Part IV
Anticompetitive Strategies

Part IV builds on the game theoretic analysis of the previous three chapters to explore the tactics that firms can employ to blunt competitive pressures and thereby earn supracompetitive profits. In the Stackelberg setting, the first mover has to worry about later entry or expansion by rivals. In the Cournot model and, to an even greater extent, in the Bertrand model the competition among firms prevents them from maximizing their joint profit. It is natural therefore to consider what strategies incumbent firms may use to prevent rival entry, and to investigate the potential for existing firms to suppress their competition by colluding and thereby achieving something closer to the monopoly profit.

Chapters 12 and 13 focus on the use of market power by an incumbent firm either to keep potential rivals from entering or to drive existing rivals from the market. Such predation, as it is usually called, has been at the core of antitrust policy and antitrust cases ever since the antitrust laws were passed. Standard Oil, Microsoft, and American Airlines are just some of the firms that have been accused of predatory practices. Chapter 12 focuses primarily on price tactics by which the dominant incumbent prices below cost in an effort to exclude rivals from the market. In Chapter 13, we consider contractual and other non-price strategies that achieve this same purpose. We also present an empirical analysis of possible predatory advertising behavior in the pharmaceutical industry.

Chapters 14 and 15 then turn to a consideration of the ability of firms to cooperate and suppress competitive pressures. Such collusion amounts to what is popularly called price-fixing and it is also a major concern of the antitrust laws. Indeed, the period since the 1990s has witnessed the successful prosecution of a record number of price-fixing cartels. In Chapter 14 we present the obstacles to successful collusion and the well-known Folk theorem describing the conditions under which those obstacles can be overcome. We also present an empirical examination of such collusion in the real estate market.

In Chapter 15 we return to a historical consideration of price-fixing cases and what these tell us about how such agreements can be uncovered by authorities. Many believe that an important element in the recent string of successful cartel prosecutions has been the adoption of a leniency policy that typically drops any criminal charges against the first member of a cartel to confess to the authorities. Therefore, this chapter concludes with an exploration of antitrust policy towards cartels and the role of such leniency provisions. This includes an analysis of a game theory experiment designed to simulate cartel behavior when there is a positive probability of detection and when the first member of the cartel that confesses goes free.

12

Limit Pricing and Entry Deterrence

For most of the twentieth century, Campbell's accounted for 70 percent or more of canned soup sales in the U.S. For at least two decades, the American firm, Sotheby's, and the British firm, Christie's, have together controlled roughly 90 percent of the world auction market while each has more than half of its own domestic auction market. The semiconductor firm Intel has accounted for 75 percent or more of the market for PC processors for some two decades. Over that same period, Microsoft has maintained control of over 90 percent of the market for operating systems software.[1] There can be little doubt that each of these firms has substantial market power. Some appear almost to be pure monopolies. Accordingly, we must expect that such dominant firms are able to exercise their market power and earn supra-competitive profits.

The Microsoft, Intel, and other examples of sustained market power just described are not isolated cases. Analyses by Baldwin (1995) and Geroski and Toker (1996) find that, on average, the number one firm in an industry retains that rank for somewhere between 17 and 28 years. The fact that continued market power is so common does, however, raise the question as to how such firms can sustain this profit-winning position. Why don't new rivals emerge to compete away that market share and profit? Are there strategies that the dominant firms can adopt to prevent this from happening? If so, what are these strategies and what are their implications for market outcomes?

The questions just raised are the focus of this chapter and the next one. They continue our theme of strategic interaction. Here, the interaction is between an existing dominant firm and potential or actual entrants. We emphasize at the outset that this issue is of much more than mere academic interest. The question of whether large incumbent firms can eliminate or prevent the entry of rivals goes to the heart of many concerns that inspired the creation of the antitrust laws that have remained central in antitrust cases ever since. This concern lay at the crux of the Microsoft antitrust case.[2] Section 2 of the Sherman Act deems it illegal to "monopolize or attempt to monopolize . . . any part of the trade or commerce." Enforcement of this provision requires an understanding of what a firm can do in order to "monopolize" the market.

[1] See, "Squeeze Gently," *Economist*, November 30, 1996, pp. 65–6.

[2] Indeed, each of the firms mentioned has been accused of unfair practices and has been the subject of antitrust scrutiny.

Strategies that are designed to deter rival firms from competing in a market are what economists call *predatory* conduct.[3] A firm engaging in predatory conduct wants to influence the behavior of its rivals—either those currently in the market or those thinking of entering it. Predatory conduct often involves the making of threats and, if necessary, actually implementing the threats in a way that ensures such threats are *credible*. Credibility is absolutely essential for predatory conduct to be successful. After all, as we learnt from the Chain Store Paradox in the last chapter "talk is cheap." A threat aimed at dissuading a rival from entering one's market will only have the desired effect if it is credible. Such threats work when the rival or prey believes that the predator really "means business" and will pursue the predatory conduct *when the rival chooses to ignore the threat*.

In this chapter we investigate predatory conduct that is designed to deter rivals from entering an incumbent's market. In doing so, we limit ourselves to cases of certainty or complete information. We defer the examination of predatory conduct under uncertainty or incomplete information until the next chapter.

Considerable care is required in an investigation of predatory conduct. For example, we must be careful not to characterize actions by a firm either to improve its cost-efficiency or to promote its product as predatory, even if such actions have the effect of enhancing the firm's market position. For a firm's conduct to be predatory or anti-competitive it must be the case that the firm's action is profitable *only if* it causes a rival firm to exit, or deters a potential rival from entering the market in the first place. This is in keeping with the spirit of the antitrust provisions themselves, which focus on efforts "to monopolize . . . any part of the trade or commerce" and to "materially reduce competition."[4] The basis for this legislative concern is, of course, the fear that with existing rivals and the threat of entry removed, a dominant firm will pursue monopoly practices that reduce efficiency.

12.1 MONOPOLY POWER AND MARKET STRUCTURE OVER TIME: SOME BASIC FACTS

The evolution of an industry's structure, whether into one of persistent monopoly, concentrated oligopoly, or more competitive configurations, depends on a number of factors. One of these is the relationship between a firm's size and its growth rate. An early finding in this respect is known as the Law of Proportionate Effect or, more commonly, Gibrat's Law after its originator Robert Gibrat (1931). Gibrat asked what would happen if, starting with a population of say 100 equally sized firms, each firm in each period was randomly assigned a growth rate drawn from a distribution with a constant average growth rate and variance of growth rates over time. The answer is perhaps surprising. Even though the firms in the industry all start at the same size and even though each has the same chance for growth in every period thereafter, it is still the case that over time the industry becomes more and more concentrated. In particular, the distribution of firm sizes approaches a log normal one in which the logarithm of firm sizes approaches a normal distribution. Gibrat (1931) and later others, e.g., Kalecki (1945) produced some evidence that was very supportive of this natural concentrating tendency.

The Gibrat hypothesis has been enormously influential. To a large extent, this influence has been for what Gibrat's analysis leaves out rather than what it keeps in. This is because

[3] See, e.g., Fisher (1991).

[4] Our definition is also similar to that of Ordover and Willig (1981).

Derivation Checkpoint

The Gibrat Logic

Let x_t denote a firm's size at time t, where size might be measured in sales or assets or employees. Similarly, denote the firm's size in period $t - 1$ as x_{t-1}. Now let ε_t be the rate of growth of the firm from time $t - 1$ to time t, where growth is measured as the rate of proportional change, i.e., a growth rate of 4 percent is expressed as $\varepsilon_t = 0.04$. This growth factor is a random variable drawn each period from a normal distribution with constant mean and variance, and that is the same for all firms. It then follows that the firm's size from time $t - 1$ to time t evolves according to the equation:

$$x_t = (1 + \varepsilon_t)x_{t-1}$$

Next, take the log of both sides. If the time interval between t and $t - 1$ is short, then the random growth term ε_t is small. This permits us to use the approximation that $\log(1 + \varepsilon_t) \approx \varepsilon_t$. With this approximation we may now write:

$$\log x_t = \log x_{t-1} + \varepsilon_t.$$

In turn, this implies that we may also write

$$\log x_{t-1} = \log x_{t-2} + \varepsilon_{t-1}$$

By repeated substitution, we then obtain:

$$\log x_t = \log x_0 + \varepsilon_t + \varepsilon_{t-1} + \varepsilon_{t-2} + \varepsilon_{t-3} + \ldots + \varepsilon_0$$

This last equation says that the logarithm of the firm's size at time t will just be a random variable reflecting the accumulation of all the random growth shocks it has experienced up to that time. Since each shock is assumed to be a random variable drawn from the normal distribution, the sum over time of all those accumulated shocks is also a normal random variable. Recall however that logarithms reflect exponential power. As the log of a firm's assets doubles the actual volume of those assets is squared. So, although the log of firm size may be normally distributed, the distribution of actual firm sizes will be skewed. Those firms with above average values for the log of firm size will have way above average values when size is measured without logs. Hence, if firm sizes evolve so that each firm is generated by the process described above, the industry will eventually become quite heavily concentrated.

as originally presented, Gibrat's process is very mechanistic. There is no talk of research and cost-saving innovations. There is no consideration of mergers and firm combinations over time. Perhaps most relevant for our present purpose, there is no discussion of new firms entering an industry or older firms leaving; or what strategic interaction may lie behind such entry and exit. Subsequent research has tried to remedy these omissions and to develop theoretical models of industry evolution that build in these features (see for example Jovanovic 1982; Nelson and Winter 1982; Sutton 1997; and Klepper 2002).

Of course, any theoretical model must ultimately confront the real world facts. On this front, too, however, there was a need for much work. In the 1950s and 1960s, we knew precious little regarding the lifecycle of firms, their births (entry) and their deaths (exit). Since the 1980s, however, economists have worked hard to review the data and to document any empirical regularities or stylized facts that appear. Any valid theory must be consistent with these facts.

