Are Sunk Costs a Barrier to Entry?

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Abstract

The received wisdom is that sunk costs create a barrier to entry—if entry fails, then the entrant, unable to recover sunk costs, incurs greater losses. In a strategic context where an incumbent may prey on the entrant, sunk entry costs have a countervailing effect: they may effectively commit the entrant to stay in the market. By providing the entrant with commitment power, sunk investments may soften the reactions of incumbents. The net effect may imply that entry is more profitable when sunk costs are greater.

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1 Introduction

The role of sunk costs in the persistence of competitive advantage has been an important question in modern strategy thinking. Research in the area has generally taken one of two approaches toward modeling the importance of sunk costs: the structural approach, which views sunkness as a factor which increases the height of entry barriers; and the behavioral approach, which emphasizes sunkness as a form of commitment.

Consider first the structural approach. Borrowing from the industrial organization literature and work in antitrust economics, sunk costs have been shown to create barriers to entry for new firms into profitable industries, thus protecting incumbents and their profits. The sunk investments that give rise to these barriers may be largely exogenous (for example, the need for purpose-built production facilities with little value in alternative uses); or endogenous (for example, expensive brand-building activities such as advertising). In either case, sunk costs will represent investments put at risk by an entrant uncertain of its ability to successfully establish itself in the market. The greater the sunk investment required for entry, the riskier entry becomes and the less likely it is that incumbents will be challenged.1

In contrast to the structural approach, the behavioral approach derives from the strategy literature on commitment. As argued by, for example, Ghemawat [1991], commitment to the right strategies can influence the play of other actors in ways beneficial to players able to commit.2 Competitors can be persuaded to compete less aggressively or not at all, suppliers can be convinced to make important relationship-specific investments, and customers’ loyalty can be cultivated — in other words, the ability to make the right kind of commitment can be the source of a firm’s competitive advantage.3

1See, for example, the contestability literature, which considers the profitability of hit-and-run entry in which sunk costs play a central role, e.g. Baumol et al [1982]. See also Ross [2004]. Related treatments of sunk costs as a barrier to entry can be found in a variety of strategy and industrial organization texts (e.g. Church and Ware [2000] and Spulber [2004]) and in merger enforcement guidelines of a number of antitrust agencies, e.g. Canada [2004, paragraphs 6.10 to 6.14], European Commission [2004, paragraphs 69 and 73] and United States [1997, Section 3].

2Many strategy texts have now picked up on this theme. See, e.g. Besanko et al. [2004, Chapter 7].

3The value of commitment goes beyond competition in the market, as those familiar with the famous examples of generals burning bridges and ships to commit their soldiers to fierce military engagements will recognize. These military examples are often repeated in strategy texts, e.g. Dixit and Skeath [1999, p 309], Dixit and Nalebuff [1991, p. 156] and Besanko et al. [2004, p. 234].
challenge for firms seeking competitive advantage through commitment lies in finding ways to make those commitments — that is, to take important irreversible actions that change other players’ best responses in the right way. As sunk costs represent, by definition, irreversible investments, they are a natural candidate for such strategic behavior.

Past work on strategic approaches to sunk costs has studied the ability of incumbents to protect monopoly positions through sunk investment in large capacity production facilities. Large sunk capacity in these models (e.g. Dixit [1980]) serves to commit the incumbent to higher output rates, and this lowers post-entry price and profits for prospective entrants. If it lowers profits enough, there will be no entry. In this way, sunk costs are seen, as under the structural approach, as barriers to entry.

Our interest here is also in the strategic use of sunk costs as commitment devices. However, we believe the entry barrier view of sunk costs is incomplete in an important sense. Through its focus on sunk investments by incumbents, it misses the potential for entrants to use sunk investments to commit to entry and thereby influence the behavior of their incumbent rivals. If an entrant, who would otherwise anticipate an aggressive response by the incumbent (in an effort to chase the entrant from the market), can commit itself irreversibly to that entry, it can defeat the purpose of the incumbent’s retaliation. In this view, high levels of sunk investment may actually facilitate entry if they serve to commit entrants to staying in the market and thereby induce the incumbent to adopt a more accommodating strategy.

When Archer Daniels Midland (ADM) decided to enter the lysine market in July 1989, it invested heavily in the construction of the world’s largest manufacturing facility in Decatur, Illinois — a plant three times the size of the next largest facility in the world. ADM used the excess capacity (a largely irreversible investment) to influence its rivals, specifically persuading them to enter into a price-fixing agreement (until caught and successfully prosecuted

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5The idea that sunk costs can strengthen an entrant’s position is recognized in at least one strategy text, though we are unaware of any formal modeling on this point. See Saloner et al. [2001, p. 229].

