Sunk costs, entry deterrence, and financial constraints

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Abstract

This paper studies how sunk costs affect a financially constrained incumbent's ability to deter entry into its market. Sunk costs make it less attractive to the incumbent to accommodate entry by liquidating assets in place and exiting the market. This may render entry by a prospective rival unprofitable, and thereby facilitate entry deterrence. However, sunk costs also make it harder for the incumbent to pledge valuable collateral to outside investors. To make up for the poor collateral value, the incumbent will have to give stronger liquidation rights to its lenders. Consequently, a larger fraction of the incumbent's assets will be liquidated in the event of a liquidity default. This potentially creates room for profitable entry. The overall effect of sunk costs on the incumbent's ability to deter entry into its market is thus ambiguous.

Keywords: Sunk Costs, Irreversible Investment, Entry Deterrence, Financial Constraints
JEL Classification: G2, G3, L1

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1 Introduction

This paper studies how sunk costs affect a financially constrained firm's ability to deter entry into its market. We consider a scenario where a firm has the opportunity to launch a new product, but lacks sufficient financial resources to self–finance the purchase of production facilities. While the firm initially has a monopoly position, it faces the threat of future entry by a prospective rival with deep pockets. To model financial constraints, we draw upon Bolton and Scharfstein (1996).[1] Specifically, we assume that the incumbent's profits are non–verifiable and can be diverted by the incumbent. In this situation, the only way for the incumbent to obtain external funds is to give its lenders the right to liquidate part or all of its assets in case of a default. This improves the incumbent's payout discipline in high profit states, but it may also jeopardize its survival prospects in low profit states when the incumbent must default for liquidity reasons.

We show that sunk costs (as measured by the degree to which initial investment costs cannot be recouped in liquidation) can have two effects on entry deterrence in this framework. On the one hand, sunk costs make it less attractive to the incumbent to accommodate entry by liquidating assets in place and exiting the market. This may render entry unprofitable, and thereby facilitate entry deterrence. On the other hand, sunk costs make it harder for the incumbent to pledge valuable collateral to outside investors. To make up for the poor collateral value, the incumbent will have to give stronger liquidation rights to its lenders. Consequently, a larger fraction of its assets will be liquidated in the event of a liquidity default. This potentially creates room for profitable entry. The overall effect of sunk costs on the incumbent's ability to deter entry into its market is thus ambiguous. In particular, we show that for some parameter constellations an increase in the degree to which investment costs are sunk actually gives rise to *more*, rather than less, entry.

To endogenize sunk costs, we consider a setting where R&D enhances the efficiency of phys-

[1] See also Bolton and Scharfstein (1990), Berglöf and von Thadden (1994), and Hart and Moore (1998).

ical capital, so that investment in physical capital can effectively be substituted for investment in R&D. While physical capital has some salvage value, investment in R&D is assumed to be firm–specific and nonrecoupable in liquidation. In this setting, the incumbent can choose the degree to which the initial investment is sunk: as more physical capital is substituted for R&D, investment becomes more irreversible and the resale value of assets decreases. This makes it less appealing to accommodate entry by liquidating assets in place. However, it also entails more liquidation in the event of liquidity default, and hence more scope for profitable entry in low profit states. Since these inefficiencies become less pronounced when financial constraints become less binding, incumbents with relatively high internal funds prefer high levels of investment irreversibility. Incumbents with relatively low internal funds instead prefer to maximize the resale value of assets and accommodate entry by exiting the market. This points to a positive relationship between incumbents' own financial resources and the extent to which they deter entry into their markets.

