant has a cost disadvantage with respect to an established firm, this is a factor that can allow the established firm to maintain price above cost. But one does not have to go far to uncover problems with the notion of absolute cost advantages as a barrier to entry. A cost disadvantage arising from inefficient production techniques should not be considered a barrier to entry. At a minimum, absolute cost disadvantages should be qualified to refer to some factor of production that is denied the potential entrant, and but for this omitted factor, the firm would be as efficient as established firms.

An ambiguity in Bain's discussion of absolute cost advantages is the role of opportunity costs. A scarce factor of production, be it a retail outlet on the best street in town, managerial expertise, or a superior ore deposit, has an opportunity cost of use. This opportunity cost must be considered in any decision to continue operations or to transfer ownership of a scarce factor to a competitor. When this opportunity cost is considered, an apparent absolute cost advantage may disappear.

Demsetz [1982] poses as a conundrum for definitions of barriers to entry the example of taxi medallions issued by a municipality and traded at market-determined prices. The medallions are limited in supply and are required to operate a taxi. The medallion requirement is an impediment to the total entry of taxi services in this market. Yet because medallions trade at market-determined prices, they are not an absolute cost advantage for any established taxi and they do not allow established taxis to elevate price

above cost (given the opportunity cost of medallions). Even if established taxis obtained their medallions for free, the market price remains the opportunity cost of their use.

Consider a more extreme example, that of a key patent such as the xerography process. Although there is no public, market-determined price for the patent, it has a market value which is the present value of the profits it can earn in its next best use. This is the opportunity cost of the patent for its owner. Unless the patent is worth more to its owner than its opportunity cost, it should be sold and thus would not be a barrier to entry for any firm willing to pay the price.

There is no distinction between the taxi medallion and the patent as a barrier to entry. In either case, the medallion or the patent may give its owner some power to set price, depending of course on the circumstances of competition in the markets where they are used. But neither the patent nor the medallion allow their owners to earn an economic profit when the value to each owner equals the value in its next best use, and this opportunity cost of ownership is taken into account.

In the context of mobility barriers, the question is whether absolute cost advantages confer a rent to incumbency. The test for the existence of a mobility barrier is whether access to the scarce resource allows a firm to earn positive profits after accounting for the opportunity cost of the resource, when there is potential entry from equally efficient firms. If the value of the resource in its next best use is the same as its value to the incumbent, its opportunity cost includes the profits that can be earned with the resource, and hence there can be no rent to incumbency.

An absolute cost advantage can confer an incumbency advantage if the value of the resource in its next best use is less than its value to the incumbent firm, for reasons other than inefficiency on the part of potential entrants. One possibility, discussed in Section V below, is that resources may be specific to particular firms. For example, it may be the case that the value of the xerography patent, (prior to expiration and mandatory licensing), to the owners and managers of the physical assets called the Xerox Corporation exceeded its value to any other firm.

Although absolute cost advantages need not be mobility barriers, they may nonetheless impede the total entry of productive resources into an industry and interfere with economic efficiency. The supply of taxi medallions reduces the supply of taxi services. Patent rights intentionally impede total entry into an industry. But neither the patent nor the medallions necessarily confer an incumbency advantage.

As Demsetz [1982] maintains, the real entry barrier in the taxi service industry is at the level of the municipality that has the power to issue medallions. Similarly, in the patent example, the entry barrier is at the level of the legal authority in the Patent Office to issue patents. Moreover, at these stages, incumbency rents can be identified. The incumbent in this case is the legal authority that governs the supply of the scarce resource. Regulatory barriers to the supply of patent rights, or the supply of alternative (legally recognized) taxi medallions, confer rents on the established authorities. The barriers to the mobility of resources are not typically present in the "downstream" industries that use the scarce resources, but rather exist "upstream" in the structure of regulatory authority.

## **B.2. Endogenous Cost Advantages**

Strategic behavior intended to impede the mobility of capital may take place on the demand side of the market, for example through advertising designed to exploit brand preferences, or on the supply side by attempting to increase cost asymmetries. This section considers strategic behavior targeted to exploiting experience-related cost advantages (or "learning-by-doing") and network economies that arise in demand. As these cost asymmetries either result from or are intensified by firm behavior, they are grouped under the category of "endogenous" cost advantages. This section concludes with a brief review of the more general topic of strategic attempts by incumbent firms to raise rivals' costs.

### **B.2.(a) Experience-Related Cost Asymmetries**

"Practice makes perfect" is the underlying presumption of theoretical and empirical studies of economies related to on-the-job experience. There are many engineering and econometric studies in support of the conclusion that, at least in several important industries, more time on the job is associated, *ceterus paribus*, with lower production costs (see e.g., Lieberman [1984]). Experience may be measured by time, cumulative output or some other variable related to job tenure. From the perspective of mobility deterrence, the interesting characteristic of experience-related economies is that an established firm enjoys a cost asymmetry relative to new entrants, and this asymmetry can be preserved by merely imitating the actions of competing firms. This presumes that the benefits of experience are a private good and do not spread to other industry participants. If so, the cost asymmetry may be lost or at least severely reduced and any strategic advantages that may follow from



experience would be correspondingly limited. Lieberman [1984] has found that the diffusion of learning is common, but it will be ignored in what follows in order to concentrate on the value of experience economies in entry deterrence.

The learning-by-doing phenomenon can be illustrated with a simple two-period model. In the first period, there is an established firm with constant marginal cost  $c_1$ . In the second (and final) period, the firm's constant marginal cost depends on its first period output  $x_1$  with

$$c_2(0) = c_1 \quad \text{and} \quad c_2'(x_1) < 0$$

In the second period one or more firms may enter the industry. Each of the potential entrants has a constant marginal cost  $c_1$ , the same as the incumbent's first-period marginal cost (and lower than the incumbent's current cost if  $x_1 > 0$ ).

The conditions of entry and in particular whether entry will be prevented depend not only on the cost advantage of the established firm, but also on the nature of competition in the second period. For example, with Bertrand-Nash competition and any cost advantage for the established firm, the second period price will be just below the entrant's cost. Hence any cost advantage for the incumbent would be sufficient to prevent entry.

Depending on the nature of competition in the industry and the rate at which learning-by-doing lowers costs, learning economies need not have the effect of making entry more difficult. Indeed, it is possible that learning economies can make the established firm more willing to allow entry into the

industry. Consider an example where the established firm has one of two choices. It can either prevent entry by committing to a price less than  $c_1$  in the second period, or it can choose to allow entry, in which case all firms in the industry act as Cournot competitors. The assumption that the incumbent can commit to a second-period price is analogous to the quantity commitment in the BSM limit pricing model. It also shares with that model the problem of maintaining a credible commitment.

Assume that there is a single potential entrant, although the analysis is easily extended to more than one. The established firm can prevent entry and earn arbitrarily close to

$$\pi^L = (c_1 - c_2)X(c_1) \quad (10)$$

where  $c_2$  is the firm's cost in the second period ( $c_2 = c_2(x_1) \leq c_1$ ) and  $X(c_1)$  is total demand at the entry-preventing price  $c_1$ .

If  $c_2$  is very close to  $c_1$ , the established firm can't earn much by preventing entry and is better off allowing entry to occur. In addition, if  $c_2$  is much less than  $c_1$ , the established firm may be better off with entry because the resulting price could be higher than the entry-preventing price,  $c_1$ . This means that learning economies need not make entry more difficult into an industry.

The circumstances for which the established firm would allow entry are summarized in Figure 8 for the case of linear demand. Entry would be allowed if  $c_2$  is close to (or larger than)  $c_1$ . If  $c_1$  is close to the demand intercept,  $a$ , or if  $c_1$  is very small, entry is allowed for any value of  $c_2 < c_1$ . Entry

is blockaded by the monopoly output when  $c_2$  is much less than  $c_1$ . For intermediate values of  $c_1$ , the established firm would allow entry if learning is either very slow or very rapid. Entry prevention occurs only for intermediate cost advantages. For a small cost advantage, entry is allowed because preventing entry by pricing at  $c_1$  squeezes the established firm's profits more than competition does. This is all the more important a consideration when  $c_1$  is small. If the established firm's cost advantage is large, entry is allowed (or blockaded) because the entrant will not produce much anyway, and this is less costly than pricing at a level sufficient to deter all entry.<sup>12</sup>

Experience-related economies do not necessarily constitute a barrier to entry and their existence may facilitate entry in some situations. Experience-related economies do imply increasing returns to scale, as the concentration of production allows a greater cost reduction. This assumes, of course, that there are no other factors at work that inhibit the value of learning, and it also assumes that learning is firm-specific and does not spill-over to competitors. These restrictions are severe. (See Spence [1984] and Kreps and Spence [1984] for a discussion of the consequences of spill-overs in a model with learning.

The consequences of experience-related advantages for strategic behavior are likely to depend on the specific competitive situation in which they may occur. Fudenberg et al [1983] and Harris and Vickers [1985] consider models of innovation in which experience lowers the expected cost of winning a patent. One can imagine the process of research and development toward a patentable product as an Easter egg hunt, and a firm that has spent longer at the hunt and turned over more stones is at an advantage in securing the

ultimate prize. In the Fudenberg et al model, a firm that is ahead in the race for a patent can be "leapfrogged" by a particularly aggressive (and lucky) rival. Nonetheless, they show that if a firm has a large enough lead, rival firms will exclude themselves from the race and the leader will enjoy a monopoly. If the firms are close in experience, they compete vigorously until one of the firms pulls ahead and becomes the clear leader, at which point the other firms drop out of the race.

### **Network Economies**

Network economies refer to complementarities that may exist in consumption or production. The telecommunications industry is an often-cited example of network economies. The value of telephone service to any one subscriber depends on the number of subscribers to the system with whom the customer might wish to speak. Learning economies are a special case of network economies where experience replaces the effects of market size.

A simple way in which to model network economies that arise on the demand side of the market is through an inverse demand specification,  $P(Q,N)$ , where  $Q$  is total demand and  $N$  is the number of subscribers, with  $P_N(Q,N) > 0$ . This captures the positive externality of market size for willingness-to-pay for the service. Network economies imply an economy of scale: either willingness-to-pay increases or production cost decreases with the size of the market. The implications for entry-deterrence parallel the results for markets with experience-related economies. Their consequences are explored in Katz and Shapiro [1985,1986] and Farrell and Saloner [1986].

Product standardization is a means to appropriate economies that arise as a result of complementarities in production or demand and hence is closely related to network economies. Adams and Brock [1982] suggest that compatibility standards can be used by an established firm to maintain monopoly power. Matutes and Regibeau [1986a,b] explore this proposition further and find that the opportunity to produce compatible (or incompatible) products can have diverse effects. The opportunity to produce compatible products can lead to higher profits and increased total surplus, although consumers can be worse off with product standardization. Product standardization can lessen a firm's ability to price discriminate among different customers. This can be particularly disadvantageous for a large firm, but it can also enable a firm to forestall entry by making a credible commitment to charge uniform prices across markets that may serve as entry points into the industry.

### **Raising Rivals' Costs<sup>13</sup>**

Production decisions that exploit experience-related economies are one example of strategic behavior that has consequences for cost asymmetries. Salop and Scheffman [1983, 1986] explore a general market environment in which unilateral behavior by established firms has the effect of raising industry costs of operations. The gist of their model follows closely Bain's second condition for the absence of absolute cost advantages: "...(b) that the entry of an added firm should have no perceptible effect on the going level of any factor price." Salop and Scheffman argue that behavior intended to increase industry costs can benefit established firms (despite increasing their own cost) because it causes rival firms to reduce their output (perhaps to zero).

Salop and Scheffman's arguments are related to an observation by Williamson [1968], who noted that efforts to increase union wages in coal mining could benefit a firm by making entry of rival firms into the industry more difficult. A classic allegation of strategic behavior designed to raise costs for potential competitors is the Alcoa Corporation's acquisition of bauxite ore deposits which, it was argued, was designed to foreclose entry.<sup>14</sup>

Patent activity can be directed to increasing the cost of entry as well as improving productivity. An extreme example is a "sleeping patent" whose value derives from denying access to the technology by competing firms (see Gilbert [1981] and Gilbert and Newbery [1982]). But patents are rarely of sufficient scope to block competing technologies and hence their value in entry prevention is limited.

The "raising rival cost" argument can be illustrated with a simple model. Suppose there is an established firm and a single potential entrant. The entrant's costs depend on its own output,  $x_e$ , and the vector of factor costs,  $w$ . The latter depend on the competitive environment, which I will summarize by a vector  $a = (a_i, a_e)$  describing the actions of the incumbent firm ( $a_i$ ) and the entrant ( $a_e$ ). The entrant's profit conditional on entry is

$$\begin{aligned} \pi_e &= \max_x P(x)x - C_e(x, w(a_i, a_e)) \\ &= \pi_e(a_i, a_e) \end{aligned} \quad (11)$$

Similarly, the incumbent's profit is  $\pi_i(a_i, a_e)$

Now consider the example in which the incumbent and a potential entrant compete for a scarce resource. This could be a superior ore deposit, a

favorable retail location, or a key patent. Let  $a = (1,0)$  correspond to the case where the incumbent wins the bidding race and  $a = (0,1)$  correspond to the case where the entrant wins. Furthermore, suppose  $\pi_e(0,1) > 0$  and  $\pi_e(1,0) < 0$ , so that if the incumbent wins, entry is prevented.

Following Gilbert and Newbery [1982] and Geroski and Jacquemin [1985], the incumbent can outbid the entrant at a cost  $V = \pi_e(0,1)$ . Its net return would be  $\pi_i(1,0) - V$ , and preemption would be preferred to entry if

$$\pi_i(1,0) - V > \pi_i(0,1) \quad (12)$$

or if 
$$\pi_i(1,0) > \pi_i(0,1) + \pi_e(0,1) \quad (13)$$

The profit on the left is the monopoly profit when entry is prevented and the right-hand side is the total duopoly profit with entry. In circumstances where the incumbent can choose a monopoly price when preemption of the scarce resource excludes entry, this inequality will be satisfied and "raising rivals' costs" through preemption of the scarce resource would be a preferred strategy for the incumbent.

This simple example illustrates the exclusionary power of a strategy designed to raise rivals' costs. Williamson [1968] provides another example in which union wage rates are exploited by an incumbent in order to raise an entrant's average cost and make entry unprofitable.

Despite the apparent advantages to incumbent firms of strategies that raise rivals' costs, there are reasons to doubt whether such strategies can be supported as equilibrium outcomes of market competition. Although preemptive

behavior may increase incumbent profits with potential entry, an incumbent may be unable to commit to a preemption strategy (in the patenting case see Reinganum [1983] and Gilbert and Newbery [1984]). Entry prevention may require an incumbent to lower prices instead of, or in addition to, acquiring scarce assets (as in the BSM model), which could reverse the inequality in (13) and make the incumbent prefer to accommodate entry.

Even in situations where preemptive acquisition is sufficient to deter entry and the incumbent can commit to an entry-preventing strategy, accommodation may be preferable. Lewis [1983] considers the case in which a dominant firm and a competitive fringe bid for indivisible units of a scarce resource (e.g. ore deposits). He shows that the profitability of the resource to the dominant firm (and therefore the winner of the bid) depends on the size of the acquisition. While a dominant firm would outbid an entrant for a single, once-and-for-all, acquisition, (as in Gilbert and Newbery [1982]), this typically will not be the case when there are many sources of supply. Each successful bid by the dominant firm results in a higher price. The higher price makes a subsequent acquisition by an entrant more profitable and increases the cost of preemption by the dominant firm. Thus in Lewis' example, the profitability of raising rivals' costs through preemptive acquisitions is mixed. Lewis also notes that it can be optimal for a dominant firm to divest some of its assets before it acquires new capacity. By doing so, the firm lowers the value of the new capacity to the fringe and hence reduces the price of preemption.

Related to strategies that raise rivals' costs are agreements amongst established firms and/or customers that limit access by actual or potential competitors to particular markets.<sup>15</sup> Aghion and Bolton [1987] provide an



interesting and potentially far-reaching example of self-enforcing contracts that facilitate entry prevention. They consider the simple case of a single established firm, a single potential entrant, and a single customer who is willing to pay a maximum of \$1 for one unit from either firm. The incumbent has a known cost  $c_i = 1/2$ . The entrant's cost,  $c_e$  is uncertain, but it is common knowledge that  $c_e$  is distributed uniformly in the interval  $[0,1]$ . The potential entrant observes the realized cost  $c_e$  before it has to make the entry decision. If it enters the market, the two firms act as Bertrand competitors, so that the resulting price is  $P_e = \max [c_i, c_e] = \max [1/2, c_e]$ .