6Bagwell and Ramey [1996] adapt the Dixit model by allowing the incumbent to have avoidable fixed costs and show that if they are large enough the entrant may be able to persuade the incumbent to leave the market after entry. As in our present work, their focus in on strategies available to entrants to elicit accommodating responses from incumbents. The key in their model, however, lies in the split between sunk and avoidable costs of the incumbent, while here our focus is on the entrant’s cost structure.
by the Antitrust Division of the U.S. Department of Justice). Bagwell and Ramey [1996, p. 662] cite other examples that support the notion that large investments by entrants may serve to discourage aggressive post-entry behavior by incumbents.

By contrast, the airline industry, frequently presented as a paradigm of low sunk costs, is a frequent source of failed entry attempts, frequently due to, at least in part, the aggressive and possibly even predatory responses by incumbents. In summary, anecdotal evidence shows that higher sunk costs do not necessarily mean more difficult or less likely successful entry.

In this paper, we consider two models of rational predation to see if the degree of sunkness of entry costs can alter the incumbent’s incentives to predate. In both cases, we show there exist equilibria with rational entry, possible predation by the incumbent and exit by the entrant. We then consider equilibrium comparative statics and show there are cases when the entrant benefits (in terms of ex-ante expected payoff) from higher sunk costs.

The first model is built on a simple Dixit-type framework in which an entrant and incumbent play a two stage game. In the first stage the entrant decides whether or not to enter, and if entry is the choice, makes the necessary fixed cost investments, a fraction of which is sunk. In the second stage the players select output levels in the Stackelberg fashion with the incumbent moving first. The incumbent then must choose between a predation strategy that involves setting a large output in an effort to encourage the entrant to leave the market (reclaiming its non-sunk fixed costs), and a strategy of accommodation that concedes some market share to its new rival. In this model, a higher proportion of fixed costs that are sunk means that exit will be less profitable for the entrant; this will make the predation strategy more costly for the incumbent.

Sunk investments operate a little differently in the second model. This two-period model is based on asymmetric information and is similar to the “deep-pockets” model of predation of Bolton and Sharfstein [1990]. Here the entrant needs continued financing from a bank that will only offer second

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7See Connor [2001, p. 170].
8On the prevalence of predation in the airline industry see, for example, Bolton et al. [2000]. The set of airlines accused of predatory reactions to new entry includes American Airlines, Northwest Airlines, Lufthansa and Air Canada.
9The predation strategy will not in general involve prices below cost (without a recoupment period after exit it cannot be profitable for the incumbent to sell below cost) and so may not satisfy some cost-based definitions of predation. However, as a strategy that is only profitable because it induces the exit of a rival, it will satisfy the well-known Ordover-Willig [1981] definition of predation. See also Cabral and Riordan [1994].
period financing if the first period’s loan is repaid in full. In the first period, predatory actions by the incumbent can increase the chance of low profits for the entrant, but the entrant can invest resources to resist predation and will be more inclined to do so if it has little to claim (little non-sunk investments) on exit. Hence, in this model, the degree of sunkness of the entrant’s investments affects the entrant’s incentive to take actions to resist predation.

Common to both models is the result that increasing the fraction of fixed costs that are sunk makes the entrant locally worse off, almost everywhere. However, in each case there will be a critical level of sunkness such that for higher levels the incumbent cannot induce exit and the entry will not be resisted. In this way, our models illustrate how sunk costs can, in some cases, deter entry, while in others facilitate it.

2 A quantity setting model

Consider an industry with two potential firms, 1 and 2, which compete in the market for a homogeneous product with demand $p = 1 - q_1 - q_2$, where $p$ is price and $q_i$ is firm $i$’s output level. Firm 1 is committed to being in the market. Firm 2 must initially decide whether to enter. If firm 2 enters, it pays an entry cost $K$ and Nature generates its marginal cost. For simplicity, we assume that firm 2’s marginal cost can either be equal to $c$, with probability $\theta$, or zero, with probability $1 - \theta$. Firm 1’s marginal cost, in turn, is equal to zero.

Upon observing firm 2’s entry decision and its cost, firm 1 chooses its output. Firm 2 must then decide whether to be active or to exit; if active, firm 2 must also choose its output level. Finally, if firm 2 decides to exit, then it recovers $\phi \equiv (1 - s)K$ from its initial investment, where $s$ is the degree of entry cost sunkness.

Having a particular example in mind may help in following the model. Consider the case of airline competition. An entry cost will include, among other things buying (or leasing) an aircraft fleet (cost $K$). Once the incumbent airline learns that a new airline plans to enter a particular market, the incumbent decides how many flights it wants to schedule in that market (output $q_1$). The entrant then decides whether it wants to remain active and, if so, how many flights it wants to schedule in the market (output $q_2$). Finally, equilibrium fares, $p_1 = p_2 = p$, result from the total number of available flights:
Table 1: Timing in the first model.