We extend the model towards monitored finance. Under monitored finance, the financier can force the incumbent to repay, so that the threat of liquidation is no longer needed to ensure repayment (cf., Diamond 1984). However, monitored finance is subject to a monitoring cost. In making the choice between monitored and arm's length (i.e., non–monitored) finance, the incumbent thus needs to trade off the inefficiencies of arm's length finance with the monitoring cost. The main result pertains to the relationship between the incumbent's internal funds and entry deterrence: we show that very poor and very rich incumbents do not experience entry, while some incumbents with intermediate levels of internal funds do. Very poor incumbents are credit–rationed under arm's length finance, and hence they have no choice but to use monitored finance. Yet, given that they do so, entry will be deterred. Very rich incumbents do not experience entry either, regardless of their financing choice. Some incumbents with intermediate levels of internal funds do experience entry, however. For these firms, the inefficiencies of arm's length finance are not large enough to justify incurring the monitoring cost. Yet, under arm's length finance, these firms will experience entry at least in low profit states. In short, once monitored finance is allowed for, the relationship between internal funds and entry deterrence may turn out to be *non–monotonic*.

The notion that sunk costs and/or irreversible investment can facilitate entry deterrence is central to a large industrial organization literature.[2] For example, Eaton and Lipsey (1980, 1981) emphasize that sunk capital, to the extent that it constitutes a barrier to exit, can serve as a barrier to entry. Dixit (1980) has a model where an incumbent can reduce its *ex post* marginal cost of production by sinking capacity investment costs *ex ante*. This makes the incumbent more aggressive vis–à–vis prospective rivals, and thereby facilitates entry deterrence. Allen, Deneckere, Faith, and Kovenock (2000) show that irreversible capacity can have commitment value even if capacity investment costs, and hence sunk costs, are zero. They have a setting of sequential capacity build–up, followed by Bertrand–Edgeworth price competition. In their model, expanding capacity commits the incumbent to price more aggressively in the mixed strategy equilibrium of the post–entry pricing game. Faced with this threat, the entrant may be induced to stay out.[3] Our article builds on this literature insofar as sunk capital can facilitate entry deterrence in our model. The contribution of our paper is to show that financial constraints provide a channel by which sunk costs may actually give rise to more, rather than less, entry.

This paper also relates to the literature on the interaction between financial and product market decisions.[4] We draw in particular upon Bolton and Scharfstein's (1990) insight that

[2]See, e.g., Spence (1977), Dixit (1980), Eaton and Lipsey (1980, 1981), Bulow, Geanakoplos, and Klemperer (1985), and Allen, Deneckere, Faith, and Kovenock (2000). For surveys, see Tirole (1988) and Wilson (1992).

[3]Whether or not the capacity expansion induces the entrant to act less aggressively depends on the entrant's cost advantage vis–à–vis the incumbent. If the entrant does not enjoy too much of a cost advantage, then the capacity expansion induces the entrant to enter at smaller scale or to stay out. By contrast, if the entrant's cost advantage is sufficiently high, then the entrant responds by investing aggressively and pricing the incumbent out of the market. In this case, the incumbent underinvests in order to induce the entrant to respond less aggressively.

[4]See, among others, Titman (1984), Brander and Lewis (1986), Maksimovic (1988), Bolton and Scharfstein (1990), Maksimovic and Titman (1991), Fulghieri and Nagarajan (1996), Hendel (1996), Snyder (1996), Faure–

debt finance can make firms vulnerable to aggressive behavior by rivals.[5] In their model, aggressive behavior by a rival (i.e., predatory pricing) erodes *short–term* profits, which potentially triggers bankruptcy and liquidation. This differs from our setting where aggressive behavior by the rival (i.e., entry) reduces *long–term* profits, which potentially makes liquidation and exit efficient.

The paper is organized as follows. The next section presents the basic model and highlights the effects of sunk costs on entry deterrence. Section 3 endogenizes the degree to which investment costs are sunk. Section 4 extends the model towards monitored finance. Section 5 concludes.

2 Basic Model and Analysis

2.1 Setup

All agents are risk–neutral and protected by limited liability, and there is no discounting.