In the absence of agreements between the agents in this market, entry will occur with probability  $q = \text{prob}[c_e < 1/2] = 1/2$ . The incumbent earns an expected profit

$$\pi_i = q \cdot 0 + (1-q) \cdot (p^m - c_i) \quad (14)$$

Entry occurs only if the entrant has a lower cost, in which case the incumbent earns nothing with Bertrand competition. If entry does not occur, the incumbent is a monopolist and chooses  $p^m = 1$ . Thus  $\pi_i = 1/4$ .

Similarly, the buyer's expected consumer surplus is

$$S = q \cdot 1/2 + (1-q) \cdot 0 = 1/4. \quad (15)$$

The entrant has an expected profit of  $1/8$ , so that total surplus in this market is  $5/8$ .

Now suppose the incumbent offers the customer a contract which specifies a price of  $P$  if the customer buys from the incumbent and a payment of  $P_0$  if the customer buys from the entrant. The contract is of the "take or pay" variety. If accepted, the customer can buy from the incumbent at a price  $P$  or from the entrant at a price  $P_e + P_0$ , where  $P_e$  is the entrant's price. If the rival enters, its optimal price is  $P_e = P - P_0$ , and the condition  $c_e < P_e$  is necessary and sufficient for the entrant to make a profit.

Consider  $P = 3/4$  and  $P_0 = 1/2$ . Entry occurs only if  $c_e$  is less than  $P - P_0 = 1/4$ , which is also the probability of this event. The buyer is indifferent between this contract and potential competition with no contract. The contract yields the same expected consumer surplus (the subscript "c" denotes the contract):

$$S_c = (3/4) \cdot (1 - 3/4) + (1/4) \cdot (1 - (1/4 + 1/2)) = 1/4 \quad (16)$$

But the incumbent earns an expected profit of

$$\pi_c = (3/4) \cdot (3/4 - 1/2) + (1/4) \cdot (1/2) = 5/16, \quad (17)$$

which is better than the  $1/4$  it earned with no contract. The entrant has an expected profit of  $1/32$ .

Although the incumbent is better off and the buyer is no worse off, total surplus is reduced with the take or pay contract:  $19/32$  versus  $5/8$ . The loss is in the potential entrant's expected profit, which is reduced from  $1/4$  to  $1/32$ .

Although the take or pay contract reduces the probability of entry and total surplus, the customer is no worse off. This is possible because with Bertrand competition, no contract, and entry, the customer's surplus depends only on the incumbent's cost and not on the entrant's. The customer benefits from competition, but not from the entrant's lower cost (the price equals  $1/2$  with entry). As a result, the incumbent is able to strike a deal with the customer that leaves the customer no worse off.

The key to entry prevention in the Aghion and Bolton model is the entrant's inability to negotiate with the customer. Suppose the entrant could sign a contract that would give the customer 51% of the profits it would earn from entry. This would increase the consumer's reservation surplus level from  $1/4$  to more than  $5/16$ . This reservation level would be high enough to make the take or pay contract unprofitable for the incumbent.

Aghion and Bolton provide a stimulating analysis of the scope for entry preventing contracts with important implications for issues in competition and public policy (for example, antitrust issues associated with complex leasing agreements).<sup>16</sup> Their work is also closely related to the economics of "switching costs" discussed in Section C.1 below, as the take or pay contract has the characteristic of generating an endogenous cost for switching to another supplier.

### C. Product Differentiation

Product differentiation exists whenever consumers do not view goods as perfect substitutes. This may arise as a consequence of differences in product

quality and performance, or for reasons that have to do with the reputation of the seller or a perception on the part of the buyer of "status" associated with a particular brand name. Switching from one brand to another may incur costs, in which case products that are identical ex ante may be viewed as imperfect substitutes once the consumer has chosen a particular brand.

Product differentiation allows producers some flexibility to raise price without losing all of their customers. This is the sine qua non of monopoly power; but as Chamberlin [1933] observed, monopoly power does not imply that firms earn monopoly profits. Entry, in the Chamberlain model, results in normal profits despite the local monopoly enjoyed by producers of differentiated products.

Although product differentiation need not imply monopoly profits, Bain [1956] nonetheless concluded that product differentiation was the single most important determinant of the ability of firms to earn supranormal profits. Using survey techniques, Bain identified the following factors contributing to product differentiation entry barriers in twenty industries studied: customer inertia, habit and loyalty; advertising-induced brand allegiance; product reputation; established dealer systems; customer dependence on services from established firms; patents; and prestige from conspicuous consumption of known brands.<sup>17</sup> Not surprisingly, the highest product differentiation entry barriers were associated with consumer-goods industries. This agrees with Comanor and Wilson's [1979] review of the advertising-profits relationship, which supports the conclusion that product differentiation advantages associated with advertising occur disproportionately in the consumer goods sector.

Product differentiation necessarily implies a barrier to entry in the sense that the producer of one brand cannot replicate another brand without incurring a disadvantage in either cost or sales. In this sense, product differentiation is similar to an absolute cost advantage (but note that, unlike a pure cost advantage, each brand can have a product differentiation advantage over other brands).

Although product differentiation precludes perfect imitation and therefore limits the effectiveness of entry, it does not mean that established firms are advantaged relative to latecomers. The producer of a new product or service has to prove its worth to skeptical consumers. Subsequent producers must contend with the reputation of an established firm, but may have the advantage of a better-informed customer base.<sup>18</sup> It is not obvious whether the first firm or subsequent entrants have the tougher job.

This is the essence of the conclusions in Schmalensee [1974], who argues that any firm-specific advantages resulting from advertising expenditures must depend on the existence of an asymmetry in the way that firms' advertising expenditures affect their demands. An established firm benefits from a stock of advertising "goodwill", but this goodwill arises from previous expenditures and does not influence post-entry advertising decisions.

Advertising and marketing expenditures may serve to impede the mobility of capital into (and out of) an industry by increasing product differentiation and by exacerbating the effects of scale economies on the profitability of entry. As Demsetz [1982] maintains, these effects should not be categorically interpreted as entry barriers in the sense of reducing economic performance and leading to prices above minimum average cost. Product differentiation

is a reflection of consumer preferences which must be respected in any welfare calculation. Brand preferences may be based on a product's reputation for quality or a firm's reputation for service. They may reflect a belief that an established brand will provide better value in the long run. Any analysis of product differentiation as a barrier to capital mobility must contend with the private and social value of these beliefs.

Advertising and marketing expenditures may have implications for strategic entry deterrence when these activities complement scale-related barriers. Suppose we begin with the proposition that product differentiation per se has no normative implications for capital mobility. However, when combined with a scale-related barrier to entry, firms might find it profitable to enhance product differentiation in order to exploit the benefits of scale. Spence [1980] shows how advertising expenditures can influence the optimal scale of production by affecting both the cost of operations and the revenues that can be collected at a particular level of output. Bresnahan [1986] investigates the extent to which advertising expenditures actually contribute to economies of scale.

Although advertising and marketing can clearly affect the optimal scale of operations, the direction is by no means obvious. Advertising provides an important information function for a new entrant. Advertising is a means by which new firms can inform customers of an alternative, and perhaps more attractive, source of supply. The classic example is Benham's [1972] study of the effects of advertising restrictions on the market prices of eyeglasses. Benham found that prices of eyeglasses in states that imposed advertising restrictions were significantly higher than the prices in states with more permissive advertising regulations.<sup>19</sup>

Using a variant of the BSM model that allows for differentiated products, Dixit [1979] traces the interactions between economies of scale, the extent of product differentiation, and the scope for entry deterrence.<sup>20</sup> There is an established firm (firm 1) and a potential entrant (firm 2), with demands of the form

$$\begin{aligned} p_1 &= \alpha_1 - \beta_1 x_1 - \gamma x_2 \\ p_2 &= \alpha_2 - \beta_2 x_2 - \gamma x_1 \end{aligned} \tag{18}$$

with  $\alpha_i, \beta_i > 0$  and  $\gamma^{\frac{1}{2}} \leq \beta_1 \beta_2$ . The products are substitutes if  $\gamma > 0$ .

Each firm has costs  $C_i = mx + F$ . As in the BSM model, the established firm can commit to an output and act as a Stackelberg leader. The limit output in this model is

$$Y = [\alpha_2 - m - 2(\beta_2 F)^{\frac{1}{2}}] / \gamma \tag{19}$$

The extent of product differentiation affects all of the parameters of demand for the two brands. Dixit calls particular attention to the effects on the intercepts of the inverse demand functions ( $\alpha_i$ ) and the cross-product term ( $\gamma$ ).<sup>21</sup> An increase in advertising and marketing expenditures that enhances brand 1 at the expense of brand 2 may increase  $\alpha_1$  relative to  $\alpha_2$  and decrease  $\gamma$ . The  $\alpha$  effect measures an increased willingness to pay for brand 1 relative to brand 2 at every level of output. A decrease in  $\gamma$  lowers the cross-elasticity of demand for the two brands (they become poorer substitutes).

Ignoring the cost of product differentiation, the incentive for product enhancing activities can be examined by comparing the Stackelberg profits with entry in the BSM model to the profits earned at the limit output. A decrease in  $\alpha_2$  lowers the limit output, while a decrease in  $\chi$  has the opposite effect. The  $\alpha$  effect increases the profit when entry is prevented and the  $\chi$  effect goes the other way. Entry prevention is more difficult when products are poorer substitutes. This result seems to contradict much of the literature that associates product differentiation with entry deterrence. It is, however, intuitive. Products must be substitutes in order for the output of one product to adversely affect the profits earned by the other products. If the products are independent, limit pricing is useless.

The effect on the limit output is not sufficient to determine the consequences of product differentiation for entry deterrence because it is necessary to compare the incumbent's profit when entry is prevented to the profit the firm would earn if entry occurred. Dixit does this and concludes that an increase in  $\alpha_1$  relative to  $\alpha_2$  makes entry deterrence more likely (meaning that the set of parameters for which firm 1 will successfully impede entry is larger). The  $\chi$  effect goes the opposite way. Product differentiation, corresponding to a lower  $\chi$ , makes entry deterrence less likely. A lower cross-elasticity lowers the profit when entry is deterred and raises the profit when entry occurs, making entry easier on both counts.

Dixit's results are an important lesson for the role of product differentiation in strategic entry deterrence. He concludes that

"a greater absolute advantage in demand (or cost) for established firms makes entry harder, but lower cross-price effects with potential entrants make entry easier. This suggests that industrial organization economists should keep



these two aspects distinct, instead of lumping them together into one vague concept of product differentiation as they usually do."

He adds a caveat warning the reader of added complications that may emerge from the dynamics inherent in the problem and the assumption of Stackelberg commitment behavior in the BSM model. In view of more recent developments, these warnings are particularly apt.

### C.1. Switching Costs

Switching costs represent a consumer disutility from changing brands. A change from one brand to another may incur direct costs, such as investment in training required to change from one brand of word processing software to another. A switch need not consume economic resources to be perceived as costly. Those loyal to a particular brand of beer may have a distaste for sampling other brands.

Switching costs are a source of economies of scale in consumption when repeat purchases are involved. With switching costs, a customer is better off continuing to purchase from his original supplier even though another supplier offers the same product at a slightly lower price. A firm that has sold  $Q$  units to customers each of whom has a switching cost,  $f$ , has a demand curve for subsequent sales as shown in Figure 9. Ignoring possibilities for price discrimination, the firm has a choice of pricing high to exploit existing customers (e.g. selling to its old customers at a price  $P_0$ ), or pricing low to attract new customers (e.g. selling to both old and new at a price  $P_n$ ).<sup>22</sup>

The cost of switching is an obvious source of monopoly power to established suppliers (see Schmalensee [1981] and Klemperer [1986]). It also suggests

that there may be many equilibrium configurations of supply for a market with switching costs, which may depend on the historical circumstances that lead to a particular pattern of trade.

Switching costs favor an established supplier, but their implications for industry structure are far from obvious. Customer expectations of how firms will react to price competition is crucial to the effects of switching costs. For example, suppose that customers of established firms believe that equilibrium prices will be the same for all firms. Given any cost of switching suppliers, however small, they will chose to remain with their original supplier. This gives established firms a sure hold over their customer base. Alternatively, customers may act in the spirit of Nash and evaluate competitive price offers assuming other prices will not change. In this case an established firm's grip on its old customers may be less secure. But the presence of fixed costs makes reaction functions non-convex and equilibria in pure strategies need not exist. There is nothing inherently wrong with this result. It merely underscores the critical importance of competitive behavior in deducing equilibrium outcomes from the structural characteristics of markets.

Farrell and Shapiro [1986] investigate an overlapping-generations model of competition with switching costs in which either a new supplier or the established supplier acts as a Stackelberg price leader and there is no opportunity for price discrimination. Both firms have identical and constant marginal costs. When the entrant moves first and sets a price,  $p$ , the incumbent can either (a) sell to only its old customers at a price  $p+f$  (or slightly below) or (b) compete for all customers by setting a price slightly below  $p$ . They show that there is a unique equilibrium in which the entrant

serves only new customers at a price  $p$  and the established supplier serves only old customers at a price  $p+f$ . The incumbent never competes for the new customers. The reason is that the new customers are equally valuable to the incumbent and the rival, but the incumbent has an incentive to price higher and keep its old customers.

In the presence of economies of scale, Farrell and Shapiro show that a customer base with switching costs can lead an established firm to allow entry when entry prevention would be more efficient. This result parallels the example with learning. In the learning case, it would be efficient for the firm with lower costs to price low and exploit experience economies. But the firm may choose to exploit its low cost by pricing high and allowing entry. Similarly, the firm with a customer base could price low and prevent entry or price high, keep its old customers, and allow entry to occur. If economies of scale are not too great, the latter course of action is the best strategy.

These results follow under the assumption that the entrant acts as a Stackelberg price leader. If the incumbent is the price leader, there is a unique equilibrium with a single price charged by both firms (the same for both new and old customers). Old customers strictly prefer to buy from their old firm, while new customers are indifferent. Profits for both firms are higher when the incumbent is the price leader, but curiously the entrant benefits even more in this instance. There is a "second-mover advantage" in the game with the incumbent as the price leader.

The presence of switching costs need not lead to entry deterrence in the Farrell/Shapiro models. Switching costs do allow firms to profit from locked-in customers and they affect the structure of the market. These models

are further examples of the distinction between the effects of structural factors on entry and their effects on market structure and performance.

### III. Fat-Cats and Puppy-Dogs

The models discussed so far indicate a wide range of strategic behavior by established firms faced with the threat of entry. In the Dixit model, a firm may invest aggressively in order to tip the scale of the post-entry game in its favor, and in doing so may prevent entry. But in Farrell and Shapiro's switching cost model, the established firm may choose to mine its installed base of customers and allow entrants to serve new customers. A similar result occurs in a model of advertising by Schmalensee [1983]. An established firm's goodwill leads a firm to price high and allow entry. Is there any rhyme and reason to these examples? Is there a prescription to follow that will tell when an established firm will choose to accommodate or actively prevent entry?

Fudenberg and Tirole [1984] and Bulow, Geanakopolis and Klemperer [1985] provide a taxonomy of behavior in response to entry. Their approach does not permit an instant answer to how established firms will behave in a particular competitive situation, but they succeed in identifying key factors. I will follow the approach in Fudenberg and Tirole [1984], who employ an unconventional, but descriptive, notation in their characterization of firm behavior.

The incumbent can respond to the threat of entry with a strategic investment,  $K$ . This could take many forms, including capacity, advertising, R&D, or a combination of these activities. The incumbent's profit with entry,

conditional on  $K$ , is a function of its own output,  $x_i$ , and the entrant's output,  $x_e$ :  $\pi(x_i, x_e | K)$ . The consequence of an increase in  $K$  for the incumbent's profit is

$$(\partial\pi/\partial x_i)dx_i/dK + (\partial\pi/\partial x_e)(\partial x_e/\partial x_i)dx_i/dK + \partial\pi/\partial K \quad (20)$$

The key factors in Fudenberg and Tirole's taxonomy are the slope of entrant's reaction curve and the effect of incumbent investment on the firm's equilibrium output.<sup>23</sup> The slope of the entrant's reaction curve is  $\partial x_e/\partial x_i$  and the effect of incumbent investment on its equilibrium output is  $dx_i/dK$ . If  $dx_i/dK > 0$ , investment makes the incumbent "tough" and in the opposite case, investment makes the incumbent "soft". As an example, in the Dixit entry deterrence problem, reaction curves slope down and investment makes the incumbent tough.

