Entry for Buyout

Eric Rasmusen

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The possibility of buying out an entrant has an important effect on entry deterrence. Entrants can blackmail the incumbent by threatening to keep prices low, and buyout can make entry profitable which otherwise would not be. In particular, the entry deterrence policy of excess capacity to reduce the post-entry price can not only fail, but work against the incumbent. The presence of multiple oligopolistic incumbents or multiple potential entrants, however, can discourage entry for buyout.

I. INTRODUCTION

THE LONG literature on entry deterrence has always assumed that if entry is made unprofitable, no entry will occur. But as followers of professional football may have suspected, a clearly unprofitable competitor might rationally enter a market in the hopes of selling out to the incumbent. I will model such a situation, and try to show what conditions facilitate entry for buyout.

In the simplest entry deterrence model, the incumbent successfully maintains monopoly by threatening to expand output and cut price after other firms enter, but he succeeds only because potential entrants believe the threat. If entrants are rational this strategy fails: price warfare hurts the incumbent as well as the entrant, so the monopolist would let the entrant have a share of profits after entry; potential entrants, foreseeing the accommodating response, ignore the threat.

Deterred entry is a Nash equilibrium, but not a "perfect" Nash equilibrium. It is Nash because the entrant chooses to stay out, given the incumbent's strategy of cutting prices after entry, and the incumbent does not mind committing himself to cutting prices, given that entry never occurs. A perfect Nash equilibrium is a set of strategies that is a Nash equilibrium for every proper subgame: if the game is started at any of the nodes of the game tree, including those off the equilibrium path, the strategies the agents pick to maximize their objective function from that node onwards must be part of the equilibrium strategy for the entire game. In the subgame which begins after entry has already occurred, the incumbent would not choose to cut prices, so cutting prices after entry is not part of a perfect equilibrium. In the perfect equilibrium, entry occurs and is accommodated.

The point is older than the concept of perfect equilibrium and has been made, for example, by McGee [1958] in the context of predatory pricing, which he argues is not a credible threat because it hurts the predator as well as the preyed upon. McGee concludes that Standard Oil's episodes of price warfare in the nineteenth century and its ultimate buyout of small refineries are examples not of predatory behaviour, but simply merger to increase market power.

Many economists feel that the layman's widespread belief that entry deterrence does occur is justified by something missing from a model like McGee's, and have searched for the misssing element. Entry deterrence requires some way for the incumbent to commit himself to unprofitable post-entry pricing. The incumbent cannot sign a contract requiring himself to lower the price after entry, but he can perhaps change his investment policy to make such behaviour optimal. Spence [1977] shows how the incumbent would build capacity in excess of normal use, if he could credibly threaten to use it after entry. Dixit [1980] constructs a similar model in which firms follow Cournot behaviour and incur fixed as well as variable operating costs. After entry occurs output can be so great that both firms' profits net of capacity costs are negative. Having already sunk the capacity cost, the incumbent fights entry without further expense. The entrant's capacity cost is not yet sunk, so he refrains from entry.[1]

An outcome not modelled by Spence and Dixit is that the incumbent buys out the entrant. An incumbent who fights entry bears two costs: the loss from selling at a price below average total cost, and the opportunity cost of not earning monopoly profits. He can make the first a sunk cost, but not the second. The entrant, foreseeing that the incumbent will buy him out, will enter despite knowing that the duopoly price will be less than his average total cost. The incumbent faces a second perfectness problem, for while he may try to deter entry by threatening not to buy out entrants, the threat is not credible, and as a rational agent he will indeed buy them out once they have entered.

The possibility of buyout changes the direction of credible threats. In the Spence and Dixit models the incumbent threatens the entrant with low prices; with buyout, the entrant threatens the incumbent with low prices. For the threat to be credible the entrant's optimal behaviour if he is not bought out must be to stay in the market and continue to depress the price (an exception, explained below, being when the entrant might drive the incumbent from the market). To fulfill this condition, once the entrant has entered, his capacity cost sunk, the duopoly price must at least equal average variable cost.

Section II sets up a buyout game with one potential entrant and solves for the equilibrium of a numerical example. Section III is a more general analysis

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[1] In Dixit [1980], the incumbent never holds unused capacity as he does in Spence [1977], although he might hold more capacity than without the threat of entry. Bulow, Geanakoplos, and Klemperer [1985] show that with a slight change of Dixit's assumptions the incumbent does hold unused capacity.