There are four stylized facts worth noting. The first is that *entry is common*. Dunne, Roberts, and Samuelson (1988, 1989), using U.S. census data between 1963 and 1982, computed rates of entry in a wide cross-section of two-digit SIC manufacturing industries. Their estimate of the average entry rate in manufacturing—defined as the number of *new* firms over a five-year period relative to the number of incumbent firms at the start of that period—ranged between 41.4 percent and 51.8 percent (about 8 percent to 10 percent on an annual basis). For the U.K., Geroski (1995) estimated somewhat smaller but still significant annual rates of entry for a sample of 87 three-digit manufacturing industries. These ranged between 2.5 percent and 14.5 percent over the period 1974 to 1979. Cable and Schwalbach (1991) show that similar rates of entry obtain across a wide range of developed countries. More recently, Jarmin, Klimek, and Miranda (2004) show that rates of entry are even higher in the retail sector and may reach well over 60 percent, especially during periods of economic prosperity.[5]

The second stylized fact is that when entry occurs it is, by and large, *small-scale entry*. The studies by Dunne, Roberts, and Samuelson (1988, 1989) showed that the collective market share of entrants in an industry ranged between 13.9 percent and 18.8 percent again over a five-year interval.[6] Similarly, in Geroski's (1995) U.K. study, the market share of entrants was found to be quite modest, ranging from 1.45 percent to 6.35 percent. In the U.S., Cable and Schwalbach (1991) find that while new entrants typically constitute 7.7 percent of an industry's firms in any year, they account for only 3.2 percent of its output. The typical share of entrants in retailing is noticeably larger, say closer to 25 percent according to Jarmin, Klimek, and Miranda (2004) but they also find that this value has been declining over recent years.

The third stylized fact is that the *survival rate is relatively low*. Dunne, Roberts, and Samuelson (1988, 1989) find that roughly 61.5 percent of all entrant firms exited within five years of entry and 79.6 percent exited within ten years. The corresponding exit rates found in retailing by Jarmin, Klimek, and Miranda (2004) are a very similar, between 59 percent and 82 percent. Birch (1987) used Dun and Bradstreet data for all sectors in the U.S. including, but not limited to, manufacturing and found that about 50 percent of all new entrant firms fail within the first five years.

Our final stylized fact that appears to hold in every study is that while rates of entry and exit vary across industries, *industries with high entry rates also have high exit rates*. In other words, entry and exit rates are strongly correlated. To take just one clear example, Cable and Schwalbach (1991) find that corresponding to an entry rate of 7.7 percent accounting for 3.2 percent of industry output, the exit rate is 7.0 percent and similarly it accounts for 3.3 percent of industry output. This finding is a little surprising because it does not appear consistent with the hypothesis that entry occurs in response to above-normal profit or that exit reflects a below-normal profit. If profit is high, and therefore entry attractive, there is no reason for firms to leave. Similarly, if profit is so low that firms are induced to leave the industry, there ought to be little incentive for new entrants to emerge.

[5] The Dunne et al. (1988, 1989) entry (and exit) estimates are generally higher than those obtained by other researchers owing to the fact that they explicitly recognize the multiproduct and multiplant nature of firms.

[6] Dunne et al. (1988) do find that existing firms who enter a new market through diversification typically enter at a larger scale than new, or *de novo*, entrants do.

Taken together, the stylized facts reported above can be read as suggesting a sort of revolving-door setting in which mostly small firms enter, eventually fail and exit, only to be replaced by a new cohort of small-scale entrants. In this view, the major difference across industries would be the pace at which this entry–fail–exit cycle proceeds. One interpretation of this evidence is that it reflects repeated attempts and, just as often, repeated failures of small firms to penetrate the markets dominated by large incumbents. This may help explain the correlation between entry and exit rates. Incumbents in markets that may seem the most tempting entry targets may for that very reason fight the hardest against new entrants.

More formal support for this revolving door interpretation is offered by Urban, Carter, Gaskin, and Mucha (1984) on the benefits of incumbency. They studied 129 frequently purchased brands of consumer products in 12 U.S. markets and found that market shares were a decreasing function of the order of entry of the brand. Earlier entrants enjoyed larger market shares, all else equal. Similar results have been found by Lambkin (1988), Mitchell (1991) and Brown and Lattin (1994).[7] Generally, this finding probably reflects the fact that early (and surviving) entrants possess superior cost efficiency and more favorable locations (either in geographic or product space). However, it is frequently alleged (especially by the failed entrants) that the ability of early entrants to sustain a dominant industry position also reflects predatory behavior aimed at driving new entrants out. This is the primary issue addressed in this and the subsequent chapter.

12.2 PREDATORY CONDUCT AND LIMIT PRICING

Economists define predatory conduct to be actions taken by a firm that are profitable *only if* they drive existing rivals out of the market or deter potential rivals from coming in to the market. Predatory conduct is some costly action for which the only justification is the reduction in competition that such action is designed to achieve. If there is no cost to the firm to engage in some conduct, then that behavior could be simply be part of profit-maximizing strategy and, hence, not explicitly “anti-competitive”. To put it somewhat loosely, predatory conduct must appear on the surface to reduce the predator firm’s profit and seem to be “irrational”. The rationality for such conduct would be the additional profit the predator earns if the conduct is successful.

When a firm charges an “irrationally” low price so that other rival firms cannot compete it is called *predatory pricing*. Historically, predatory pricing refers to cases where rival firms are driven out of the market. However setting a low price that deters firms from entering the market is also predatory. The low price with the purpose of deterring entry is known as the *limit price*. However, actual litigation rarely involves limit pricing. Instead, the courts and policy makers have focused on cases in which existing firms are forced to leave the market.

It is not difficult to understand how and why there is this legal bias in predatory pricing. Predatory pricing cases in which existing firms are driven from the market have no *habeas corpus* problem. There is an actual victim or victims. As a result, there is a supply of plaintiffs ready to press charges against the alleged predator. Moreover, the existence of a “body” can serve as powerful evidence to persuade a judge or a jury that a crime has been committed. In contrast, the victims of limit pricing are typically *potential* competitors. Here, no

[7] As Caves, (1998) notes though, there is regression toward the mean in firm growth rates. That is, really large firms tend to grow more slowly than do small ones. This feature blunts the ever-increasing concentration tendency implied by Gibrat’s law.

firm actually dies, some are just prevented from ever being born. Such cases are difficult to prosecute.

However, economic theory can proceed even where lawyers fear to tread. Accordingly, we start the important work of this chapter by reviewing two approaches to limit pricing. The first one is an earlier approach predating the advent of a game theoretic treatment of the subject. The second approach takes the insight of the first and investigates the entry deterrent effect in a dynamic game between the incumbent and the entrant.

12.2.1 An Informal Model of Entry Deterrence

The traditional limit-pricing story of entry deterrence is told in the work of Bain (1956) and later modeled in Sylos-Labini (1962). These earlier industrial organization economists were shrewd observers of everyday business practices and had reasons to believe that predatory pricing and entry-deterring behavior occurred. We can illustrate the essence of the limit pricing strategy using a simple variant of the Stackelberg model. Recall from the previous chapter that the strategic variable in the Stackelberg model is quantity. So, the analysis we present might more properly be labeled a limit output model, rather than a limit price one. Yet the basic idea of setting the strategic variable so as to deter entry is the same in either case—especially since the dominant firm's output choice will greatly influence the industry price. That is, we might regard the resulting price in our model as the limit price.

Figure 12.1 illustrates the essential features of the model.[8] The incumbent firm is the Stackelberg leader and is allowed to choose its output first. We begin by making a simple and yet strong assumption that whatever this choice is, the entrant believes that its own entry into the market will not alter the leader's choice of output. That is, the entrant regards the incumbent as irrevocably committed to its output choice. A further crucial assumption is that the entrant's average cost declines over at least the initial range of low levels of production. When both of these assumptions hold then, by the correct choice of its pre-entry output level, the incumbent can manipulate the entrant's profit calculation and discourage entry.

In Figure 12.1, the appropriate production level to which the incumbent must commit to deter entry is $\bar{Q}$. If the entrant stays out, this implies a market price $\bar{P}$. What would happen to market price if the entrant now produced any positive output? The answer is also shown

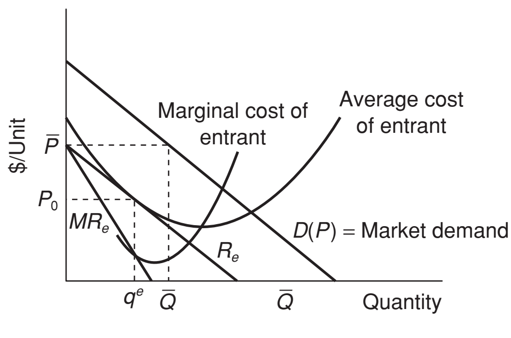

Figure 12.1 The limit output model
By producing at $\bar{Q}$, the incumbent can preclude profitable entry.

[8] This presentation borrows heavily from that of Gilbert (1989).

in Figure 12.1. Because the entrant believes that the incumbent will maintain $\bar{Q}$, the demand the new entrant faces at any price P is the total quantity that is demanded at that price, $D(P)$, less $\bar{Q}$. That is, the entrant faces a *residual demand curve* R^e which, in this case, is simply the market demand curve $D(P)$ shifted inward along the horizontal axis by the amount $\bar{Q}$. Corresponding to this residual demand curve is the entrant's marginal revenue curve MR^e. The entrant maximizes its profit by selecting output q^e at which its marginal revenue just equals its marginal cost. As shown in Figure 12.1, this output is such that when it is added to the output $\bar{Q}$ of the incumbent firm market price becomes P_0 and this price barely covers the entrant's average cost. In other words, by committing to the output $\bar{Q}$, the incumbent firm removes any profit incentive for the entrant to actually participate in the market.

