3. In the setting of (2), is a profitable merger welfare-increasing or decreasing? Explain your findings.

4. Consider now a single merger after which the merged firm has costs with \( c_m \leq c_o \) and \( F_m = F_o \). Derive the exact condition for a merger to be profitable when there is free entry before and after the merger.

5. In the setting of (4), is a profitable merger welfare-increasing or decreasing? Explain your findings.

15.4 Essay question: Mergers and innovation

Katz and Sherlanski (2007, p. 2) write the following: "In some instances, innovation may be greater when concentration is greater. Hence, merger policy's problem: if antitrust enforcement is to promote and not disrupt the benefits of innovation, and if antitrust is properly to account for innovation's effects on market performance over time, to what extent should it adhere to its conventional presumptions regarding concentration in markets characterized by technological change?" In the light of this quote, discuss whether merger enforcement should take innovation considerations into account, and if so, how. (You may want to read first Sections 18.1 and 18.2, where we describe the two-way relationship between innovation and market structure.)

16 Strategic incumbents and entry

If natural (or innocent) entry barriers in an industry are sufficiently large, entry is said to be blocked for additional firms. In some markets, entry barriers are at a level that only a single firm can enter. In such a situation, the single incumbent firm can behave as a monopolist without fearing entry. In contrast, for lower entry barriers, entry is a threat that the incumbent cannot ignore. Facing potential entry, the incumbent will thus react strategically with a view either to make entry unprofitable or, at least, to minimize the harm that entry causes. Entry is said to be deterred in the former case, and accommodated in the latter.

Because an incumbent is already established in the industry, it has the advantage of being able to act before a potential entrant decides whether or not to enter. However, acting before is not sufficient to influence the entrant's decision: the incumbent must also act in a credible way. We already raised this issue in Chapter 4 when analysing the Stackelberg game. In the present context, a threat to make the entrant's life impossible or hard if it enters can only be effective if this threat is turned into a commitment. That is, the incumbent's action must modify its incentives in such a way that if entry was to happen, it would be in the incumbent's best interest to carry out the threat.

To achieve such commitment, the incumbent will invest prior to entry and in an irreversible way in some strategic variable that will affect its future conduct and, thereby, the profit the entrant could attain upon entry. It may also affect directly the entry cost so that this cost becomes endogenous. In Section 16.1, we show how the incumbent's investment decision depends on the strategic effect of this investment and on the type of product market competition. Combining these two dimensions with the two potential attitudes with respect to entry (deterrence or accommodation), we propose a taxonomy of entry-related strategies. Next, we apply this taxonomy to a number of specific examples of investments that an incumbent can make when facing the possibility of entry. In Section 16.2, we examine strategies affecting cost variables, namely investments in capacity, investments in R&D and strategies designed to raise the entrant's costs. In Section 16.3, we turn to strategies affecting demand variables. Here, we show how brand proliferation, bundling decisions and manipulation of an installed base of customers in the presence of switching costs can be used as entry deterrence tools. All these actions may be seen as anticompetitive and are thus subject to antitrust investigations.

Finally, we extend the previous analyses in two directions: imperfect information in Section 16.4 and multiple incumbents in Section 16.5. Regarding the former, we argue that limit pricing can deter entry when the entrant is uncertain about the cost level of the incumbent. As for the latter, we examine whether entry deterrence can be achieved, non-cooperatively, by a group of established firms.

---

56 The terminology is due to Bain (1956).
57 See Schelling's (1960) analysis of conflicts.
58 For an analysis of industries with endogenous sunk costs, see Sutton (1991).
16.1 Taxonomy of entry-related strategies

The incumbent’s investment decision in anticipation of the possibility of entry depends on the strategic effect of this investment and on the type of product market competition. To show this dependence, we analyse the following two-stage game between one incumbent firm (indexed by 1) and one potential entrant (indexed by 2). At the first stage, the incumbent chooses the level of some irreversible investment, denoted by $K_1$. At the second stage, after observing $K_1$, the entrant decides whether or not to enter and then product market decisions are taken. In particular, if the entrant enters, a duopoly results; otherwise, the incumbent remains in a monopoly position. Payoffs are described as follows.

- If the potential entrant decides to enter, the two firms simultaneously make their second-stage decisions, $\sigma_1$ and $\sigma_2$. Typically, this decision is either a price ($\sigma_1 = p_1$) or a quantity ($\sigma_1 = q_1$). Profits are given by $\pi_1(K_1, \sigma_1, \sigma_2)$ and $\pi_2(K_1, \sigma_1, \sigma_2)$, where by convention $\pi_2$ includes entry costs (if any). It is assumed that profit functions are such that a unique and stable Nash equilibrium exists in stage 2 for any $K_1$; we denote this equilibrium by $(\sigma^*_1(K_1), \sigma^*_2(K_1))$.

- If the potential entrant does not enter, it makes zero profit, while the incumbent obtains $\pi_1(K_1, \sigma^*_1(K_1))$, where $\sigma^*_1(K_1)$ is the monopoly choice in stage 2, expressed as a function of the first-stage investment.

As for the first stage, we assume that both $\pi_1(K_1, \sigma^*_1(K_1), \sigma^*_2(K_1))$ and $\pi_2(K_1, \sigma^*_1(K_1), \sigma^*_2(K_1))$ are strictly concave in $K_1$, and that the functions $\sigma^*_1(K_1)$ and $\sigma^*_2(K_1)$ are differentiable. A strategic incumbent chooses its first-stage investment $K_1$ either to deter entry, or to accommodate it in the least harmful way. In the case of entry deterrence, the incumbent’s objective is to choose $K_1$ such that $\pi_2(K_1, \sigma^*_1(K_1), \sigma^*_2(K_1)) \leq 0$. In the case of entry accommodation, the incumbent chooses $K_1$ so as to maximize its own profit, $\pi_1(K_1, \sigma^*_1(K_1), \sigma^*_2(K_1))$, taking as given that firm 2 has entered, that is, $\pi_2(K_1, \sigma^*_1(K_1), \sigma^*_2(K_1))$. Consequently, in both cases, we want to compare the investment level at the subgame-perfect equilibrium of the two-stage game with a hypothetical ‘non-strategic’ investment level. Such ‘non-strategic’ choice could be made by a ‘myopic’ incumbent which does not internalize the effects of its investment on the entrant’s second-stage decisions. Alternatively, the incumbent would choose ‘non-strategically’ if its investment was not observable by the entrant. We take this benchmark in order to define the notions of strategic overinvestment and underinvestment. In particular, we talk of overinvestment when the strategic level exceeds the non-strategic level, and of underinvestment otherwise.

16.1.1 Entry deterrence

Consider first the case where the incumbent chooses its investment level so as to make entry unprofitable. We rule out the possibility that the monopoly choice of $K_1$ is sufficient to deter entry. We thus focus on situations where the incumbent must distort its investment choice. As distortion is costly, the incumbent will choose the investment level that is just sufficient to deter entry, so $K_1$ is chosen such that

$$\pi_2(K_1, \sigma^*_1(K_1), \sigma^*_2(K_1)) = 0.$$ 

To see in which direction the level of $K_1$ must be distorted, we compute the impact of a change in $K_1$ on the entrant’s profit. That is, we totally differentiate $\pi_2$ with respect to $K_1$:

$$\frac{d\pi_2}{dK_1} = \frac{d\pi_2}{d\sigma_1} \frac{d\sigma_1}{dK_1} + \frac{d\pi_2}{d\sigma_2} \frac{d\sigma_2}{dK_1}.$$ 

Note that $\sigma^*_2(K_1)$ is such that $\frac{d\sigma^*_2}{d\sigma_1} \pi_2(K_1, \sigma^*_1(K_1), \sigma^*_2(K_1)) = 0$ because of the envelope theorem. The previous expression can thus be rewritten as

$$\frac{d\pi_2}{dK_1} = \frac{d\sigma^*_2}{d\sigma_1} \frac{d\sigma^*_1(K_1)}{dK_1}.$$ 

(16.1)

There are two channels through which the incumbent’s investment can affect the entrant’s profit. First, it can have a direct effect ($\frac{d\pi_2}{dK_1}$). The direct effect can be of any sign. For instance, suppose that the incumbent’s investment is advertising. As we have seen in Chapter 6, if advertisement is persuasive, firm 1 will increase its market share at the expense of firm 2 (hence, $\frac{d\pi_2}{dK_1} < 0$); in contrast, if advertisement is informative, it might expand aggregate demand and, thereby, benefit firm 2 (hence, $\frac{d\pi_2}{dK_1} > 0$). Alternatively, if the incumbent invests in capacity (as we will analyse in the next section), the entrant’s profit will not be affected directly ($\frac{d\pi_2}{dK_1} = 0$). The incumbent’s investment can also have an indirect or strategic effect: by changing its ex ante decisions, the incumbent modifies its ex post behaviour ($\frac{d\sigma_2^*(K_1)}{dK_1}$), which affects firm 2’s profit in a proportion given by $\frac{d\pi_2}{d\sigma_2}$. We say that the investment makes the incumbent tough if the total effect on the entrant’s profit ($\frac{d\pi_2}{dK_1}$) is negative. Conversely, if the total effect is positive, then the investment makes the incumbent soft. Naturally, as the objective of entry deterrence is to reduce the entrant’s profit to zero, the incumbent wants to look aggressive. So, if the investment makes him tough ($\frac{d\pi_2}{dK_1} < 0$), the incumbent has an incentive to overinvest. This is the so-called ‘top dog strategy’. The opposite prevails when the investment makes the incumbent soft: in that case, in order to look aggressive, the incumbent must underinvest. This is the so-called ‘lean and hungry look’.