1. Firm 2 decides whether to enter; if so, it pays entry cost $K$.
2. Nature generates firm 2’s cost level ($c$ with probability $\theta$, zero with probability $1 - \theta$).
3. Firm 1, with zero marginal cost, chooses output level, $q_1$.
4. Firm 2 chooses output level $q_2$ or exits. If it exits, it recovers $(1 - s)K$.

$$p = 1 - q_1 - q_2.$$ \textsuperscript{10}

The timing of the game is described in Table 1. We assume that both the prior distribution of firm 2’s marginal cost and its actual realization are common knowledge. So, while there is uncertainty in our model we do not assume any information asymmetry across firms.

In order to focus on the relevant parameter range, we make the following assumptions regarding the values of $K$ and $c$:

**Assumption 1** \quad $K < \frac{1}{16}$.

**Assumption 2** \quad $c < \frac{1}{5}$.

Assumption 1 ensures that we are not in a situation of “natural monopoly,” in which firm 2 decides never to enter. Assumption 2 ensures that, if firm 2 enters and has high cost then, in the standard Stackelberg outcome with firm 1 as the leader and 2 as the follower, firm 2 will have a strictly positive output rate. Put another way, firm 1 will have to take some action stronger than simply selecting the Stackelberg leader output if it wants to drive firm 2 from the market.

Suppose that firm 2 enters. Firm 1’s expected payoff is then given by $(1 - q_1 - q_2)q_1$. Firm 2’s continuation payoff, in turn, is given by $(1 - q_1 - q_2 - c)q_2$ if it remains active and $\phi$ if it exits.\textsuperscript{11} If firm 2 is to remain active, then its optimal output level is $q_2^* = \frac{1}{2}(1 - q_1 - c)$, yielding a continuation profit of $\pi_2^* = \frac{1}{4}(1 - q_1 - c)^2$.\textsuperscript{12}

Let us now consider firm 1’s decisions, under two alternative scenarios. Consider first the case in which firm 2 remains active. Call this the Stackelberg

\textsuperscript{10}See Kreps and Sheinkman (1983) for a justification of this reduced-form approach.

\textsuperscript{11}Throughout the paper, we refer to continuation profit as firm 2’s profit excluding the entry cost.

\textsuperscript{12}This is true if $q_1 < 1 - c$, which we show below is the case.
case. Firm 1 maximizes
\[ \pi_1 = (1 - q_1 - q_2) q_1, \]
\[ = \left(1 - q_1 - \frac{1}{2}(1 - q_1 - c)\right) q_1, \]
yielding \( q_1^S = \frac{1}{2}(1 + c) \) and
\[ \pi_1^S = \frac{1}{8}(1 + c)^2. \quad (1) \]

Consider now the case when firm 1 increases its output level with a view at inducing firm 2 to exit. Call this the Predation case. For the time being, suppose that \( c \) is very small. Assumption 1 implies that, even if all entry costs can be recovered, firm 2 prefers to remain active against a Stackelberg incumbent. In fact, a Stackelberg follower receives a payoff of \( \frac{1}{16}(1 - 3c)^2 \approx \frac{1}{16} \), whereas exit would give firm 2 a payoff of \( (1 - s)K < \frac{1}{16} \). It follows that, in order to induce exit, firm 1 will have to set an output greater than Stackelberg output.

Specifically, firm 1 must choose an output level so that \( \frac{1}{4}(1 - q_1 - c)^2 \leq \phi \). Since \( q_1 > q_1^S > \frac{1}{2} \) firm 1’s profit is decreasing in its output and the above inequality is binding; solving \( \frac{1}{4}(1 - q_1 - c)^2 = \phi \) yields
\[ q_1^P = 1 - c - 2\sqrt{\phi}. \quad (2) \]

Firm 1’s profit is then given by
\[ \pi_1^P = (1 - q_1^P) q_1^P \]
\[ = (c + 2\sqrt{\phi}) \left(1 - c - 2\sqrt{\phi}\right). \quad (3) \]

Notice that \( \pi_1^P \) is decreasing in \( q_1^P \). Moreover, \( q_1^P \) is decreasing in \( \phi \) (see (2)) and \( \phi \equiv (1 - s) K \) is decreasing in \( s \). We conclude that \( \pi_1^P \) is decreasing in \( s \). Notice also that, as \( s \to 1, \pi_1^P \) becomes very small if \( c \) is small, as (3) shows. It follows that there exists an \( s^*(c) \in (0, 1) \) such that \( \pi_1^P > \pi_1^S \) if and only if \( s < s^*(c) \). Specifically,
\[ s^*(c) = 1 - \frac{1}{64K} \left(2 - 4c + \sqrt{2 - 4c - 2c^2}\right)^2. \quad (4) \]