12.1 **Practice Problem**

Suppose that market demand is described by $P = 100 - (Q + q)$, where P is the market price, Q is the output of the incumbent firm and q is the output of a potential entrant to the market. The incumbent firm's total cost function is $TC(Q) = 40Q$, whereas the cost function of the entrant is $C(q) = 100 + 40q$, where 100 is a sunk cost incurred to enter the market.

a. If the entrant observes the incumbent producing $\bar{Q}$ units of output and expects this output level to be maintained, write down the equation for the residual demand curve that the entrant firm faces.
b. If the entrant firm maximizes profit given the residual demand curve in a) what output q^e will the entrant produce? (Your answer should be a function of $\bar{Q}$.)
c. How much output would the incumbent firm have to produce to just keep the entrant out of the market? That is, solve for the limit output $\bar{Q}_L$. At what price will the incumbent sell the limit output?

It should be clear that successful predation of the type just described depends crucially on the entrant's belief that the incumbent is truly committed to its action. In the language of the last chapter, the strategy must be subgame perfect. The issue then becomes whether this is possible. Can the incumbent truly commit to produce output $\bar{Q}$ even if the entrant enters the market?

Earlier scholars such as Bain (1956) and Sylos-Labini (1962) did not make use of the formal model just described. Nevertheless, they too appear to have understood that in order deter entry the incumbent firm had to commit or "lock in" to the predatory behavior. They assumed that such commitment was achieved by further supposing that the incumbent's output $\bar{Q}$ was "very" costly to adjust. Hence, the potential entrant was correct to assume that the incumbent's output would remain at $\bar{Q}$ because it was too costly to change. In other words, the presence of adjustment costs once the incumbent is already producing at a particular level acted as a mechanism to commit the incumbent to the output $\bar{Q}$ even in the face of entry.

The idea sounds plausible and may well be true. Unfortunately, as stated, it is a little *ad hoc*. Without a full specification of how such costs are generated and how they fit into a complete analysis of strategic interaction between the two firms, the adjustment cost story amounts to little more than a statement that the incumbent's output is given because it is given. Producing $\bar{Q}$ is a credible action only if $\bar{Q}$ is the incumbent's best response to the entrant coming into the market and choosing an output level to produce. Limit pricing can only work if the incumbent firm can commit to producing the limit output even if entry occurs.

12.2.2 Capacity Expansion as a Credible Entry-deterring Commitment

In a key article, Spence (1977) recognized that what may make limit pricing a credible deterrent strategy is the incumbent firm's ability to make a prior and irrevocable investment in production capacity, and specifically an investment in the *capacity* to produce the limit output $\bar{Q}$. Spence did not work out the underlying logic of this approach in a complete manner. He did make it clear that if the entrant believes that the incumbent will, after entry, produce at its pre-entry capacity, then the incumbent firm has an incentive to invest in a capacity level that keeps the potential entrant at bay. What was still required, however, was an analysis demonstrating that in the post-entry game between the incumbent and the new entrant the entrant's belief that the incumbent's post-entry output is equal to its pre-entry capacity is reasonable, i.e., subgame perfect. This was the contribution of Dixit (1980). Dixit modeled the post-entry game between the two firms. We present the essentials of his model below. We warn the reader in advance that this model is hard work. While no one piece of the analysis is difficult, considerable care is required in putting all the pieces together.

The game Dixit posits between the two firms is a dynamic, two-stage one. In the first stage, the incumbent firm moves first and chooses a capacity level $\bar{K}_1$ at a cost $r\bar{K}_1$. This capacity is measured in terms of output, and the cost r is the constant cost of one unit of capacity. By investing in capacity $\bar{K}_1$ in the first stage of the game, the incumbent firm has the capability of producing any output less than or equal to $\bar{K}_1$ when the second stage of the game begins. The incumbent's capacity can be further increased in stage two of the game. However, it cannot be reduced. One may think of the capacity investment as the construction of say, a uranium processing plant, a plant for which any other industry has little use. If so, the plant cannot be resold if the firm decides it no longer needs it. In this sense, the $r\bar{K}_1$ spent on capacity investment in stage one is an irrevocable or sunk cost.

The potential entrant is assumed to observe the incumbent's choice of capacity in stage one. It is only after that observation that the potential entrant makes its entry decision in stage two. If entry does occur then, in the second stage of the game, the two firms play a Cournot game in output. Market demand for the product in stage two is described by $P = A - B(q_1 + q_2)$. It is very important to note that the two firms simultaneously choose both their outputs (q_1, q_2) and their capacity levels (K_1, K_2) in stage two. For the incumbent, the capacity choice is constrained because its capacity in the second stage cannot be less than the capacity chosen in the first stage, i.e., $K_1 \geq \bar{K}_1$. The incumbent firm can increase its capacity in stage two but not decrease it.

We will denote any sunk costs incurred by the incumbent other than those associated with its capacity choice $\bar{K}_1$ as F_1. For simplicity, we will further assume that every unit produced requires the input of one unit of labor as well as a unit of capacity. If labor can be hired at the wage w, then the incumbent's marginal cost of production in stage two for output $q_1 \leq \bar{K}_1$ is just wq_1. However, if the incumbent wishes to produce an output greater than q_1 then it must hire additional capacity, again at the price of r per unit. That is, for every unit of output above $\bar{K}_1$ the incumbent must hire one unit of labor at price w and one unit of capital at price r. Hence, the marginal cost of production for output greater than $\bar{K}_1$ is $w + r$. These relationships are reflected in the following description of the incumbent's cost function in stage two of the game:

$$
\begin{aligned}
C_1(q_1, q_2; \bar{K}_1) &= F_1 + wq_1 + r\bar{K}_1, \quad \text{for } q_1 \leq \bar{K}_1;\ \text{Marginal Cost} = w \\
&= F_1 + (w + r)q_1, \quad \text{for } q_1 > \bar{K}_1;\ \text{Marginal Cost} = w + r
\end{aligned} \tag{12.1}
$$

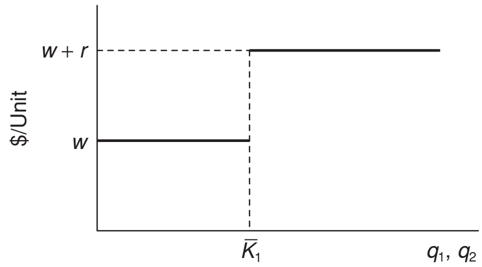

Figure 12.2 The effect of previously acquired capacity on current marginal cost
The incumbent has previously acquired capacity $\bar{K}_1$ and therefore incurs a marginal cost of only w up to this level of production. Fore greater levels, its marginal cost is $w + r$. The entrant has no previously acquired capacity. Its marginal cost is $w + r$ for all production levels.

The only difference between the entrant and the incumbent is that the entrant cannot invest in capacity in stage one. Instead, the entrant must hire both labor and capital as they are needed to produce whatever output it selects during the second stage. Thus, the entrant's marginal cost is always $w + r$ no matter what output it chooses. If we denote any sunk cost the entrant incurs as result of participating in the market as F_2, its cost function in stage two is:

$$C_2(q_2) = F_2 + (w + r)q_2;\ \text{Marginal cost} = w + r \tag{12.2}$$

It is important to note that the two firms face different *marginal* costs of production in stage two of the game. For the incumbent firm, the marginal cost of producing any output q_1 is equal to w so long as it is within its initial capacity, or so long as $q_1 \leq \bar{K}_1$. However, because the entrant does not enjoy the first mover advantage of having already invested in capacity in stage one, it faces a marginal cost of production equal to $(w + r)$ for all output levels. This difference is reflected in Figure 12.2 where we draw the marginal cost curve for both firms. The diagram suggests why investment in capacity can have a commitment value. The incumbent's commitment to produce at least as much as $\bar{K}_1$ is made more believable by the fact that up to that production level, its marginal cost is *relatively* low.

In a sequential game, we begin by working out what happens in the last stage in order to work out the incumbent firm's optimal move in the first stage. To solve for a subgame perfect equilibrium strategy for the incumbent firm, we need to determine how the incumbent's choice of capacity in stage one affects the market outcome when the two firms compete in stage two. So, we start by working out what happens in stage two for any particular level of capacity chosen in stage one. We determine what happens in stage one by choosing the capacity that maximizes the incumbent's profits in stage two.

In stage two the firms are playing a Cournot game in quantities. The incumbent firm's profit will be:

$$\begin{aligned}
&\pi_1(q_1, q_2, \bar{K}_1) = \text{Revenue} - \text{Cost} = [A - B(q_1 + q_2)q_1] - [wq_1 - F_1] \quad \text{for } q_1 \leq \bar{K}_1 \\
&\pi_1(q_1, q_2, \bar{K}_1) = \text{Revenue} - \text{Cost} = [A - B(q_1 + q_2)q_1] - [(w + r)q_1 - F_1] \\
&\hspace{20em} \text{for } q_1 > \bar{K}_1
\end{aligned} \tag{12.3}$$

From equation 12.3, we can see that the marginal revenue to the incumbent associated with an incremental unit of q_1 is always given by $MR_1 = A - 2Bq_1 - Bq_2$. However, its marginal cost will change depending on whether or not the firm decides to add capacity. When the incumbent firm's best response q_1^* to the entrant's choice of output q_2 is such that it does not need to add capacity, i.e., when $q_1^* \leq \bar{K}_1$, the incumbent's marginal cost is just w. But if the incumbent's best response q_1^* is such that it needs additional capacity $q_1^* > \bar{K}_1$, its marginal cost becomes $(w + r)$. Accordingly, equating the incumbent's marginal revenue and marginal cost and solving for its optimal output in stage two, thus leads to a best response function with two parts. These are:

$$
\begin{aligned}
q_1^* &= \frac{(A - w)}{2B} - \frac{q_2}{2} \qquad \text{when } q_1^* \leq \bar{K}_1\text{; and} \\
q_1^* &= \frac{(A - w - r)}{2B} - \frac{q_2}{2} \quad \text{when } q_1^* > \bar{K}_1
\end{aligned}
\tag{12.4}
$$

This means that the incumbent firm's best response function jumps at the output level $q_1^* = \bar{K}_1$. We can see the jump more clearly when we draw the reaction function for the incumbent firm in the second stage of the game. We do this in Figure 12.3. Again, $\bar{K}_1$ is the incumbent's capacity that is given is stage two but chosen in stage one of the game.