The optimal behavior for the incumbent depends as well on the other factors in (20) and on whether the incumbent chooses to deter or accommodate entry. Fudenberg and Tirole describe four types of behavioral strategies that an incumbent may use: the "top dog", the "puppy-dog ploy", the "fat-cat", and the "lean and hungry look".

(i) The "Top-Dog". The top dog overinvests to deter entry. This is the optimal deterrence strategy in models such as Spence [1977] and Dixit [1981]. Investment makes the incumbent tough and, in response, the entrant would cower and produce less (the reaction curve is downward sloping). Top-dog behavior is optimal in this case whether or not entry is actually prevented. Even if entry is allowed in the Dixit model, the incumbent will play the top dog role to increase its post-entry profits.

(ii) "Fat-Cat". Suppose reaction curves are upward sloping as in the case of Bertrand competition with differentiated products. In addition, suppose that more investment makes the incumbent soft. Fudenberg and Tirole provide an example where the incumbent's optimal price is an increasing function of investment in advertising because the ads lower the elasticity of demand for the product, so that more advertising makes the incumbent soft. By being soft, the fat-cat encourages its rival to be less aggressive. This strategy involves over-investment (relative to the case where the strategic interactions are ignored) in order to optimally accommodate entry.

(iii) "The Lean and Hungry Look". If reaction curves are upward sloping and investment makes the incumbent soft, entry prevention calls for a lean and hungry look. In the advertising example, the incumbent may under-invest (relative to no entry) in order to commit itself to aggressive pricing if entry occurs.

(iv) "The Puppy-Dog Ploy". The "puppy dog" ploy is under-investment in order to make the incumbent firm appear more friendly to a new entrant. This can be an optimal strategy if reaction functions are upward sloping, less investment makes the incumbent soft, and the incumbent expects entry to occur. Gelman and Salop [1983] provide an example where the entrant is the puppy-dog. By committing itself to a low investment strategy, the entrant projects a friendly image that is intended to evoke a more accommodating strategy by the incumbent.

#### IV. Entry, Dynamics and Industry Structure

The BSM model of limit pricing inspired early criticism directed in particular to the assumptions about the entry of a rival firm. Stigler [1968] argued that it may be more desirable to retard the rate of entry rather than impede entry altogether. Harrod [1952] and Hicks [1954] pointed to the tradeoff between short run profits and long run losses from entry. Caves and Porter [1977] criticized the theory of entry deterrence for confining itself to the either/or question of whether a dominant firm will exclude an entrant, and ignoring the more subtle and important issues of the movement of capital into, out of, and among segments of an industry.

These criticisms are still relevant: there is as yet no coherent theory that can describe the evolution of market structure and it may be presumptuous to expect that such a theory can be constructed. Many attempts have been made to refine models of entry deterrence, adding elements of realism in the dynamics of the entry and exit and in competition among established and new firms. What follows is a sampling from a large and growing literature.

##### A. Dynamic Limit Pricing

Gaskins' [1971] influential paper was one of the first attempts to characterize optimal pricing over time for an industry faced with a continuous threat of entry. Gaskins specified entry as a flow rate of change of rival output  $x(t)$  that depends on the price set by established firms,  $p(t)$ , and the rivals' long-run marginal cost,  $c_e$ :

$$dx/dt = f(p(t), c_e) \quad (21)$$

At any time  $t$ , the total amount of rival output is

$$x(t) = \int_0^t f(p(t), c_e) dt \quad (22)$$

which depends only on the time path of the prices set by the established firms. Established firms choose a price path  $p(t)$  to maximize present value profits

$$\pi = \int_0^t (p(t) - c_i) q(p(t), t) e^{-rt} dt \quad (23)$$

where  $q(p(t), t)$  is the difference between demand at price  $p(t)$  and rival output  $x(t)$ .

With entry characterized by equation (21), the established firms' optimal price policy can be determined by the solution to a classical one control variable ( $p$ ) and one state variable ( $x$ ) optimal control problem. The optimal policy is a tradeoff between the gains from monopoly pricing and the cost of entry induced by a high price. Entry erodes the established firms' market share and pushes price down at a rate that depends on industry growth. For a stationary market, price approaches the competitive level.

A main criticism of Gaskins' model is that entry is not an equilibrium process. The entry equation (21) is not the result of optimizing decisions by a pool of potential entrants, but is specified exogenously in the model. The incumbent firm (or cartel) is presumed to act rationally, choosing a price policy to maximize present value profits. But there is no corresponding maximization problem for the firms that make up the flow of entry into the



industry. Firms are not symmetric in the Gaskins model in their degree of rationality. Indeed, even if entry continues to the point where the incumbent firm(s) make up a very small share of the industry, they continue to act strategically, taking into account the reactions of their competitors, while the behavior of the new entrants is given exogenously. Only incumbent firm(s) can boast an identity in the Gaskins model. Entrants are relegated to a nameless component of an output flow.

The entry rate depends only on the current industry price. This need not be a deficiency of the model if there is no other information available which firms can use to condition their entry decisions. Of course actual entrants should be concerned not with current prices, but with the prices that will prevail after they enter the industry. The Gaskins model implies entry behavior that is too myopic. If nothing else, potential entrants should make use of the entry equation (21) to forecast future profitability. After all, if this is known to the incumbent firm(s), it should be common knowledge for the potential entrants as well. The one case in which this information has no value would be for potential entrants that have no investment at risk, e.g. if the investment required for entry is completely reversible.

Some of the theoretical shortcomings of the Gaskins model have been addressed by others. Kamien and Schwartz [1971] extend the Gaskins model to the case of stochastic entry. The probability that entry occurs by time  $t$  is  $F(t)$ . If entry occurs at time  $t$ , the incumbent firms (which act as a monolithic cartel) earn a flow profit  $e^{gt}\pi_2$ , where  $g$  is a market growth rate. This is less than the maximum monopoly profit,  $e^{gt}\pi_1$ . Unlike the monopoly profit, the profit with entry is given exogenously and does not depend on the market price. The rate of change in the probability of entry, conditional on no

entry by date  $t$ , is the hazard rate  $F'(t)/(1-F(t))$ . The entry hazard rate in the Kamien and Schwartz model evolves according to the function  $h(p(t),g)$  where  $p(t)$  is the market price and  $g$  is the market growth rate. The hazard rate is an increasing function of the market price and the growth rate.

Established firms choose a price function  $p(t)$  to maximize

$$\int_0^{\infty} e^{-(r-g)t} [\pi_1(p(t))(1-F(t)) + \pi_2 F(t)] dt \quad (24)$$

subject to

$$F'(t) = h(p(t),g)(1-F(t)) \quad \text{and} \quad F(0) = 0.$$

Kamien and Schwartz show that the solution to this optimal control problem is a constant  $p^*$ . Given  $p^*$ , the cartel's total discounted profit is

$$V(p^*) = (\pi_1(p^*) - \pi_2) / (r - g + h(p^*)) + \pi_2 / (r - g) \quad (25)$$

The optimal price balances the gain from entry prevention (a lower probability,  $h$ , of entry) against the effects of a lower price on the transient profits earned before entry occurs. If  $\pi^m$  is the unconstrained monopoly profit, they show that, given some smoothness assumptions about the effect of price on the entry probability,

$$\pi^m > \pi_1(p^*) > \pi_2$$

The Kamien and Schwartz formulation is quite elegant in that it represents entry as a fully dynamic and stochastic process. Its major shortcoming, however, is that the entry process is still an exogenous specification of the

model. Entry is not determined as the result of optimizing decisions on the part of potential rivals.

Flaherty [1980] introduces a model of rational entry, but assumes that firms commit to output paths for all future time. This assumption is similar to the output commitment in the BSM model (and to the price path commitment in Gaskins [1971] and Kamien and Schwartz [1971]). The output commitment allows an incumbent firm to prevent entry by specifying an output path that it may not choose to produce if it did not have the commitment option. Encaoua and Jacquemin [1980] extend the limit pricing model to include non-price strategic variables.

Gilbert and Harris [1984] model an oligopolistic market with free entry and increasing returns to scale in new capital investment. Not surprisingly, the implications for equilibrium market structure depend on the behavioral strategies of the firms. The extension of Nash-Cournot behavior to this market implies that each firm takes the planned investment sequence of its competitors as given and responds with the sequence that maximizes its present value profits. If firms compete as Nash-Cournot oligopolists, the evolution of the market is similar to that assumed in the Gaskins limit pricing formulation. The market converges gradually over time to a long run equilibrium and firms earn profits that are proportional to their initial market shares. However, entrants account for all new investment, so that a dominant firm's profits are limited to its earnings on its installed base. Furthermore, firms earn a positive profit in the long run, even with free entry.

In contrast to the Nash-Cournot case, if firms act to preempt rival investment in the expectation that early investment will force rivals to alter their investment plans, each new investment earns zero profits and the scope for entry deterrence depends critically on the post-entry pricing game. If post-entry price competition is such that all capacity owned by incumbents pre-entry would be used post-entry, incumbents cannot prevent entry and earn positive profits when there are no entry costs other than the cost of a new plant (see Mills [1987] for the consequences of entry costs). If, however, incumbent firms can hold excess capacity pre-entry which they would (credibly) use after entry occurs, entry can be prevented. The ability of incumbents to prevent entry is constrained by the amount of capacity that they can maintain as excess before entry, and use after entry occurs.

In a recent addition to the dynamic limit pricing literature, Judd and Petersen [1986] introduce financing into the entry process. They assume that the rate of entry is governed by the need for firms to finance their expansions with internally-generated funds. The extent to which this is possible depends of course on the rate of profit, which the established firm(s) can control through its pricing decision. The connection between the pricing decision and the entrant's flow of funds to finance entry is a convenient way to make entry an endogenous feature of the model. Their results retain many of the features of Gaskins model, but differ in some predictions. For example, with slow growth the optimal price drops to the fringe long-run marginal cost in finite time. If the market has a high initial growth rate and then slows, the optimal price path may rise to a peak as the growth rate declines. While the market is growing it pays the established firms to keep the price low and retard the growth of the fringe. When the growth rate slows, the established firms take their profits and then

price gradually falls to a competitive level as the fringe continues to expand. The Judd and Petersen model is a useful extension of the limit pricing theory, but one can question its relevance to a world with venture capitalists, junk bonds, and innovative corporate finance.

Despite its theoretical limitations, the Gaskins model of dynamic limit pricing (along with its refinements) is an appealing description of pricing behavior for industries that are characterized by dominant firms. The exogenous specification of the entry flow is not theoretically justified, but it may capture an important element of dynamic competition. The Gaskins model identifies entry as a disequilibrium process. The exogenous specification of the entry flow is not inconsistent with an environment in which potential entrants have imperfect information about the existence of entry opportunities and where searching out entry opportunities is costly and time-consuming.<sup>24</sup> If it were possible to model these aspects of the entry process, the result could be an entry flow rate that appears similar to equation (21) in the Gaskins model. Indeed, perhaps models of entry deterrence that assume potential entrants are rational and fully informed are missing a critical aspect of entry dynamics. For these reasons, it is not surprising that the Gaskins model has been used successfully in empirical models of dominant firm pricing, such as Blackstone [1972] and Brock [1975].

A major criticism of the dynamic limit-pricing literature is the assumption of Stackelberg behavior by the dominant firm. Spence [1979] describes a model in which firms are strategically similar, yet a form of limit-pricing behavior emerges. In Spence's model firms are constrained in their maximum rates of growth. Either as a result of a head start or a larger maximum growth rate, one firm may win the race for market share. At any point in the race, either

firm may stop or continue to invest, thereby altering the future structure of the market. These simple alternatives lead to some interesting, and complex, outcomes. For example, suppose there are two firms, 1 and 2, and firm 1 is ahead. If both firms continue to invest, firm 2 will lose money. Through rapid growth it is feasible for firm 1 to prevent the entry of firm 2. But firm 2 may threaten to remain in the market and, if its threat is taken seriously, firm 1 may choose to stop investing and accommodate its rival. The position in the race for market share gives each firm a menu of threats and counterthreats that may influence the eventual structure of the market. Fudenberg and Tirole [1983] identify those threats which are credible in the Spence model and show how they affect equilibrium industry structure.

The Spence model and its refinement by Fudenberg and Tirole illustrate the endogeneity of industry structure. The scope for entry deterrence and the emergence of dominant firms derive from strategic advantages related to technology, demand, behavior and initial structural conditions. Firms may begin on a common footing, but over time their relative positions in the market confer different strategic opportunities. The outcomes in these models reflect a comment by Caves and Porter: "The incumbent's actions affect both the entrant's conjectures about industry conditions following his entry and the "structural" barriers to entry. Thus, the entry barriers we observe are partly structural but at least partly endogenous."<sup>26</sup>

## **B. Multiple Incumbents and Entrants**

The classic description of entry-detering behavior is posed in the context of a single dominant firm or a perfectly coordinated cartel. The BSM model

and its extensions yield sharp conclusions about the behavior of firms in the face of potential entry, but these conclusions are not tempered by the forces of competition within an established industry. The restrictive assumptions of the BSM model led Stigler to comment that the BSM approach to limit pricing solves the theory of oligopoly "by murder".<sup>25</sup>

Few industries are represented by a single firm that acts to impede entry over a sustained period. Tight as well as loose oligopolies face problems of coordination among their own activities. These problems are compounded if they must also coordinate activities aimed at deterring entry.

Moving from the monolithic case of the dominant firm/perfect cartel to more realistic situations of oligopolistic competition raises new questions about the scope for entry prevention. For example, can meaningful distinctions be drawn with respect to competition between incumbent firms versus competition between incumbents and new entrants? What role does potential entry play with respect to the evolution of industry structure? Does oligopolistic competition facilitate entry prevention or do the problems of coordination in oligopoly make entry prevention more difficult?<sup>27</sup>

Most of these questions remain as unresolved topics for further research. Despite the great progress that has been made in oligopoly theory and entry deterrence, relatively little is known about the interactions between strategic entry deterrence and market structure. One exception to this general trend is the extensive literature on contestability theory, which is discussed separately in Section VII.

Gilbert and Vives [1986] extend the BSM model of entry prevention to the case of more than one incumbent firm. There are  $i = 1, \dots, M$  incumbents and a single entrant (the results generalize to more than one potential entrant if entry occurs sequentially - see Vives [1982]). Incumbents act non-cooperatively and each chooses an output  $x_i$ , taking other firm's outputs as given. Entry is prevented if  $\sum x_i = X_i \geq Y$  where  $Y$  is the limit output. Demand is linear and the technology is as in equation (7): constant marginal costs with a fixed cost associated with entry.

Gilbert and Vives show that as a result of non-cooperative behavior entry prevention is excessive in the sense that the industry prevents entry at least as much as would a perfectly coordinated cartel. Moreover, there are multiple equilibria involving entry prevention and these can co-exist with an equilibrium in which entry is allowed. When equilibria involving entry prevention and accommodation occur simultaneously, the accommodation equilibrium dominates the equilibrium in which entry is prevented. Each incumbent firm and the entrant is better off with entry.

Entry prevention is a public good for the incumbents, much as national defense is for a country's citizens. Yet there is no tendency to provide too little entry deterrence in the Gilbert and Vives model. Each incumbent benefits from entry prevention by an amount proportional to its output. When entry is prevented and the aggregate incumbent output is  $Y$ , each incumbent earns

$$\pi_i^L = (P(Y) - m)x_i - F \quad (26)$$

The limit price exceeds  $m$  and (26) is strictly increasing in  $x_i$  for  $x_i \leq Y$ . Furthermore, given the output of all other incumbents,  $X_{-i}$ , any decrease in



firm  $i$ 's output below  $Y - X_{-i}$  would lead to entry and a discontinuous fall in firm  $i$ 's profit. Thus if entry is prevented, each incumbent would like the task of entry prevention. This incentive, coupled with non-cooperative behavior in which incumbent firms choose investments simultaneously, results in equilibria with "excessive" entry prevention.