Let us now consider firm 2’s payoff. If firm 1 preys \( (s < s^*(c)) \), then
\[ \pi_2^P = (1 - s)K. \quad (5) \]
If firm 1 does not prey \((s > s^*(c))\), then

\[
\pi_2^S = \frac{1}{4}(1 - q_1^S - c)^2
\]

\[
= \frac{1}{4} \left( 1 - \frac{1}{2}(1 + c) - c \right)^2
\]

\[
= \frac{1}{16}(1 - 3c)^2
\]

(6)

To summarize:

\[
\pi_2 = \begin{cases} 
(1 - s)K & \text{if } s < s^*(c) \\
\frac{1}{16}(1 - 3c)^2 & \text{if } s > s^*(c)
\end{cases}
\]

(7)

Our first result pertains the relation between the entrant’s continuation profit and the degree of cost sunkness:

**Lemma 1** If \(c\) is close to zero, then \(d\pi_2 / ds < 0\) for \(s < s^*(c)\). Moreover, \(\lim_{s \downarrow s^*(c)} \pi_2(s) < \lim_{s \downarrow s^*(c)} \pi_2(s)\).

Figure 2 depicts the value of firm 2’s continuation profit, conditional on remaining active, for particular values of \(K\) and \(c\). One first result, which can also be seen from Equation (7), is that \(\pi_2\) is weakly decreasing almost everywhere. In other words, for almost every value of \(s\) (that is, except for a set of measure zero), a small increase in \(s\) implies (weakly) a decrease in \(\pi_2\). This result corresponds to the “conventional wisdom” that entry cost sunkness creates a barrier to entry.

A second important property of the equilibrium \(\pi_2\) map is that it discontinuously increases as \(s\) crosses the \(s^*(c)\) threshold. The reason for this is that a higher value of \(s\) implies a shift from the predation regime to the no-predation regime. Past this threshold we remain in a “no predation and no exit” regime in which the degree of sunkness of the fixed costs is irrelevant. We thus conclude that increasing the degree of cost sunkness has two opposing effects.

So far we have only considered the second part of the game, namely the subgame where firm 2 enters. (We have also considered the particular case when \(c\) is close to zero.) At this point, a natural question to ask is, if firm 2 expects that firm 1 will chase it out of the market, why should it enter in the first place? The answer is given by firm 2’s uncertainty regarding its production cost. We will now show that there exist equilibria where firm 2 enters if entry costs are sufficiently sunk; and, given that firm 2 enters, its expected payoff is decreasing in the degree of entry cost sunkness.
Proposition 1 Suppose \( \theta \) is close to zero. There exist values \( 0 < s_1 < s_2 \leq 1 \) such that

(a) Entry takes place if and only if \( s > s_1 \).

(b) If \( s_1 < s < s_2 \), then firm 2’s ex-ante expected payoff is strictly decreasing in \( s \).

Proof: See Appendix. ■

Proposition 1 is illustrated in Figure 2, where \( s_1 = s^*(0) \), \( s_2 = s^*(c) \) and \( s^*(\cdot) \) is given by (4).\(^{13}\) For \( s < s_1 = s^*(0) \), firm 2 correctly anticipates that, no matter what its costs, firm 1 will prey it out of the market. It follows that the expected payoff from entry is \( -s K \), the measure of entry sunk costs. Since

\(^{13}\)So, \( s^*(c) \) is given by (4) and in particular \( s^*(0) = 1 - \frac{1}{\theta^2 K} \left( 2 + \sqrt{2} \right)^2 \).
expected payoff is negative, firm 2 does not enter. If \( s > s_1 = s^*(0) \), then a low cost firm would be met by an accommodating incumbent. Moreover, firm 2’s profits if it has low cost and firm 1 behaves as a Stackelberg leader are greater than the entry cost \( K \). Since \( \theta \) is close to zero, it follows that firm 2’s optimal strategy is to enter. This corresponds to part (a) of Proposition 1.

Suppose that \( s \) is close to, but greater than, \( s_1 = s^*(0) \). Suppose that, as the equilibrium indicates, firm 2 enters, expecting its cost to be low, but the actual cost is high. If, for \( s = s_1 = s^*(0) \), the incumbent was indifferent between accommodating and fighting a low cost entrant, clearly the incumbent will strictly prefer to induce exit by a high-cost firm 2. We conclude that firm 2 will exit if it has high cost. Its payoff is then given by \(-sK\), the fraction of its entry cost that it cannot recover. This implies part (b) of Proposition 1.