Model Structure.— The model has two periods (and three dates, $t = 0, 1, 2$). At date 0, a firm (henceforth, "incumbent") with no productive assets has the opportunity to launch a new product. Setting up production facilities requires a fixed investment outlay of \$1. The incumbent has internal funds $w < 1$; it thus needs to borrow $1 - w$ from an external financier. The market for external funding is perfectly competitive. In the first period, the incumbent has a monopoly position in the product market (but it may face future entry, see below). First period profits realize at date 1. For simplicity, we model profits in reduced form. First period profits are $\Pi > 1$ with probability θ ("high profit state") and zero with probability $1 - \theta$ ("low profit state").

The realization of first period profits is observed by a potential entrant with deep pockets,

Grimaud (1997, 2000), Chemla and Faure–Grimaud (2001), Fernández–Ruiz (2004), and Povel and Raith (2004).

[5] Of related interest are, among others, Snyder (1996), Faure–Grimaud (1997), and Fernández–Ruiz (2004).

who then has the opportunity to enter the market and compete against the incumbent in the second period. After the entrant made the entry decision, and still at date 1, part or all of the incumbent's production facilities (henceforth, "assets") may be liquidated (for reasons which will become clear below). Assets have a liquidation value $L < 1$ at date 1 and, for simplicity, zero liquidation value at date 2. The term $1 - L$ measures the degree to which the initial investment cost is *sunk* (or investment is *irreversible*) at date 1. For the moment, we take the level of investment irreversibility as exogenously given; this assumption will be dropped in Section 3.

Second period profits realize at date 2. The incumbent's second period profits depend on entry and the extent to which the incumbent is downsized at date 1. For the sake of simplicity, we consider a constant returns to scale technology: if a fraction β of the incumbent's assets is liquidated, then the incumbent makes expected profits $(1-\beta)\hat{X}$ in the second period, where

$$\hat{X} = \begin{cases} X > 0 & \text{if the entrant stays out,} \\ X - \Delta \in (0, X) & \text{if the entrant enters.} \end{cases}$$

The value of the liquidated assets is in turn given by βL. The firm value maximizing liquidation decision thus amounts to $\beta = 1$ if $\hat{X} < L$ and $\beta = 0$ if $\hat{X} \geq L$.

Turning to the entrant, we consider a small market in that entry is profitable for the entrant if and only if the incumbent is sufficiently downsized. Formally, if the incumbent is downsized by a fraction β, then the entrant's net profit from entering the market is

$$\beta\overline{Y} + (1-\beta)\underline{Y} - F$$

where $0 \leq \underline{Y} < F < \overline{Y}$, and F denotes the entry cost, which, for simplicity, is immediately sunk.[6]

Figure 1 summarizes the sequence of events.

Self–Financing Benchmark.— As a point of reference, consider the outcome which would result if the incumbent could self–finance itself. This corresponds by and large to the "standard" case analyzed in the industrial organization literature. Assume investment is profitable

[6]All what matters here is that the entrant, once in the market, is committed to stay.

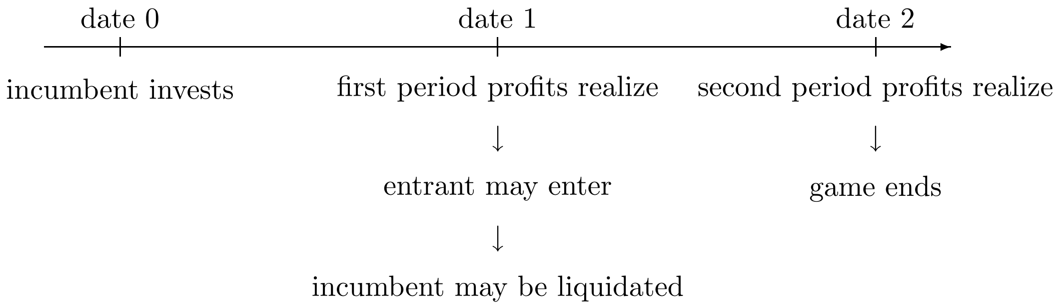

Figure 1: Sequence of Events

for the incumbent, and suppose the entrant enters. At date 1, the incumbent exits (i.e., $\beta = 1$) if and only if the liquidation value of assets in place exceeds the continuation value, i.e., $L > X - \Delta$. Thus, for $L > X - \Delta$, there is a unique subgame perfect equilibrium in which the entrant enters and the incumbent exits. Conversely, for $L \leq X - \Delta$, the incumbent would stay (i.e., $\beta = 0$) even if the entrant entered. In consequence, entry is unprofitable, and the incumbent is able to protect its monopoly position. This illustrates the idea that sunk costs can help to deter entry. The aim of our analysis is to explore the applicability of this idea when financial constraints matter.