Elements of a theory of strategic entry deterrence and market structure can be gleaned from a simple extension of the BSM model to allow for sequential entry by more than one firm. Following Vives [1982] suppose there is a single incumbent firm,  $i = 0$  and a sequence of entrants,  $j = 1, \dots, N$ . Each entrant is identified with a (timeless) period in which it may choose to enter the industry. In period 0 the incumbent may choose any output  $x_0$ , which it must produce in period 0 and in all future periods. Firm  $j$  may choose to enter only in period  $t = j$  and each firm that enters takes as given the output of the incumbent firm and all prior entrants, but is strategic about the effect of its output on possible future entrants.

These assumptions describe a simple market in which new firms may enter sequentially as in Prescott and Visscher [1978]. The behavioral assumptions imply that each new firm acts Cournot with respect to the incumbent and all previous entrants, and acts as a Stackelberg leader with respect to future entrants.

Let  $X_j$  be the total output of the first  $j$  firms in the market and let  $R_i(X_j)$  be firm  $i$ 's optimal output taking  $X_j$  as given, but taking into account the reactions of all future entrants  $k = i+1, \dots, n$ . Firm  $i$ 's output is the solution to

$$\max_{x_i} \pi(x_i, X_{i-1}, R_{i+1}(X_i), \dots, R_n(X_{n-1})) \quad (27)$$

Each firm's optimal output, (if it exists), can be determined through backward induction beginning with the last firm,  $n$ , but this computation can be very difficult for general cost and demand conditions. As a simple example, consider again the case of a homogeneous industry with linear demand,  $P = a - bX$ , constant marginal cost,  $m$ , and a fixed cost of entry,  $F$ , which becomes sunk once entry occurs. Vives [1982] and Gilbert [1986] show that the optimal response for firm  $i$  is

$$R_i(X_j) = ((a-m)/b - X_j)/2 \quad (28)$$

That is, it is optimal for each firm to act as a monopolist with respect to the residual demand function formed by subtracting from total demand the total output of the incumbent and all previous entrants.<sup>28</sup>

The incumbent firm has to choose whether to exclude all entrants by setting the limit output or allowing entry to occur. In this model, there is no point in allowing one or more firms to enter and then excluding others. Also, if the incumbent allows entry, it is in the interest of all future entrants to allow entry. Limit pricing earns the incumbent a profit equal to

$$\pi^L = (P(Y) - m)Y - F \quad (29)$$

while if entry is allowed, the incumbent's profit is

$$\pi^E = (P(X_j) - m)x_0 \quad (30)$$

Here  $X_j$  is the total output given that  $j$  firms enter and  $x_0$  is the incumbent's optimal output.

The free entry number of firms is the largest number,  $J$ , for which  $X_j < Y$ . If the number of potential entrants,  $N$ , is strictly smaller than  $J$ , the incumbent maximizes profits by allowing entry to occur. If  $N$  is equal to  $J$  (or larger), the incumbent should limit price (see Omari and Yarrow [1982] and Gilbert [1986]). If entry is deterred, the market structure is, of course, a monopoly. Even if entry is allowed, this market would be very concentrated, with first four firms accounting for at least 93% of the industry output.

This simple model is clearly unsatisfactory as a predictive model of industry structure. Some of its limitations are quite obvious. It is essentially a static model. Entry is instantaneous and perfectly predictable. In addition, the incumbent and successful entrants are able to commit to outputs which are sustained in the face of subsequent entry. This behavior is consistent with the BSM model, but it is patently unrealistic as a model of actual behavior in a dynamic market.

The model can be extended to constrain the behavior of firms to outputs that can be sustained as post-entry equilibria given the production technology and behavioral strategies by applying the principles discussed in Dixit's formulation of the limit pricing model to the case of many potential and actual entrants. Eaton and Ware [1987] investigate the consequences of credible commitment in a model with sequential entry. The structure of their model parallels the assumptions above, with the number of potential entrants arbitrarily large (free entry) and with the added restriction that all outputs

must be credible (i.e., all outputs must be Cournot equilibria of the post-entry game). They assume a technology with irreversible capital investment and a demand function with everywhere decreasing marginal revenue. A main conclusion of their analysis is that the equilibrium number of firms in the industry is the smallest number which can deter the entry of an additional firm. With free entry, incumbent firms in their model would maximize profits by deterring entry if they could. If  $Y$  is the limit output, the first incumbent firm  $i$  that could produce  $Y - X_{i-1}$  as an equilibrium output would do so and entry would be deterred. If firm  $i$  and the firms that precede it cannot produce enough in equilibrium to equal or exceed the limit output, entry will occur. Entry will continue to occur until the limit output can be sustained as a perfect equilibrium by the incumbent firms.

Bernheim [1984] offers a description of industry dynamics employing sequential entry. As in Eaton and Ware [1987], incumbent firms choose whether to prevent or accommodate entry. If they accommodate, the new entrant joins the incumbents in choosing whether to prevent or accommodate further entry. By characterizing the industry in terms of general functional forms for profits and the cost of entry deterrence, Bernheim achieves an apparent increase in generality, but the analysis necessarily employs assumptions that may limit the applicability of the results. Bernheim argues that there are, in general, more than one stable size for an industry, defined as a number of established firms which will prevent further entry. If the number of actual established firms is not stable, additional firms will enter unopposed until the smallest stable size exceeding the initial industry size is reached. It is reassuring that these conclusions do not contradict the results in Eaton and Ware [1987].

These models presume that incumbents' strategies are limited to the choice of output. With this restriction, they analyze the incentives for entry deterrence and the credibility of outputs intended to deter entry. Of course incumbent firms have a much larger arsenal of deterring strategies, such as advertising, brand proliferation, and technology choice. McLean and Riordan [1987] go a significant step toward a more general theory of the effects of strategic behavior on industry structure by allowing firms to make discrete technology choices with the objective of affecting future market structure. Firms enter sequentially in their model and choose either a "normal" or a "deterring" technology. Let  $j = 1, \dots, N$  denote the firm's position in the entry sequence, with  $N$  the number of firms that would enter if all previous entrants choose the normal technology. They show that when entry is deterred the market can be partitioned according to the firms' technology choices. If the normal technology is always more profitable for given entry and technology choices of rival firms, there is a critical firm  $m \in [1, N]$  such that all firms  $j \leq m$  choose the normal technology and all firms  $j > m$  choose the deterring technology (if they actually enter). They call the case with  $1 > m < N$  a situation of "delegated entry deterrence". The early entrants assign the task of entry prevention to subsequent entrants. If, instead, the deterring technology is more profitable when the number of firms and their technology choices are fixed, the first  $m$  firms will choose the deterring technology and the remainder the normal technology. They call the case with  $1 > m < N$  a situation of "partial entry deterrence".

The classifications in McLean and Riordan [1987] shed considerable illumination on the interactions between strategic behavior and market structure. The model is non-parametric, but important assumptions include the sequential pattern of entry and the absence of uncertainty. Although

under-investment in entry prevention can occur in their model, the assumption of sequential entry eliminates the possibility of overinvestment in entry deterrence (in the sense that each firm would be better off with less deterrence) because each firm can act to allow entry given the actions of preceding firms. The assumption of no uncertainty means that each firm has perfect foresight about the actions and subsequent evolution of the industry. This rules out not only environmental uncertainty, but also uncertainty arising from unpredictable actions of subsequent entrants.

Potential entrants have to evaluate not only the response of incumbent firms to entry, but also the likelihood that future entry will undermine profits. The threat of excessive entry is particularly severe when entrants act with incomplete information about the decisions of potential competitors. Incomplete information about rival decisions will exist if the time between the decision to enter and actual entry is long and the entry decision is irreversible. Then an entrant cannot know if, and how many, other firms will choose to enter. Sherman and Willett [1967] considered the consequence of simultaneous entry and concluded that the possibility of mistakes can discourage entry and (in the context of the BSM model), lead to a higher limit price. Dixit and Shapiro [1985] considered how the possibility to rectify entry mistakes, through exit or additional entry, may affect entry incentives.

With incomplete information about the actions of other competitors the entry decision is an investment under conditions of uncertainty. This gives rise to what Richardson [1960] called "the nomination problem". There is an optimal number of entrants (most likely greater than one) but no mechanism to determine which of many potential entrants should be "nominated" to enter. Farrell [1986b] investigates how non-binding communications (in the absence

of side-payments) among potential entrants might avoid the waste from too much or too little entry. He shows that communication, which he calls "cheap talk", can mitigate, but not in general eliminate, the nomination problem. His results provide some substance for the type of industry displays, pronouncements and jawboning that often precede a significant entry decision. As in the mating rites of birds, such behavior may have important efficiency consequences and need not be a mere flaunting of intent.

## V. Exit Barriers and Asset Specificity

Exit barriers are costs or foregone profits that a firm must bear if it leaves an industry. For example, a firm might have to pay workers severance fees if it abandons a market. A regulated firm might be forbidden to abandon a market, or have to guarantee service in certain markets in exchange for the right to leave another market. Exit barriers exist if a firm cannot move its capital into another activity and earn at least as large a return. In this respect sunk costs are likely to contribute to exit barriers. Sunk capital expenditures generate earnings that would be lost if a firm exits the market.

Barriers to exit affect entry in two ways. They have a direct impact on an entrant by adding to the costs that an unsuccessful entrant must bear to exit an industry. They also have an indirect effect on entry by influencing the incentives of established firms. If exit barriers are large, established firms can be counted upon to remain as competitors if entry occurs (and may act as if their backs are to the wall).

The Dixit model of credible entry deterrence is an example of the indirect effect of a barrier to exit. Sunk costs affect the behavior of established firms. With Cournot competition, sunk costs make an incumbent firm more aggressive. If capital investments were recoverable, the opportunity cost of capital would be an additional component of the firm's marginal cost function and the firm's reaction function would shift to the left. The firm would produce less at every level of rival output and perhaps exit the market, making entry more profitable.

Capital is sunk only to the extent that it is embodied in a durable investment. Eaton and Lipsey [1980, 1981] make the point that the durability of capital is a constraint on a firm's ability to exploit a sunk cost barrier to entry. When capital wears out, an established firm and an entrant are on a level playing field (provided all of the firm's capital wears out at the same time, which seems rather unlikely). The durability constraint also would favor, for reasons of entry deterrence, investments in long-lived capital and would discourage leasing.

Exit costs depend on a firm's opportunities to move capital into alternative markets. Many firms operate in several markets that have similar production technologies and that share the benefits of the firm's marketing experience and goodwill. A firm in such a multi-product environment has relatively low barriers to the movement of capital from one market to another. Judd [1985] argues that entry should be relatively easy in such markets. Heads-on competition with a new entrant reduces an incumbent firm's profit both in the market where entry occurred and in markets for substitute goods where the incumbent may operate. By leaving the market where the incumbent competes heads-on with the the new firm, it can raise profits both in the entry market



and in the markets for substitute goods. Anticipating this incentive for exit by the incumbent, a potential rival would be encouraged to enter the incumbent's market. Judd's argument suggests that the strategy of "brand proliferation" suggested by Schmalensee [1978] is not a credible deterrence against the threat of potential competition if the incumbent does not face substantial costs associated with exit from the production of a each brand.

Unlike the Dixit model of entry deterrence, the presence of sunk costs do not confer a strategic advantage for a multi-product incumbent firm faced with entry in a single market. Sunk costs benefit the incumbent in Dixit's single-product market because they lower the incumbent's marginal cost, and this makes the incumbent act more aggressively in response to entry. In the multi-product case, the losses that competition imposes on substitute products is an incentive to exit that is independent of any sunk costs that have been incurred in the entry market. Judd's model is a good example of the general proposition in Fudenberg and Tirole [1984] and Bulow et al [1985] that strategic behavior in a particular market is shaped by competitive effects in related markets.<sup>29</sup>

Exit costs increase the cost of entry into an industry that proves unprofitable. The direct cost of exit is irrelevant if, as assumed so far, potential entrants correctly forecast post-entry profits and avoid markets where earnings would fall below the opportunity cost of their capital. Perfect foresight is rare and the cost of potential mistakes is likely to be a major factor in the decision to enter markets and in the availability of external financing. Caves and Porter [1976] investigate the significance of exit costs and how they correlate with industry behavior. Ghemawat and

Nalebuff [1985] and Fudenberg and Tirole [1986] show how barriers to exit can lead to wars of attrition which make entry mistakes costly.

Caves and Porter [1976] argue that exit costs are attributable to specific assets that impede capital mobility. An asset is specific to a particular economic activity if the value of its services strictly exceeds its value in an alternative use. The difference in value relative to the next best use is a measure of the cost of exit. Williamson [1975, 1985] uses the concept of asset specificity to develop a theory of market and institutional structure and it is tempting to extend this approach to the determination of entry and exit barriers.

Asset specificity is at the heart of Bain's absolute cost advantage and product differentiation barriers to entry. I have argued that absolute cost advantages need not be a barrier to entry. The owner of a unique asset should value the asset at its opportunity cost, which is determined by the market. If the asset is specific, its opportunity cost is less than its value and there is an absolute (opportunity) cost advantage. Consider the example of the xerography patent. If the patent were not specific to the Xerox Corporation, it would have a market value exactly equal to its value to Xerox and it would not represent a barrier to entry. But if Xerox has physical and human capital that is complementary to the xerography patent and that enhance its value relative to other uses, the xerography patent becomes a specific asset and represents a true absolute cost advantage. Other firms cannot pay Xerox enough to make the company part with the patent. The complementary capital can take varied and subtle forms. The company may have technological skills, other patents, marketing experience, or a reputation for service that complement the basic xerography patent and increase its value. The management

of the company may have human capital that depends on the xerography patent and that causes them to value the patent more than its opportunity cost. Caves and Porter [1976] suggest that managers' specific human capital is one reason why firms appear to cling to apparently unprofitable activities. Managerial asset specificity impedes the mobility of capital out of struggling industries.

Investments in advertising and marketing are asset specific. Goodwill is a measure of the success of product differentiation. Economic profits would not exist if any firm could replicate the product of another firm at the same cost. Thus asset specificity is also fundamental to product differentiation as an apparent barrier to entry.

The concept of asset specificity is central to the mobility of financial capital in the structuring of markets. Although the entry deterrence literature has focused on movements of physical capital, industry structure can change as a result of merger, divestiture and takeovers. Strategies that discourage the movement of physical capital need not impede the movement of financial capital. But asset specificity can be a barrier to financial capital movements. The performance of physical assets may be specific to the reputation of a particular firm or to the executive style of a particular management team. As a result, the value of these assets may be strictly greater when they exist under the logo of a particular firm or when they operate under a particular management team. The value of the assets to an entrant would be less than in its present use and a takeover would be unsuccessful.

The concept of asset specificity is also central to the BSM and Spence/Dixit models of entry deterrence. In the Dixit model, sunk costs allow an established firm to commit to an output large enough to deter entry. Sunk costs are asset specific, and this example of entry deterrence appears to be another case where asset specificity is at the heart of barriers to entry and exit. More generally, entry deterrence is feasible because the incumbent firm has a mechanism which enables it to commit to an output level that makes entry unprofitable. In the Dixit model, this mechanism is sunk costs (specific assets). But any mechanism that allows the incumbent firm to commit to an output at least as large as the limit output will do, provided that the incumbent is also able to signal this capability to potential entrants. The incumbent might have a magic button that it could push and shift its reaction function to the right by an amount large enough to deter entry. One might argue that the entrant would want to push this button too, and would be willing to buy the button from the incumbent. The incumbent would be willing to sell the button at a price equal to its value. If the value to the entrant is the same as the value to the incumbent, the magic button becomes no different from a taxi medallion and does not confer an incumbency advantage. However, if the magic button is an asset whose value is specific to the established firm, its value will exceed the price an entrant would be willing to pay and it could provide an incumbency advantage.

## VI. The Role of Information in Entry-Deterrence

Limit pricing sacrifices current profits in order to discourage entry. It has value only to the extent that potential entrants interpret pre-entry prices as indicative of post-entry market conditions. The signalling aspect of limit pricing suggests analyzing strategic entry deterrence as a problem in the economics of information. This observation was made by Salop [1979] and posed in game-theoretic form by Milgrom and Roberts [1982a].