For output levels $q_1^* \leq \bar{K}_1$, the incumbent firm's reaction function is the solid line described by $L'L$, whereas for output levels $q_1^* > \bar{K}_1$ the reaction function jumps to the lower solid line described by $N'N$.

Now consider the situation facing the entrant in stage two. Profits for the entrant firm are, as always, the difference between its revenue and its cost, which implies:

$$\pi_2(q_1, q_2, \bar{K}_1) = \text{Revenue} - \text{Cost} = [A - B(q_1 + q_2)q_2] - [(w + r)q_2 - F_2] \tag{12.5}$$

The requirement that marginal revenue equals marginal cost implies that the entrant firm's best response function is:

$$q_2^* = \frac{(A - w - r)}{2B} - \frac{q_1}{2}. \tag{12.6}$$

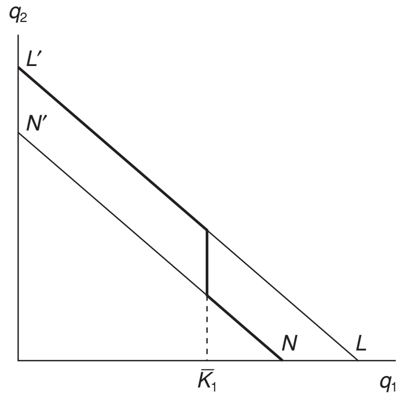

Figure 12.3 The best-response function of the incumbent firm depends on its first-stage choice of capacity

For output less than $\bar{K}_1$, the incumbent will have a low marginal cost and operate on the higher response function $L'L$. For output greater than $\bar{K}_1$, the incumbent will have a high marginal cost and operate on the lower best response function.

Derivation Checkpoint

The Calculus of Predation: Limit Output/Price and Capacity Commitment

In the Stackelberg limit output model, inverse market demand is given by: $P = A - BQ$. Once the dominant firm commits to a specific output q^F, the entrant's residual demand is: $P = A - B(q^F + q)$, where q is the amount produced by the entrant. The entrant's marginal revenue curve is then described by: $MR = A - Bq^F - 2Bq$. Setting this equal to the entrant's marginal cost then yields the entrant's optimal output, q^*. The incumbent's limit output is that choice of Q^F such the entrant's residual demand curve is just tangent to its average cost curve at the output choice, q^*.

The Dixit model of capacity commitment to deter entry relies on the fact that while the capacity can be installed in varying amount it is, once made, a sunk cost. Because the incumbent firm will not want to let installed capacity stand idle, its ability to build capacity prior to any entrant, allows it to transform the structure—but not the total amount—of its costs. The incumbent's marginal cost will be w for output less than or equal to its capacity choice $\bar{K}$, but $w + r$ for all outputs greater than that amount. In contrast, the entrant's marginal cost is always $w + r$. Competition is of the Cournot or quantity type. The industry inverse demand function is: $P = A - BQ = A - B(q_1 + q_2)$, where q_1 and q_2 are the outputs of the incumbent and entrant firm, respectively. This implies a profit function of: $\pi_1 = A - B(q_1+q_2)q_1 - wq_1 - r\bar{K} - F_1$ if output is less than $\bar{K}$, and $\pi_1 = A - B(q_1 + q_2)q_1 - (w + r)q_1 - F_1$ if output is greater than $\bar{K}$. Setting the derivative with respect to q_1 equal to zero in each case then yields the incumbent's two possible reaction functions. For output less than or equal to $\bar{K}$, the incumbent's optimal response curve is: $q_1 = \dfrac{A - w}{2B} - \dfrac{q_1}{2}$. For output above $\bar{K}$, its optimal response is: $q_1 = \dfrac{A - (w + r)}{2B} - \dfrac{q_1}{2}$. Firm 2's best response function is the same as firm 1's for $q_1 > \bar{K}$.

We may simultaneously solve for q_1 and q_2 using the best response curve of each firm. If both firms follow the response function, $q_i = \dfrac{A - (w + r)}{2B} - \dfrac{q_j}{2}$, each firm will produce $q_i = \dfrac{A - (w + r)}{3B}$. This corresponds to the outputs at point T in Figure 12.3. If the entrant has the response function $q_2 = \dfrac{A - (w + r)}{2B} - \dfrac{q_1}{2}$, but the incumbent has the response function, $q_1 = \dfrac{A - w}{2B} - \dfrac{q_2}{2}$, the incumbent will produce at level $q_1 = \dfrac{A - w}{3B} + \dfrac{r}{3B}$. In this case, the entrant will produce at level $q_2 = \dfrac{A - w}{3B} - \dfrac{2r}{3B}$. This combination corresponds to point V in Figure 12.6. The monopoly or Stackelberg leader output is $q_1 = \dfrac{A - (w + r)}{2B}$. The equilibrium must be one in which firm 1 produces between the monopoly output and V_1. In the example in the text, $A = 120$, $B = 1$, and $w = r = 30$. The incumbent's output as a Stackelberg leader is therefore: $q_1 = 30$. The intersection of the best response functions corresponding to point V is one at which $q_1 = 40$ and $q_2 = 10$. The final outcome must lie within the interval defined by these two points.

One point worth stressing before going further is that equation (12.6) is the entrant's best response function *given* that it chooses to produce a positive level of output at all, i.e., so long as it is the case that the entrant's profit at that output will be nonnegative. The best response function is derived using the marginal conditions and therefore does *not* take account of the sunk cost F_2 that the potential entrant incurs should it actually decide to enter. The intercept of equation (12.6) with the q_2 axis, $(A - w - r)/2B$, is the entrant's optimal output if the incumbent somehow decided to produce nothing. That would correspond to the entrant being a monopoly and would almost certainly imply positive profits (otherwise we could rule out entry from the start). However, as one moves from left to right along the best response function, the entrant's output becomes successively smaller as it adjusts to larger and larger output choices by the incumbent. This decline limits the volume over which the entrant's fixed cost may be spread. As a result, firm 2's average total cost rises as its output falls. It is quite possible that, at some point where the incumbent's output q_1 is sufficiently large, the market price implied by the combined output of both firms will not cover the entrant's average cost *at the production level implied by its best response curve*. Accordingly, the entrant will lose money if it actually produces that output once the fixed cost F_2 is taken into account. Recall, however, that the entrant always has the option of ***not*** producing at all, instead staying out of the market and thereby earning a zero profit. If, at the output implied by equation (12.6), the entrant's profit would in fact be negative, it will not produce that level but simply refrain from entering the market. We will return to this point below.

We know that the Nash equilibrium in stage two will occur at the intersection of the incumbent's best response function and the best response function of the potential entrant providing, as just noted, that the latter earns a nonnegative profit. This brings us back to the first stage. Understanding how competition works out in stage two, the incumbent firm also understands that it can manipulate this intersection by its choice of $\bar{K}_1$ in stage one. Naturally, the incumbent firm will choose $\bar{K}_1$ in the first stage to give itself the maximum profit possible in stage two. Let us now investigate this choice and whether or not it implies the possibility that the incumbent firm will choose $\bar{K}_1$ to deter the second firm from entering.

We begin by drawing a diagram that describes all the possible equilibria for stage two of the game. In Figure 12.4 we draw the two reaction functions for firm 1, one corresponding to the low marginal cost of production w labeled $L'L$, and the other reaction function corresponding to the higher marginal cost of production $(w + r)$ labeled $N'N$. We then add the reaction function for firm 2, labeled $R'R$. We denote the point where firm 2's reaction function meets $N'N$ by $\boldsymbol{T}$. This point corresponds to stage two outputs for the incumbent and entrant of T_1 and T_2, respectively. Similarly; the point where $R'R$ meets $L'L$ is labeled $\boldsymbol{V}$ and corresponds to respective outputs of V_1 and V_2.

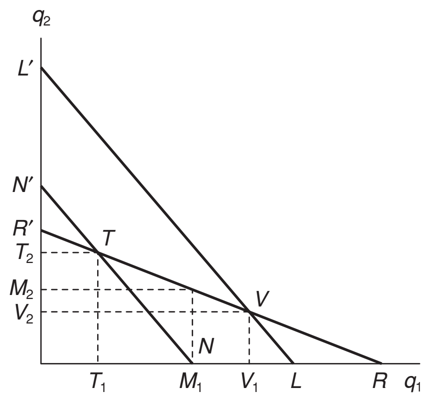

Figure 12.4 The rational bounds on the incumbent's initial choice of capacity, K_1
The incumbent will choose and initial capacity investment somewhere in the interval from T_1 to V_1.

In the second stage, firm 2 is either going to enter or stay out. Consider what happens if firm 2 does enter. In this case, the Nash equilibrium must lie somewhere between points ***T*** and ***V*** on firm 2's best response function $R'R$. The actual point will depend on the capacity choice of the incumbent and, in particular, on the output level at which the incumbent shifts from response function $L'L$ to $N'N$. The minimum amount that firm 1 will produce if its rival enters is T_1 and the maximum amount it will produce is V_1. Accordingly, firm 1 would never wish to choose a capacity level less than T_1 or larger than V_1 if it foresaw that firm 2 was definitely going to enter.

What if firm 2 does not enter? First, think of what this means. If firm 2 does not enter it must be because entry is not profitable. This could happen if firm 2 is unable to make a positive profit even in its most favorable Nash equilibrium, namely, the one at ***T***. At ***T***, firm 2 produces its highest equilibrium output T_2. If it cannot break even at this volume then it surely cannot break even at any smaller output level such as that at V_2. However, if this is the case, and if firm 1 understands this fact, then firm 1 will recognize that it will be a monopolist in stage two. A monopoly firm in this market would of course produce at production level M_1. The marginal cost of producing any output that fully utilizes capacity is $(w + r)$. Equating this amount with its marginal revenue gives the pure monopolist's profit-maximizing output, and it is the production level M_1, corresponding to firm 1's optimal output when firm 2 produces zero. Firm 1 would choose in this case a capacity equal to M_1.