Duopoly

Entrant Monopoly

Incumbent Monopoly

Empty
Market

IN

OUT

IN

OUT

I 5

I 6

NI

OUT

Incumbent Monopoly
with Buyout

E 4

Buyout

Competition

I 3

$K_e > 0$
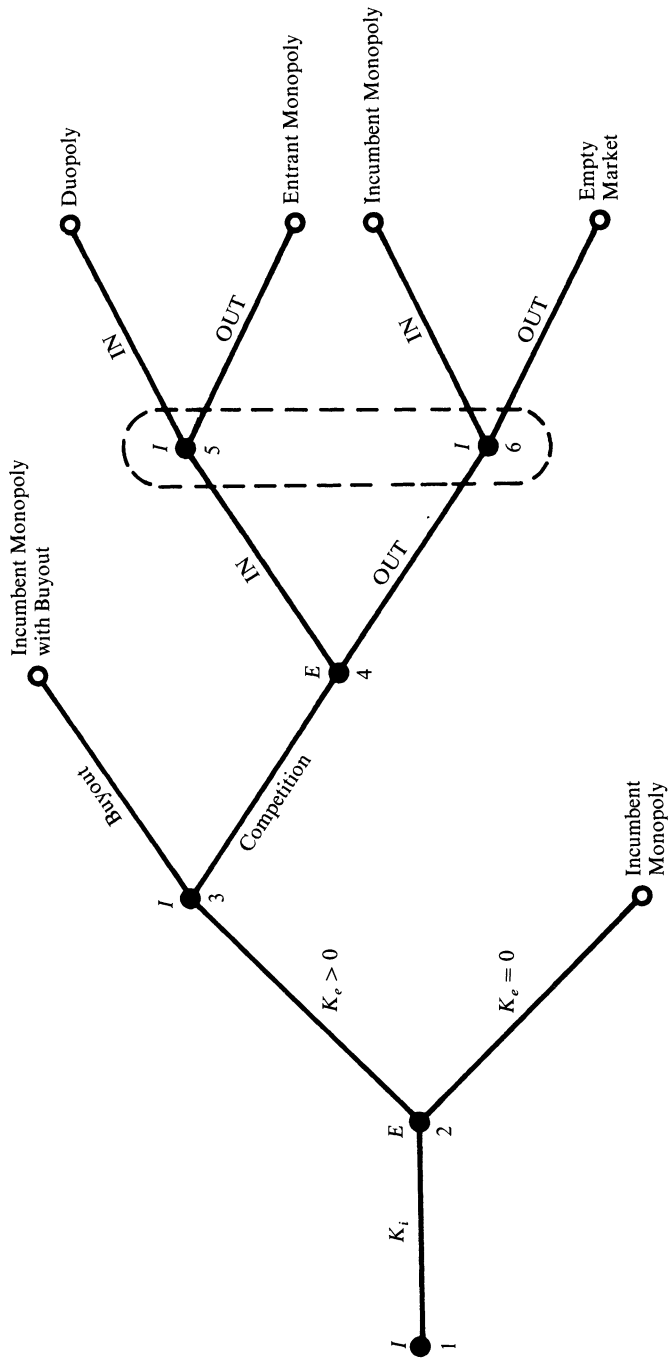
$K_e = 0$

Incumbent
Monopoly

E 2

K_i

I 1

Figure 1.

of the one-entrant game, relating it to the Spence and Dixit models and discussing briefly what happens if the incumbent is an oligopoly rather than a single firm. Section IV extends the model to two potential entrants.

II. ONE ENTRANT

II(i).　*The model*

An incumbent firm faces one potential entrant under conditions of symmetric information. Each unit of capacity costs a, the interest rate is r, and a firm's output cannot exceed its capacity.

Figure 1 shows the extensive form of the game. The incumbent moves first, selecting capacity K_i. The entrant then decides whether to enter, choosing a capacity K_e greater than zero, or to stay out of the market. If the entrant picks a positive capacity the incumbent decides whether to buy him out at price B and be left with the discounted value of the industry's net revenues as a monopoly, the value R^*. Two implicit assumptions are made by choosing this extensive form: The entrant must build a plant (for otherwise he could be paid not to enter at all); and once bought out, the entrant does not re-enter. Whether the incumbent buys out the entrant or vice versa is unimportant; I adopt this convention only for ease of exposition.

If the incumbent does not buy out the entrant, both firms decide whether to stay in the industry or exit, which is modelled as a simultaneous decision to avoid giving either firm an unwarranted first-mover advantage. In Figure 1 the IN/OUT decisions are represented by the entrant's decision at node four and the incumbent's decisions at nodes five and six. These decisions are non-trivial because the price might be less than average variable cost. The incumbent, who does not observe the entrant's decision before he makes his own, cannot distinguish between nodes five and six; the dotted line around the nodes indicates that they are in the same information set for him.

If both firms stay in, they produce output according to the appropriate duopoly solution concept, which is yet to be specified. The present value of the net duopoly revenues of the incumbent and entrant are denoted by R_i^d and R_e^d.

Table I is the normal form of the game, which displays the payoffs from

TABLE I
THE NORMAL FORM

Entrant: Incumbent:	$K_e = 0$		$K_e > 0, IN$		$K_e > 0, OUT$	
Buyout, IN	$R^* - aK_i,$	0	$R^* - aK_i - B,$	$B - aK_e$	$R^* - aK_i - B,$	$B - aK_e$
No buyout, IN	$R^* - aK_i,$	0	$R_i^d - aK_i,$	$R_e^d - aK_e$	$R^* - aK_i,$	$-aK_e$
No buyout, OUT	$R^* - aK_i,$	0	$-aK_i,$	$R^* - aK_e$	$-aK_i,$	$-aK_e$

different strategy combinations. The incumbent chooses the capacity K_i, whether to buy out the entrant, and whether to stay in after deciding not to buy him out. The entrant chooses the capacity K_e and whether to stay in if not bought out.

The payoffs depend on the discounted value of the net monopoly revenue R^*, the discounted values of net duopoly revenues R_e^d and R_i^d, the capacity cost a, and the buyout price B. To find the equilibrium strategies we need to make two stronger assumptions about firm behaviour. First, we need a duopoly solution concept to determine the duopoly net revenues as a function of the two firms' capacities. Second, we need a bargaining solution to determine the buyout price as a function of the monopoly and duopoly revenues. Duopoly and bargaining are the subjects of large and continuing literatures, but they are of subsidiary importance in this model, which only tries to say what the equilibrium of the dynamic game will be for given solution concepts.