The exact outcome of the subgame following entry and high marginal cost depends on the particular value of the marginal cost. If \( c \) is sufficiently small, then we will have a situation similar to Figure 2. In this case, there exists a value \( s_2 = s^*(c) < 1 \) beyond which the incumbent accommodates entry even by the high cost firm; and for values of \( s \) between \( s_1 = s^*(0) \) and \( s_2 = s^*(c) \) a high cost firm is met by a predatory response by the incumbent. If the value of \( c \) is very high, however, then for all values of \( s \) a high-cost firm 2 exits. In some cases (when \( c \) and \( K \) are high enough), firm 1 is a “natural monopoly,” that is, it sets monopoly price and firm 2 still prefers to exit. For lower values of \( c \) and \( K \), firm 1 sets output above the monopoly level (either above or below the Stackelberg output).

3 An asymmetric information model

Our second model is based on Bolton and Scharfstein’s [1990] theory of predation and financial contracting. Bolton and Scharfstein consider a situation where a “deep pockets” firm faces a “shallow pockets” firm. The latter requires outside funding in order to operate. Since the only verifiable action by the borrowing firm is whether it repays its loans, the optimal contract specifies the renewal of a one-period loan if and only if repayment takes place. In this context, the “deep pockets” firm has an incentive to prey: by reducing the small firm’s profitability, the predator increases the probability that the prey will not be able to repay its loan, thus exiting and leaving the predator as a monopolist in the future.

We extend Bolton and Scharfstein’s [1990] model by considering the possibility that the small firm can, at a cost, “resist” the predator’s efforts and
reduce the likelihood that exit will take place. Specifically, we consider the following model. There are two firms, 1 ("incumbent") and 2 ("entrant") that compete in two periods. At the beginning of each period, both firms must incur a fixed cost $F$. Firm 1 has a "deep pocket" which it can use to finance its fixed costs. Firm 2, by contrast, has a "shallow pocket"; it must raise funds in the capital market. The entrant’s profits in each period may be high, $\pi_2 + F$, or low, which we normalize to zero. Absent any actions by incumbent and entrant, the latter’s profits are low with probability $\theta$.\(^{14}\) The incumbent may engage in predatory actions, at a cost $c_1$. If it does so and the entrant does not react, then the probability the entrant receives low profits increases to $\mu > \theta$. The entrant, in turn, may react to predatory efforts, at a cost $c_2$. If it does so, then the probability of low profits is restored to the lower value $\theta$.\(^{15}\)

Before the first period, the entrant decides whether to enter, at a cost $K$.\(^{16}\) In case the entrant exits at the end of the first period (because it is unable to secure period 2 financing) then it is able to recover $(1 - s)K$ from its initial investment, $s$ measuring the degree of sunk costs. This assumption requires some comment. Normally, we would expect no repayment to lead to bankruptcy and liquidation, with the bank acquiring the firm’s assets. In order for our results to go through, we must assume that firm 2’s owners are able to keep a fraction $\gamma$ of the liquidated firm’s assets. What is crucial is that the firm’s payoff from exit is increasing in $s$. Our (implicit) assumption that $\gamma = 1$, while simplifying the notation and the analysis, is not necessary. It suffices that $\gamma > 0$.

Table 2 summarizes the timing of the model. With respect to Bolton and Scharfstein (1990), we add the initial entry step and the possibility that the entrant resists the predator’s actions. Bolton and Scharfstein (1990) show that the optimal financial contract is to renew financing if and only if the first loan is repaid. They also show that, for certain parameter values, the incumbent decides to prey. Under our extended model, the equilibrium financial contract is identical (refinancing in period 2 if the loan is repaid in period 1). We now consider to what extent firm 2’s ability to resist predation influences the likelihood that predation takes place.

First we enunciate a series of assumptions regarding the entry cost, the

\(^{14}\)Thus $\theta$ in this model, as in the first, represents the probability of a “bad” state from the entrant’s perspective.

\(^{15}\)This assumption is made for convenience. Our results would follow if the entrant’s resistance led to a value lower than $\mu$ but different from $\theta$.

\(^{16}\)For simplicity, we assume the entrant has enough capital to cover this investment, requiring financing for operations only.
Table 2: Timing in the second model.

1. Firm 2 decides whether to enter; if so, it pays entry cost $K$.
2. Lender makes take-it-or-leave-it offer to entrant (a loan, the renewal of which is conditional on repayment).
3. Firm 1 decides whether to prey (at a cost $c_1$).
4. If firm 1 preys, firm 2 decides whether to resist predation (at a cost $c_2$).
5. Period 1 payoffs received (entrant receives low profits with probability $\mu$ under unresisted predation, $\theta$ otherwise).
6. Firm 2 pays lender.
7. Firm 2 receives period 2 loan or exits if no loan is offered.
8. Period 2 payoffs received.