Fudenberg and Tirole [1986] provide a simplified description of the Milgrom-Roberts model, which I follow here. There is a single incumbent and a single potential entrant. All aspects of the market are known with certainty, with the exception that the entrant does not know the incumbent's cost. The incumbent's marginal cost is a constant equal to either  $C_1$  or  $C_2$  with  $C_1 < C_2$ . There are two periods: "pre-entry" and "post-entry". Post-entry profits are discounted by a factor  $\delta$ . The entrant's profits, conditional on the incumbent's cost, are

$$\pi^e(C_2) > 0 > \pi^e(C_1) \quad (31)$$

The entrant can guarantee a return of 0 if it stays out. With complete information about the incumbent's cost, entry would occur only if the incumbent is high cost. With incomplete information, the firm will choose to enter only if the prior probability that the incumbent has cost  $C_2$  is sufficiently high, which I assume to be the case.

The incumbent wants to avoid competition and it can accomplish this if it could convince the entrant that it is low cost ( $C_1$ ). Suppose that in order

to deter entry the incumbent can choose either a low price  $P_1$  or a high price,  $P_2$ , which it must charge in both periods if entry does not occur. As there are only two "types" of incumbents, two pre-entry prices are sufficient to distinguish the incumbent's cost if the pricing decision is a function of cost. An equilibrium that accomplishes this distinction is called a "separating" equilibrium. If the entrant believes that the pricing decision is not correlated with the incumbent's cost, price does not convey information about the incumbent's type and the equilibrium is called "pooling".

Fudenberg and Tirole argue that a pooling equilibrium does not exist in this model. For if a pooling equilibrium did exist, the incumbent's pricing decision would not convey any information about its cost and would have no effect on the entry decision. In that case, the incumbent's best pre-entry price would be its monopoly price. But the monopoly price depends on its cost, so an entrant would know the incumbent's cost by observing its price. This can't be in a pooling equilibrium, so a pooling equilibrium cannot exist.

Let's turn next to a separating equilibrium. It is reasonable (although not absolutely necessary) to assume that the high price will be associated with a high cost incumbent. If the firm is known to be high cost, it might as well choose the monopoly price. Therefore,  $P_2 = P_2^m$ . Our task, then, reduces to showing the existence of a separating equilibrium with  $P_1 < P_2^m$ .

For a separating equilibrium to exist, it must be incentive compatible for both a low cost and high cost incumbent. A high cost firm should not want to imitate a low cost firm. If the high cost firm can imitate a low cost firm by charging a price  $P_1$ , entry would be deterred and it would earn  $\pi^1(P_1 | C_2)$  in both periods. This must be less than the profit it would earn by being

honest. Since honesty would lead to entry, an honest high cost firm would charge a monopoly price in the first period. Entry would occur in the second period and the firm would earn  $\pi^d(C_2)$ , where "d" represents the profit earned in a duopoly. The incentive compatibility condition for a high cost firm reduces to

$$\pi^m(C_2) - \pi^i(P_1 | C_2) > \delta [\pi^i(P_1 | C_2) - \pi^d(C_2)] \quad (32)$$

Similarly, a low cost incumbent should not want to deviate from a limit pricing strategy. If it did, it could do no better than charge a monopoly price in the first period. If a low cost incumbent deviates from  $P_1$ , it is reasonable to assume that a high cost incumbent would also deviate. This could risk entry if the first period price no longer signalled low cost. Thus the low cost incumbent has to compare  $\pi^i(P_1 | C_1)(1 + \delta)$  with  $\pi^m(C_1) + \delta\pi^d(C_1)$ , which reduces to

$$\pi^m(C_1) - \pi^i(P_1 | C_1) < \delta[\pi^i(P_1 | C_1) - \pi^d(C_1)] \quad (33)$$

Figure 10 shows the the comparison. The first incentive compatibility condition, inequality (32), is satisfied for any  $P_1$  less than  $P_a$ . Inequality (33) is satisfied for any  $P_1$  greater than  $P_b$ . Thus any  $P_1 \in (P_b, P_a)$  can be part of a separating equilibrium in which an incumbent charges  $P_1$  in the first period only if it is low cost, and charges  $P_2^m$  if it is high cost. Entry is deterred at  $P_1$ , but occurs if the first period price is  $P_2^m$ .

The uncertainty of the incumbent's cost is crucial to the existence of limit pricing in this model. If the incumbent's cost were known to the entrant, the entry decision would be independent of the incumbent's price in the

pre-entry period. Entry would occur if, and only if, the incumbent is high cost.

Limit pricing in the Milgrom and Roberts model is a means by which the incumbent can send a signal to the potential entrant about post-entry market profitability. Note that in a separating equilibrium the incumbent's true cost is revealed to the potential entrant. This leads Milgrom and Roberts to conclude that limit pricing need not "limit" entry. The probability that entry will occur is just the probability that the incumbent is high cost. This is the same probability of entry for a perfect-information model, in which nature moves first to determine whether the incumbent is high or low cost and the potential entrant is informed of the result. Yet the important distinction is that incumbent pricing is a strategic decision in the imperfect information model.

The consequences of imperfect information for entry deterrence depend on the information structure. Matthews and Mirman [1983], Saloner [1981], and Harrington [1984] describe signalling models in which prices are noisy signals of market conditions. As a result of exogenous disturbances, a potential entrant is not able to determine post-entry market conditions with certainty given an incumbent's pricing decision. They show that in a noisy information structure, the probability of entry can be an increasing function of an incumbent's price, which provides a theoretical foundation for models of limit pricing such as Kamien and Schwartz [1971] and Gaskins [1971]. Moreover, the probability of entry depends on the information structure and may differ from the entry probability with perfect information about market conditions.



An extension of the Milgrom and Roberts model by Harrington [1986] illustrates the importance of the information structure. Harrington allows the entrant's cost function to be uncertain and positively correlated with the incumbent's cost (not unreasonable if they use similar production technologies). If the potential entrant believes its cost is high, it will stay out of the industry. With the extra twist of positively correlated costs, the incumbent has an incentive to price high in order to signal a high cost and thereby convince the entrant that its cost is high too. In order to discourage entry, the incumbent prices high, not low.

### VII. Contestable Markets

The theory of contestable markets targets potential entry as a primary determinant of market structure and performance. Baumol, Panzar and Willig [1982] (Henceforth BPW) define a "perfectly contestable market" with reference to the notion of sustainable industry configurations. Let  $y$  be a vector of industry outputs,  $C(y)$  the cost of producing  $y$ , which is assumed to be the same for all firms,  $p$  the industry price vector and  $Q(p)$  the vector of demands at price  $p$ . Suppose a potential entrant offers to sell  $y^e$  at a price  $p^e$ . An industry price vector is sustainable if

$$p^e y^e \leq C(y^e) \tag{34}$$

for all  $p^e \leq p$  and  $y^e \leq Q(p^e)$

Note that implicit in the definition of sustainability is the presumption that capital movements take place instantaneously, while prices are fixed. An entrant can test the market and bring capital into production while prices

charged by established firms remain fixed. This contrasts with the behavioral assumptions in models such as Bertrand-Nash, in which prices can change instantaneously and quantities adjust to clear markets.

The definition of a perfectly contestable market is a market in which a necessary condition for an industry configuration to be in equilibrium is that it be sustainable. Contestability is not the outcome of a particular dynamic game, but rather is defined as a property of equilibrium outcomes (but see BPW [1986] for a dynamic treatment of contestable markets). Sustainability from entry is the essential element. A market is perfectly contestable if an equally efficient entrant is unable to find a combination of price and outputs that enable it to enter and earn a profit.

A perfectly contestable market is an illustration of a market without barriers to entry or exit. There is no product differentiation and no cost advantages. There is no uncertainty. Switching costs and learning economies are nonexistent. Production may exhibit increasing returns to scale, but firms do not incur any costs that are not perfectly reversible in the event of exit from the market (there are no sunk costs).

The realism of the contestability assumptions can be questioned (see, e.g. Reynolds and Schwartz [1983], Weitzman [1983] and Brock [1983]), but that is not my purpose. The absence of barriers to entry and exit in the contestability theory provide a convenient benchmark to ascertain the consequences of barriers to competition. BPW show that if a market is perfectly contestable and if an equilibrium exists, then price will equal marginal cost for any product produced in positive amounts by two or more

firms. If only one firm exists in a perfectly contestable market equilibrium, total revenues will exactly equal total production costs.<sup>30</sup>

The contestability result is about as good as anyone can hope for. Contestable markets either mimic perfectly competitive markets, or they act as perfectly regulated monopolies with (average) price equal to average cost.<sup>31</sup> Central to the contestability result is the assumption that no costs are sunk. The absence of sunk costs is important in two respects. First, with no sunk costs, a potential rival can consider hit-and-run entry without concern about irreversible investments. A potential rival would enter the market if he anticipated any possible situation in which profits would be positive. In a contestable market, entry is an option which can be exercised at no cost. If there is any possibility of profit, however small, it pays to enter. Second, with no sunk costs and with identical technologies, the incumbent firm and a potential entrant bear the same cost at each level of output. There is no strategic asymmetry between an entrant and an established firm because each faces exactly the same cost and revenue function.

The theory of perfectly contestable markets illustrates how market structure and performance may be determined in a world free of barriers to the mobility of capital. As a theoretical description of strategic behavior, it is a special case whose assumptions can be criticized, but the acid-test of any theoretical model is its predictive performance. Contestability theory has support in the observation of competitive conditions in markets for commuter air service (see Bailey and Panzar [1981] and Bailey, Graham and Kaplan [1984]). What remains uncertain, however, is the extent to which markets that have weak barriers to capital mobility conform to the theory of contestable markets, and at what point are mobility barriers large enough that markets

are not contestable. (See Farrell [1986b] for a discussion of the robustness of contestability).

### VIII. Mobility Barriers and Economic Performance

Economic analysis of entry barriers is motivated by the search for structural factors that undermine market performance, and the discussion of various determinants of mobility barriers in this chapter may suggest a causality that runs from a barrier to an impediment to market efficiency. But this would be a mistaken conclusion. Although product differentiation can be associated with high profit rates and economies of scale can allow a firm to elevate price above minimum average cost (or at least above marginal cost), this does not mean that market performance is compromised. Product differentiation exists because consumers value one brand more than another and there are likely to be good reasons for this to be the case. As Demsetz [1982] argues, firms that enjoy the benefits of product differentiation do so as the result of investments in reputation and quality and the "barrier" that may exist to imitation is a flow of quasi-rents that are the earnings from these investment activities. (see Shapiro [1983]).

Entry in actual markets can fall short of the amount that would be desired by an enlightened and perfectly informed social planner whose objective is to maximize economic surplus. This is demonstrated by the results in, for example, Spence [1976], Dixit and Stiglitz [1977], and Perry [1984]. Mankiw and Whinston [1986] describe market externalities that lead to too much or too little entry.

The economies-of-scale/sunk cost entry barrier provides an illustration of the welfare effects of a barrier to competition. The existence of scale economies itself implies that an efficient market structure would be concentrated. If costs are everywhere subadditive, the efficient market structure is a single firm. Entry prevention is consistent with an efficient market structure.

Welfare judgements as to the effects of mobility barriers in actual markets are difficult to make because actual markets inevitably operate in a region of the second-best and any attempt to improve market performance must recognize the imperfections of market intervention. We can say that a single firm is the optimal market structure with increasing returns to scale, but optimality is rarely a feasible alternative in markets characterized by imperfect competition.

As an illustration of competitive alternatives, consider the BSM model with a single established firm and a single entrant. The cost functions are as in equation (7): constant marginal costs and a fixed cost of entry. Figure 3 shows the range of alternative market structures as a function of the limit price. The established firm prevents entry whenever  $Y$  is less than  $Z_1$  (entry is blockaded when  $Y$  is less than  $Z_0$ ) and allows entry otherwise.

Suppose a central planner can tax either output or factor prices in this simple economy and can exclude entry, but firms cannot operate at a loss. What is the (constrained) optimum for this economy? Contestability theory provides the answer - a single firm operating at the point where price equals average cost. This market structure minimizes cost and pricing at average cost yields the maximum consumer surplus subject to the break-even constraint.

The contestability outcome can be sustained by means of a nonlinear tax that is arbitrarily large for any output less than  $x^*$ , where  $x^*$  is the output at which the demand price is equal to the firm's average cost, and zero otherwise. The nonlinear tax supports the constrained optimum and allows the operation of only one firm - the rival is deterred.

What if the planner is limited to controlling only the conditions of entry? In the BSM model, this amounts to controlling only the cost of entry, or effectively, the limit output  $Y$ . Making entry easier has the effect of increasing  $Y$ , while making entry more difficult lowers  $Y$ . Assuming transferable utility,  $U$ , and linear costs, total surplus is

$$U(X) - mX - nF \quad (35)$$

where  $X$  is total output,  $m$  the marginal cost of production,  $F$  the fixed cost and  $n$  the number of firms. If entry of a second firm is allowed, total surplus is  $U(X^E) - mX^E - 2F$  while if entry is prevented, surplus is  $U(X^P) - mX^P - F$ .

Provided  $X_p$  is no greater than the perfectly competitive level where price equals marginal cost, a sufficient condition for entry prevention to be welfare increasing is  $X^P > X^E$ . If marginal production costs are constant and there is a fixed cost associated with entry, limit pricing can be superior to entry in terms of aggregate welfare even if  $X_p < X_E$ .

Consider the case of linear demand and constant (and equal) marginal production costs. Suppose that incumbent firms act as Stackelberg leaders in the choice of post entry output. It is not difficult to show that for the limit output at which incumbent firms are indifferent between allowing and

preventing entry, the limit output exceeds the total industry output with entry.<sup>32</sup> This level of the limit output is shown as  $Z_1$  in Figure 3. For  $Y = Z_1$ , even if entry incurs no additional fixed costs, welfare is strictly greater when the incumbent firms prevent entry. This result also holds for a (nontrivial) range of limit outputs around  $Z_1$ . Any additional fixed costs that an entrant would contribute further tip the welfare balance in favor of entry prevention.

If  $Y > Z_1$ , the incumbent will not prevent entry. As shown in Figures 2b and 3, the large limit output makes entry prevention too costly and incumbents would be better off if entry occurred. But suppose the central planner purposely taxes entry so that the higher fixed costs result in a new limit output  $Y' = Z_1$  (or slightly less). The incumbent will prevent entry and welfare will be increased relative to the case where there is no tax and entry occurs. This leads to the following result for the case of linear demand and constant (and equal) marginal costs. If the incumbent firm does not prevent entry, there exists a tax on entry which leads to entry prevention and results in a strict improvement in economic welfare.<sup>33</sup> The welfare economics of mobility barriers depend on the magnitude of the barriers as measured, for example, by the size of a minimum efficient scale plant as a fraction of market demand, and on the behavioral of incumbent firms in exploiting any barriers that may exist. Economies of scale limit the number of firms that may co-exist in an industry absent any actions of incumbent firms designed to limit entry. This is an example of what Salop [1979] has termed an "innocent" barrier to entry. In contrast, incumbent firms may coordinate a limit pricing strategy and in so doing erect what Salop [1979] has called a "strategic" barrier to entry.<sup>34</sup> While the use of behavior to exploit mobility barriers is a central theme in this area, caution is advised in attributing

any welfare significance to this behavior. Behavior that converts a barrier from the innocent to the strategic category can result in increased output and lower costs. Economic welfare can be improved with a loss of innocence.

## IX. Concluding Remarks

I have chosen to focus in this Chapter on the factors that interfere with the mobility of capital into and out of an industry and that specifically confer an advantage to incumbency. In the process, many of the historically advanced determinants of barriers to entry were found to be irrelevant to the gains from incumbency. Economies of scale, per se, are not sufficient to protect a firm from potential competition. Absolute cost advantages do not imply incumbency rents, unless the scarce factors are also specific to the incumbent firm. The concept of asset-specificity surfaced frequently as an underlying determinant of the gains to incumbency.

The emphasis in this Chapter on mobility barriers and incumbency should be distinguished from classical concerns with barriers to entry. The latter can be interpreted to include policies that affect the aggregate supply of productive resources in an industry. This is the focus of von Weizsacker, who defines a barrier to entry in terms of cost differentials between established firms and new entrants that imply a distortion in the allocation of resources from a social point of view. In contrast, I define a barrier to entry as a rent that is derived from incumbency. A limitation on the number of available taxi medallions is a barrier to entry of productive resources because it reduces the supply of taxi services. But it does not confer an advantage to early entrants in the taxi market, because the opportunity cost



of the medallion is an (equal) cost of service for incumbent firms and new entrants alike.

Strategic behavior can exploit mobility barriers to the advantage of an established firm. Sunk costs and economies of scale allow a firm to commit to a level of output that prevents entry. Learning and network economies confer a first-mover advantage that can be manipulated to enhance profits. Investments in advertising and product differentiation can be used to exploit scale-related barriers to capital mobility and limit competition by potential rivals.