II(ii). *A numerical example*

Before going on to solve for the equilibrium of the general game, let us analyze an example, loosely based on Dixit [1980], which uses a particular duopoly concept and bargaining solution. The market lasts one period and has the demand curve

$$(1) \qquad P = 100 - Q_i - Q_e$$

where Q_i and Q_e are the outputs of the two firms. The cost per unit of capacity is $a = 10$, the marginal cost of output is 10, and the fixed cost is $F = 601$. Output follows Cournot behaviour and the bargaining solution splits the surplus equally.[2] Figure 1 shows the extensive form.

If the incumbent faced no threat of entry, it would behave as a simple monopolist, choosing a capacity equal to the output which solves

$$(2) \qquad \underset{Q_i}{\text{Max}} \, (100 - Q_i)Q_i - 10Q_i - 10Q_i$$

which has the first order condition

$$(3) \qquad 80 - 2Q_i = 0$$

The monopoly capacity is $K_i = 40$ and the monopoly output is $Q_i = 40$, yielding a net operating revenue of $R^*(40) = (60 - 10)40 - 601 = 1399$, where the notation $R^*(40)$ signifies the net operating revenue of a monopolist with a capacity of 40. The return of 1399 is well above the capacity cost of 400.

It turns out that this is the same output and capacity the incumbent

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[2] Splitting the surplus evenly between two bargaining players can be justified axiomatically (it is identical to the Nash [1950] bargaining solution here), or as the perfect equilibrium of a dynamic game with a small but positive discount rate (Rubinstein [1982]).

chooses if entry is possible, but buyout is not. If the potential entrant were to enter he could do no better than to choose the capacity $K_e = 30$, which costs 300. If the two firms are in the market with capacities of $K_i = 40$ and $K_e = 30$, following Cournot behaviour they solve

(4) $\underset{Q_i}{\text{Max}}\,(100 - Q_i - Q_e)Q_i - 10Q_i$ subject to $Q_i \leqslant 40$

and

(5) $\underset{Q_e}{\text{Max}}\,(100 - Q_i - Q_e)Q_e - 10Q_e$ subject to $Q_e \leqslant 30$

which have first order conditions

(6) $90 - 2Q_i - Q_e = 0$

and

(7) $90 - Q_i - 2Q_e = 0$

The Cournot outputs are $Q_i = 30$ and $Q_e = 30$, yielding a price of 40 and net revenues of $R_i^d = R_e^d = (40 - 10)30 - 601 = 299$. The entrant's profit net of capacity cost would be $(299 - 300) = -1$, which is less than the zero he can obtain by not entering.

The reader familiar with Dixit [1980] will note that the calculation of the Cournot outputs here is different. Here, the implicit assumption is that the choice of capacity is a decision prior to the choice of output, rather than simultaneous with it. The marginal cost of the entrant used in the Cournot calculation is therefore 10, the same as the incumbent's. The entrant's marginal cost viewed from before his plant is built is the higher figure of 20, because he faces the capacity cost as well. In this model the capacity cost is sunk by the time the output decision is made.

Let us next consider the situation when both entry and buyout are possible, but the incumbent still chooses $K_i = 40$. The R_e^d and R_i^d depend on the capacities of the two firms. If the entrant chooses $K_e = 30$ again, then $R_e^d = R_i^d = 299$, just as above. If he buys out the entrant, the incumbent, having increased his capacity to 70, produces a monopoly output of 45. Half of the surplus from buyout is

(8) $B = 1/2[R^*(70) - (R_e^d + R_i^d)]$

           $= 1/2[45(55 - 10) - 601 - (299 + 299)] = 413$

The entrant is bought out for his Cournot net operating revenue of 299 plus the 413 which is his share of the buyout surplus, a total buyout price of 712. Since 712 exceeds the entrant's capacity cost of 300, allowing buyout leads to entry which would otherwise have been deterred.

The incumbent cannot deter entry by picking a different capacity. Choosing K_i greater than 30 leads to the same Cournot output of 60 and the

same buyout price of 712. Choosing K_i less than 30 allows the entrant to make a profit even without being bought out.

Realizing that entry cannot be deterred, the incumbent would not choose an initial capacity of 40. A Cournot player whose capacity is less than or equal to 30 produces a quantity equal to his capacity. Since buyout will occur, if a firm starts with a capacity less than 30 and adds one unit, the marginal cost of capacity is 10 and the marginal benefit is the increase (for the entrant) or decrease (for the incumbent) in the buyout price. If it is the entrant who adds a unit of capacity, R_e^d rises by at least (40 − 10), the lowest possible Cournot price minus the marginal cost of output. Moreover, R_i^d falls because the entrant's extra output lowers the market price. Under our bargaining solution, the buyout price rises by at least (40 − 10)/2, and since this is greater than the capacity cost of 10, the entrant should add extra capacity up to $K_e = 30$. A parallel argument shows why the incumbent should build a capacity of at least 30. The buyout price is unaffected by increasing the capacities beyond 30, because the duopoly net revenues are unaffected; thus both firms choose capacities of exactly 30.