Financial Constraints.— To endogenize financial constraints, we use the framework introduced by Bolton and Scharfstein (1996). Specifically, we assume that the incumbent's profits, while being observable to firms and financiers, are non–verifiable in court and can be diverted by the incumbent. Thus, being protected by limited liability, the incumbent may have an incentive to default strategically in the high profit state, i.e., declare that it generated no profit, pay out zero, and divert profits. In this situation, the only way for an outside investor to ensure a sufficient repayment is to threaten to liquidate part or all of the incumbent's assets in case of a default. Formally, we know from Bolton and Scharfstein (1996) that an optimal financial contract in our context specifies a date 1 repayment R and the financier's liquidation right $\beta \in [0, 1]$, meaning that if the incumbent fails to repay R at date 1, then the financier is entitled to liquidate a fraction β of the incumbent's assets and to seize the proceeds.[7] Conversely, if the incumbent repays R, then the financier is not entitled to liquidate. Both R and β will be determined endogenously. Notice that the incumbent cannot commit to repay the financier out of second period profits. This is because at date 2 the financier no longer has leverage over the incumbent. As a result, the incumbent would default on any date 2 repayment, claiming that it made no profit.[8]

We allow for renegotiation between the incumbent and the financier (thus none of our results will be driven by an assumption that the parties can commit not to renegotiate). For simplicity, the incumbent has full bargaining power in renegotiation.[9]

In Section 4, we will introduce an alternative financing method, namely, monitored finance.

2.2 Equilibrium

We now characterize the equilibrium. Two cases need to be distinguished: (i) exit following entry is efficient for the incumbent and the financier, $L > X - \Delta$, and (ii) exit following entry is inefficient for the incumbent and the financier, $L \leq X - \Delta$. We analyze these cases in turn.

Efficient Exit. Suppose exit following entry is efficient for the incumbent and the financier, $L > X - \Delta$. In this case, once the entrant is in the market, the best the incumbent and the financier can do to maximize their joint payoff is to liquidate assets in place and exit the market. Entry thus induces exit, which in turn makes entry profitable *ex post*.[10]

In this context, an optimal financial contract with investment (if feasible) is given by $(R, \beta) = (\infty, (1-w)/L)$. Under this contract, the incumbent is forced to default in the high and the low profit state. Since liquidation is efficient, the financier exercises his liquidation right. This gives him a payoff of $\beta L = 1 - w$, which makes him just break even on his initial

[7] We assume that entry is non–contractible, so that the contracting variables cannot condition on entry.

[8] We assume that zero is within the support of the distribution of second period profits.

[9] This assumption is inessential for the qualitative results (see footnote 14).

[10] It is worth emphasizing that this holds regardless of what is stipulated in the loan contract, for any contract that did not stipulate exit would be renegotiated and the efficient exit decision would be made.

investment. The incumbent then voluntarily liquidates the remaining assets. By inspection, the contract is feasible if and only if $w \geq 1 - L$. Thus, for $w < 1 - L$, the incumbent is credit–rationed. If not, investment is profitable for the incumbent if and only if its expected payoff, $\theta\Pi + L - (1 - w)$, exceeds its internal funds, w, which we assume to hold. In summary,

Proposition 1 *Suppose exit following entry is efficient, $L > X - \Delta$. Then,*

(i) *for $w < 1 - L$, the incumbent is credit–rationed, i.e., external finance is not feasible.*