There is no doubt that structural market characteristics which impede the mobility of capital can be used to the benefit of an established firm. The welfare implications of this advantage are another matter. Barriers to capital mobility are the result of technological conditions and consumer preferences that must be considered in any welfare analysis. Strategic behavior that exploits capital barriers can improve economic performance relative to a more accommodating stance toward potential entrants.

Structural barriers to capital mobility can be used to impede entry of rival firms, but they may also support strategies that welcome competition. An established firm might open the door to a new competitor, betting that the two firms will reach a mutually beneficial arrangement, while relying on entry barriers to discourage further competition. A firm with a large base of "locked-in" customers may choose to price high and thereby encourage new competitors to enter and lock-in other customers, instead of pricing low and keeping the market for itself. In some situations, as in Farrell and Gallini [1986] and Shepard [1986], an established firm may go out of its way to

encourage competition. In these models, a monopolist is disadvantaged by its (unavoidable) temptation to exploit locked-in customers. Customers know they will be exploited and, as a result, are reluctant to trade. By encouraging competition, the monopolist can guarantee that customers will be treated fairly in the future, and this can increase the value they place on trading with the monopolist in the present.

Contestability theory illustrates how markets that are free of barriers to capital mobility might perform and the results are admirable. Production costs are minimized and price is equal to marginal cost except in markets that are natural monopolies. The equilibria in the examples discussed in this Chapter are rarely as appealing. Although many of the market equilibrium outcomes described in this Chapter could, in principle, benefit from the visible hand of an omniscient intervenor, they may be as good as can be expected given imperfect competition, imperfect information, and the limited policy instruments available for the regulation of market performance.

## Footnotes

- <sup>1</sup> Bain [1968], p.252
- <sup>2</sup> Stigler [1968], p.67.
- <sup>3</sup> Demand considerations are not excluded from Stigler's measure of barriers to entry. For example, consumer loyalties affect the costs that a new firm must incur in order to reach a particular level of sales. To the extent that the new firm has to overcome more consumer resistance than did the established firm, the entrant would experience a Stiglerian barrier to entry.
- <sup>4</sup> Baumol and Willig [1981], p. 408.
- <sup>5</sup> Ferguson [1974], p.10.
- <sup>6</sup> Von Weizsacker [1980a], p.400.
- <sup>7</sup> See Dixit and Stiglitz [1977].
- <sup>8</sup> Bain [1968], p. 13
- <sup>9</sup> The limit output is treated as a parameter in Figure 3, but it need not be outside the influence of the incumbent firm(s). Williamson [1963] describes the use of marketing expenditures to influence limit prices. Expenditures that affect factor prices may affect limit prices as well (see Williamson [1968] and Salop and Scheffman [1983]) This is discussed below under "raising rivals' costs".
- <sup>10</sup> The importance of behavioral expectations is evident in the work of Kreps and Wilson [1982] and Milgrom and Roberts [1982b], in the context of Selten's [1978] and Rosenthal's [1981] chain store paradox. While these considerations are clearly relevant to entry deterrence, they have been examined primarily in the context of "predatory" behavior, and are discussed by Ordover and Saloner [1987] in Chapter of this Handbook.
- <sup>11</sup> Bain [1956], p.12
- <sup>12</sup> Mookherjee and Ray [1986] find similar strategic incentives for entry deterrence in a repeated game model with learning.
- <sup>13</sup> This subject is discussed in more detail by Ordover and Saloner in Chapter of this Handbook.
- <sup>14</sup> U.S. v. Aluminum Company of America, 148 F.2d 416 (2d Cir. 1945)
- <sup>15</sup> Strategies that limit the size of a rival's market increase average costs if the rival's production technology exhibit increasing returns to scale. Hence demand-reducing strategies can be similar in effect to cost-increasing strategies.
- <sup>16</sup> For examples of contracts and entry prevention in U.S. antitrust law, see Telex v. IBM and Brown Shoe v. U.S.

17 Bain [1956], p. 123.

18 Farrell [1986a] notes that new entrants may have a tougher time convincing customers that they will deliver comparable quality. In Farrell's model, competition lowers the future benefits from investments in quality. If consumers believe that new entrants do not have sufficient incentives to invest in high quality, they may be reluctant to experiment with their products. This result depends on the value of future profits to the entrant and on the firm's ability to warrant the quality of its goods.

19 Benham's conclusions have been verified by Haas-Wilson [1986] in a follow-up study of the eyeglass market. But note Peters' [1984] theoretical result that, in some circumstances, advertising restrictions can lead to lower prices.

20 Note that Dixit's model assumes perfect information and therefore ignores the role of advertising as an information source. The implications of advertising for consumer search and consequent market performance are discussed in Grossman and Shapiro [1984].

21 Note that product differentiation can be expected to affect the  $\beta$  terms as well.

22 The existence of "locked-in" customers is a powerful incentive for firms to develop strategies that permit discriminating between old and new customers. An example is the alleged price discrimination by IBM in the pricing of disk drives to new and old computer purchasers (see Telex v. IBM).

23 In the terminology of Bulow et al [1985], these factors determine whether the firms' products are "strategic complements" or "strategic substitutes".

24 These considerations suggest the applicability of the literature on bounded rationality, disequilibrium economics and innovation to the dynamics of entry (see e.g. Williamson [1975] and Nelson and Winter [1982]).

25 Stigler [1968], p. 21.

26 Caves and Porter [1977], p. 250.

27 For example, Caves and Porter [1977] write, "...an investment in entry deterrence generally protects not just the investor but his oligopolistic rivals as well, and thus raises special problems for the form and extent of collusion....the industry's level of investment in deterrence, in the absence of collusion among going firms, could be either greater or less than its level in the case of full collusion on the design of these investments and distribution of the rents. The negative effect of nonappropriable benefits from the collective good cuts against the positive effect of styling the investment to divert the benefits toward the firm making it." (pp. 247-248).

28 Firm  $j$ 's optimal output, conditional on entry, is (coincidentally) the same as the Cournot output ignoring all future entry (see equation (4)). In this special case, strategic and myopic behavior on the part of new entrants yield the same outputs.

29 For an interesting application of the importance of multi-market interactions to the case of product standardization choice, see Matutes and Regibeau [1986a,b].

30 But note that a perfectly contestable market equilibrium need not exist.

31 With vector-valued outputs, the relevant consideration is whether total revenue equals total cost. The correspondence to price and average cost is exact for the case of a scalar output.

32 A similar result can be demonstrated for the case in which the firms compete as Cournot competitors if entry occurs.

33 For an interesting discussion of the welfare effects of entry subsidies and protectionist policies in an international context, see Dixit and Kyle [1985].

34 See Encaoua, Geroski and Jacquemin [1986] for a further discussion of strategy and innocence.

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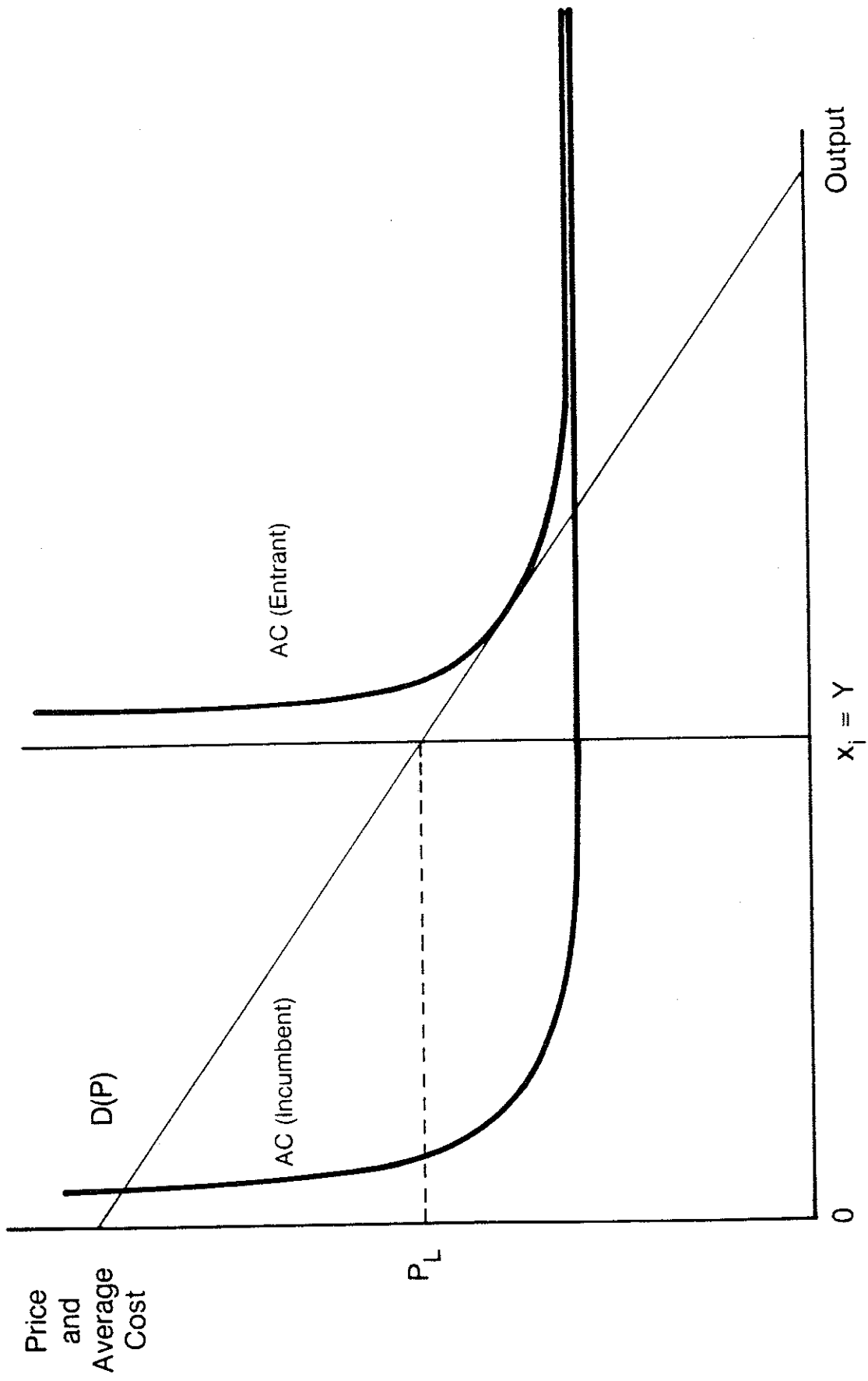