The industry capacity equals 60 when buyout is allowed, but after the buyout only 45 is used. Monopoly profits in the absence of entry would have been 1399 − 400 = 999, while after entry they are 1424 − 600 = 824, so buyout has decreased industry profits by 175. Consumer surplus has risen from 0.5(100 − 60)(40) = 800 to 0.5(100 − 55)(45) = 1012.5, a gain of 212.5, so buyout has raised total welfare in this example. The inefficiency of the entrant's rent-seeking investment in capacity is outbalanced by the increase in output, an outcome, I warn the reader, that is not true in all examples.

III. A MORE GENERAL ANALYSIS OF EQUILIBRIUM WITH ONE ENTRANT

III(i).   *The duopoly subgame*

In the numerical example the entrant enters solely to be bought out, but the equilibrium strategies for the game in Figure 1 depend on the exogenous parameters. We will now try to pin down what determines whether entry for buyout succeeds. To solve for the perfect equilibrium of a game we work back from later to earlier subgames, beginning with the subgame in which both firms have entered, buyout has failed to occur, and each firm is considering exiting the market. Afterwards we will consider the buyout decision and the entry decision.

Suppose first that both the entrant and the incumbent are in the market with positive capacities, the game having reached node four of Figure 1. The capacity costs are sunk and irrelevant to current decisions, so the normal form for this subgame is given by Table II.

If R_i^d is positive the dominant strategy for the incumbent is IN, and if R_e^d is positive the dominant strategy for the entrant is also IN. Thus if the duopoly

TABLE II
DUOPOLY SUBGAME

Entrant: Incumbent:	$K_e > 0, IN$	$K_e > 0, OUT$
No buyout, IN	R_i^d, R_e^d	$R^*, 0$
No buyout, OUT	$0, R^*$	$0, 0$

price exceeds the average variable cost of each player both stay in if buyout does not occur and node four is reached.

If only R_i^d is positive then IN is still a dominant strategy for the incumbent, and using iterated dominance we can expect the entrant to choose OUT, with its payoff of zero, rather than IN, with its payoff of $R_e^d < 0$ if the incumbent chooses IN. The incumbent has enough of an advantage in variable costs that the entrant's threat to remain in the market is not credible. Similarly, if the entrant has enough of an advantage in variable costs he can force out the incumbent.

If both R_i^d and R_e^d are negative the subgame has no symmetric equilibrium in pure strategies. There are two asymmetric pure strategy equilibria, (IN, OUT) and (OUT, IN), and a mixed strategy equilibrium in which each player chooses both IN and OUT with positive probability. We will use the mixed strategy equilibrium because of the appealing feature that its payoffs are equal for the two firms: each firm's payoff is zero, because in equilibrium each must be indifferent between exiting, which has a payoff of zero, and staying in, which has a payoff that depends on the behaviour of the other firm.

The subgame with negative payoffs if both players remain in the market is an example of the "War of Attrition", a game formulated by Maynard-Smith [1974]. We model the game simply here using one set of simultaneous moves. An alternative is to use a more complicated War of Attrition along the lines of the model in section IV of this paper. Whichever way the subgame is formulated, the expected payoff for each player is zero in the symmetric equilibrium, and for the buyout model it is the value of zero that is important, not why it is zero.

Examples of markets with negative net duopoly revenues are those that are natural monopolies because of declining average operating costs rather than set-up costs. If the duopoly price is close to marginal cost and both firms incur a fixed cost of production each period, the net duopoly revenues are negative, and profits (net duopoly revenues minus capacity costs) are negative *a fortiori*.

III(ii). The buyout decision

The entrant is only bought out if he might not exit in the duopoly subgame. If the entrant is known to choose OUT, the incumbent prefers to wait rather

than pay him to exit. Similarly, if the incumbent is known to choose OUT, the entrant can wait for the incumbent to exit.

If both the entrant and the incumbent would choose IN as either a pure strategy or part of a mixed strategy, the expected payoffs are either (R_i^d, R_e^d) for pure strategies, or $(0, 0)$ for mixed. Since $(R_i^d + R_e^d)$ and 0 are both less than R^*, there is an industry surplus from buyout. Buyout occurs if we assume that the bargaining solution is such that $(R^* - B) \geq R_i^d$ and $B \geq R_e^d$, (that is, each player receives at least his threat point payoffs). In a natural monopoly, where the expected duopoly payoffs of both firms are zero, any buyout price such that $0 < B < R^*$ induces buyout. If the game reaches node three, and an entrant not bought out stays in with positive probability, we expect buyout to occur.

In this paper we will not delve into the justifications for different bargaining solutions, but merely note what is important for buyout. A more elaborate model would make the buyout price a function of the structural parameters.

III(iii).   *The capacity decisions*

The potential entrant enters if he would be bought out for a price exceeding his capacity cost or if he could make a profit without buyout.

Proposition 1:   Entry is deterred if and only if for any capacity the entrant might choose, one of the following sets of conditions holds:

(A)   The entrant's duopoly profit is negative and the incumbent's is not:

     (i) $R_e^d < 0$ and $R_i^d \geq 0$;   or

(B)   The buyout price and the present value of the entrant's net duopoly revenues are both less than his capacity cost, and the incumbent cannot be driven from the market:

     (ii) $B < aK_e$,   and
     (iii) $R_e^d < aK_e$ and $R_i^d \geq 0$.