The cost of predation, and the cost of resisting predation such that the equilibrium is non-trivial.

**Assumption 3** $c_2 < (\mu - \theta)(1 + \theta)\pi_2$.

Assumption 3, requiring the value of $c_2$ not to be too high, implies that the critical value of $s$ is strictly below 1.\(^{17}\) If $c_2$ is higher than the limit in Assumption 3, then the entrant does not resist predation regardless of the value of $s$. We are interested in the case when the entrant’s decision depends on the value of $s$.

The following additional assumptions regarding the value of $c_2$ are required to guarantee that, in the relevant range, firm 2 enters if and only if it anticipates firm 1 will not prey:

**Assumption 4** $\frac{\mu - \theta}{\mu} \left( (1 + \theta)\pi_2 - K \right) < c_2 < \frac{\mu - \theta}{\theta} \left( (1 + \theta)\pi_2 - K \right)$.

As we will see below, these inequalities imply that, around the critical value of $s$, firm 2 anticipates a positive net discounted value if and only if it expects that firm 1 will not prey.\(^{18}\)

\(^{17}\)Below we provide a condition such that the critical value of $s$ is strictly positive.

\(^{18}\)Notice that the first part of Assumption 4 implies that $(\mu - \theta) \left( (1 + \theta)\pi_2 - K \right) < c_2$, which in turn implies that, at least for some values of $s$, firm 2 will resist predation. In other words, whereas Assumption 3 implies that the critical value of $s$ is less than one, the first part of Assumption 4 implies that such critical value is strictly positive.
Notice that the upper bound on $c_2$ implied by Assumption 3 is consistent with the lower bound on $c_2$ implied by Assumption 4; it suffices to choose the value of $K$ accordingly. Consequently, there exists a non-empty set of parameter values that satisfy Assumptions 3 and 4.

Our final parameter assumption is required to ensure the incumbent is better off by preying if it expects the entrant not to resist predation:

**Assumption 5** $c_1 < (\mu - \theta)(\pi_1 - \pi_1)$.

We are now ready to analyze the equilibrium of the game. Suppose the incumbent preys. The entrant’s expected payoff if it resists the incumbent’s effort is given by

$$V_2^R = -K - c_2 + \theta(1 - s)K + (1 - \theta)(2 - \theta)\pi_2,$$

where $(1 - \theta)(2 - \theta)\pi_2$ denotes expected profits over the two periods (net of fixed costs) if the entrant does not exit. To see this, note first that, with probability $\theta$, firm 2 receives zero profits in period 1. Since it is not able to renew the loan to pay its fixed cost, it receives zero profit in the second period as well. With probability $1 - \theta$, firm 2 receives positive profits in the first period and is able to repay its loan. Since the second period is the last one, firm 1 has no incentive in preying, and so firm 2 receives low profits with probability $\theta$. We thus have $(1 - \theta)\pi_2$ (first period expected net profits) plus $(1 - \theta)(1 - \theta)\pi_2$ (expected second period profits).

By not resisting predation expected payoff is given by

$$V_2^N = -K + \mu(1 - s)K + (1 - \mu)(2 - \theta)\pi_2.$$

Simple computations imply that the entrant’s best response is to resist predation if the value of $s$ is sufficiently high. Specifically,

**Lemma 2** The entrant resists predation by the incumbent if and only if $s > s^*$, where

$$s^* \equiv 1 - \frac{(\mu - \theta)(2 - \theta)\pi_2 - c_2}{(\mu - \theta)K} \in (0, 1).$$

**Proof:** Substituting (8) and (9) into the inequality $V_2^R > V_2^N$ and solving with respect to $s$, we obtain the inequality in the result. The condition $s^* < 1$ is equivalent to Assumption 3. Finally, the condition $s^* > 0$ is implied by the first part of Assumption 4. ■

We finally turn to the main result in this section:
Figure 3: Firm 2’s value as a function of entry cost sunkness \((\theta = .6, \mu = .8, K = .6, c_2 = .12)\).

**Proposition 2** There exist values \(0 < s_1 < s_2 < s_3 < 1\) such that

(a) Entry takes place if \(s \in (s_2, s_3)\) but not if \(s \in (s_1, s_2)\).

(b) If \(s \in (s_2, s_3)\), then firm 2’s ex-ante expected payoff is strictly decreasing in \(s\).

**Proof:** Lemma 2 states that firm 2, having entered, will resist predation if and only if \(s > s^*\). Let \(s_2 = s^*\).