Even at this early stage of our analysis then we have obtained some useful results. First, the incumbent's choice of capacity in stage one must lie in the interval ranging from T_1 to V_1. Second, if the entrant cannot break even at output T_2, the incumbent's best choice within this interval is M_1, namely the output chosen by a pure monopolist with marginal cost $(w + r)$ which is precisely what the incumbent will be.

What we need to do now is to determine the incumbent's best initial choice of capacity when the entrant *can* at least break even at output T_2. In this regard, the capacity level of M_1 is again relevant because it is not only the monopoly output but, as just noted, also the output of a Stackelberg leader. Because only the incumbent gets to choose capacity in stage one, we might expect that even if the entrant can operate at levels of output below T_2, the incumbent still ought to be able to achieve the market share and profit of a Stackelberg leader. In other words, we should expect that the incumbent will never choose an initial capacity less than M_1. Note though that if this presumption is true, we have then reduced the set of sensible initial capacity choices from the broad range of T_1 to V_1, to the much narrower range of M_1 to V_1. In fact, we will soon see that this conjecture is quite correct. The incumbent's profit-maximizing initial capacity choice will always lie within the M_1 to V_1 range.

To see why the incumbent will do best by choosing initial capacity in the M_1 to V_1 range, and also to determine precisely what point within that range is best we proceed as follows. We denote by the point ***B*** the output level at which the entrant, firm 2, ceases to make a profit, i.e., when the revenue from the entrant's best output response just covers both its variable and its fixed cost so that $\pi_2 = 0$. By definition, the relevant range of ***B*** lies somewhere on the entrant's response function, RR'. Indeed, ***B*** must lie on RR' somewhere to the left of where that response curve intersects the q_1 axis, since with a sunk cost of F_2, the entrant cannot break even if it enters but produces nothing ($q_2 = 0$).

The incumbent firm's best choice of its initial capacity $\bar{K}_1$, which again determines both where the jump occurs in its reaction function and the location of the stage two equilibrium, depends on just where the point ***B*** lies. Figure 12.5 shows four possibilities. For example, suppose that because of a relatively high sunk cost F_2, firm 2's profit is negative when it produces T_2 and firm 1 produces T_1, or $\pi_2(T_1, T_2) < 0$. In other words, ***B*** is at a point like $\boldsymbol{B_L}$

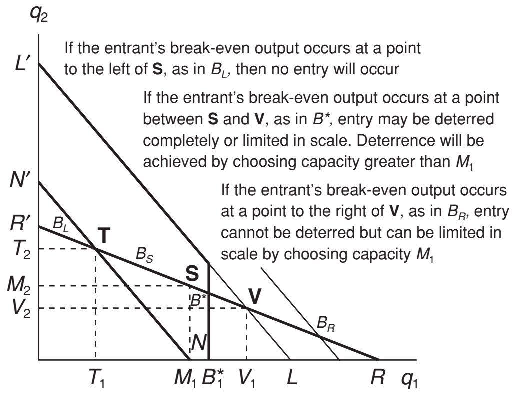

Figure 12.5 Possible locations of the entrant's break-even point

to the left of $\boldsymbol{T}$. This is the case that we have already discussed. Here, entry by firm 2 is not profitable under any condition and will not occur. The incumbent firm understands at the time of its first stage investment that it will be a monopoly in stage 2, and therefore will choose the pure monopoly capacity level M_1. It will then produce at output $q_1 = M_1$ in stage two.

What if $\boldsymbol{B}$ is at a point such as $\boldsymbol{B_S}$? This means that the entrant can break even at a production level below T_2 so long as it is above M_2. What is the incumbent's best choice now? In Figure 12.5 we have designated the output combination (M_1, M_2) by $\boldsymbol{S}$. The reason for this notation is that as noted above, M_1 is not only the incumbent's pure monopoly output but also the output chosen by the Stackelberg leader. The key point here is that even if the entrant can break even at output levels less than T_2, so long as it cannot cover its costs at output levels M_2 or less, then M_1 remains the optimal capacity choice by the incumbent.[9] If the entrant cannot profitably enter when the incumbent produces the pure monopoly output M_1, then by selecting that capacity the incumbent guarantees that entry will not occur. In turn, this will justify the incumbent's decision to build capacity M_1 in the first place. Using Bain's (1956) terminology, this is a case of blockaded entry. It is not really predatory conduct, however. The firm is producing and pricing like the monopolist that it is. It is not engaging in any action that is solely profitable by virtue of its entry deterring effect.

We now consider a third possibility at the other end of firm 2's reaction function. Here we consider a break-even point $\boldsymbol{B}$ that lies to the right of V as is the case at $\boldsymbol{B_H}$. This means that firm 2's costs are such that its profit is still positive at (V_1, V_2), where it produces the relatively small amount V_2 and firm 1 produces the much larger quantity V_1. As we noted above, this implies that firm 2 will definitely find it profitable to enter the market. Not only is entry not blockaded in the sense of Bain (1956), it is in fact inevitable.

Think a bit about what this really means. The incumbent knows that entry is inevitable. It simply cannot maintain a monopoly position. Yet if entry cannot be prevented it may at least be limited. Since the incumbent can see that it will have an active rival in stage 2, it may as well take actions in stage one that give the incumbent the best possible profit potential when competing with firm 2. The obvious choice in this regard is to play the Stackelberg leader. In this linear model the pure monopoly output choice is the same as the Stackelberg

9 Strictly speaking, when the entrant's break-even output lies between T_2 and M_2, the incumbent would be indifferent between choosing M_1 or a smaller capacity just sufficient to preclude entry and then expanding output in stage two to the level of $\boldsymbol{M_1}$.

leader's, and so again the incumbent has an incentive to install an initial capacity equal to M_1. True enough, this will no longer lead to an equilibrium in which the incumbent is a monopoly in stage 2. Entry will occur and output will rise above the monopoly level while the market price will decline. Yet the installation of capacity equal to M_1 will force the entrant to enter on the limited scale of a Stackelberg follower producing only M_2. To install less than M_1, foregoes some of the incumbent's first mover advantage. To install more would further limit the scale of the entrant's production but this gain would be more than offset by the negative price effect that the extra production would exert. M_1 is then the best choice. Entry is not deterred but it is limited or, to use Bain's (1956) terminology, is "ineffectively impeded."

What we have just shown is that so long as the point $\boldsymbol{B}$ lies to the left of $\boldsymbol{S}$, such as in the cases of $\boldsymbol{B_L}$ or $\boldsymbol{B_S}$, or to the right of $\boldsymbol{V}$, as in the case of $\boldsymbol{B_H}$, the incumbent's optimal choice of initial capacity $\bar{K}_1$ is to set $\bar{K}_1 = M_1$. These possibilities cover the case in which entry is blockaded and the entrant cannot break even at any output M_2 or less, and the case in which entry is certain and the best that the incumbent can do is to limit the entrant's scale.

The remaining and perhaps the most interesting case to consider is what happens when firm 2's costs of production are such that firm 2's profit, as we move down its reaction function, is positive at M_2 but negative at V_2. This implies that the $\boldsymbol{B}$ where firm 2 just breaks even lies between $\boldsymbol{S}$ and $\boldsymbol{V}$, such as $\boldsymbol{B^*}$. In this case, firm 1 has a choice to make. On the one hand, it can continue to play the Stackelberg leader by initially installing capacity M_1 and producing at that level in stage two. Firm 2 will then choose its optimal response of producing M_2. On the other hand, firm 1 can expand its initial capacity choice to the level B_1^*. This will require that it produce more output which lowers the industry price, but it is also enough to prevent firm 2 from entering, preserving the incumbent's monopoly in the market. The latter strategy may well prove the more profitable one. This case is where entry deterrence is a real possibility. If the incumbent earns less profit when sharing the market at $\boldsymbol{S}$ than it earns when it deters entry by choosing in stage one capacity B_1^*, it will act so as to preclude entry altogether. This outcome corresponds to what Bain (1956) describes as the case in which entry is effectively impeded. We emphasize that this will not always be the case. Even if $\boldsymbol{B}$ lies at $\boldsymbol{B^*}$ so that the output at which the entrant breaks even lies between M_2 and V_2, the incumbent may still better exploit its first mover advantage by acting as a Stackelberg leader. Yet credible deterrence by a capacity choice greater than M_1 is now a real possibility. Moreover, even when absolute deterrence does not occur, the incumbent can still limit the scale of entry by playing the Stackelberg leader. Practice Problem 12.2 provides a numerical example of these calculations.