Proof: If Condition (i) is true, the incumbent refrains from buyout because he knows the entrant would exit with probability one if not bought out. The entrant knows he would not be bought out and his profits without buyout would be negative, so he does not enter. Condition (i) is sufficient to deter entry.

If Conditions (ii) and (iii) are true, the incumbent might choose to buy out the entrant, but for a price less than the entrant's capacity cost. The entrant does not earn enough in a duopoly market to pay for his capacity if he is not bought out, and if there is no buyout the market will be a duopoly. Therefore he does not enter. Conditions (ii) and (iii) are jointly sufficient to deter entry.

If (i) and either (ii) or (iii) is false, then the entrant can enter, credibly threaten to stay in the market, and end up with a positive payoff. For entry to be deterred it is necessary that (i) and either (ii) or (iii) be true. ||

Condition (ii) is true if the buyout price, which depends on the surplus acquired by moving from duopoly to monopoly, is less than the entrant's capacity costs, which may happen for either of two reasons: (a) the surplus to be split is small; or (b) the bargaining solution gives the entrant a small share of the surplus.

The surplus is small if the duopoly price is high and close to the monopoly price, although a high duopoly price also makes it less likely that Condition (iii) is satisfied. If aK_e is large enough, both (ii) and (iii) can be simultaneously true and entry is deterred.

If the surplus is large, the entrant's share might still be small enough for Condition (iii) to be satisfied if the bargaining solution is biased against the entrant or the bargainer with less capacity. Even if the bargaining solution is not biased, the buyout price depends on the duopoly solution, and if the entrant's duopoly revenues are small and the incumbent's are large, the buyout price could be less than the entrant's capacity cost.

The incumbent chooses his capacity depending on whether he can satisfy one of the two sets of conditions for entry deterrence. He chooses the monopoly capacity or some larger capacity if he can deter entry cheaply enough. Otherwise his capacity is less than the monopoly level, unless under the bargaining solution a large K_i helps reduce the buyout price.

The importance of perfectness can be seen at every node of Figure 1. If one of the players was able to commit himself at the start of the game to an action at a future node, then any of the following commitments might be profitable. The entrant might commit to enter at node two. The incumbent might commit not to buy out the entrant at node three. The entrant might commit to staying in at node four, and the incumbent to staying in at nodes five and six. Finally, the incumbent might commit to high output in the duopoly market, to make the entrant's net duopoly revenue negative. Since none of the commitments are optimal if the nodes are actually reached, they are useful only as threats to prevent them from being reached. The possibility of commitment vastly increases the number of equilibria; the many non-perfect Nash equilibria make behaviour unpredictable.

III(iv).   *The Spence and Dixit models*

Spence [1977] and Dixit [1980] examine games similar to this one. Spence assumes that the incumbent follows the behavioural rule of using all of his capacity after entry. From this one can calculate the capacity which deters entry by making the entrant's duopoly profit negative. The incumbent chooses that capacity, and the entrant chooses to stay out.

Condition (i) is not satisfied in the Spence model, but Condition (ii) is satisfied. If entry for buyout is to be deterred, it must be because the buyout solution is biased in one direction, or the surplus from buyout is small relative

to capacity cost. The difference between duopoly and monopoly revenue is large, so buyout is the likely outcome.

The Spence model represents one extreme of duopoly behaviour: heavy price-cutting after entry, which is the behaviour most vulnerable to entry for buyout. The deeper is the price-cutting, the greater is the surplus from buyout and the greater the buyout price. For the incumbent to commit to price-cutting is counterproductive unless he can also commit to abstain from buyout. This is a phenomenon much like the "judo economics" of Gelman and Salop [1983]. In their model, as in this one, the entrant makes use of the vulnerability of the larger incumbent to lower prices. Their point, that the entrant can enter profitably if he limits his capacity, is different from that of the present paper, but both points are based on the entrant's ability to profit from price warfare.

The Dixit model assumes that marginal cost is constant, that each firm incurs a fixed operating cost, and that duopoly behaviour is Cournot. If the fixed cost is high enough, the entrant's net revenue is less than the sum of his various costs, and entry is deterred even if the Cournot price is also less than the incumbent's average cost. Whether the incumbent decides to deter entry by choosing a large capacity depends on the size of the fixed cost: he may be unable to deter entry, able and willing, or able but unwilling because of the cost. In the numerical example we looked at above, entry-deterring capacity was the same as the monopoly capacity, so the incumbent chose to deter entry.

If buyout is introduced, the same range of possibilities exists, but entry deterrence is less often possible or profitable. The fixed cost has two offsetting effects. Entry is more difficult, because unless the entrant's Cournot revenues cover his fixed cost of production (as distinct from his sunk entry cost), he cannot credibly threaten to remain in the market. If the fixed cost is large, however, the surplus from moving to monopoly from duopoly is greater, which increases the buyout price.

The equilibrium depends on the size of the fixed cost. With Cournot pricing and a fixed cost of zero, the profits per unit sold are positive and identical for the incumbent and the entrant. If the fixed cost is small enough, entry cannot be deterred, because Conditions (i) and (iii) are violated. In the numerical example Conditions (i) and (iii) are violated if F is between 0 and 600, so that even if the entrant is not bought out, he can profit by entering and selling at the duopoly price.