Suppose that firm 2 were not to resist predation. Then firm 1 would prefer to prey if and only if

\[
\pi_1 + \mu \pi_M^1 + (1 - \mu) \pi_1 - c_1 > \pi_1 + \theta \pi_M^1 + (1 - \theta) \pi_1,
\]

which is equivalent to Assumption 5. So, if firm 1 anticipates firm 2 does not resist then firm 1 preys. If, on the other hand, firm 1 anticipates that firm 2 will resist predation then its payoff is strictly lower (by \(c_1\)) under predation, and not to prey is the optimal choice.

We thus conclude that firm 1 is better off not preying if and only if \(s > s_2\). If follows that, if \(s < s_2\), firm 2’s ex ante expected payoff from entry is

\[
V_2^N = -K + \mu (1 - s) K + (1 - \mu) (2 - \theta) \pi_2;
\]

whereas, if \(s > s_2\), firm 2’s ex ante expected payoff from entry is

\[
V_2^R + c_2 = -K + \theta (1 - s) K + (1 - \theta) (2 - \theta) \pi_2.
\]

Assumption 4 implies that, at \(s = s_2\), \(V_2^N < 0\) whereas \(V_2^R + c_2 > 0\). Since the inequalities are strict, we can find \(s_1\) and \(s_3\) such that firm 2 expects a negative payoff from entry when \(s \in (s_1, s_2)\) and a positive payoff from entry when \(s \in (s_2, s_3)\). This implies part (a) of the result.

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From (8), we get
\[
\frac{\partial V^R}{\partial s} = -\theta K < 0,
\]
which implies part (b) of the result.

Figure 3 illustrates Proposition 2. Three dashed lines are plotted, one corresponding to \( V_2^N = -K + \mu (1 - s) K + (1 - \mu) (2 - \theta) \pi_2 \), a second one to \( V_2^R = -K - c_2 + \theta (1 - s) K + (1 - \theta) (2 - \theta) \pi_2 \), and a third one to \( V_2^R + c_2 \). Notice that \( V_2^R \) has a lower slope than \( V_2^N \) (in absolute value). It follows that there exists a value \( s_2 \) such that \( V_2^R > V_2^N \) if and only if \( s > s_2 \). By Assumptions 3 and 4, \( s_2 \in (0,1) \). We can also find threshold values \( s_1, s_3 \) such that the dashed lines for \( V_2^N \) and \( V_2^R + c_2 \) cross the horizontal axis. It follows that, if \( s < s_1 \), then firm 2 anticipates that firm 1 will prey, but since the degree of entry cost sunkness is very low it’s worth giving it a try—there is always the chance that predation, though not resisted, is unsuccessful.

If \( s_1 < s < s_2 \), firm 2 anticipates that, if it enters, it will not resist firm 1’s predatory attempts. Moreover, since a good fraction of the entry cost is sunk, firm 2 expects a negative net value from entering. If \( s_2 < s < s_3 \), firm 2 is committed to resist firm 1’s predatory attempts. Knowing this, firm 1 prefers not to prey. This moves us into a higher branch of the value function, one where the probability of low profits in the first period is \( \theta < \mu \). Moreover, the value is positive, so firm 2 decides to enter. Finally, if \( s > s_3 \), then, even absent predatory behavior by firm 1, firm 2 expects a negative net value from entry: the fraction of entry costs is very high.

We must note that not all the features depicted in the figure are general. In particular, the characterization of firm 2’s behavior for very low and very high values of \( s \) depends on the particular constellation of parameter values.\(^{19}\) There can be corner solutions, however. For example, if \( K \) is sufficiently high, then the critical value of \( s_1 \) is equal to zero; and if \( \mu \) is much greater than \( \theta \) then the value of \( s_3 \) is equal to 1.

Figure 3 and Proposition 2 illustrate the implication of the two main effects of sunk costs. For a given behavior on the part of the incumbent (i.e., prey or do not prey), a higher degree of entry cost sunkness discourages entry: if the entrant ends up exiting, it will recover less of its initial entry costs, so the expected cost of entry is higher. This corresponds to part (b) in Proposition 2. In terms of Figure 3, this is most apparent looking within the \((0, s_2)\) region and within the \((s_2, 1)\) region. Between 0 and \( s_2 \), conditional on entry, the

\(^{19}\)We consider in Proposition 2 the most general case.
incumbent will prey. In this range the entrant will not resist and will exit if it draws low profits. Thus, increasing $s$ in this range changes no predation/resistance decisions but lowers the entrant’s profits in the states in which it must exit — to the point that from $s_1$ to $s_2$ the entrant chooses not to enter in the first place. Between $s_2$ and 1 the predation/resistance strategies are again unchanging: now the incumbent will not prey, because, if it did, the entrant would resist. However, there is still the chance that the entrant would wish to exit, thus higher levels of $s$ will again lower expected profits — to the point that from $s_3$ onward the entrant chooses not to enter because ex-ante expected profits are negative.