Practice Problem 12.2

Suppose that the inverse demand function is described by: $P = 120 - (q_1 + q_2)$, where q_1 is the output of the incumbent firm and q_2 is the output of the entrant. Let both the labor cost and capital cost per unit be 30, i.e., $w = r = 30$. In addition, let each firm have a fixed cost of $F_1 = F_2 = 200$.

a. Suppose that in stage one the incumbent invests in capacity $\bar{K}_1$. Show that in stage two the incumbent's best response function is $q_1 = 45 - \frac{1}{2}q_2$ when $q_1 \leq \bar{K}_1$ and $q_1 = 30 - \frac{1}{2}q_2$ when $q_1 > \bar{K}_1$.

b. Show that the entrant's best response function in stage two is $q_2 = 30 - \frac{1}{2}q_1$.

c. Show that the monopoly or Stackelberg leader's output is equal to 30. If the incumbent commits to a production capacity of $\bar{K}_1 = 30$ show that in stage two the entrant will come in and produce an output equal to 15. Show that in this case firm 2, the entrant, earns a profit equal to \$25, whereas the incumbent earns a profit of \$250.
d. Show that if the incumbent instead commits in stage one to a production capacity $\bar{K}_1 = 40$ then in stage two the entrant's best response to this choice is to produce $q_2 = 10$. However in this case the entrant does not earn sufficient revenue to cover its total cost. Specifically the entrant earns −100.
e. Now show that if the incumbent chooses a $\bar{K}_1 = 32$ in stage one then the entrant in stage two can not earn a positive profit if it enters the market. In this case the incumbent produces slightly more output than the monopolist and earns a profit equal to \$632, which is far greater than the profit earned in part (c). Compare your analysis with that described in Figure 12.6

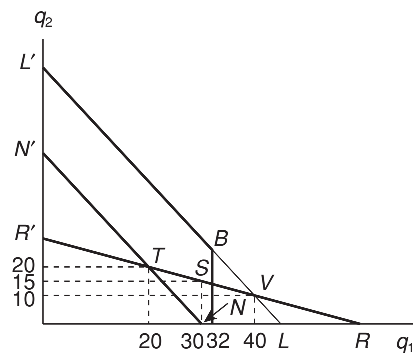

Figure 12.6 An example of entry deterrence
By initially investing in capacity of 32 in stage one, the incumbent firm insures that it will operate on the response function $L'L$ up to this output level in stage two. It also signals the potential entrant that the incumbent will produce an output of $q_1 \geq 32$ in this later stage. The entrant's best response to this production level is to set $q_2 = 14$. However, the entrant will not cover its cost even with this best response. Therefore, by committing to an output of $q_1 = 32$, the incumbent deters any actual entry.

In sum, entry may well not occur. This can happen because the entrant's costs are so high that it cannot profitably enter even if the incumbent produces and prices non-strategically as a pure monopolist. It can also happen when entry might otherwise be profitable except that the incumbent, foreseeing this, acts strategically and deters entry by investing in enough capacity to produce beyond the output of a pure monopoly. Even if entry cannot be profitably deterred the incumbent still retains the lion's share of the market because it acts as a Stackelberg leader.

The Dixit model makes clear that the incumbent firm has an advantage. More importantly, the model reveals precisely the source of that advantage. It is the incumbent's ability to commit credibly to a particular output level in stage two by means of its choice of capacity in stage one. Effectively, the incumbent commits to producing at least as much as the initial capacity it installs because to produce any less amounts to throwing away some of that investment, which is costly. In this respect, two further aspects of the model are worth noting. First, when the incumbent deters entry it does so by deliberately *over* investing in initial capacity. That is, installing an initial capacity greater than M_1 would not be profitable

Reality Checkpoint

Take-Or-Pay . . . And Win!

Firms typically have contracts with their key suppliers that stipulate the amount of the input to be bought and the price to be paid for the coming year. A common additional feature of such contracts, especially for supplies of natural gas, electricity, and commodity raw materials, is a "take-or-pay" clause. A contract that includes a take-or-pay clause requires that the purchasing firm either uses all the amount of the input initially contracted or, that if it orders less than that amount, it still pays some amount, usually less than the full contract price, for the additional amount remaining.

Take-or-pay contracts stabilize both the production schedule and the revenues of supplier firms. However, as you should recognize, they also serve another purpose. They are a straightforward way to implement the Dixit entry deterrence strategy.

For example, Corning is one of the leading manufacturers of fiber optic cables. One of its key suppliers is Praxair, a major producer of specialty gases. Suppose that Corning signs a contract with Praxair that calls for Corning to purchase 1,000,000 cubic feet of helium (which is used as a coolant in the production of fiber optic cable) at \$400 per 1,000 cubic feet. The contract also includes a take-or-pay contract where Corning has to pay \$300 per cubic feet for any amount of the 1,000,000 that it does not use. What this does is effectively transform the structure of Corning's costs. If Corning orders all of the 1,000,000 cubic feet its helium bill will be: (\$400/1,000) × 1,000,000 = \$400,000. Suppose though that Corning only uses 900,000 cubic feet of helium (perhaps because a new rival steals some Corning customers). Because of the take or pay clause, it will still pay \$300 per thousand cubic feet for the 100,000 cubic feet that it did not order. Hence, Corning's total helium cost in this case will be: (\$400/1,000) × 900,000 + (\$300/1,000) × 100,000 = \$390,000. In other words, using the last 100,000 cubic feet of helium only raises Corning's total helium bill by \$10,000. Effectively, the contract has changed the marginal cost of helium for Corning from \$400 to \$100 per thousand cubic feet. Note that it has not changed the total cost of using one million cubic feet of helium. The contract has simply transformed some of those costs into fixed costs so that up to the one million volume, Corning has a very low marginal cost.

There is of course a downside to the take-or-pay contract. This is that if another large rival, e.g., the British fiber optic producer Marconi, already exists and both firms sign take-or-pay contracts with their helium suppliers, the industry could find itself in a nasty price war in which prices fall to the low levels of marginal cost vie Bertrand competition. Some believe that this is part of what happened in the fiber optic market following the burst of the telecommunications bubble.

Sources: A. M. Brandenburger and B. J. Nalebuff, *Co-opetition*, New York: Doubleday, 1996; and F. Norris, "Disaster at Corning: At Least the Balance Sheet is Strong," *New York Times*, July 13, 2001, p. C2.

were it not for the fact that doing so eliminates the competition. Therefore, such capacity expansion is predatory in the usual sense of the word. Such a choice is illustrated in the practice problem, where the incumbent's strategy to increase capacity to $\bar{K} = 32$ *is* predatory. If the entrant could break even at low levels of output, the incumbent would not choose the initial capacity level $\bar{K} = 32$ to deter entry. In other words this investment is only profitable because it keeps the entrant from the market altogether so that the incumbent can sell its 32 units at a very high price.

Second, note that capacity expansion is credible as a deterrent strategy only to the extent that capacity, once in place, is a sunk cost. If unused plant capacity can be sold off for a fee *r*, then capacity is truly flexible and acquiring it does not reflect any real commitment on the part of the firm. When such flexibility is not possible, which is often the case, then capacity investment is a much more effective way to deter strategy than simply a promise to set a low price. A price commitment is much less credible precisely because it may easily be changed.

Now think back to the empirical evidence on entry that we reviewed at the beginning of the chapter. Two of the stylized facts are: (1) entry is commonly observed in a wide cross-section of industries, and (2) market penetration as measured by market share is relatively low for the entrants. These stylized facts are consistent with this model. The incumbent has a strategic advantage in being the first to invest in capacity, and can use this advantage to strategically limit the impact of entry into its market—perhaps eliminating it altogether.

12.3 **Practice Problem**

The extensive form for a dynamic game between an incumbent and an entrant firm is described in Figure 12.7. The incumbent firm moves first and chooses whether or not to spend C as a means of enhancing its ability to be aggressive. The entrant moves next and decides whether or not to enter the market. If the entrant enters then the incumbent decides whether to accommodate its new rival or to fight. If the entrant does not enter, the incumbent earns 8 – C if it has made that expenditure, and 8 if it has not. If the entrant does enter, the incumbent's payoffs depend on whether it fights or accommodates. Fighting when the expenditure C has been sunk yields a payoff of 3. Fighting is bloodier when the incumbent has not spent C. Accommodation when C has been spent wastes that investment. The final payoffs are described in parentheses, the first being the incumbent's payoff and the second the entrant's.

a. Show that for C greater than or equal to 1, the incumbent will always fight *if* it has invested in the capacity to do so, i.e., if it has initially made the expenditure, C.
b. Show that for C greater than or equal to 3.5, the incumbent will not make the initial investment, C.

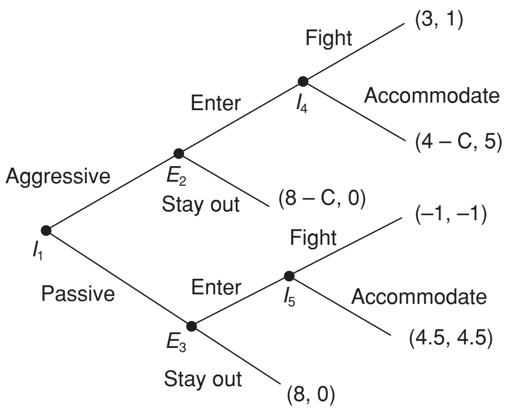

Figure 12.7 Extensive form for Practice Problem 12.3
Nodes labeled *I* indicate that it is the incumbent's turn to move. Nodes labeled *E* indicate that it is the entrant's turn to move.

12.3 PREEMPTION AND THE PERSISTENCE OF MONOPOLY

The scale of a plant or plant capacity is rarely a continuous variable. Instead, it comes in discrete sizes, say one efficient scale corresponding to the U-shaped average cost curve. This means, for example, that one plant may be the most efficient way to supply an industry even if that plant is operating at a volume beyond the point of minimum average cost. Because a second plant cannot be built to operate at an arbitrarily small scale but must, instead, be of the same size as the first, it pays to operate just one plant at a high volume and somewhat high average cost rather than to build an additional establishment. Only when market demand has expanded sufficiently to operate a second plant at close to the minimum average cost will building that plant be worthwhile.

In this setting, the possibility arises for an incumbent firm to take actions that are similar to but logically distinct from the predatory investment of the Spence and Dixit models. In particular, the first mover advantage of the incumbent is to *preempt* the entry of a rival firm by investing before that entry is on the horizon. The distinction between this and the investment stories told earlier is subtle. Here, we are essentially talking about *timing* with the issue being who will build the next plant first. Will it be the entrant as the expanding market offers the entrant an opportunity to participate or, will it be the incumbent rushing ahead of the entrant and thereby eliminating the entrant's opportunity?