If the fixed cost is larger, Condition (i) is still violated because net duopoly revenues are positive, but Condition (iii) becomes true because the revenues are not great enough to compensate for the capacity cost. The entrant still might enter, but only to be bought out. This happens for F between 600 and 900.

If the fixed cost is greater than 900 and the entrant's capacity and output is smaller than the incumbent's, Condition (i) might become true. It can never be

true in the numerical example, because the costs and the net duopoly revenues are the same for both firms, but it would be if the two firms faced different fixed costs, such as $F_i = 800$ and $F_e = 1000$. The entrant's net duopoly revenue then does not exceed the fixed cost, but the incumbent's does. Entry is deterred because the incumbent would simply wait for the entrant to exit.

If the fixed cost is still larger, (i) is false because net duopoly revenue is negative for both firms. In the numerical example this happens over the range $F = 900$ to $F = 1425$, because the gross Cournot revenue is 900 for each firm. Condition (iii) is still true, so for entry to be deterred, Condition (ii), that $B < aK_e$, must be true of every possible K_e. The surplus from buyout is very high, so (ii) can be true only if the bargaining solution is biased against one of the firms or capacity is very expensive, neither of which is the case in the numerical example.

Finally, if the fixed cost is large enough entry is deterred because the entrant cannot obtain a positive payoff even with buyout. If F exceeds 1425 then $R^* < 45(55 - 10) - 1425 = 600$, so half of the monopoly revenues does not compensate the entrant for his capacity cost of 300. An industry with such high fixed costs is a natural monopoly.

III(v). *One entrant and many incumbents*

Oligopolists care as much about entry deterrence as do monopolists, but they face the additional problem that deterred entry is a public good. If deterring entry is costly, as it is when achieved via excess capacity, one might think that each firm would hope to free-ride on the others, and total investment in entry deterrence would be suboptimal from the point of view of the oligopoly.

Bernheim [1984] has shown that this simple argument is flawed. Entry is a discontinuous event—the entrant is either in or out—so a small amount of under-investment in entry deterrence by any one oligopolist results in entry and a large loss in both group and individual profits. Optimal investment in entry deterrence is a Nash equilibrium, since no single firm has incentive to deviate and induce entry.[3]

Waldman [1985] shows that Bernheim's result changes if we add uncertainty over the amount of entry deterrence required to deter entry. Uncertainty smooths out the discontinuity in the payoff function, and an oligopolist can reduce his spending on entry deterrence without being certain that he will provoke entry. Entry may or may not be deterred in equilibrium, but there is always underinvestment in entry deterrence.

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[3] Optimal investment in entry deterrence is not the unique Nash equilibrium; there is another in which all firms underinvest and entry occurs. Readers familiar with agency theory will note that the Bernheim problem is analogous to the problem of team members choosing effort under a contract which punishes them if the group output falls below a threshold level (Holmstrom [1982]).

What is the effect of possible buyout? When buyout is involved, the oligopoly is actually better than a monopoly at deterring entry, precisely because of the free rider problem. Once the entrant has entered, buying him out is a public good. The firm that buys him out bears the entire cost, but the benefit is shared by all the oligopolists. The buyout price that any oligopolist is willing to pay is much smaller than the gain in industry profits, so the oligopoly buyout price is more likely to be less than the entrant's capacity cost. Because of the lower buyout price, entry into an oligopoly is less attractive, even if the oligopoly output is the same as the monopoly output.

IV. TWO POTENTIAL ENTRANTS

An incumbent who can keep out a single potential entrant can keep out any number, but when entry cannot be deterred the number of potential entrants is important. In buying out the first entrant, the incumbent takes into account future buyouts, as does the entrant in deciding whether to be bought out immediately or to wait.

The complexity of the game increases rapidly with the number of potential entrants, so we will simplify by abstracting from the choice of capacity and oligopoly output. We will use discrete time, and a discount rate specified to be small enough that the model is genuinely multi-period: $0 < r < 1/3$. Instead of choosing a particular capacity, assume that any entrant must pay an entry fee of K, and that operating revenue is rR if there is one firm in the market, zero otherwise. The present value of monopoly profits starting from any period is thus R.

The two potential entrants simultaneously decide each period whether to enter or wait. After this decision is made, the incumbent can offer to buy out any entrants in the market, and the entrants can agree or not agree to be bought out. The following period these decisions are repeated, except that an entrant cannot re-enter once he has been bought out.

We assume that the outcome of bargaining is that the buyout price for one entrant is half of the incumbent's gross gain from the buyout, and that the buyout price for each of two entrants bought out simultaneously is one third of the incumbent's gross gain from their buyout. If all three firms are in the market, both entrants are bought out immediately and together.

The game's structure is therefore:

0 1   The potential entrants choose Enter or Wait separately and simultaneously.
0 2   The incumbent offers Buyout or Not Buyout to any firms in the market.
0 3   If all three firms are in the market, the entrants are bought out. If only one has entered, he chooses to Agree or Not Agree.
1 1   Potential entrants that have not yet entered choose Enter or Wait.

1 2   The incumbent offers Buyout or Not Buyout to any firms in the market.

1 3   If all three firms are in the market, the entrants are bought out. If only one has entered, he chooses to Agree or Not Agree.