Lesson 16.1

If investment makes the incumbent tough (i.e., if investment decreases the entrant’s profit), then the incumbent must behave as a top dog to deter entry: he must overinvest (be strong or big) to look aggressive. Conversely, if investment makes the incumbent soft (i.e., if investment increases the entrant’s profit), then the incumbent must adopt a lean and hungry look to deter entry: he must underinvest (be weak or small) to look aggressive.
16.1.2 Entry accommodation

Entry may happen to be too costly for the incumbent (we will determine when this is so more precisely in the specific examples below). In this case, firm 1 takes entry as given and shifts its focus from the entrant’s profits towards its own. That is, it no longer chooses \( K_1 \) to make \( \pi_1 \) negative but to maximize \( \pi_1 \). Hence, to derive the incumbent’s incentive to invest, we need to totally differentiate \( \pi_1(K_1, \sigma_1^*(K_1), \sigma_2^*(K_1)) \) with respect to \( K_1 \). Noting as above that \( \sigma_1^*(K_1) \) is such that \( \frac{\partial K_1}{\partial K_1} \) is 0, we have:

\[
\frac{d\pi_1}{dK_1} = \frac{\partial \pi_1}{\partial K_1} + \frac{\partial \pi_1}{\partial \sigma_1^*} \frac{d\sigma_1^*}{dK_1}.
\]

The total effect can again be split into two effects. The direct effect is the profit-maximizing effect that exists even if \( K_1 \) has no effect on firm 2. Therefore, we can neglect this effect when comparing our results with the benchmark situation, since it appears in both cases. It is the strategic effect that makes the difference. It results from the influence of firm 1’s investment on firm 2’s second-stage behavior \( (d\sigma_1^*(K_1)/dK_1) \), which affects firm 1’s profit in proportion to \( \partial \sigma_1^*/\partial \sigma_2 \). In the present case, we say that the incumbent should overinvest if the strategic effect is positive; it should underinvest otherwise.

What determines the sign of SEA, the strategic effect in the entry accommodation case? Presuming that the reaction function of firm 2 does not depend directly on \( K_1 \), we can show that it depends (i) on the sign of the strategic effect in the entry deterrence case (SED) and (ii) on the strategic substitutability or complementarity of the firms’ second-stage choices. We proceed in three steps.

1. Assuming that the firms’ second-stage choices have the same nature, we have that \( \partial \pi_1/\partial \sigma_1^* \) and \( \partial \pi_2/\partial \sigma_2 \) have the same sign, implying that:

\[
\text{sign} \left( \frac{\partial \pi_1}{\partial \sigma_2} \frac{d\sigma_2^*}{dK_1} \right) = \text{sign} \left( \frac{\partial \pi_2}{\partial \sigma_1^*} \frac{d\sigma_1^*}{dK_1} \right).
\]

2. Using the chain rule, we have:

\[
\frac{d\sigma_2^*}{dK_1} = \frac{d\sigma_2^*}{d\sigma_1^*} \frac{d\sigma_1^*}{dK_1}.
\]

3. Combining the latter two expressions, we can write:

\[
\text{sign} \left( \frac{\partial \pi_1}{\partial \sigma_2} \frac{d\sigma_2^*}{dK_1} \right) = \text{sign} \left( \frac{\partial \pi_2}{\partial \sigma_1^*} \frac{d\sigma_1^*}{dK_1} \right) \times \text{sign} \left( \frac{d\sigma_1^*}{d\sigma_2} \right). \tag{16.2}
\]

There are thus four possible cases. To link entry deterrence and entry accommodation more easily, let us suppose that in the entry deterrence case, the direct effect is negligible (or zero), in the sense that the sign of the total effect \( (d\pi_1/dK_1) \) is determined by the sign of the SEA in expression (16.1). This means, using our previous terminology, that investment makes firm 1 tough if the SED is negative and soft if the SED is positive.

Consider first that second-stage choices are strategic substitutes. As we explained in Chapter 3, this implies that reaction curves are downward-sloping (as is usually the case when firms compete in quantities). Hence, from expression (16.2), we see that SEA has the reverse sign to SED. We thus have the following relational tips:

\[
\begin{align*}
\text{investment makes firm 1 tough } & \Rightarrow \text{SED } < 0 \Rightarrow \text{SEA } > 0 \Rightarrow \text{overinvest}, \\
\text{investment makes firm 1 soft } & \Rightarrow \text{SED } > 0 \Rightarrow \text{SEA } < 0 \Rightarrow \text{underinvest}.
\end{align*}
\]

We observe thus that entry accommodation and entry deterrence call for the same conduct when second-stage choices are strategic substitutes. That is, if investment makes the incumbent tough, he should overinvest (i.e., follow the top dog strategy), whether he chooses to deter entry or to accommodate it. Intuitively, a commitment to be aggressive both reduces the entrant’s profit (which is good for deterrence) and increases the incumbent’s profit because of the entrant’s ‘friendly’ reaction (which is good for accommodation). The reverse applies when the investment makes the incumbent soft. Here, deterrence and accommodation both call for underinvestment, that is, the lean and hungry look.

It is easy to see that the previous equivalence is broken under strategic complements. Now, because reaction curves are upward-sloping, expression (16.2) tells us that SEA has the same sign as SED, and thus

\[
\begin{align*}
\text{investment makes firm 1 tough } & \Rightarrow \text{SED } < 0 \Rightarrow \text{SEA } < 0 \Rightarrow \text{underinvest}, \\
\text{investment makes firm 1 soft } & \Rightarrow \text{SED } > 0 \Rightarrow \text{SEA } > 0 \Rightarrow \text{overinvest}.
\end{align*}
\]

So, when deterrence calls for overinvestment (top dog), accommodation calls for underinvestment. This accommodation strategy is called the ‘puppy dog strategy’, which consists of being weak or small to look ineffective. By the same token, when deterrence calls for underinvestment (lean and hungry look), accommodation calls for overinvestment. This is called the ‘fat cat strategy’, which consists of being big to look ineffective. The intuition is clear. Under strategic complementarity and accommodation, the commitment to be aggressive reduces the incumbent’s profits as the entrant reacts in an aggressive way. Therefore, the incumbent wants to look ineffective, so as to trigger a favourable response from the entrant.

We collect all our previous results in the following lesson.

Lesson 16.2
The optimal business strategies for entry deterrence (D) and for entry accommodation (A) are summarized in the following table.

<table>
<thead>
<tr>
<th>Investment makes the incumbent</th>
<th>tough</th>
<th>soft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic substitutes</td>
<td>(D and A)</td>
<td>(D and A)</td>
</tr>
<tr>
<td>Substitutes</td>
<td>Top Dog</td>
<td>Lean and Hungry</td>
</tr>
<tr>
<td>Strategic complements</td>
<td>(D)</td>
<td>(D)</td>
</tr>
<tr>
<td>Complements</td>
<td>Top Dog</td>
<td>Lean and Hungry</td>
</tr>
<tr>
<td>(A)</td>
<td>(A)</td>
<td></td>
</tr>
<tr>
<td>(Puppy Dog)</td>
<td>(Fat Cat)</td>
<td></td>
</tr>
</tbody>
</table>
In Case 16.1, we illustrate the taxonomy by examining how Kodak first deterred and eventually accommodated Fuji’s entry in the US photographic film market (we will return to this case twice more in this chapter).

Case 16.1 Kodak vs. Fuji - Act 1

The US consumer market for photographic film was mostly dominated by a single firm, Eastman Kodak Company (Kodak), up to the 1970s. It was only in 1980 that Fuji Photo Film of Japan (Fuji) managed to successfully enter the market: Fuji reached a 5% market share in that year and strengthened its foothold in the following years. As it appears that Fuji’s entry was first deterred and then accommodated by Kodak, it is important to understand why and how this happened.

To this end, Kadiyali (1996) studied the two firms’ pricing and advertising strategies for entry, deterrence and accommodation. She collected quarterly firm-level time series data on quantities, prices, advertising dollars and costs of factors and materials for both the pre-entry (1970–79) and post-entry (1980–90) periods. Using these data, she estimated a simultaneous equation system of firm-level optimization rules for pricing and advertising choices, and firm-level demand and cost functions. She did this first for the pre-entry monopoly market and second for the post-entry duopoly market. In the latter case, she estimated a menu of market structure hypotheses in order to uncover the competitive regime underlying the observed market outcome data (in the spirit of the ‘new empirical IO’ framework that we described in Chapter 3). The final step consisted of using the pre- and post-entry descriptions of the market to create a third picture that explains the links and similarities between them.

The empirical result is that Kodak deterred Fuji’s entry in the 1970s and that Kodak and Fuji jointly deterred further entry in the 1980s. We defer the explanation of these conducts to Cases 16.6 and 16.8. We focus here on the explanation of entry accommodation. The analysis reveals that by 1980, Kodak was compelled to accommodate Fuji, as it suffered from both demand and cost disadvantages relative to Fuji. To show this, the author first solved for the equilibrium where Kodak sets prices and advertising to deter Fuji’s entry. She then compared Kodak’s hypothetical profits under this scenario with its actual profits in 1980. The conclusion is that Kodak’s profits would indeed have been lower if it had not accommodated Fuji’s entry.