The strategic effect of sunk entry costs (part (a) of Proposition 2) can be seen in the transition from the $(s_1, s_2)$ region to the $(s_2, s_3)$ region. If the degree of entry cost sunkness is sufficiently high, then the entrant’s “threat” to resist predatory efforts is credible. As a result, the incumbent prefers not to prey, which places the entrant on a higher branch of the expected value function.

4 Conclusion

The idea that sunk costs serve to deter entry has been supported by at least two sets of theories. The first sees sunk costs as investments put at risk when entry may be followed by a quick exit, whether that exit is deliberate (as in hit-and-run entry) or not. The greater is this potential loss, the less attractive entry will seem. The second set of theories views sunk investments — in capacity, for example — as means through which first-mover incumbents can commit to rates of output so large as to not leave enough room for profitable entry.

In this paper, we have argued that by largely ignoring the potential for sunk investments to provide a vehicle for entrant commitment, the literature has missed the possibility that sunk investments might actually facilitate entry. We have illustrated this potential with two models in which an entrant making a large enough sunk investment can alter the behavior of the incumbent. By rendering exit so unattractive for the entrant (as the recoverable share of entry costs is so low), the incumbent’s predation strategy becomes unprofitable. When ADM invested so much money in the world’s largest (by far) lysine facility, none of its rivals could have reasonably expected that ADM could be persuaded to exit; accordingly, their rational response was accommodation. On the other hand, with exit relatively easy, poorly capitalized new-entrant
airlines have frequently been the target of very aggressive pricing responses from their incumbent rivals.

While our main objective here has been to integrate two different strands of the strategy/industrial organization literature to provide a more complete treatment of the effects of sunk costs on entry, we recognize that our results have potentially important implications for antitrust policy. Ease of entry into the relevant markets is a critical element in the review of most competition cases and the analysis provided here suggests that in some circumstances the ability of entrants to make commitments to entry via sunk investments may in fact facilitate entry. The flip side of this, however, is that when sunk costs are low (but not zero), incumbents may have an easier time expelling entrants through predatory actions.
Appendix

Proof of Proposition 1: Throughout the first part of the proof, we will assume $\theta = 0$ and $c = 0$. The result then follows by continuity. Consider first the case when $s = 0$. If firm 2 enters, its opportunity cost from being active is $\phi = K$ (all of the entry cost can be recovered). By accommodating entry, firm 1 gets $\frac{1}{8}$. From (3), firm 1’s payoff from predation is given by $2 \sqrt{K} \left(1 - 2 \sqrt{K}\right)$. The first part of Assumption 1 implies that $2 \sqrt{K} \left(1 - 2 \sqrt{K}\right) > \frac{1}{8}$. By continuity, it follows that, for $\theta \approx 0$ and $c \approx 0$, firm 1 strictly prefers to prey when $s = 0$.

Consider now the case when $s = 1$, which implies $\phi = 0$. In order to induce firm 2 to exit, firm 1 would need to set $q_1 = 1$, yielding a profit of zero. By accommodating firm 2, firm 1 gets $\frac{1}{8}$. By continuity and the fact firm 1’s predation profit is decreasing in $s$, there exits an $s^*(0)$ strictly between zero and 1 that divides the predation and accommodation regions.

If $\theta = 0$, then $K < \frac{1}{16}$ implies that firm 2 enters if and only if $s > s^*(0)$. In fact, if $s$ is lower then firm 1 will prey and firm 2 will exit, recovering only a fraction of the entry cost; whereas if $s > s^*(0)$ then firm 1 will accommodate firm 2’s entry and the latter will gain a profit greater than the entry cost (by Assumption 1).

Consider now the case when $\theta$ is greater than, but close to, zero. By continuity, firm 2 will continue making the same entry decisions. In fact, expected profit from entry is strictly negative if $s < s^*(0)$ and strictly positive if $s > s^*(0)$. Clearly, if firm 2 exits when $c = 0$ then it also exits with $c > 0$. So, if $s < s^*(0)$ nothing changes: firm 2 would exit regardless of its cost. However, if $s$ is slightly greater than $s^*(0)$ then a low-cost firm will be accommodated, but a high-cost firm will be preyed upon and exit. If firm 2’s cost is very high, it may happen that firm 1 is a “natural monopoly,” that is, setting an output between monopoly output and Stackelberg output suffices to induce firm 2 to exit. Whichever is the case, a high-cost firm 2 exits, collecting $\phi = (1 - s)K$ for a total negative profit of $-sK$. This implies that firm 2’s ex-ante expected payoff, $(1 - \theta) \frac{1}{8} + \theta (-sK)$, is decreasing in $s$. ■
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