Each entrant's strategy must tell him whether to enter and whether to agree to a buyout for each possible history of the game, even though there may be a unique equilibrium history. For example, the strategy I describe below as *Never Enter* specifies that the entrant never enters—but to be a strategy, it must also specify what happens if, off the equilibrium path, the player suddenly finds he has entered and has the option of being bought out. Because the model must specify behaviour at all nodes of the game, expanding the model beyond two entrants is more tedious than productive.

Fortunately, different combinations of the six relatively simple strategies listed below are subgame perfect Nash equilibria. I have given each strategy a descriptive name and starred the parts of the strategies which are never used unless some player deviates from equilibrium.

Entrant strategies

Immediate entry

1. Enter immediately, whatever the past history of the game.
*2. After entry, do not agree to be bought out if the other firm has not yet entered.

Delay entry

1. If the other entrant has not yet entered, enter with probability θ.
2. If the other firm has entered and been bought out, enter with probability 1.
*3. If the other firm has entered and not been bought out, do not enter.
4. After entry, agree to be bought out immediately.

Responsive entry

1. If the other entrant has not yet entered, do not enter.
*2. If the other firm has entered and been bought out, enter.
*3. If the other firm has entered and not been bought out, do not enter.
*4. After entry, be bought out immediately.

Never enter

1. Never enter.
*2. After entry, be bought out immediately.

Incumbent strategies

Buy now

1. Offer to buy out any entrant.

Hold out

1. Do not offer a buyout unless both entrants have entered.

There are two equilibria with the outcome of deterrence, which results when revenue is low relative to the cost of entry:
Equilibrium A. *Never Enter* and *Buy Now*.
Equilibrium B. *Responsive Entry* and *Buy Now*.
There are three equilibria with the outcome of entry, which results when revenue is high relative to the cost of entry:
Equilibrium C. *Immediate Entry* and *Buy Now*.
Equilibrium D. *Immediate Entry* and *Hold Out*.
Equilibrium E. *Delay Entry* and *Hold Out*.

If $R/2 \leqslant K$, the equilibrium is A: (*Never Enter* and *Buy Now*). Entry without buyout is unprofitable because the net operating revenues are zero after entry, and buyout is unprofitable because the buyout price cannot compensate for the cost of entry. If an entrant did enter, however, both he and the incumbent would wish for a buyout to take place immediately.

If $R/3 \leqslant K \leqslant R/2$, the equilibrium is B: (*Responsive Entry* and *Buy Now*). In this parameter range falls the interesting situation in which if there were just one potential entrant, entry would occur, but because there are two, entry is deterred. If both entrants were bought out simultaneously, the buyout price of $R/3$ would be insufficient to compensate for the cost of entry. If one entrant were bought out first, the buyout price of $R/4$ would not compensate for his cost of entry. But if (off the equilibrium path) one entrant entered and was bought out, the sole remaining entrant would find it profitable to enter. Entry is deterred only by the threat of future entry.

If $0 \leqslant K \leqslant R/3$, entry is not deterred, and both C: (*Immediate Entry* and *Buy Now*) and D: (*Immediate Entry* and *Hold Out*) are possible. Given that one entrant is going to enter, the other might as well enter also; no buyout will occur till he enters, so the payoff would just be delayed, which is undesirable because of discounting. No buyout of just one entrant occurs because if (off the equilibrium path) one entrant fails to enter, immediate buyout would give the entrant who did enter $(rR/2 + R/4)$ and the incumbent $(rR/2 + R/4)$, whereas waiting would give each of them $(1/(1+r))R/3$, a lower amount because we assumed that the discount rate is less than 1/3. The incumbent has two possible equilibrium strategies here because even if he offers a buyout, a lone entrant would refuse him.

If $0 \leqslant K \leqslant R/4$, Equilibrium E: (*Delay Entry* and *Hold Out*) is also possible,

along with Equilibria C and D. In this equilibrium, the entrants would be willing to be bought out by themselves if the alternative were not to enter at all, but they each prefer to be bought out second. As a result, there is no pure strategy equilibrium. Instead, they enter probabilistically, a strategy we will have to consider carefully.

First, consider what happens after entry has occurred. The second entrant is not going to enter until a buyout happens. Off the equilibrium path, if a buyout fails to occur immediately, the second entrant is quite happy to stick with his strategy of delaying entry, because he expects the other entrant to be bought out in the next period. He would consider entering only if he expected a whole series of deviations from equilibrium behaviour, but perfect equilibrium only demands that a strategy be Nash for each subgame. The incumbent will buy out the first entrant, who will agree. The first entrant's payoff will be $(rR/2 + R/4)$, the same as the incumbent's, and lower than the $(1/(1 + r))R/2$ of the second entrant.

Why does an entrant enter first with any positive probability? Because if he does not, there is some chance that both entrants will stay out so long that the discounted payoffs will be very low. This is the typical problem in a war of attrition.