The remaining issue is to determine Kodak’s accommodation strategy. The estimates of demand and cost reveal that one firm’s price and advertising were strategic complements for the other firm. Hence, we know that an incumbent accommodating entry is better off not acting in an aggressive way, so as to avoid an aggressive reaction from the entrant (which would have been especially harmful as Fuji enjoyed both demand and cost advantages at that time). The analysis confirms that Kodak adopted a conciliatory stance in both its pricing and advertising strategies. In terms of pricing, a commitment to low prices makes the incumbent tough and therefore, according to the above taxonomy, the appropriate conduct is to 'underinvest' (puppy dog strategy). As Kadiyali reports, Kodak’s pre-entry average price was $3.53 per roll, which, given marginal cost estimates, implied a profit of $0.74 per roll. Kodak’s post-entry price and margin were $2.06 and $1.28 per roll (note that the marginal cost dropped from $2.79 per roll before entry to $0.78 after entry; this suggests that Fuji’s entry might have spurred Kodak to invest more R&D in an effort to lower its own costs down to Fuji’s level). At the same time, Fuji’s price was $1.66 per roll. Clearly, Kodak could have cut its price (given Fuji’s lower price and its own profit margin), but decided against this in accordance with a puppy dog strategy. As for advertising, the analysis reveals that investment made Kodak soft: advertising contributed mainly to expand the market and it was estimated that an increase in Kodak’s advertising budget benefited Fuji proportionally more than it benefited Kodak. Applying the taxonomy in this case tells us that the fat cat strategy is appropriate (overinvest to appear inoffensive). Kodak clearly adopted this strategy as its post-entry advertising budget was 3.2 times its pre-entry budget in real dollar terms.

In the next two sections, we apply the previous taxonomy to a number of specific examples, in which the 'investment' $X$ takes on various meanings.

16.2 Strategies affecting cost variables

While the incumbent's strategic options are often multiple, we present here a number of selected strategic actions an incumbent firm may take to affect post-entry competition and thus entry itself. We start with actions related to cost variables, either the incumbent’s own cost or the entrant’s cost. We consider actions related to demand variables in the next section.

16.2.1 Investment in capacity as an entry deterrent

In this part of the analysis, we focus on installed capacity as a strategic variable. The idea is that an incumbent firm, by installing capacity early on, credibly conveys to its potential competitor that it will have low marginal costs and thus be a tough competitor to deal with. This may convince a potential entrant that it will not recover its entry costs. In this case, the incumbent can maintain its monopoly position in spite of the threat of entry. In particular, for an intermediate level of entry costs, the incumbent may strategically distort its investment upwards. Note that in practice many investment decisions are lumpy and thus automatically give commitment. However, in other cases, capacity is related to contracts with upstream suppliers. Here, the incumbent may sign long-term supply contracts that are costly to revise. It may also sign long-term labour contracts which make part of the labour costs a fixed cost that cannot be avoided.

To relate the present analysis to our previous taxonomy, note that we analyse a situation where investment makes the incumbent tough and where firms compete in quantities in the second stage (strategic substitutability). We will check that the incumbent chooses to follow the top dog strategy, whether he deters or accommodates entry.

We analyse the following multistage game between an incumbent firm (indexed by 1) and a potential entrant (indexed by 2). At stage 1, the incumbent sets capacity $Q_1$. At stage 2,
the entrant decides upon entry and the active firms (i.e., the incumbent and the entrant if it is decided to enter) set additional capacity and produce a quantity that is not larger than the installed capacity; that is, the incumbent sets \( \Delta \bar{q}_1 \geq 0 \) and \( q_1 \leq \bar{q}_1 + \Delta \bar{q}_1 \), and the entrant sets \( \Delta \bar{q}_2 \geq 0 \) and \( q_2 \leq \Delta \bar{q}_2 \). The products of the two firms are assumed to be homogeneous and the inverse demand has the linear form \( P(q) = 1 - q = 1 - q_1 - q_2 \).

We assume the following cost structure. Let \( e \) denote the sunk costs paid at stage 2 in case of entry; let \( k \) denote the marginal cost of an expansion in capacity; and let \( c \) denote the marginal cost of production. Accordingly, the incumbent’s cost function at stage 1 is given by

\[
C_1(q_1) = k \bar{q}_1.
\]

At stage 2, the variable costs of the incumbent and the entrant are respectively given by

\[
C_1^*(q_1, \Delta \bar{q}_1) = c q_1 + k \Delta \bar{q}_1, \quad C_2^*(q_2) = c q_1 + k \Delta \bar{q}_2.
\]

To understand this cost structure, we can think of production requiring the input of both capital and labour, the cost of one unit of capital being \( k \) and the cost of one unit of labour being \( e \). If the incumbent wishes to produce more than its installed capacity \( \bar{q}_1 \), it must hire the additional capacity \( \Delta \bar{q}_1 \) at cost \( k \) per unit and it must also hire the corresponding additional labour at cost \( e \) per unit.

If firm 2 has decided to enter at stage 1, the firms play a Cournot duopoly at stage 2. The incumbent’s profit function is \( \pi_1 = (1 - q_1 - q_2 - c)q_1 - k \Delta \bar{q}_1 \). Suppose firm 1 installs additional capacity at stage 2, that is, \( \Delta \bar{q}_2 > 0 \). To be profit-maximizing it must make its total capacity, \( \bar{q}_1 + \Delta \bar{q}_1 \), available on the market. Any additional unit sold requires additional capacity. Hence, if the incumbent wishes to produce more than the capacity installed in stage 1, \( q_1 > \bar{q}_1 \), it has to acquire additional capacity and the marginal cost is \( c + k \). Suppose now that firm 1 does not install additional capacity, so that \( q_1 \leq \bar{q}_1 \). The marginal cost of production then is \( c \). The first-order derivative of profits with respect to \( q_1 \) is thus

\[
\frac{\partial \pi_1}{\partial q_1} = \begin{cases} 1 - 2q_1 - q_2 - c - k & \text{for } q_1 > \bar{q}_1, \\ 1 - 2q_1 - q_2 - c & \text{for } q_1 \leq \bar{q}_1. \end{cases}
\]

It follows that the incumbent’s best-response function takes the following form:

\[
q_1(q_2) = \begin{cases} \frac{1}{2} (1 - q_2 - c - k) & \text{for } q_1 > \bar{q}_1, \\ \frac{1}{2} (1 - q_2 - c) & \text{for } q_1 \leq \bar{q}_1. \end{cases}
\]

As depicted in the left panel of Figure 16.1, there are two possible curves: the upper curve becomes the reaction function if there is spare capacity (i.e., for \( q_1 \leq \bar{q}_1 \)) and the lower curve if capacity has to be extended (i.e., for \( q_1 > \bar{q}_1 \)). Note that at the capacity level \( \bar{q}_1 \), the incumbent’s best response at stage 2 is not affected by small changes of the competitor’s quantity, namely for quantities between \( \bar{q}_2 = 1 - c - k - 2 \bar{q}_1 \) and \( \bar{q}_2 = 1 - c - 2 \bar{q}_1 \). This can be illustrated by considering the incumbent’s profit function for different values of \( q_2 \), as is done in Figure 16.2.

As for the entrant, the profit function is given by \( \pi_2 = (1 - q_1 - q_2 - c)q_2 - k \Delta \bar{q}_2 - e \). Because the entrant has no initial capacity, \( q_2 = \Delta \bar{q}_2 > 0 \) and the first-order condition for profit maximization is

\[
\frac{\partial \pi_2}{\partial q_2} = 1 - q_1 - 2q_2 - c - k = 0.
\]

Solving for \( q_2 \), the latter expression, we find firm 2’s candidate best response to firm 1’s quantity:

\[
q_2(q_1) = \frac{1}{2} (1 - q_1 - c - k). \tag{16.3}
\]

This quantity is firm 2’s actual best response as long as it generates non-negative net profits:

\[
\pi_2(q_1) = (1 - q_1 - q_2(q_1) - c - k)q_2(q_1) - e
= \frac{1}{2} (1 - q_1 - c - k)^2 - e \geq 0,
\]

which is equivalent to

\[
q_1 \leq \bar{q}_1 = 1 - c - k - 2 \sqrt{e}.
\]

We assume that \( e < \frac{1}{4} (1 - c - k)^2 \) so that \( \bar{q}_1 > 0 \) (otherwise, entry would not even be profitable if the entrant could become a monopoly). In short, the potential entrant optimally chooses to
enter and produce the positive quantity given by (16.3) as long as the incumbent’s quantity does not exceed \( q_1 \), and to stay out of the market otherwise (which amounts to producing nothing and saving the sunk entry cost \( e \)). The right panel of Figure 16.1 depicts the entrant’s reaction function.

The second-stage equilibrium takes place at the intersection of the two firms’ reaction functions. Which intersection is obtained depends on where the two functions ‘jump’. The entrant’s reaction function jumps down to zero at \( \tilde{q}_1 \) (i.e., at the output of firm 1 above which entry is not profitable, which is itself a decreasing function of the entry cost \( e \)). As for firm 1’s reaction function, the jump is endogenous as it depends on the incumbent’s initial choice of capacity \( \tilde{q}_1 \). That is, the incumbent has the option of choosing which reaction function it presents in the post-entry duopoly by committing to a level of installed capacity.

There are three possibilities to consider. The first possibility corresponds to the case of blocked entry. In that case, entry is not profitable although the incumbent behaves as an unconstrained monopolist. What would be the choice of an unconstrained monopolist? It would install a capacity \( \tilde{q}_1 \) at cost \( k\tilde{q}_1 \) and then produce up to this capacity at cost \( c\tilde{q}_1 \). Therefore, an incumbent monopolist chooses \( \tilde{q}_1 \) to maximize \( \pi_1 = (1 - c - k - q_1)q_1 \), which gives

\[
q_1^M = \frac{1}{2} (1 - c - k).
\]

Entry is blocked if the monopoly output is larger than the output \( \tilde{q}_1 \) under which entry becomes profitable: \( q_1^M > \tilde{q}_1 \), which is equivalent to

\[
e > e^* = \frac{1}{8} (1 - c - k)^2.
\]

This possibility is depicted in the left panel of Figure 16.3.