Figure 1. Limit Pricing

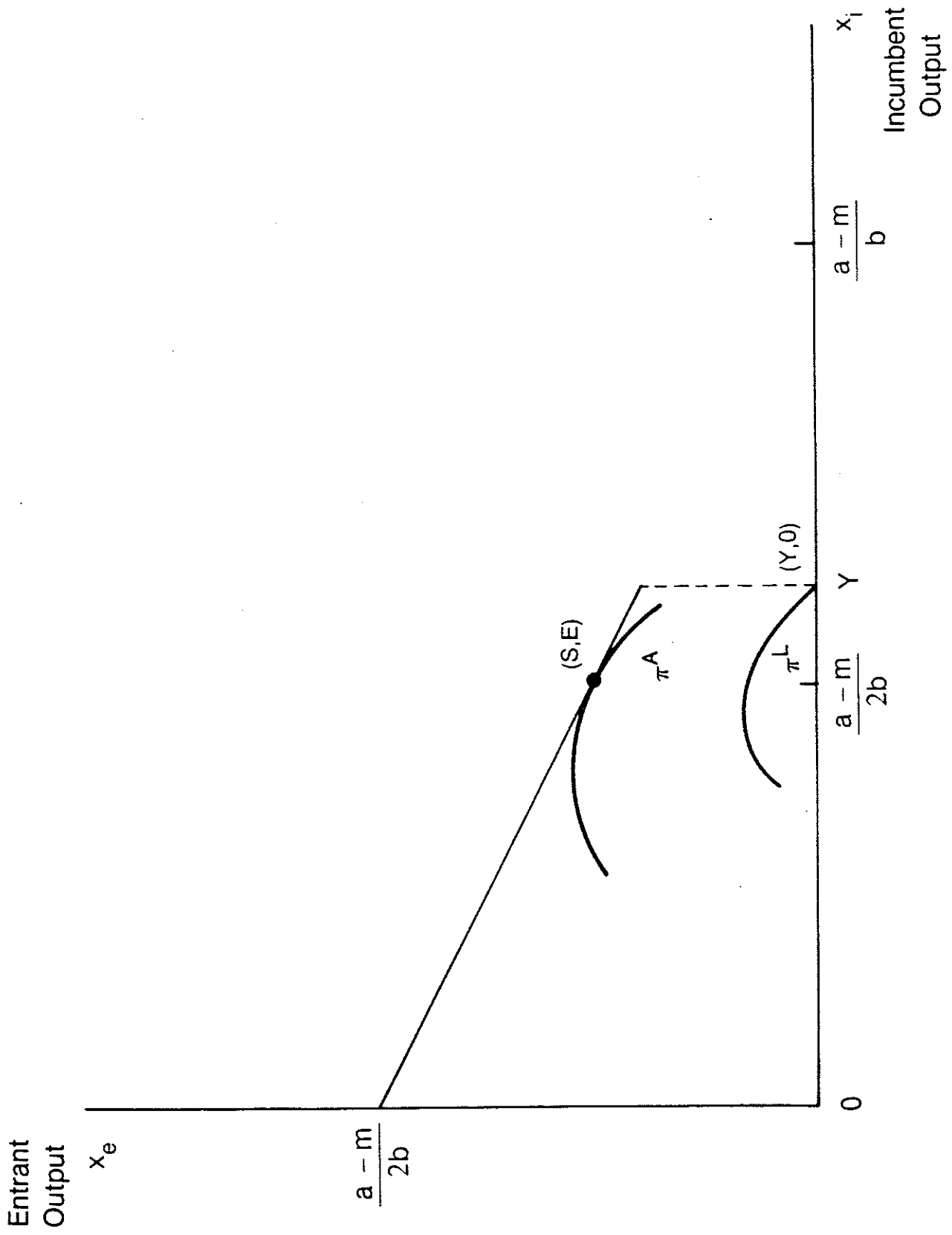


Figure 2a. Effectively Impeded Entry

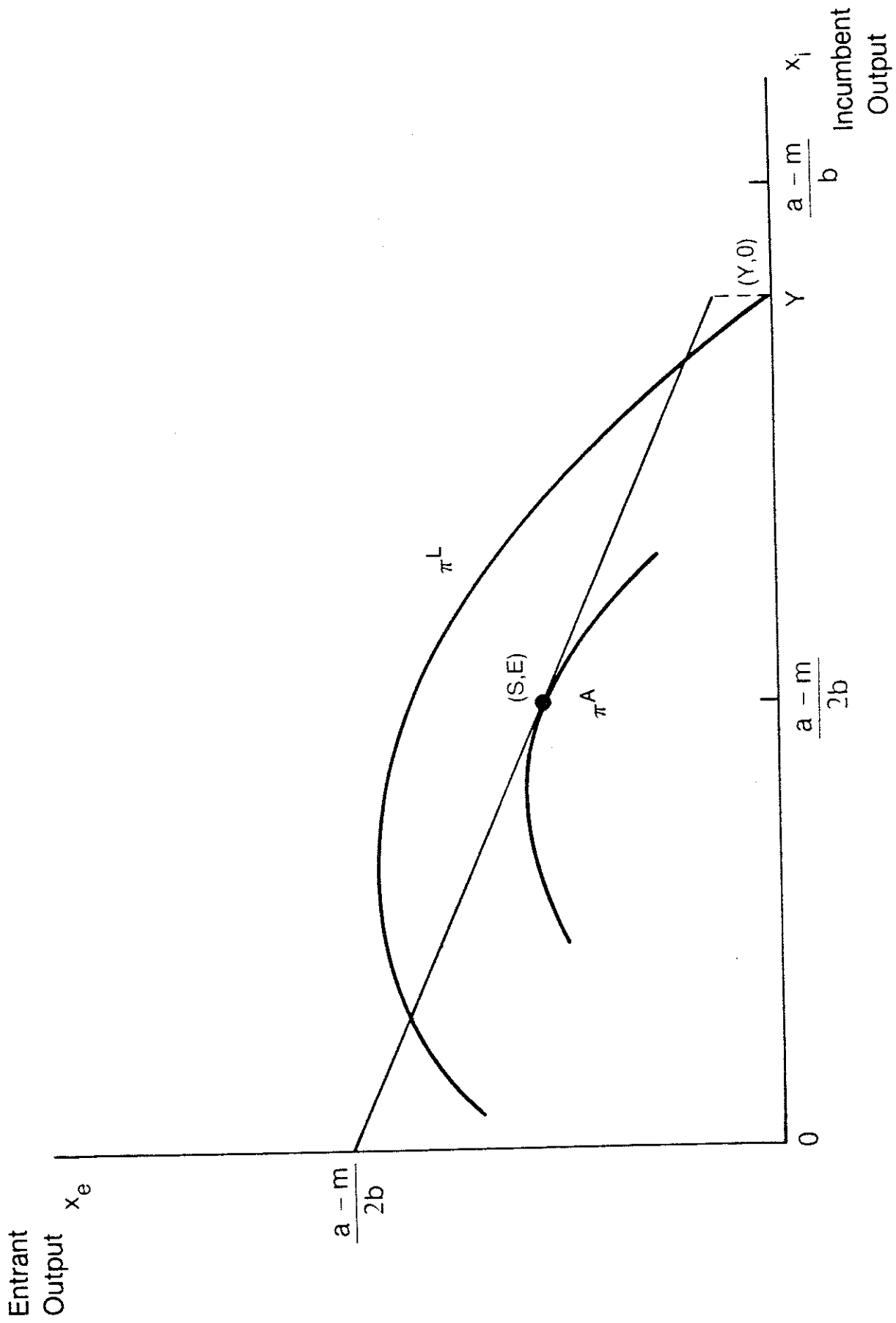


Figure 2b. Ineffectively Impeded Entry



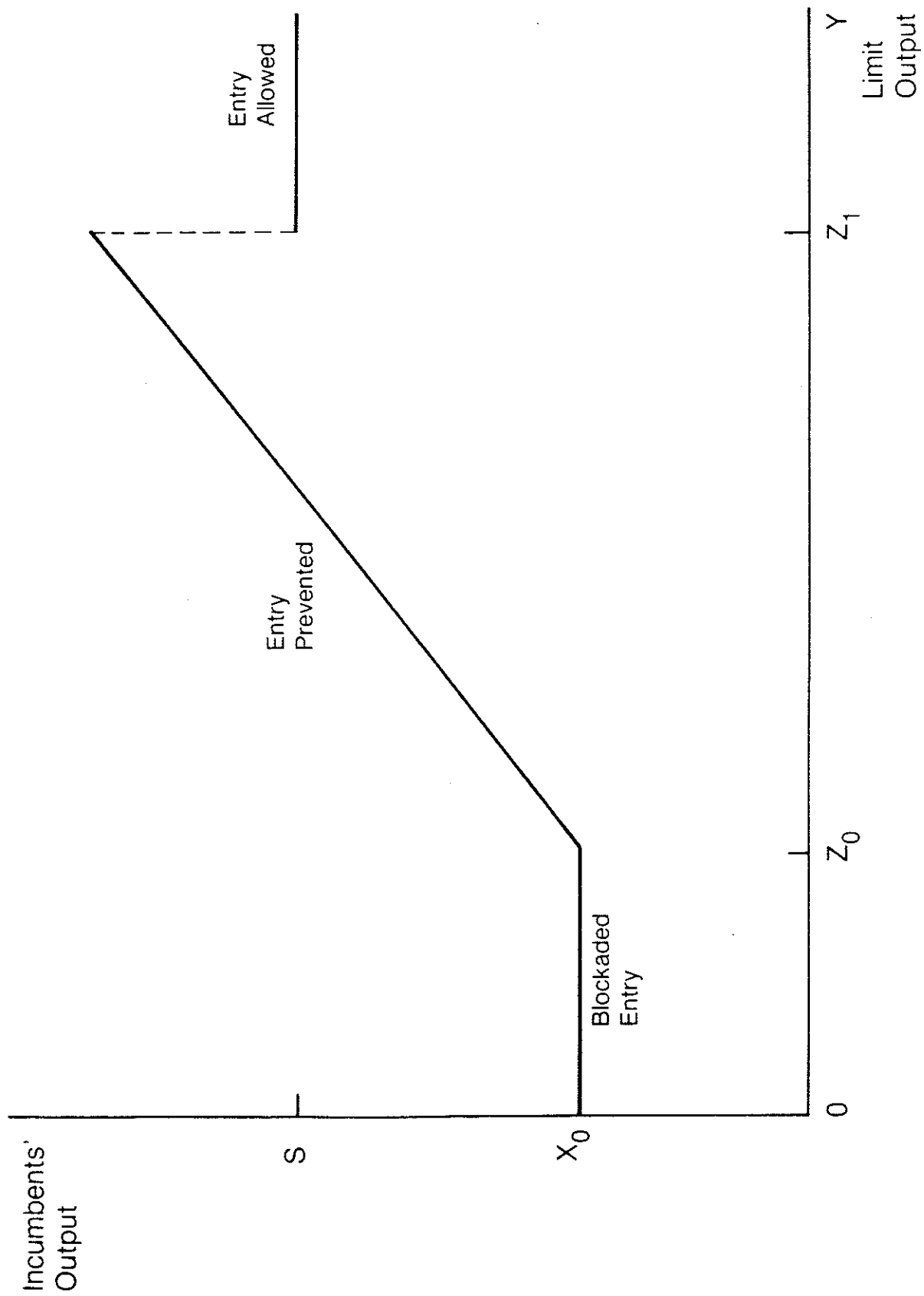


Figure 3. Zones of Strategic Behavior

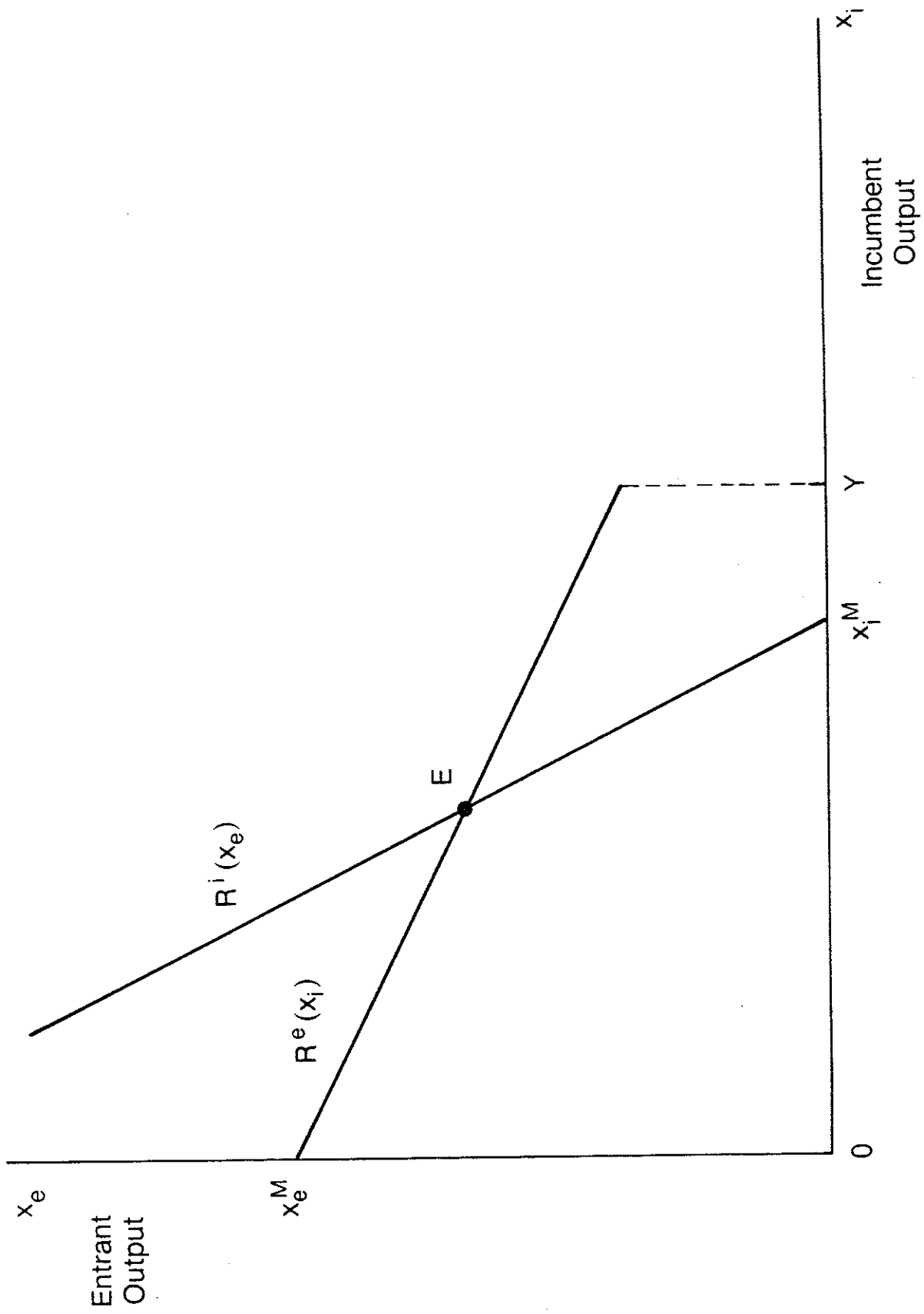


Figure 4. Equilibrium with Entry

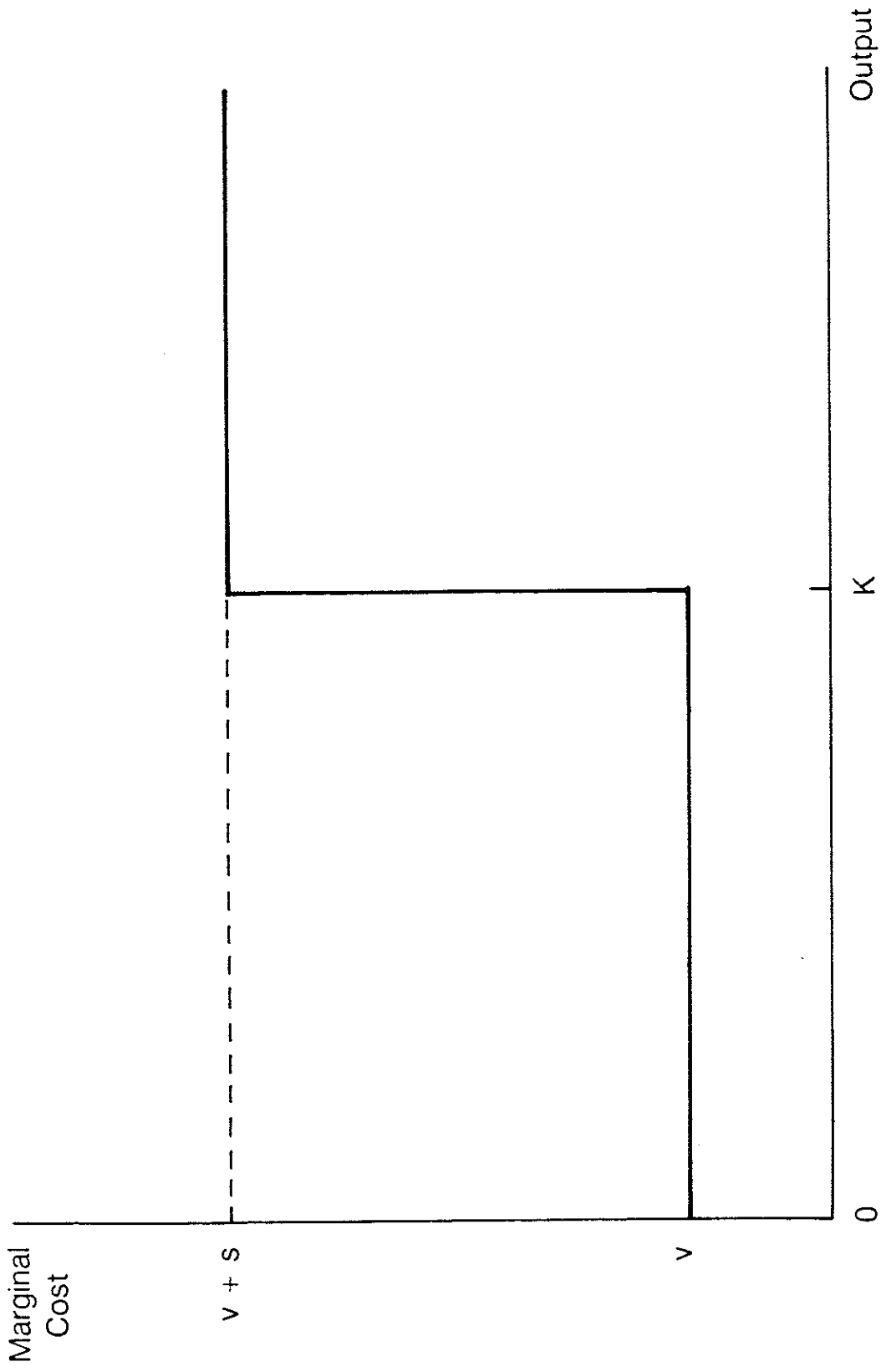


Figure 5. Marginal Cost Function with Sunk Costs

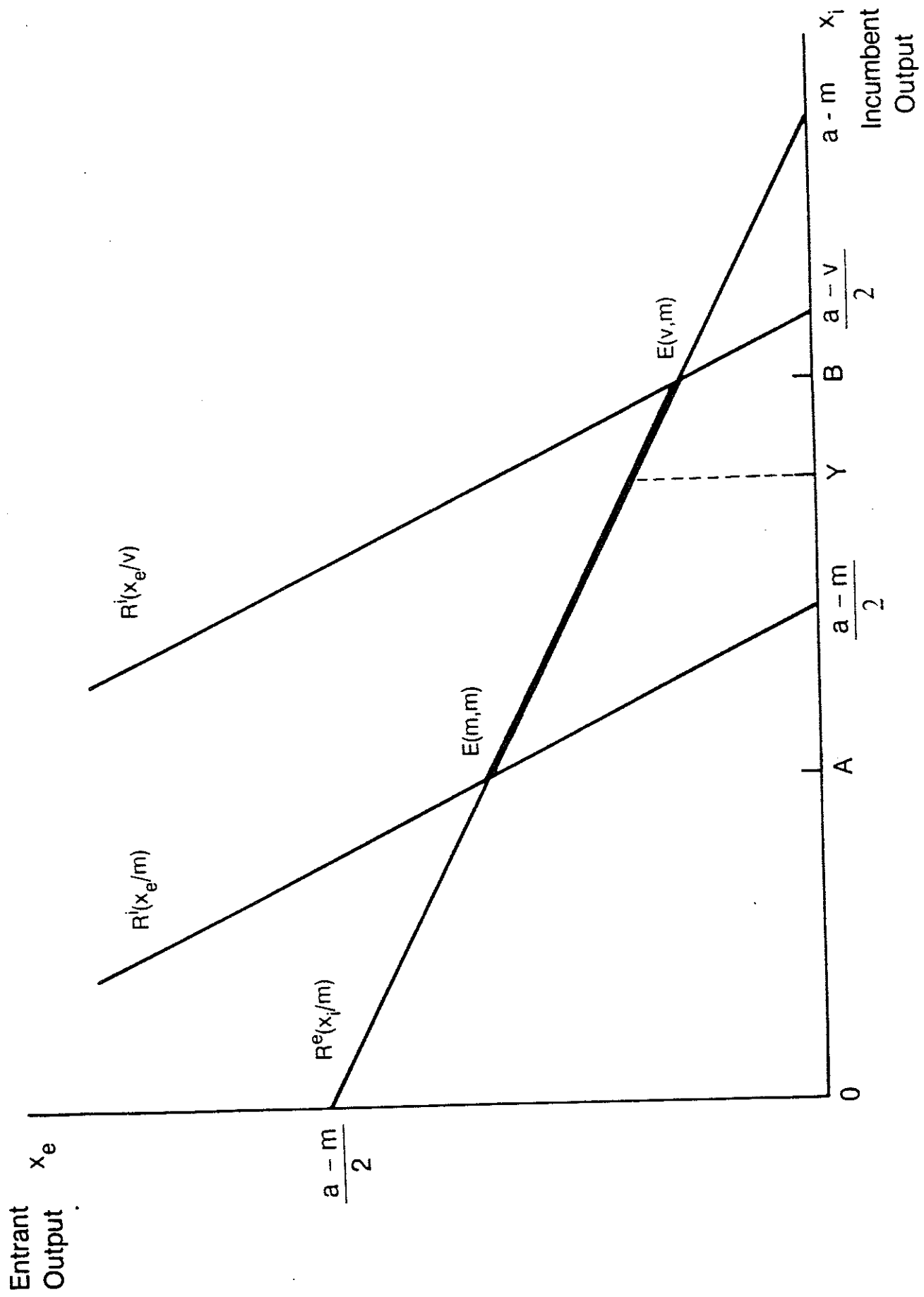