We can calculate the probability of entry θ as follows. Adopting the perspective of one entrant (Alpha), fix the mixing probability of the other entrant (Beta) at θ. Denote Alpha's expected present value of payoffs as V_{IN} if he enters and V_{OUT} if he waits. These two pure strategy payoffs must be equal in a mixed strategy equilibrium. If Alpha enters, he is bought out at a price of $R/4$ if Beta has not entered (which happens with probability $[1 - \theta]$), and a price of $R/3$ if Beta does enter. Thus,

$$(9) \qquad V_{IN} = (1 - \theta)(R/4 - K) + \theta(R/3 - K)$$

If Alpha and Beta both stay out, the expected value of Alpha's payoff is unchanged (except for discounting) the following period. If Beta does enter immediately, then Alpha enters next period and receives the high buyout price of $R/2$. Thus,

$$(10) \qquad V_{OUT} = \left[\frac{1}{1 + r} \right] [(1 - \theta) V_{OUT} + \theta(R/2 - K)]$$

and with a little rearranging we obtain

$$(11) \qquad V_{OUT} = \left(\frac{\theta}{r + \theta} \right)(R/2 - K)$$

To find the mixing probability, equations (9) and (11) could be set equal to each other, and solved for θ using the quadratic formula, but the details of this computation are not interesting enough to occupy us here. What is important to note, however, is that for the range of discount rates we are considering, θ is small, because the difference between the buyout price $R/2$ (obtainable by

waiting) and $R/3$ or $R/4$ is large relative to the discounting loss from waiting. If, for example, the parameters have the values $K = 1$, $R = 5$, and $r = 0.10$, the equilibrium value of θ obtained from equations (9) and (10) is only about 0.021. Thus, this equilibrium can be almost equivalent observationally to equilibria A and B, in which entry is deterred.

The model could be generalized to n potential entrants, but because the strategies must specify behavior for every possible combination of moves off the equilibrium path, the mechanics would be so complicated as to be unenlightening.

What we have seen in this section is that adding a second potential entrant can either reduce the incumbent's payoff or increase it. The incumbent's payoff is reduced if both potential entrants do enter, whether they enter together or at different times; it is increased if adding a second potential entrant deters entry altogether by making it credible that the incumbent would not buy out the first entrant at a satisfactory price. In either case the first entrant is hurt by the presence of a second entrant.

V. FURTHER IMPLICATIONS

The possibility of buying out entrants makes it more difficult for a monopolist to use excess capacity to deter entry. The entrant, hoping to be bought out, may enter even if expected revenues are less than costs, if having entered he is as credibly willing to remain as the incumbent. Otherwise the incumbent refuses to buy him out, and the entrant, foreseeing this, does not enter.

Although the incumbent may not be able to fully protect his profits, entry does not make the output market competitive, because the incumbent charges the monopoly price except during the brief intervals between entry and buyout. Entry undertaken solely for buyout helps the consumer only insofar as monopoly output rises as a result of the increase in the monopolist's capacity, but the squandering of monopoly rents on the real costs of entry always decreases industry profits.

Antitrust laws prevent us from observing blatant examples of entry for buyout today, but in the nineteenth century the great trusts invariably faced the problem of entry, whether motivated by direct profits from undercutting prices or by the prospect of buyout. In some cases entrants re-entered and were bought out a second time, suggesting that buyout was their motive. A certain Mr. Kellog left his job at the Gunpowder Trust to manage a new gunpowder firm, which he quickly sold to the Trust. Soon afterwards, he founded a second gunpowder firm which he also sold, after a period of fierce price competition. Some years later, Indian Powder was founded by another ex-employee. After driving the price down to near or below cost, he sold out to the Trust, which included in the buyout contract a provision that he stay out of the powder business for twenty years (Elzinga [1970]).

The Sugar Trust faced similar problems. The American Sugar Refining

Company was formed in 1888 by merging firms owning a total of twenty plants, of which ten were shut down within a year. In the 1980s other firms frequently entered and were bought out by American. At least one of these entrants could not have operated at a profit, and we are told that

> "A contractor, Adolph Segal, apparently made a regular business of building refineries to sell to the trust. With the backing of Frederick Hipple, Segal in 1895 built the United States Sugar Refinery at Camden, New Jersey, with authorized capitalization of $2,000,000. This was sold to the trust and later events showed that it must have been built for this purpose since lack of a proper water supply rendered it inoperative." — Zerbe (1969).

Entry in these circumstances is rent-seeking behaviour, of which the dissipation of monopoly rents is the typical result (Posner [1975]). In deciding whether to allow buyout, the government must balance the possible increase in output against the certain increase in industry costs. The increase in costs is especially likely to dominate if there is more than one potential entrant, since after the first is bought out, subsequent buyouts are less likely to increase the amount of capacity the incumbent uses.

Even an incumbent with lower production costs than the entrant is not necessarily safe from entry. A firm which is a natural monopoly because of a set-up cost independent of output is still vulnerable to entry for buyout since the set-up cost has no effect on pricing. Nor is entry necessarily deterred if the incumbent's variable costs are lower than the entrant's, since the duopoly net revenue of each firm could still be positive.

Whatever the relative costs of the firms may be, outside observers might interpret these episodes using the classic story that a small firm enters the market, the incumbent monopolist lowers his price to below cost, and the unfortunate entrant is forced to sell out, a victim of predatory pricing. Appearances are deceiving; the unfortunate entrant is the one not bought out. In this model, incumbents favor laws banning buyouts, entrants oppose them, and consumers are commonly indifferent. The model excludes the many other reasons entrants might be bought out—to combine strengths of different firms, or to liquidate high-cost firms which entered mistakenly—so any policy implications should be regarded carefully, but it serves as a reminder that buyout is one motivation for entry and can influence a firm's entry deterrence policy.

ERIC RASMUSEN,
Anderson Graduate School of Management,
University of California,
Los Angeles,
CA 90024,
USA.

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