The second possibility is the exact opposite of the first. It corresponds to the case where entry is inevitable. Firm 1 always finds it profitable to enter because it knows that the maximum amount firm 1 is willing to produce is below \( \tilde{q}_1 \). What is this maximum amount? If firm 2 enters, the best Nash equilibrium from the point of view of firm 1 is on the upper part of firm 1’s reaction function, that is, the curve corresponding to the case where unlimited initial capacity would be available (meaning that marginal cost is \( c \) rather than \( c + k \), see Figure 16.1). The Nash equilibrium is the solution of the following system of equations: \( q_1 = \frac{1}{2} (1 - q_2 - c) \) and \( q_2 = \frac{1}{2} (1 - q_1 - c - k) \). Solving for \( q_1 \), we find

\[
q_1^P = \frac{1}{2} (1 - c + k).
\]

Facing firm 2’s entry, the incumbent does not find it profitable to produce more than \( q_1^P \). Therefore, in stage 1, it will not find it profitable either to install a larger capacity than \( q_1^P \). In other words, capacity levels above \( q_1^P \) are not credible threats of entry deterrence and firm 2 thus has no reason to fear them (which confirms the incumbent’s decision not to install such levels). Hence, if \( q_1^P \) is below \( \tilde{q}_1 \), then firm 2 can achieve positive profits at this Nash equilibrium, it will certainly enter. This is so if

\[
e < e^* = \frac{1}{8} (1 - c - 2k)^2.
\]

Now, knowing that entry is inevitable, firm 1 will exploit its first-mover advantage to limit the scale of entry. To maximize its profit in the face of entry, firm 1 will behave as a Stackelberg leader. As we described in Chapter 4, the incumbent anticipates the entrant’s reaction when choosing its capacity in stage 1. That is, firm 1 sets \( q_1 \) to maximize

\[
\pi_1 = (1 - c - k - q_1 - q_2(q_1))q_1 = \frac{1}{2} (1 - c - k - q_1)q_1.
\]

The maximum is easily found as

\[
q_1^F = \frac{1}{2} (1 - c - k).
\]

In this linear model, a Stackelberg leader happens to choose the same capacity (and output) as a monopolist: \( q_1^F = q_1^M \). Note that \( q_1^F \) will be firm 1’s choice in this situation provided \( q_1^F \leq q_1^P \). It can be checked that this is so as long as the cost of capacity expansion is large enough (precisely if \( k \geq (1 - c)/5 \), which also guarantees that \( e^* > e^+ \)).

The last possibility corresponds to the case where \( e \) is neither blocked nor inevitable, that is, \( q_1^P = q_1^F \leq \tilde{q}_1 \leq q_1^P \) or \( e^* \leq e \leq e^+ \). This case is probably the most interesting as entry depends on the incumbent’s initial capacity choice. The incumbent has indeed two options: it can either accommodate or deter entry. Entry accommodation corresponds to our previous case: firm 1 behaves as a Stackelberg leader and chooses capacity \( q_1^P \), which yields a profit of

\[
\pi_1^F(e) = (1 - c - k - q_1^P) q_1^P = \frac{1}{2} (1 - c - k)^2.
\]

To deter entry, firm 1 must install a larger capacity since \( \tilde{q}_1 > q_1^P \). This has the negative effect of lowering the market price but the positive effect of keeping the entrant at bay. In that case, firm 1’s profit is computed as

\[
\pi_1^P(e) = (1 - c - k - \tilde{q}_1) \tilde{q}_1 = 2\sqrt{e} (1 - c - k - 2\sqrt{e}).
\]

\(^\ast\) We suppose here that \( k < (1 - c)/2 \). Otherwise, \( \tilde{q}_1 < q_1^F \) even for \( e = 0 \) (in that case, even free entry would not take place because the incumbent’s advantage in terms of marginal cost would be too large).
It can be checked that $x_{1}^{*}(e)$ is an increasing function of the entry cost $e$ for $e \leq e^*$. Intuitively, entry is easier to deter when it is more costly. Hence, the incumbent prefers deterrence over accommodation if the entry cost is large enough. Some computations establish that on the relevant range of entry costs, $x_{1}^{*}(e) > x_{1}^{*}$ for $e > e^*$, with

$$e^* = \frac{(2 - \sqrt{2})}{4k} (1 - c - k)^2. $$

The latter threshold is clearly smaller than $e^* = \frac{1}{4k} (1 - c - k)^2$. Depending on the value of $k$, $e^*$ can be larger or smaller than $e^* = \frac{1}{4} (1 - c - 2k)^2$. In the former case ($e^* > e^*$), the incumbent chooses to accommodate entry for $e^* \leq e < e^*$ and to deter it for $e^* \leq e \leq e^*$; in the latter case, the incumbent always chooses to deter entry. The two options are illustrated in the right panel of Figure 16.3. We can summarize our analysis as follows.

**Lesson 16.3**

In an entry model with capacity commitment, the incumbent's conduct depends on the cost of entry, $e$. For small entry costs ($e < e^*$), the incumbent prefers to accommodate entry and behave as a Stackelberg leader. For intermediate entry costs ($e^* \leq e \leq e^*$), the incumbent chooses to deter entry by expanding its capacity. For large entry costs ($e > e^*$), the incumbent can behave as an unconstrained monopolist as entry is blocked.

Case 16.2 explains the difficulties in testing the predictions of the previous lesson, and how these difficulties can be overcome in some settings.

**Case 16.2 Entry deterrence in hospital procedure markets**

Empirically testing whether firms invest in capacity to deter entry requires estimating the ex ante threat of entry and the investments that would have been made absent strategic motives. Because each of these parameters can be a challenge to estimate, it is not surprising that the literature on this topic is rather limited. Testing becomes easier in settings where potential entrants are easy to identify, and where investment trends and deviations thereof can be observed. This happens to be the case in markets for inpatient surgical procedure, which are a primary output of the hospital industry.

Dafny (2005) focuses on electrophysiological studies (EP), a procedure to identify and correct cardiac arrhythmias. He explicitly models the demand and supply for this procedure and uses this model to illustrate the incentives to invest strategically in volume-increasing assets or activities, focusing on incumbents' ability to deter entry through this channel.

---

11 To be precise, $e^* > e^*$ for $k > 0.44 (1 - c)$. As we have assumed that $(1 - c)/5 < k < (1 - c)/2$, both cases are possible.

12 This case follows Dafny (2005).


---

The empirical test used to investigate whether the entry deterrence motive affects investment decisions is based on the following insight. Investment levels are likely to increase monotonically with market potential if firms act non-strategically. However, if firms act in a strategic way, they should invest more in markets of intermediate attractiveness because entry deterrence is unnecessary in very small markets and impossible in very large ones. Note that if entry costs are inversely proportional to market potential, this is also what Lesson 16.3 suggests. Hence a non-monotonic relationship between investment and market size constitutes evidence of a strong entry-deterrence motive.

Dafny observes such a non-monotonic relationship: in the year following an announced reimbursement increase for EP (which raised the threat of entry), incumbents in moderately attractive markets generated a volume growth that was statistically significantly greater than that in unattractive or very attractive markets.

The remaining issue is whether entry deterrence is anticompetitive. A priori, the answer seems ambiguous: actual competition does not take place but potential competition forces the incumbent to expand its capacity. To get some insight, we consider intermediate entry costs ($e^* \leq e \leq e^*$) and compare the market price that prevails when entry is deterred with the one that would prevail if entry was accommodated. When entry is deterred, the incumbent remains a monopoly and produces $q_1^{*} = 1 - c - k - 2\sqrt{k}$. The market price under deterrence is then

$$p^* = 1 - q_1^{*} = c + k + 2\sqrt{k}. $$

If entry had been accommodated, firms would play as in the Stackelberg game. That is, the incumbent would produce $q_1^{*} = \frac{1}{2} (1 - c - k)$ and the entrant would react by producing $q_2^{*} = \frac{k}{2} (1 - q_1^{*} - c - k) = \frac{1}{2} (1 - c - k)$. Hence, the market price under accommodation would be

$$p^* = 1 - q_1^{*} - q_2^{*} = \frac{1}{2} (1 + 3c + 3k). $$

Comparing the two expressions, we observe that the market price is lower under deterrence than under accommodation if

$$p^* < p^* \Leftrightarrow e < \frac{1}{4k} (1 - c - k)^2 = e^*. $$

Observing that $(2 - \sqrt{2})^2 \approx 0.343$, it is clear that $e^* \in [e^*, e^*]$. We can thus conclude the following.

**Lesson 16.4**

Suppose that entry costs are such that the incumbent prefers to deter entry. Then, if entry costs are not too large, consumer surplus is higher if entry is deterred instead of being accommodated. The opposite prevails for larger entry costs.

We could also compare total surplus under deterrence and accommodation and we would reach a similar conclusion: because entry deterrence forces the incumbent to increase its capacity beyond the accommodation level, deterrence can turn out to be welfare-improving.

This test was introduced by Ellison and Elliston (2011).
16.2.2 Investment as an entry deterrent reconsidered

We consider now a simple model of R&D competition (an issue we will return to in Chapter 18).\(^{63}\) Let \( K_1 \) be some investment that allows firm 1 to lower its average (and marginal) cost of production in the first stage. We write \( \pi^*(K_1) \), with \( \pi'(K_1) < 0 \). The incumbent's first-period profits are \( \pi_1 = \pi^*(\pi^*(K_1)) \), which is an increasing function of \( K_1 \).

In the second period, the incumbent and the entrant compete in R&D, and potentially in prices. Regarding R&D, each firm spends resources \( x_1 \) to increase its chances of finding an innovation that allows constant average cost \( c \). The R&D technology in the second period is stochastic: firm i's probability of finding the innovation is given by \( \mu_i(x_1) \), with \( \mu_1(0) = 0 \), \( \mu'_1 > 0 \) and \( \mu''_1 < 0 \) (which represents decreasing returns to scale in R&D).