Rather than work out a formal model[10] we will simply sketch out the intuition behind the basic notion. So, imagine a market in which one firm is operating and earning a monopoly profit π^M. Everyone knows, however, that demand is about to grow. In particular, everyone can see that next period the market demand at any price will double. It will then stay at this higher level for every period thereafter. If entry were not a problem, the monopolist would expand its plant at the start of the next period, pay the cost of such expansion F, and earn $2\pi^M$ thereafter provided that present value of the profit increment $\pi^M R/(1 - R)$ of doing so exceeds present value of the cost RF, where R is the monopolist's discount factor.[11]

Recall, though, that there is a potential entrant lurking on the sidelines. Should this entrant come in, it will share the market with the incumbent and each will earn the Cournot profit. This is π^C in the first period and $2\pi^C$ for every period afterwards when the market is twice as big. For the second firm to enter, however, it must build a new plant just as the monopolist does when it expands. So the entrant would also incur a cost of F if it builds the next plant.

The point is that the entrant has a choice about *when* it enters as well as *if* it enters. That is, the entrant can come into the market now or wait until next period when the market is bigger. Consider then, the consequences of each choice. If the entrant builds its plant in the first period, it will earn π^C for one period and $2\pi^C$ thereafter. Using the discount techniques, presented in Chapter 2, the present value of this profit stream is $\pi^C + 2\pi^C R/(1 - R)$, where we assume that the entrant has the same discount factor as the incumbent. So, the net present value of entering the market now is $\pi^C + 2\pi^C R/(1 - R) - F$. If, on the other hand, the entrant delays entering until the start of next period, and *if the incumbent does not build a second plant before then*, the entrant can look forward to a net income stream whose present value is $2\pi^C R/(1 - R) - R.F$. We will assume that this is positive. This ensures that the entrant would like to enter next period, assuming, of course, no action by the

[10] See Gilbert and Harris (1984).

[11] In evaluating the present value of the profit stream we use the discounting techniques of Chapter 2.

incumbent. Let us now also make the further assumption that it is more profitable for the second firm to enter next period rather than today. In other words, we assume that the second of the two net present value streams above is the larger one.[12]

Of course, the incumbent can work this all out, too. When it does, the incumbent will understand that unless it does something right now, firm 2 will enter at the start of the next period and take away its monopoly position. The only way that the incumbent can stop this from happening is if it decides to build a second plant today. Yes, this means that it incurs the cost F right away instead of being able to put it off. However, it also means that when the next period arrives, there is no room for a new entrant. The incumbent is ready to meet the market growth fully with supply from its own factories.

Will the above strategy be in the incumbent's interest? Quite possibly, yes. If the incumbent waits and lets the entry occur next period it will only earn $2\pi^C$ in every subsequent period. The present value of its profit is $2\pi^C R/(1 - R)$ (since it does not need to add any more capacity). If, however, the incumbent invests now, it precludes later entry and so will earn $2\pi^M$ next period and indefinitely into the future. The present value of investing this period then is $2\pi^M R/(1 - R) - F$. Recall that the discount factor $R = 1/(1 + r)$. Therefore, so long as $2(\pi^M - \pi^C)/r > F$ the incumbent will invest today and thereby, preclude subsequent entry. The left-hand side is the present value of the additional profit that the incumbent makes by maintaining its monopoly. The right-hand side is the cost of installing the additional capacity necessary to pre-empt entry and maintain its monopoly.

Why is it that that investing in a new plant right away is more likely to be profitable for the incumbent than it is for the entrant? The reason is that the incumbent's gain is the maintenance of its monopoly position and the monopoly income π^M. By contrast, the best that the incumbent can do is to get a share of a Cournot duopoly and earn π^C. Since $\pi^M > \pi^C$, the incumbent's incentive to invest right now exceeds the entrant's incentive.

12.4 EVIDENCE ON PREDATORY CAPACITY EXPANSION

Both the Dixit-Spence and the preemption models discussed in the preceding sections suggest that we may observe dominant firms expanding capacity rapidly as a means to deter entry. Is this a serious concern? Is there any evidence that such capacity investment actually occurs?

To begin with there is the stylized fact noted at the start of this chapter that the same firms continue to dominate their industries and earn superior profit for long periods of time. However, this could happen for a lot of reasons, including superior management or cost efficiency at such firms. The specific question is whether there is evidence of the maintenance of such market power explicitly by means of capacity expansion or preemptive investment.

Since investment commitment strategies are more likely to occur in more capital-intensive industries, one might expect profitability to be higher in such industries, all else equal, if preemptive expansion is the norm. An early study by Caves and Ghemawat (1986) does not find support for this result. Yet if preemptive expansion is not the norm, there does seem to be clear historic instances of its practice. The Alcoa case (see inset) is perhaps the best known example, but there are others.

[12] The necessary condition is that $rF > (1 + r)\pi^C$. Roughly speaking, the interest payments on the fixed sum invested in the plant are not covered by the first-period Cournot profit.

Reality Checkpoint

The Alcoa Case: Do It First, Do It Right, . . . and Keep On Doing I

In 1945, a U.S. Court of Appeals for the Second Circuit, under the direction of Judge Learned Hand. rendered one of the most famous decisions in U.S. antitrust history. The case involved the charge against the Aluminum Co. of America (Alcoa) that it had unlawfully monopolized the domestic market for aluminum and aluminum products. Alcoa had previously been involved in an antitrust case in 1912. At that time it was found guilty of restrictive and anticompetitive practices, including: (1) signing contracts with electric power companies to obtain the large amount of electricity needed to process raw alumina and including in those contracts covenants that prohibited the power companies from selling electricity to any other aluminum manufacturer; and (2) forming a cartel with foreign manufactures to divide the world aluminum market into regions and restrict sales in any one region to primarily one member of the cartel. In part, the 1945 case was based on the allegation that these practices had continued despite the 1912 settlement. However, the court's decision against Alcoa this time was predicated primarily on the view that Alcoa expanded capacity to keep out competitors. The court noted that Alcoa increased its capacity eight-fold between 1912 and 1934. It noted that there had been "one or two abortive attempts to enter the industry, but Alcoa effectively anticipated and forestalled all competition." The court continued, saying that "we can think of no more effective exclusion than . . . to face every newcomer with new capacity already geared into a great organization".

Of course, much as the Microsoft case revealed 55 years later, the finding that a firm has illegally abused its market power does not make clear what the remedy to such abuse should be. Even a serious fine may seem to weak a penalty because it leaves the firm intact and able perhaps to resume its illegal practices. Yet breaking up a successful organization as was done in the Standard Oil case may seem overly harsh. In the Alcoa case, the government was fortunate to have an alternative remedy. The case was decided in the immediate aftermath of the Second World War. During that war, the government had operated a number of aluminum plants. The decision was made to sell these plants to two new firms, Kaiser and Reynolds, and thereby create a more competitive market structure.

Source: *U.S. v. Aluminum Co. of America*, 148 F. 2d 416 (1945).

Weiman and Levin (1994) find that preemptive investment was an explicit tactic of Southern Bell Telephone (SBT) in its effort to monopolize the local phone service market in the central southern and eastern southern regions of the U.S. Those markets had become intensely competitive after the expiration of the Bell patents so that by 1902, independent firms accounted for 60 percent of the local phone service in the region from Virginia to Alabama and Florida. Company archival records reveal that SBT's leader, Edward J. Hall, launched an aggressive capital expansion program to build a regional toll network in anticipation of market development and with the explicit goal of preempting rivals. Within four years, SBT had increased the geographic reach of its system from 2,000 to 8,600 pole miles. Even more impressively, its calling capacity as measured by toll wired grew from 5,000 to over 55,000 miles. All this was accompanied by an aggressive price-cutting campaign both in markets where it faced competition and those where it expected it. Among other features, this had the effect of restricting the investment funds available to competitors for their own expansion whereas SBT was able to rely on heavy financing from its parent firm, AT&T. The plan worked. By 1912, SBT had virtually complete control of the southern local telephone market.

A more recent example is set in the town of Edmonton, Alberta during the 1960s and early 1970s. The major retail grocer in Edmonton at that time was Safeway. However, in the early 1960s a number of other grocery stores from other regions began to enter the Edmonton market. These included two Ontario firms, Loblaws and Dominion, and one Western Canada firm, Tom Boy. Between 1960 and 1963, these three firms opened 12 new stores in the Edmonton area. By 1964, they were operating a total of 21 stores—not far behind Safeway's then total of 25. Safeway could clearly see that continued entry by these and other firms was a real possibility and it rapidly responded. It opened 4 new stores in 1963–4, another four new stores in 1965–6, and then added five new stores in 1968. Moreover, Safeway chose the locations of these new stores quite carefully. It located them in areas where due to increasing population and the fact that no other store was currently close by, it looked like a site of potential entry. In addition, just to drive home the seriousness of its intentions, Safeway also located some of its new stores almost right next to locations where its rivals also had a store. The strategy worked. By 1973, Safeway was operating 35 stores in the Edmonton area whereas, due to closings, its three major rivals were operating just 10. Indeed, Safeway had so effectively established its credibility as a preemptive competitor that whenever its major rivals or even fringe firms opened up a new store, they typically located near each other rather than in neighborhoods already served by Safeway but sufficiently densely populated to permit room for a second store.[13]

Our final anecdote comes from the market for titanium dioxide. This is a chemical additive used as a whitener in such products as paint, paper, and plastics. It can be produced by three processes. One of these is a sulfate procedure that uses ilmenite ore. Another technique is a chloride process that uses rutile ore. Both of these processes are known and available to all producers. The third process, however, is a special chloride process that because of legal restrictions is known and available for use only by DuPont. Like the sulfate process, DuPont's procedure uses ilmenite ore. Yet like the generic chloride process, DuPont's method emits little pollution. This is not the case with the sulfate procedure, which has bad pollution affects.