Figure 6. Reaction Functions and Equilibria with Capacity Investment

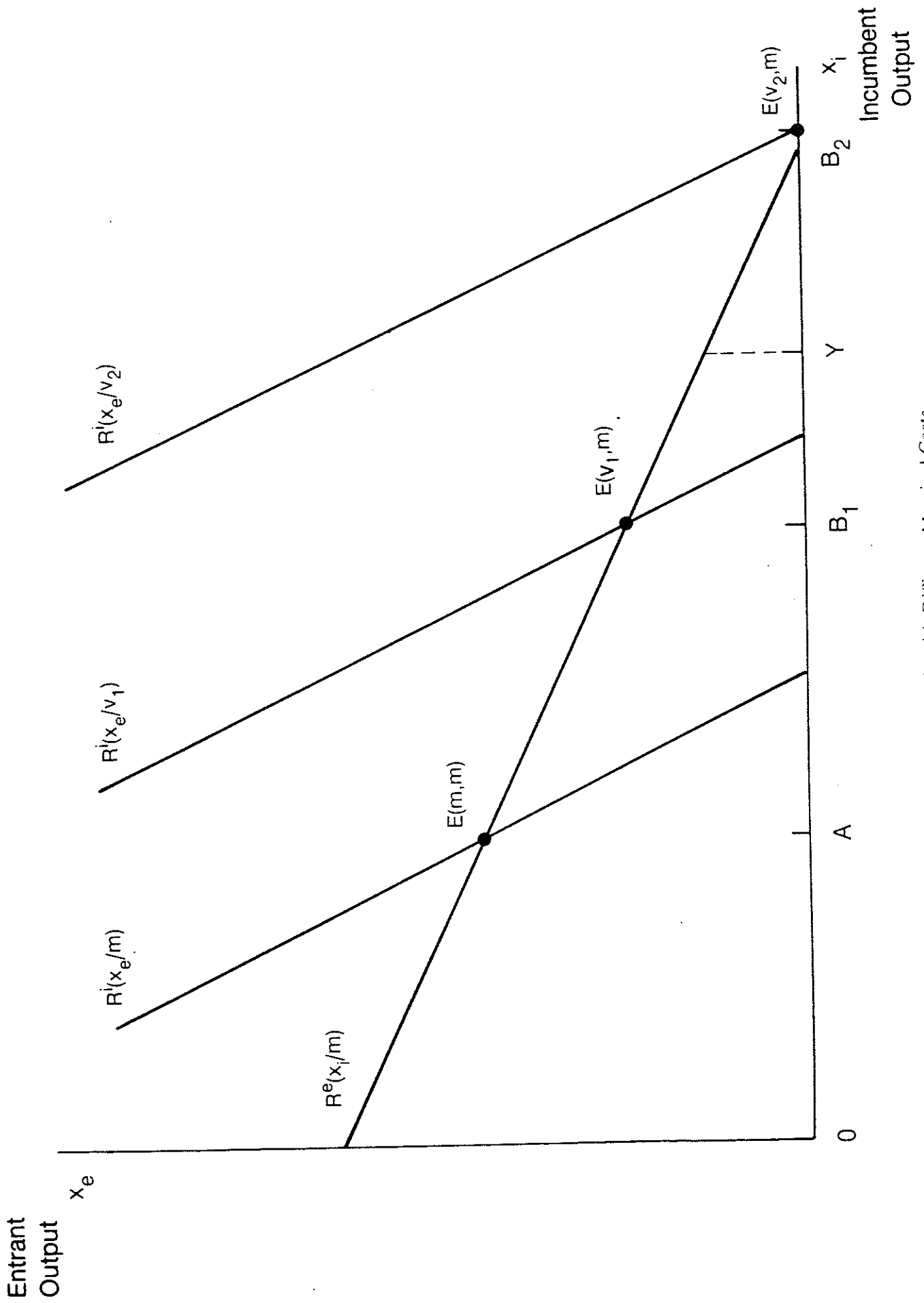


Figure 7. Equilibria with Different Marginal Costs

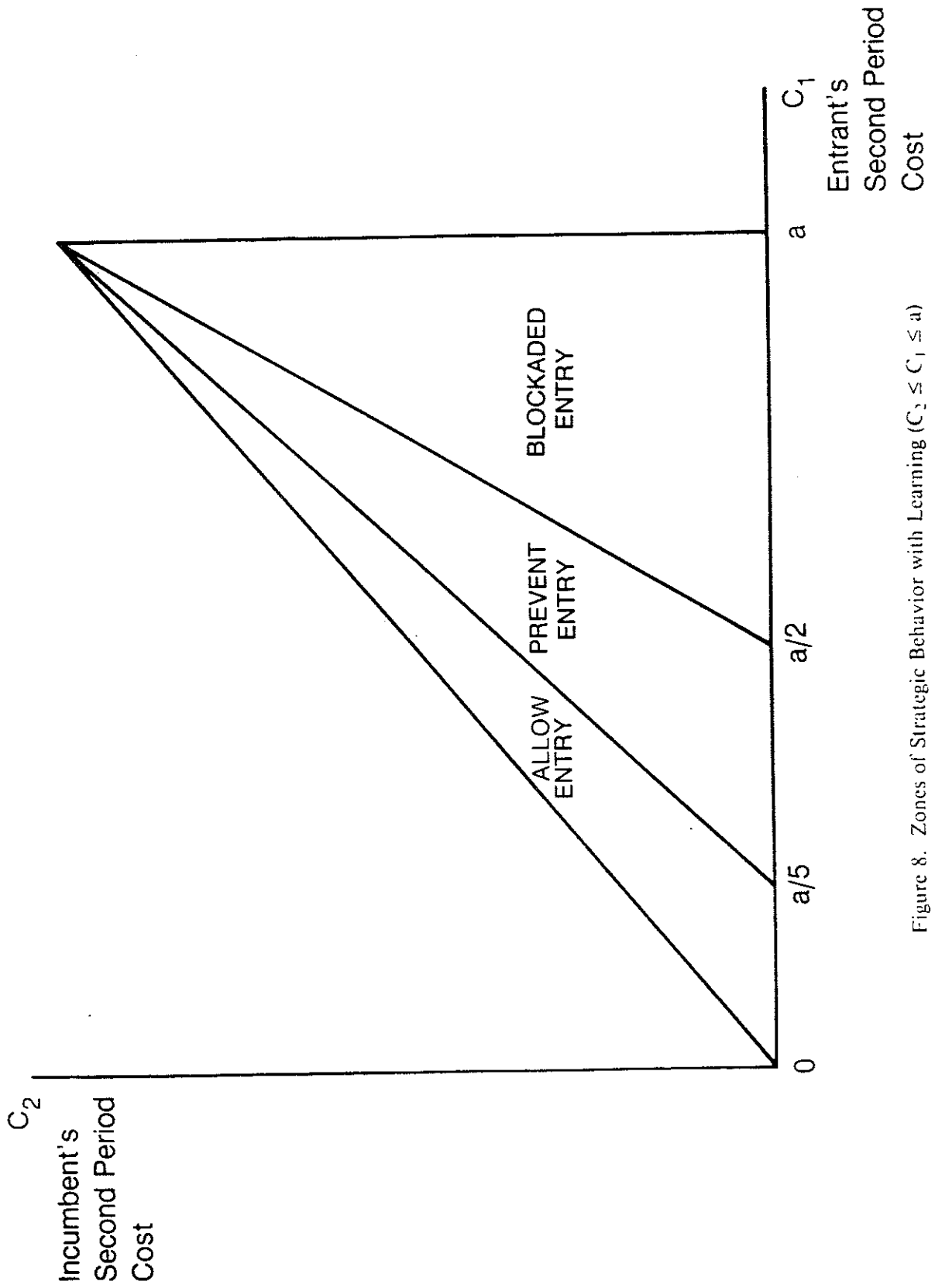


Figure 8. Zones of Strategic Behavior with Learning ( $C_2 \leq C_1 \leq a$ )

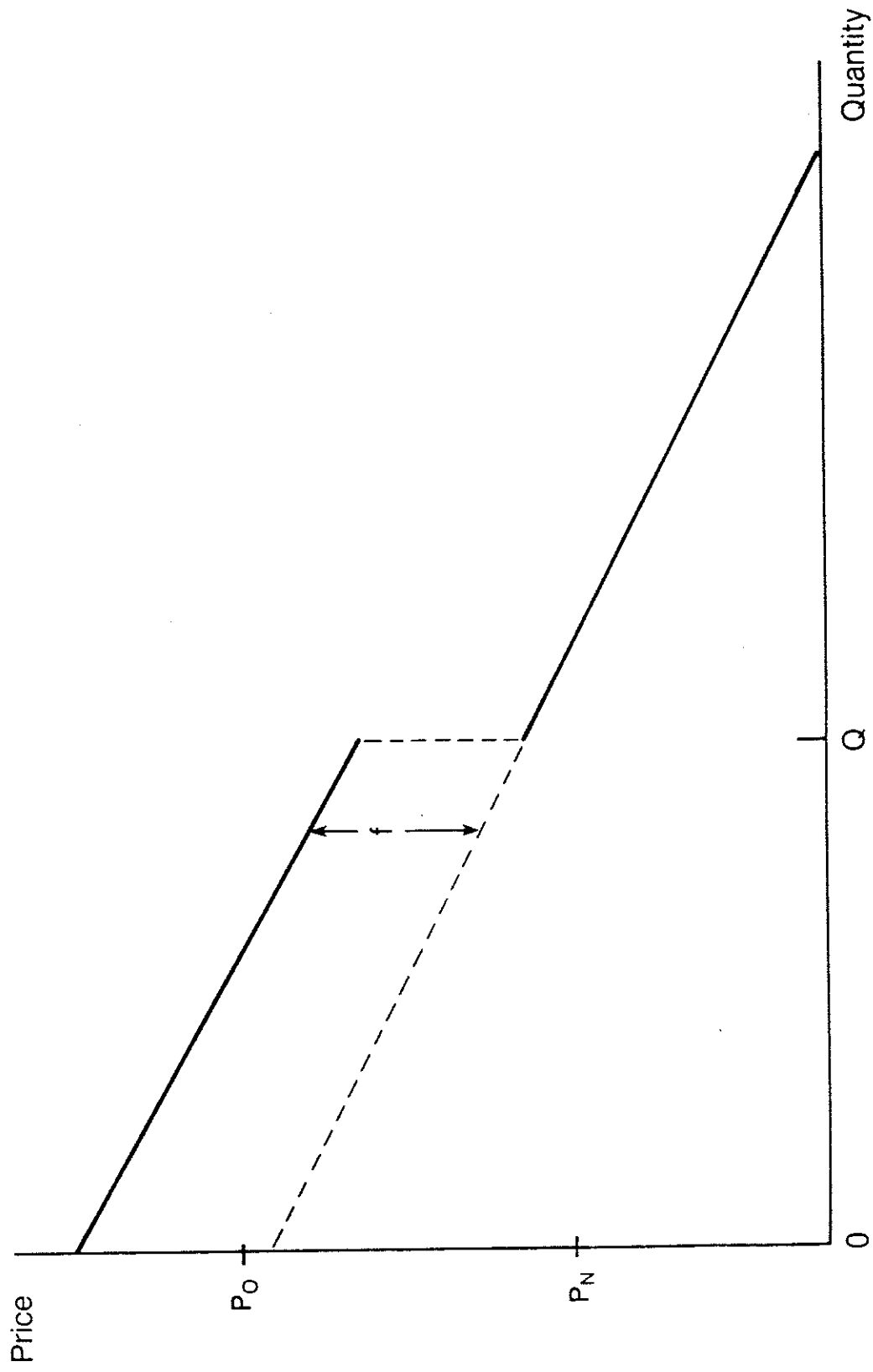


Figure 9. Demand with Switching Costs

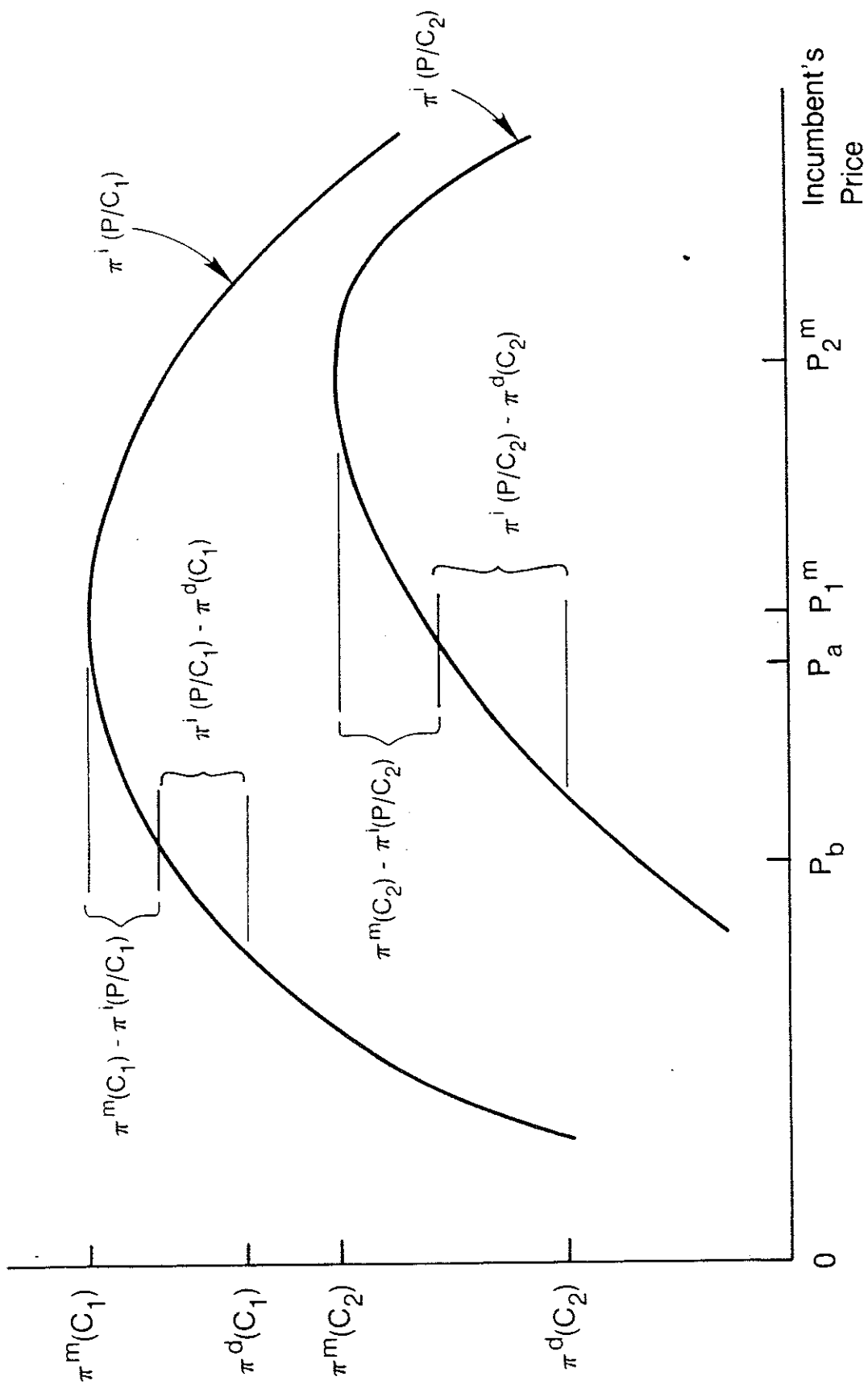


Figure 10. Incentive - Compatibility Conditions



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