The innovation is said to be drastic (or major) in the sense that if only one firm finds it, this firm is able to drive the other firm out of the market. The innovating firm then obtains profits \( \pi^*(c) \). If both firms find the innovation, they are both able to produce a homogeneous good at the same cost; price competition then drives their profits down to zero. Finally, if no firm finds the innovation, the incumbent keeps its first-period profit \( \pi^*(\pi^*(K_1)) \), whereas the entrant stays out of the market (because it has no technology to fall back on) and makes zero profit. We obtain thus the following expected profits in the second period, given entry and given \( K_1 \):

\[
\begin{align*}
\pi_1 &= \mu_1 (1 - \mu_2) \pi^*(c) + (1 - \mu_1)(1 - \mu_2) \pi^*(\pi^*(K_1)) - x_1, \\
\pi_2 &= \mu_2 (1 - \mu_1) \pi^*(c) - x_2.
\end{align*}
\]

The incumbent chooses \( x_1 \) to maximize \( \pi_1 \) and the entrant choose \( x_2 \) to maximize \( \pi_2 \).

The first-order conditions for a Nash equilibrium are

\[
\begin{align*}
\mu_1 \left[ \pi^*(c) - \pi^*(\pi^*(K_1)) \right] (1 - \mu_2) &= 1, \\
\mu_2 \pi^*(c) (1 - \mu_1) &= 1.
\end{align*}
\]

As we assume that \( \mu'_1 > 0 \) and \( \mu''_1 < 0 \), we see in both first-order conditions that \( x_1 \) and \( x_2 \) have to move in opposite directions to maintain the equality. In other words, reaction curves are downward-sloping, or R&D expenditures are strategic substitutes (if one firm spends more, the other reacts by spending less).

It remains to be seen whether first-period investment makes the incumbent tough or soft. An increase in \( K_1 \) reduces the first-period marginal cost and thereby increases \( \pi^*(\pi^*(K_1)) \). This means that the incumbent's fall-back position in the second period improves if it fails to find the innovation. Hence, a larger value of \( K_1 \) lowers the incumbent's incentive to innovate: investment makes the incumbent soft.\(^{64}\) Yet, this is precisely what the incumbent wants to avoid. Since R&D expenditures are strategic substitutes, firm 1 wants to commit to play more aggressively and increase its incentive to innovate. Therefore, it will tend to reduce \( K_1 \), that is, to underinvest in the first period.

16.2.3 Raising rivals' costs

The strategies we have considered so far in this section were turned towards the incumbent's own cost function. The incumbent's goal was to find a credible way to shift its second-stage reaction function so as to deter entry or to accommodate it in the most profitable way. Clearly, accommodation or deterrence can also be achieved by acting directly on the entrant's cost function. For instance, the incumbent could sabotage the entrant's production facilities, or lobby the government to raise taxes on imported products so as to deter the entry of foreign competitors. Here, the direct effect of the incumbent's investment on the entrant's profit (i.e., \( \partial \pi_1/\partial K_1 \)) would be sufficiently negative to allow the incumbent to deter entry without having to commit to a costly course of action. Such strategies are clearly anticompetitive and are too transparent to need further analysis.

More interesting are cost-raising strategies that force the incumbent to raise his own costs as well. These include lobbying efforts that, if successful, increase labour costs for example (or the cost for imported inputs). For example, with the liberalization of the German postal market, the incumbent Deutsche Post was pushing for minimum wage legislation in this sector to apply also to newcomers.\(^{65}\) There is now a trade-off between the harm the incumbent does to the potential entrant and the harm it does to itself. Analyses of this trade-off can be performed in models with one incumbent and a competitive fringe.\(^{66}\) Using a model of this type, we showed in Chapter 2 that the dominant firm does indeed have an incentive to increase the cost of the competitive fringe, even though this increases its own cost in the same way.

Here, we want to recast the analysis of cost-raising strategies within the framework we have used in this section. Using our previous notation, we have both \( \partial \pi_1/\partial K_1 < 0 \) and \( \partial \pi_1/\partial K_1 < 0 \). Thus, our previous taxonomy proves ill-suited to characterize strategies of this kind. In particular, we will see that the nature of the second-stage competition is of a lesser importance: all other things being equal, raising the rival's cost deteriorates the rival's position whether the firms' actions are strategic substitutes or complements. What is clear anyway is that using such strategies is a form of overinvestment, since a non-strategic incumbent would not deliberately increase its own cost. Intuitively, an incumbent would accept hurting itself only if it could hurt the rival relatively more in the process.

As above, we consider a two-stage game. At the first stage, firm 1 chooses the level of some 'investment', \( K_1 \), that has the effect of raising its own (constant) marginal cost, as well as the (constant) marginal cost of the entrant: both \( c_1(K_1) \) and \( c_2(K_1) \) are increasing functions of \( K_1 \). At the second stage, firm 2 decides to enter and product market decisions are made (in a duopoly if the entrant enters, and in a monopoly otherwise).

Let us denote the second-stage equilibrium profits by \( \pi_1(c_1(K_1), c_2(K_1)) \). Whatever the nature of second-stage competition, firm i's equilibrium profit increases with its rival's marginal

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\(^{63}\) Owing to their lower market penetration, their services are likely to be more labour-intensive. Minimum wage legislation then affects them much more than the incumbent.

\(^{64}\) See, for example, Salop and Schaffers (1983, 1987).
cost and decreases with its own marginal cost. The marginal rate of substitution between these two effects can be expressed by the following ratio:

$$\rho_i = \frac{\partial \pi_i^* / \partial c_i}{(\partial \pi_i^* / \partial c_i)} > 0.$$  \hspace{1cm} (16.4)

For a cost-raising strategy to have an entry-deterrent effect, it is necessary that the effect of $K_1$ on $\pi_i^*$ be negative:

$$\frac{\partial \pi_i^*}{\partial K_1} = \frac{\partial \pi_i^* / \partial c_i}{\partial c_i / \partial K_1} + \frac{\partial \pi_i^* / \partial c_i}{\partial c_i / \partial K_1} < 0 \Leftrightarrow \frac{\partial c_i / \partial K_1}{\partial c_i / \partial K_1} > \frac{\rho_i}{\rho_i^*}.$$  \hspace{1cm} (16.5)

In the case of entry accommodator, the incumbent chooses a cost-raising strategy if it increases its own profit:

$$\frac{\partial \pi_i^*}{\partial K_1} = \frac{\partial \pi_i^* / \partial c_i}{\partial c_i / \partial K_1} + \frac{\partial \pi_i^* / \partial c_i}{\partial c_i / \partial K_1} > 0 \Leftrightarrow \frac{\partial c_i / \partial K_1}{\partial c_i / \partial K_1} > \frac{1}{\rho_i}.$$  \hspace{1cm} (16.6)

As long as $\rho_i, \rho_i^* < 1$, we have that condition (16.6) is more stringent than condition (16.5). This implies that if the cost-raising strategy does not have an entry-deterrent effect, it will certainly not be chosen when the incumbent prefers to accommodate entry.

This conclusion seems reasonable as it turns out that $\rho_i < 1$ for a large class of models. Consider, for instance, the model of horizontal product differentiation that we introduced in Chapter 3, with the linear inverse demand schedule $p_i = a - q_i - dq_j$ (i, j $\in$ {1, 2}, i $\neq$ j). Under Cournot competition, firm i chooses its quantity $q_i$ to maximize $\pi_i = (a - q_i - dq_j - c_i)q_i$. From the first-order condition, we derive firm i's reaction function: $q_i(q_j) = \frac{1}{2}(a - c_i - dq_j)$. Proceeding in a similar way for firm j, we find $q_j(q_i) = \frac{1}{2}(a - c_j - dq_i)$. Solving for the Nash equilibrium, we obtain

$$q_i^{**} = \frac{(2 - d)q_j - 2c_i + d}{4 - d^2}.$$  \hspace{1cm} (16.7)

It is easily checked, using the first-order condition, that the equilibrium profit is simply the square of the equilibrium quantity. Hence, we find $\rho_i = d/2 < 1$ for all $d \in [0, 1]$. Repetition the analysis with price competition, we would find $\rho_i = d/(2 - d^2) < 1$ for all $d \in [0, 1]$. We can thus safely conclude the following.

**Lesson 16.5**

Cost-raising strategies (i.e., strategies that raise the rival's cost but also the incumbent's) are more likely to be used to deter entry than to accommodate it.

Case 16.3 illustrates how incumbents sometimes use the regulatory process to increase rivals' costs and thereby deter entry by presumably more efficient competitors.

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16.3 Strategies affecting demand variables

An incumbent can also react to the threat of entry by committing to reduce the demand that is available for the entrant. Several variables of the marketing mix can be used to achieve this objective. In this section, we focus on product positioning, bundling and switching costs. In terms of product positioning, an incumbent may decide to increase the number of varieties it puts on the market so as to leave fewer niches that an entrant could occupy. We study this practice of "brand proliferation" in Subsection 16.3.1. Regarding bundling, the basic idea we develop in Subsection 16.3.2 is the following: an incumbent controlling two products and facing entry on the market of

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one of them may find it profitable to offer the two products as a bundle so as to make entry less profitable. Finally, in Subsection 16.3.3, we examine the incumbent’s incentives to build an entry base of customers when threatened by entry in a market with switching costs.

### 16.3.1 Brand proliferation

Businesses typically offer a variety of products. They may do so for various reasons: to take advantage of economies of scale and scope in production, to exploit possible demand complementarities or to mitigate asymmetric information problems. However, offering a variety of products may also be the strategy of choice due to the threat of entry. An incumbent firm may indeed offer a product range beyond what would be privately optimal if it was protected from competitors. That is, due to the threat of entry by competitors, the incumbent may decide to increase its product range with the intent of keeping competitors outside the market for a certain range of products.