Seven domestic firms were active in the titanium dioxide market during the 1970s. DuPont was the largest of these with about 34 percent of the market, but NL industries—which used the sulfate procedure—was a close second. Then, two events happened in the early 1970s that gave DuPont a decided advantage. First, rutile ore became more expensive, implying that other producers using the generic chloride technique might have to cut back. Second, strict pollution controls were imposed that made the sulfate process very expensive, too. Suddenly, DuPont's proprietary chloride technique based on ilmenite ore gave the company an edge with respect to costs. A strategic firm would lose no time in exploiting that edge. It would know that those producers using sulfate were not likely to expand. It might also recognize that rutile could someday become cheap again (it did). If in addition the firm expected, as did all participants in the titanium oxide market, that demand would grow, a firm in DuPont's position might wish to expand capacity immediately. This would preclude

[13] Safeway was charged with monopolizing the Edmonton market in 1972 and, in late 1973, signed a consent decree that, among other things, prohibited it from expanding its total square footage in Edmonton for three and a half years. See Von Hohenbalken and West (1986).

those rivals using the rutile-based technique from expanding production when and if rutile prices dropped and thus, permit the firm to capture the gap caused by market growth and the declining sulfate-based production entirely for itself.

In point of fact, DuPont increased its capacity by over 60 percent in the next five years while the industry, in general, stagnated. By 1977, DuPont market share had risen to 46 percent. Moreover, when rival Kerr-McGee began to construct a new plant in 1974, just before DuPont got its planned expansion going, DuPont reacted by trumpeting its plans to the whole industry. This likely precluded any further entry beyond that of Kerr-McGee's.[14]

In short, there is much anecdotal evidence that supports the use of capacity expansion to overcome the Chain-Store Paradox and thereby maintain market power. We should note that such evidence may be even greater when we use a spatial interpretation of expansion along the lines of the Hotelling "Main Street" model that we discussed in Chapter 10. Indeed, it is often claimed that General Motors' strategy of offering many different automobile varieties, and the ready-to-eat breakfast cereal manufacturers' strategy of selling a wide assortment of cereals both reflect attempts to "crowd out" any would be rival by leaving it no market niche into which it can profitably enter.

Summary

This chapter has investigated the ability of firms to maintain a dominant market position in their industry for a prolonged period of time. Both anecdotal and formal evidence indicate that such sustained market power is a widespread feature. In turn, this implies that the entry of new rivals who can compete away an incumbent firm's profits is not as powerful in the real world as it is suggested to be in basic microeconomic texts. Something permits an incumbent to preserve its market position and successfully defend itself against rival entry.

There are good reasons to believe that market structures may evolve toward increasing concentration over time. The Law of Proportionate Effects or Gibrat's Law is a random growth process that generates such an outcome. Richer theoretical models such as Klepper's (2002), in which innovation becomes easier as firms get larger and more experienced also yield oligopoly as their equilibrium outcome. Thus, the fact that many industries are long-dominated by one or two firms does not necessarily imply that those firms have obtained and kept that dominance by predatory means. Yet the clear concerns that motivated the antitrust laws, as well as numerous court cases, also imply that predatory entry deterrence is a common concern. An important question in this respect is whether economic theory can shed light on such concern.

The proper analytical framework for studying entry deterrence is a dynamic game of sequential moves. Here, the key issue is credibility. Broadly speaking, the question is whether the incumbent dominant firm can persuade a would-be rival that it is committed to a price or output level that, if maintained, would make entry unprofitable. Capacity expansion and preemption may be ways to achieve such a commitment. There is reason to believe that such tactics have been used by real-world firms in specific cases, but often it is difficult to distinguish such predation from normal competitive behavior.

In both theory and practice, there is a distinction between preventing entry of new firms and driving existing ones out of business. In this chapter we have focused on the issue of entry deterrence or predatory conduct in a setting of complete information. However, it is important to recognize that often firms do not have complete information about each other and so are only able to guess at a rival's likely response to any action. We examine predation in the context of incomplete information in the next chapter.

[14] See Ghemawat (1984). See also, Hall (1990) for evidence that DuPont's action was consistent with the Dixit model.

Problems

1. Let the domestic market for small, specialized calculators and similar office equipment be currently served by one firm, called firm I. The firm has the following cost schedules: $TC(q_I) = 0.025q_I^2$ and $MC(q_I) = .05q_I$. Market demand is $P = 50 - 0.1Q$, and right now q is equal to q_I because the only firm in the market is the incumbent firm I.
   a. If the incumbent acts as a simple monopolist what price will it charge and what level of output will it produce?
   b. Suppose now that a foreign producer of calculators is considering exporting to the U.S. market. Because of transportation costs and tariffs this foreign firm faces some cost disadvantage vis-à-vis the domestic incumbent. Specifically the foreign firm's cost schedules are: $TC(q_E) = 10q_E + 0.025q_E^2$ and $MC(q_E) = 10 + .05q_E$. Suppose that the incumbent firm is committed to the monopoly level of output. What is demand curve faced by the potential entrant? Write it down. Facing this demand what level of output will the foreign firm actually export to the domestic market? What will be the new industry price?
   c. To what level of output would the incumbent firm have to commit in order to deter the foreign firm from entering the market? (Hint: you must solve for output level q^* with the property that if the entrant believes that the incumbent will produce q^* then the entrant's profit-maximizing response will be to produce q_E^* such that $\Pi^E(q_E^*, q^*) = 0$.) What is the incumbent firm's profit?

2. Return to problem 1. Suppose that the incumbent and the entrant instead will play a Cournot game if and when the entrant enters. What are firms' profits in this case? Is it reasonable to believe that the incumbent will try and commit to q^* in order to deter entry? Why?

3. Suppose that the inverse demand function is described by: $P = 100 - 2(q_1 + q_2)$, where q_1 is the output of the incumbent firm and q_2 is the output of the entrant. Let the labor cost per unit $w = 20$ and capital cost per unit be $r = 20$. In addition, let each firm have a fixed cost of $F_1 = F_2 = \$100$.
   a. Suppose that in stage one the incumbent invests in capacity $\bar{K}_1$. Show that in stage two the incumbent's best response function is $q_1 = 15 - \frac{1}{2}q_2$ when $q_1 \le \bar{K}_1$ and $q_1 = 20 - \frac{1}{2}q_2$ when $q_1 > \bar{K}_1$.
   b. Show that the entrant's best response function in stage two is $q_2 = 15 - \frac{1}{2}q_1$.

4. Return to Problem 3. Now show that if the incumbent commits to a production capacity of $\bar{K}_1 = 15$, the entrant will do best by producing 7.5 and earn a profit of \$12.5, while the incumbent earns a profit of \$125.
   a. Show that if the incumbent instead commits in stage one to a production capacity $\bar{K}_1 = 16$ then the entrant's best stage two response is to produce $q_2 = 7$, at which output the entrant does not earn a positive profit.
   b. In light of your answer to 2d, show that committing to a production capacity of $\bar{K}_1 = 16$, gives the incumbent a profit of \$348.

5. Two firms, firm 1 and 2, must decide whether to enter a new industry. Industry demand is described by $P = 900 - Q$, where $Q = q_1 + q_2$, $q_j \ge 0$. To enter the industry a firm must build a production facility of one of two types of: small or large. A small facility requires an investment of \$50,000 and allows the firm to produce as many as 100 units of the good at a unit production cost of zero. Alternatively, the firm can pay \$175,000 to construct a large facility that will allow the firm to produce any number of units of output at zero unit cost. A firm with a small production facility is capacity constrained whereas a firm with a large facility is not. Firm 1 makes the entry decision first. It must choose whether to enter and, if it enters, what kind of production facility to build. After observing firm 1's action, firm 2 chooses from the same set of alternatives. If only one firm enters the industry then it selects a quantity of output and sells it at the

corresponding price. If both firms are in the industry they compete as Cournot firms. All output decisions in the market stage are subject to the capacity constraints of the production facilities. The market lasts for only one period.

a. Draw the extensive tree that represents the entry game being played between 1 and 2.
b. What is the outcome? Does firm 1 enter and at what size? Does firm 2 enter and at what size?

6. Let the demand for hand-blown glass vases be given by $q = 70{,}000 - 2{,}000P$, where q is the quantity of glass vases consumed per year and P is the dollar price of a vase. Suppose that there are 1,000 identical small sellers of these glass vases. The marginal cost function of such a seller is $MC(q) = q + 5$, where q is the firm's output
   a. Assuming that each small seller acts as a price taker in this market derive the market supply curve, and the equilibrium price and quantity traded.
   b. Suppose that a new mechanized technique of producing vases is discovered and monopolized by some firm, call it firm B for "BIG". Using this technique, vases can be produced at a constant average and marginal cost of \$15 per vase. Consumers cannot tell the difference between vases produced by the old and the new technique. Given the existence of the fringe of small sellers what is the demand curve facing firm B?
   c. Facing this demand curve what is the profit-maximizing quantity produced by firm B? What is the price that it sets and the overall amount of vases traded in the market?

7. Suppose that two firms are in a race to enter a new market. For each firm, there is an advantage to taking time and perfecting its product because then consumers will pay more for it and it will be more profitable. However, there is also a disadvantage in waiting in that this has an interest opportunity cost of r. Let the time to enter t vary from 0 to 1 (year), and denote the choice of firm 1's entry and firm 2's entry be t_1 and t_2, respectively. The (symmetric) profit functions are:

$$\pi^1(t_1, t_2) = \begin{cases} e^{(1-r)t_1}; & \text{if } t_1 < t_2 \\ e^{\left(\frac{1}{2}-rt_1\right)}; & \text{if } t_1 = t_2 \\ e^{(1-t_2)-rt_1}; & \text{if } t_1 > t_2 \end{cases}$$

$$\pi^2(t_1, t_2) = \begin{cases} e^{(1-r)t_2}; & \text{if } t_2 < t_1 \\ e^{\left(\frac{1}{2}-rt_2\right)}; & \text{if } t_2 = t_1 \\ e^{(1-t_1)-rt_2}; & \text{if } t_2 > t_1 \end{cases}$$

Show that the Nash equilibrium entry times are $t_1 = t_2 = 1/2$.

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