To see this argument, suppose that an incumbent firm can produce a base product which is located at position zero in some product space. In addition, it may want to install a modification of this product, which serves as an imperfect substitute for the base product. Denote the corresponding monopolies by \( \pi^*(1) \) and \( \pi^*(2) \), respectively (where 1 and 2 refer to the number of products marketed by the firm). Suppose that \( \pi^*(1) > \pi^*(2) \). Hence, it is privately optimal to produce a single product in the protected monopoly.

Consider now the following three-stage game. At stage 1, firm 1 decides whether to offer only the base product or both products. At stage 2, a competitor may enter and offer a product that competes directly with the second, modified product. For the sake of the argument, let us suppose that the latter two products are perfect substitutes. If the competitor enters it has to pay the entry cost \( e \). At stage 3, firms simultaneously set prices. Consumers make purchasing decisions and firms collect profits.

If entry takes place at stage 2, firms will set prices in equilibrium at stage 3 such that profits \( \pi_i(\delta) \) are obtained, where \( i \) is the index of the firm and \( \delta \) is the number of products offered by the incumbent. The entrant’s profits at stage 2 are therefore \( \pi_e(1) - e \) (which we assume to be positive) if it competes against a single-product incumbent, whereas they are \( 0 - e \) if it competes against a two-product firm because it competes head-on with the second of the incumbent’s products. Clearly, entry in the latter case is not profitable. This gives the incumbent the possibility of deterring entry by offering both products. Such deterrence is profitable if \( \pi^*(2) > \pi^*(1) \). If this inequality is satisfied, there is a unique subgame-perfect equilibrium in which firm 1 uses brand proliferation to deter entry.

### Lesson 16.6

An incumbent firm may use brand proliferation to deter entry.

The ready-to-eat breakfast cereal industry provides an illustration of the use of brand proliferation to deter entry, as described in Case 16.4.31

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31 Ijima and Yang (2014) study the entry decisions of hamburger restaurants in Canada. Since most are operated as part of a chain, opening an additional restaurant in a geographic area substantiates part of the sales of other restaurants of the same chain in this area. A chain may nevertheless expand its number of restaurants aggressively to keep rivals down. According to the structural estimation results of Ijima and Yang, pre-emption motives indeed play an important role in shaping the industry structure.

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### 16.3.4 Entry deterrence in the ready-to-eat cereal industry

The production of ready-to-eat (RTE) breakfast cereal has been highly concentrated in the USA from the 1940s to the early 1970s. The four major manufacturers (Kellogg, General Foods, General Mills and Quaker Oats) were making at least 85% of sales, and this number was up to 95% when including the next two largest producers. During this period, there was no single entry of significant importance into this industry. It was only in the early 1970s that several large firms were able to enter the industry thanks to a sharp increase in demand that hadn’t been well anticipated by most of the established firms.

The lack of noticeable entry over a long period of time into a profitable and growing industry can only be attributed to the presence of some barrier to entry. None of the “usual suspects” – such as economies of scale, capital requirements, product differentiation, patents or control of raw material sources – seem sufficient to explain that large food-processing firms (like Colgate) did not find it profitable to enter during that period, although they did afterwards when the demand grew unexpectedly. For instance, the minimum efficient firm size was estimated to be a 3–5% market share, which does not appear insurmountable. This leaves brand proliferation as a potential explanation for the lack of entry. Indeed, it turns out that, although no new firm entered, new brands were regularly introduced by incumbent firms. Schmalensee (1978) reports that the six leading producers introduced over 80 brands between 1950 and 1972. It was precisely in 1972 that the Federal Trade Commission issued a complaint against the four top producers, alleging that “these practices of proliferating brands, differentiating similar products and promoting trademarks through extensive advertising result in high barriers to entry into the RTE cereal market” (quoted by Schmalensee, 1978).

Our insight that the incumbent may use brand proliferation as an entry-deterrence strategy relies on the implicit assumption that exit from the industry is sufficiently costly. With sufficiently small exit costs, our conclusions are altered drastically, as we are now going to argue.30 Suppose that between stages 2 and 3 (say at stage 2.5), both firms have the option to withdraw the modified product at an exit cost \( x \). Provided that both firms decided to offer their products and have the possibility to revise their decision, the payoff matrix at this intermediate step is that of Table 16.1.

Since the entry costs are sunk at this stage, it is a dominant strategy for the entrant to stay. Given that the entrant stays, the profit-maximizing decision for the incumbent depends on the level of exit costs. Note that \( \pi_e(2) < \pi_e(1) \) because, in the former case, intense competition among the modified products negatively affects the profits of the incumbent’s base product. In other words, the presence of the incumbent’s modified product exerts a negative effect on the incumbent’s profits with respect to its base product (a form of “cannibalization”). Therefore, if the exit cost is not too high, for example, if it is such that \( x < \pi_e(1) - \pi_e(2) \), the incumbent will withdraw its modified product. This implies that brand proliferation as an entry-deterrence strategy

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30 This case is based on Schmalensee (1978).
31 This argument is analyzed formally in Judd (1985).
### Table 16.1 Payoffs in the Brand Proliferation Game

<table>
<thead>
<tr>
<th>Firm 2</th>
<th>Stay</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm 1 Stay</td>
<td>( \pi^f(2) ), 0</td>
<td>( \pi^m(2), -x )</td>
</tr>
<tr>
<td>Exit</td>
<td>( \pi^f(1) - x ), ( \pi^m(1) - x ), ( -x )</td>
<td></td>
</tr>
</tbody>
</table>

is not credible for intermediate levels of exit costs. It is only if the incumbent can commit not to exit that brand proliferation survives as an entry deterrence.

#### Lesson 16.7

If the incumbent can withdraw its product at sufficiently low cost from a segment in which it faces a direct competitor, brand proliferation is not a credible strategy for entry deterrence.

#### 16.3.2 Bundling and leverage of market power

In Chapter 11, we already examined the practice of bundling, which consists of selling two or more products in a single package. Bundling was presented there as an effective tool for serving consumers and price-discriminating between them. Here, we consider another potential motivation for bundling products, namely entry deterrence. The basic idea is the following. Suppose that an incumbent firm is a monopolist in the market for product \( A \) but faces potential competition in the market for product \( B \). By bundling products \( A \) and \( B \), the incumbent may reduce the demand addressed to a rival firm producing product \( B \) and, thereby, make entry unprofitable or induce exit from the industry.

We check this conjecture by analysing the following model.\(^{71}\) Suppose firm 1 has a protected monopoly for product \( A \). For product \( B \), we consider a homogeneous product market on which firms 1 and 2 can be active. Consumers have valuations \( a_a \) and \( a_b \) for products \( A \) and \( B \) respectively, which are supposed to be uniformly and independently distributed on the \([0,1]\) interval. The willingness-to-pay is thus uniformly distributed on the unit square. Suppose that good \( B \) can be produced by any firm at zero marginal costs, and fixed costs are \( f > 0 \). Hence, the market for good \( B \) (considered in isolation) is a natural monopoly because at most one firm can operate profitably under price competition.

Suppose that in the status quo firm 1 serves the market for product \( A \) and firm 2 the market for product \( B \). In the status quo, firm 1 sets price \( p_1 = 1/2 \) and makes profit \( 1/4 \). Similarly, firm 2 sets price \( p_2 = 1/2 \) and makes profit \( 1/4 - f \). Suppose now that firm 1 considers entering the market of firm 2. To be precise, at stage 1a, firm 1 decides whether to enter market \( B \) and if it does so, whether to sell products \( A \) and \( B \) separately or as a pure bundle. As a response, firm 2 can exit the market at stage 1b before engaging in price competition. At stage 2, firms set prices simultaneously.

Selling separately is not necessarily profitable in equilibrium. Consider equilibria of the subgame which start after firm 1’s entry into market \( B \). Suppose firm 2 stays in the market. Then, if firm 1 also stayed, Bertrand competition would drive prices down to marginal costs. In such a situation, firm 1 would have to bear the fixed cost \( f \) without any positive profit margin in market \( B \). It is thus profitable for firm 1 to exit. This justifies firm 2’s decision to stay and firm 1 is better off not entering market \( B \) to start with.

Alternatively, firm 1 may decide to sell products \( A \) and \( B \) as a bundle at price \( p_{ab} \). In the situation with bundling, the consumers who decide to buy product \( B \) alone are such that (i) \( a_b - p_b \geq a_b - p_{ab} \Rightarrow a_b \leq p_{ab} - p_2 \) (product \( B \) only is preferred to the bundle) and (ii) \( a_b - p_2 \geq 0 \Rightarrow a_b \geq p_{ab} \) (product \( B \) only is preferred to no consumption). Hence, firm 2’s demand is \( (1 - p_2)(p_{ab} - p_2) \), as illustrated in Figure 16.4 by the area \( D_1 \). (Note that in the figure, valuations for product \( B \) are on the horizontal axis.)

Hence, the first-order condition of profit maximization for firm 2 is

\[
1 - 2p_2(p_{ab} - p_2) - p_2(1 - p_1) = 0
\]

and the best response can be written as

\[
p_{2b}^* = \frac{1 + p_{ab}}{3} = \frac{1}{3} \sqrt{1 - p_{ab} + p_{ab}^2}.
\]

The consumers who buy the bundle are characterized by (i) \( a_a + a_b - p_{ab} \geq a_a - p_2 \Rightarrow a_a \geq p_{ab} - p_2 \) (the bundle is preferred to product \( B \) only) and (ii) \( a_a + a_b - p_{ab} \geq 0 \) (the bundle is preferred to no consumption). Firm 1 thus faces demand \( (1 - p_{ab} + p_2 - p_{ab}^2) \) (see region \( D_1 \) in Figure 16.4). The first-order condition of profit maximization of firm 1 is

\[
p_{1b}^* = \frac{1}{2} p_2 - p_{ab} - 1 = 0
\]

and the best response can be written as

\[
p_{2b}^* = \frac{1 + p_2}{2} - p_{ab}^2/2.
\]

Solving the system of first-order conditions gives equilibrium prices at stage 2: \( p_{2b}^* \approx 0.61 \) and \( p_{2b}^2 \approx 0.24 \). Equilibrium profits at stage 2 are \( \pi_1^f \approx 0.369 - f \) and \( \pi_2^m \approx 0.067 - f \), respectively. Compared with the status quo, one obtains a change in profits of

\[
\Delta \pi_1 \approx 0.119 - f, \quad \Delta \pi_2 \approx -0.183.
\]

\(^{71}\) Our analysis draws on Whitmorn (1990), using the specifications in Peita (2008). A related argument is made by Nalebuff (2004), according to which bundling reduces a competitor’s profits if it decides to enter. However, in the Nalebuff model, this statement is only valid under a different timing of events.
Hence, we observe that entering with a bundle is profitable for firm 1 independently of the possibility of exit of firm 2 if \( f < 0.119 \). In the full game, entry with a bundle can induce exit of firm 2 for an intermediate range of fixed costs. Namely, if \( 0.067 < f < 0.119 \), in the unique subgame-perfect equilibrium, firm 1 enters with a bundle at stage 1a, firm 2 exits at stage 1b and the firm sets the monopoly price for the bundle \( p^B \) that has been characterized in Chapter 11. For smaller fixed costs \( f < 0.067 \), firm 1's bundling decision does not induce exit and prices are \( p^F \) and \( p^B \). The analysis provides the following lesson.

Lesson 16.8

A firm with market power in one market may be able to use pure bundling to leverage its market power into a second market and induce exit by firms operating in this second market.

The reason to bundle a product focuses here on the market with potential competition. However, it is easily conceivable that in a longer-term analysis, the monopoly position of firm 1 in market \( A \) is at risk if a competitor establishes itself successfully in market \( B \). In this case, firm 1 may forego short-term profit goals (\( \pi \)) and the use of technological bundling may allow firm 1 to induce exit of firm 2 in market \( B \). If being successful in market \( B \) is a prerequisite for entry in market \( A \), firm 1's successful attempt to induce exit in market \( B \) protects its monopoly position in market \( A \) in the long term. Even if potential competitors can attack firm 1 in either market, due to limited resources and coordination failures a bundling strategy that leads to monopoly in markets 1 and 2 may be the best long-term strategy for firm 1. An additional argument can be made for bundling to improve the prospects of firm 1, which may be challenged in its "home" market \( A \). Bundling may be used as a commitment device for spending in R&D in market \( A \), which effectively reduces the probability of entry in this market. Such dynamic considerations have been important in one of the most exciting recent antitrust cases.

Case 16.5 The European Microsoft case

In 2004, the European Commission found that Microsoft had leveraged its market power from its primary market for PC operating systems (OS) into the secondary, complementary market for work group server OS (workgroup servers are low-end servers that link with PC clients). In the primary market, Microsoft controlled over 90% of the market with Windows. In the secondary market, Microsoft's market share rose from 20% in the late 1990s to over 60% in 2001.

The Commission argued that at least part of this spectacular increase was due to anticompetitive actions and, in particular, to Microsoft's deliberate restriction of the interoperability between Windows PCs and non-Microsoft work group servers. To be effective, the OS of work group servers must indeed work well with Windows, which runs as more than 90% of PCs. This requires the support of Microsoft since it controls the interfaces. Hence, Microsoft had the ability to reduce the interoperability of rival work group server OS. The Commission argued that Microsoft also had the incentive to do so. The dynamic incentives were particularly strong as Microsoft was concerned that customers could start running applications directly on servers, thereby reducing their reliance on the PC OS functionality. Hence, a strong presence of rivals in the server OS market could threaten Microsoft's monopoly position in the PC OS market. Microsoft thus had a clear interest in reducing the attractiveness of rival work group server OS by denying them interoperability with Windows. Network effects (see Chapter 20) did the rest of the job: as rival server OS lost market share, application developers shifted away from writing for them; customers (who value OS for the variety of compatible applications) followed suit, which further decreased the developers' interest in non-Microsoft OS.

The restriction of interoperability can be seen as a form of virtual bundling between Microsoft's PC OS and work group server OS. In the parallel case on the Windows Media Player (a decoding software for media content), bundling was not virtual but real. Here, the Commission alleged that by bundling Windows Media Player with its Windows OS, Microsoft leveraged the market power derived from the PC OS into the market for encoding software for media content.

For these two cases, Microsoft was fined EUR 497 million and imposed behavioral remedies including compulsory licensing of intellectual property and forced unbundling. In 2007, Microsoft was fined a further EUR 280 million for delaying compliance with the remedy requiring the provision of technical information on the Windows interface in order to facilitate interoperability.

The conclusions in Chapter 11 are in stark contrast to the findings in this section. In a monopoly setting, we have seen that bundling may lead to expanded demand and a welfare-improving allocation relative to separate selling. In this section, we have pointed out potentially anticompetitive effects in an environment with potential entry. While in the monopoly setting, we have pointed out potentially anticompetitive effects in an environment with potential entry. While in the monopoly setting, while we have not have a clear checklist to identify situations in which bundling is welfare-reducing, we can identify a number of factors which should raise concerns about the use of bundling. These factors are a large degree of market power in at least one of the markets, high levels of fixed or entry costs, the absence of other strong firms in related markets, a positive correlation of willingness-to-pay across products and the use of pure instead of mixed bundling.

16.3.3 Switching costs as an entry deterrent

We considered switching costs in Chapter 7. Recall that the key property of switching costs is that consumers who have bought from a particular firm in the past put a premium on continuing to purchase from the same firm. Typically, switching costs result from some firm-specific investments that the consumer cannot transfer to another supplier (e.g., investments in learning, in compatible equipment, in trust). In our previous analysis, we showed that the effects of switching costs on competition are ambiguous: depending on the specificities of the industry, switching costs may relax or intensify price competition.
Here, we examine how switching costs affect entry conditions and we reach another ambiguous conclusion. We consider an incumbent firm that sells a product exhibiting switching costs and that faces the potential entry of a competing firm. The question we ask is whether the incumbent has an incentive to expand (i.e., to overinvest) or to contract (i.e., to underinvest) its installation base of customers if it wants to deter entry. The answer is ambiguous because switching costs exert two opposite forces on entry. On the one hand, by expanding its installation base, the incumbent makes it more costly for the entrant to attract customers and, thereby, reduces the profitability of large-scale entry. Faint deterrence calls then for overinvestment (top dog strategy). On the other hand, switching costs may make small-scale entry more profitable if the incumbent cannot price-discriminate between old and new buyers. In this case, an incumbent with a large installed base prefers to set a large price in order to ‘skin’ its locked-in consumers. As it sets the same price for unattached consumers, it makes it easier for an entrant to compete on that segment of the market. If this second force dominates, entry deterrence calls for underinvestment (lean and mean look).

To illustrate these two forces, we come back to the model we introduced in Chapter 7.19 Consumers of mass 1 are uniformly distributed on the interval [0, 1]. In the first period, only the incumbent, firm 1, is active. It is located at 0 and produces good 1 at zero marginal cost. Firm 2 has the possibility to enter in period 2. If it enters, its location is exogenously fixed at the other extreme of the interval; its marginal cost of production is also equal to zero. A consumer of type \( x \) incurs a disutility of \(-x\) if she purchases a unit of product 1 and \(-(1-x)\) if she purchases a unit of product 2. Moreover, a consumer who has bought from the incumbent in period 1 incurs a switching cost of \( z \) if she buys from the entrant in period 2. We assume that all consumers stay in the market from one period to the next and newly draw their taste parameter in period 2.20 Finally, to guarantee full participation, we assume that the reservation price of consumers, \( r \), is sufficiently high.

Suppose that a share \( 0 < K_1 \leq 1 \) of consumers have bought from the incumbent in period 1. In line with our taxonomy of entry-related strategies, we focus on the potential second-period competition and we are interested in signing the derivatives of the firms’ equilibrium profits with respect to the ‘investment’ \( K_1 \), which is here the size of the incumbent’s installed base of customers.

We first analyse the consumers’ behaviour. A consumer located at \( x \) in period 2 and who has not bought from firm 1 in period 1 decides to buy from firm 1 in period 2 as long as \( p_1 + x \leq p_2 + (1-x) \) or \( x \leq (1/2) (1 + p_2 - p_1) = \bar{x} \), where \( p_1 \) and \( p_2 \) are the prices set, respectively, by the incumbent and the entrant in period 2. On the contrary, if the consumer bought from firm 1 in period 1, she is more inclined to continue to do so in period 2 as switching to the entrant would cost her \( x \); the condition to buy from firm 1 in period 2 becomes: \( p_1 + x \leq p_2 + (1-x) \) or \( x \leq (1/2) (1 + p_2 - p_1) = \tilde{x} \). We can now turn to the price game that is played in period 2 if firm 2 enters. We consider two cases according to the importance of the switching costs.

---

Small switching costs

Consider first the case where the switching cost is not too large, so that \( \bar{x} + (z/2) \leq 1 \) (we make this condition precise below). In this case, the entrant manages to make some consumers switch at equilibrium. As consumers newly draw their type in period 2, there is a probability \( K_1 \) that the consumer ending up at location \( x \) bought from firm 1 in period 1 (and a probability \( 1-K_1 \) that she did not). Hence, the incumbent’s and the entrant’s second-period profits are respectively given by

\[
\pi_1 = p_1 (K_1 ( \bar{x} + \frac{z}{2}) + (1-K_1) \bar{x}) = p_1 \left( \frac{1}{2} (1 + p_2 - p_1) + K_1 \frac{z}{2} \right),
\]

\[
\pi_2 = p_2 (K_1 (1- \bar{x} - \frac{z}{2}) + (1-K_1)(1-\bar{x})) = p_2 \left( \frac{1}{2} (1 + p_1 - p_2) - K_1 \frac{z}{2} \right).
\]

From the first-order conditions for profit maximization, we find the incumbent’s and the entrant’s best-response functions:

\[
p_1 (p_2) = \frac{1}{2} p_2 + \frac{1}{2} (1 + K_1 z) \quad \text{and} \quad p_2 (p_1) = \frac{1}{2} p_1 + \frac{1}{2} (1 - K_1 z).
\]

Note that an expansion of the incumbent’s installed base shifts the incumbent’s best response upwards and the entrant’s best response downwards. That is, a larger \( K_1 \) commits the incumbent to set larger prices and forces the entrant to set lower prices in period 2. This is because more consumers have to incur a switching cost if they buy from the entrant, which deteriorates the entrant’s position on that segment of the market.

Equilibrium prices and profits are then easily found as

\[
\begin{align*}
  p_1 & = 1 + \frac{1}{2} K_1 z, \quad \pi_1 (K_1) = \frac{1}{8} (1 + K_1 z)^2, \\
  p_2 & = 1 - \frac{1}{2} K_1 z, \quad \pi_2 (K_1) = \frac{1}{8} (3 - K_1 z)^2.
\end{align*}
\]

We observe that, in this case, increasing the first-period installed base \( K_1 \) is profitable both for entry accommodation (as \( \pi_1 \) increases in \( K_1 \)), and for entry deterrence (as \( \pi_2 \) decreases in \( K_1 \)).

The top dog strategy of overinvestment is thus indicated in both instances.21

For this argument to be valid, we still need to check that our initial conditions are met. We compute that \( \bar{x} + (z/2) = \frac{1}{2} (3z - 2zK_1 + 3) \), which is below one as long as \( (3 - 2K_1) z \leq 3 \). The latter condition is satisfied, for instance, if we suppose that a non-strategic incumbent would optimally set \( K_1 = 1/2 \) and if \( z < 3/2 \).22 Then, what our result says is that for such values of the switching cost, the incumbent has an incentive to increase \( K_1 \) above 1/2.

Large switching costs

Consider now situations where \( z \) is large enough for \( \bar{x} + (z/2) > 1 \). Here, none of the previous firm 1’s buyers switch to the entrant in period 2. Then, the incumbent’s and entrant’s second-period profits are respectively given by

\[
\begin{align*}
  \pi_1 & = p_1 (K_1 (1 - K_1) \bar{x}) = p_1 \left( K_1 (1 - K_1) \frac{1}{2} (1 + p_2 - p_1) \right), \\
  \pi_2 & = p_2 (1 - K_1 (1 - \bar{x})) = p_2 (1 - K_1) \frac{1}{2} (1 + p_1 - p_2).
\end{align*}
\]

Even though prices are strategic complements, the incumbent chooses a top dog strategy under accommodation because switching costs make the high period-1 investment profitable under accommodation.

21 Even though prices are strategic complements, the incumbent chooses a top dog strategy under accommodation because switching costs make the high period-1 investment profitable under accommodation.

22 We also check that \( \bar{x} > 0 \) for these values.
The incumbent's and the entrant's best-response functions are:

\[ p_1 (p_2) = \frac{1}{2} p_2 + \frac{4 K_1}{3(1-K_1)} \quad \text{and} \quad p_2 (p_1) = \frac{1}{2} p_1 + \frac{1}{2}. \]

In contrast with the previous case, the entrant's reaction is now unaffected by the size of the incumbent's installed base as the entrant can only compete for the unattached consumers. A few lines of computation yield the equilibrium prices and profits:

\[
\begin{align*}
\pi_1 (K_1) &= \frac{1}{18} (3 + 3 - 3 K_1 - 5 K_1) = \frac{1}{18} (6 - 8 K_1), \\
\pi_2 (K_1) &= \frac{1}{18} (3 + 3 - 3 K_1 - 5 K_1) = \frac{1}{18} (6 - 8 K_1).
\end{align*}
\]

We observe now that both \( \pi_1 \) and \( \pi_2 \) are increasing functions of \( K_1 \). Although a larger \( K_1 \) reduces the number of consumers the entrant has access to, it also allows the entrant to charge higher prices as the incumbent does so as well. At equilibrium, the second positive effect dominates the first negative one. As a result, entry accommodation and entry deterrence call for contrasted conduces: the incumbent should overinvest to accommodate entry (top dog strategy) but underinvest to deter entry (lean and hungry look).

As above, this argument is valid as long as the initial conditions are met at equilibrium. We have

\[ z + (\varepsilon/2) = \frac{1}{4(1-K_1)} (3z + 3 - 3 K_1 - 5 K_1) \quad \Rightarrow \quad z > \frac{3-K_1}{3(1-K_1)}.
\]

If we continue to assume that a myopic incumbent would set \( K_1 = 1/2 \), the latter inequality is satisfied for \( z > 5/3 \). We thus illustrated the following result.

### Lesson 16.9

Switching costs affect entry conditions in two opposing ways: on the one hand, they hamper large-scale entry that seeks to attract existing customers of the incumbent; on the other hand, they induce the incumbent to harvest its base of consumers with high prices, thereby relaxing price competition for unattached consumers and making entry easier on that segment.

#### 16.4 Limit pricing under incomplete information

An important antitrust concern is the behaviour of incumbent firms to set low prices in order to avoid or delay entry. Such limit pricing raises the question of whether a temporarily low price can indeed discourage another firm from entry. The deterrence story here relies on a connection between a low price today and an unfavourable environment for the entrant tomorrow. This is illustrated by the switching cost model in the previous section, in which an installed base can be increased by lowering the pre-entry price. If, however, price is a short-run variable that can be changed at no or little cost and does not affect future demand, a low price today may be irrelevant for the entrant's entry decision. Indeed, if the entrant can perfectly predict profits after entry, the entrant will ignore today's price.

The limit pricing story, however, becomes relevant in the presence of asymmetric information. We will analyze the possibility of limit pricing in markets in which, prior to entry, the potential entrant is uncertain about the cost structure of the incumbent, while the demand function is assumed to be public information.

Consider a two-period model. Before the first period, the cost of the incumbent is realized. In the first period, the incumbent operates as a protected monopolist. After learning its cost, the incumbent sets its quantity \( q_1(c) \), which determines the first-period price \( p_1(c) \). The entrant observes the price and may infer the incumbent's cost from the price. Period 2 is divided into two subperiods. First, the entrant decides whether to enter and pay the fixed cost \( e \) which is sunk at this point; we write \( e = 1 \) if entry takes place and \( e = 0 \) otherwise. The entry strategy is denoted by \( e(p) \). Second, after the entry decision, the entrant learns the incumbent's marginal cost. Then firms compete in quantities in case of entry, whereas the incumbent remains a monopolist if entry did not take place.

A key feature of the analysis is the following: since the marginal cost of the incumbent determines its subsequent behaviour, the entrant may be in a situation where entry is profitable if the incumbent has high costs \( c_H \), while entry is not profitable ex ante if the incumbent costs are low, \( c_L \). Therefore, a high-cost incumbent may hide its type by using a pooling strategy. In consequence, the entrant cannot infer the incumbent's cost structure and may not want to enter the market.

The specifics of the model are as follows. Suppose that the prior probability of high costs is \( \mu \). Marginal costs satisfy \( c_H < 1/2 \) and \( c_L = 0 \). The entrant is always of low cost. Firms face the inverse demand curve \( P(q) = 1 - q \) in each period and maximize the sum of profits.

Suppose that entry did not take place. Then the incumbent sets the second-period quantity \( q_1(c; e = 0) = (1 - c)/2 \). Otherwise, firms compete à la Cournot and equilibrium quantities are

\[ q_1(c_H; e = 1) = \frac{1}{2} (1 - 2c_H) \quad \text{and} \quad q_2(c_H; e = 1) = \frac{1}{2} (1 + c_H) \]

if the incumbent has high cost and

\[ q_1(c_L; e = 1) = q_2(c_L; e = 1) = \frac{1}{2} \]

if the incumbent has low cost.

If the entrant knew that the incumbent is of high cost, its equilibrium profit would be

\[ \pi_1(c_H; 1) = (1 + c_H)^2/9. \]

If, on the contrary, the entrant knew that the incumbent is of low cost its equilibrium profit would be \( \pi_2(c_L; 1) = 1/9 \). Hence, for entry cost \( e \) with \( 1 + c_H)^2/9 > e > 1/9 \), the entrant does not enter if it knows that the incumbent is of low cost, whereas it enters if it knows that the reverse holds. This is the interesting parameter constellation.

What happens if the entrant does not know the incumbent's costs when making its entry decision? It then uses prior beliefs to calculate expected profits. Expected profits net of the entry cost are negative if \( \mu[(1 + c_H)^2/9 + (1 - \mu)(1/9) - e < 0 \). Hence, in the range of entry costs \( e = c_H \) with \( e = 1/9 \) and \( e = \mu[(1 + c_H)^2/9 + (1 - \mu)(1/9) \), an informed entrant enters with probability \( \mu \) (i.e., when the incumbent turns out to have high costs) whereas an uninformed entrant does not enter.

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36 The analysis is based on Milgrom and Roberts (1992a), for example, Motta (2004) provides a similar specification to ours. Interesting variations of the nature of asymmetric information are provided by Harrington (1986) and Matthews and Mirman (1983).

37 To analyze this game, we consider perfect Bayesian equilibria.