(ii) *for $w \geq 1 - L$, the incumbent invests. At date 1, the entrant enters and the incumbent exits.*

Inefficient Exit. Next, suppose $L \leq X - \Delta$. In this case, liquidation is (at least weakly) inefficient for the incumbent and the financier, regardless of whether the entrant enters or stays out. This, however, does not imply that entry does not occur. Following the low profit realization at date 1, the incumbent will have to default for liquidity reasons (as long as $R > 0$). Since the incumbent cannot commit to compensate the financier out of second period profits, the financier will exercise his liquidation right and downsize the incumbent by a fraction β. This may create room for profitable entry. Specifically, the entrant finds it profitable to enter if and only if[11]

$$\beta\overline{Y} + (1 - \beta)\underline{Y} > F \tag{1}$$

Conversely, in the high profit state, the incumbent will have sufficient cash to repay its debt (as we shall see below) and the financier will not seize its assets. In consequence, the entrant stays out.

Let ϕ denote an indicator that takes on the value one if and only if (1) holds, i.e.,

$$\phi = \begin{cases} 1 & \text{if } \beta > \lambda \equiv (F - \underline{Y})/(\bar{Y} - \underline{Y}) \in (0, 1) \\ 0 & \text{otherwise} \end{cases}$$

[11] We adopt the convention that in case of indifference the entrant stays out.

Since financiers compete, an optimal contract with investment (if feasible) maximizes the incumbent's payoff subject to the financier's break–even constraint (IR) and the incumbent's incentive constraint (IC). The incentive constraint ensures that the incumbent has no incentive to default strategically (i.e., pay out zero) in the high profit state. Formally, the problem is to

$$\max_{\beta\in[0,1],R} \quad \theta(\Pi - R + X) + (1-\theta)(1-\beta)\Big(\phi(X-\Delta) + (1-\phi)X\Big)$$

$$\text{s.t}$$

$$\theta R + (1-\theta)\beta L \geq 1 - w \tag{IR}$$

$$\Pi - R + X \geq \Pi - 0 + V \tag{IC}$$

where V is the incumbent's payoff following strategic default and renegotiation, which we now determine. Suppose the incumbent defaults in the high profit state. The financier is then entitled to seize a fraction β of the incumbent's assets. This would earn him βL. However, since liquidation is inefficient and the incumbent has actually realized profit Π, there is scope for renegotiation. Given that the incumbent has full bargaining power in renegotiation, it offers a payment βL in return for the financier waiving his liquidation right.[12] Therefore, $V = -\beta L + X$.

The financier's break–even constraint (IR) is obviously binding. Substituting this constraint into the objective function and the incentive constraint (IC), we can rewrite the problem as

$$\max_{\beta\in[0,1]} \quad \underbrace{\theta\Pi + X - (1-w)}_{\text{first best payoff}} - \overbrace{(1-\theta)\Big(\beta(X-L) + (1-\beta)\phi\Delta\Big)}^{\text{agency cost}} \tag{2}$$

$$\text{s.t.}$$

$$\beta \geq \frac{1-w}{L} \tag{IC'}$$

The problem reduces to minimizing the agency cost, i.e., the efficiency loss relative to the first best, subject to the reduced form incentive constraint (IC'). To see the intuition behind

[12]Notice that the incumbent is not liquidity–constrained in renegotiation, since $\beta L < 1 < \Pi$.

the agency cost, suppose for a moment that the incumbent did not face the threat of entry. In this case, the agency cost would be given by the expected surplus loss from inefficient liquidation, that is, $(1-\theta)\beta(X-L)$. The threat of entry gives rise to a second inefficiency, namely, $(1-\theta)(1-\beta)\phi\Delta$. This inefficiency stems from entry in the low profit state, and it materializes if and only if $\beta > \lambda$.

In the remainder of the paper, we assume that whenever external finance is feasible, investment is profitable for the incumbent.[13] We then have the following result:

Proposition 2 *Suppose exit following entry is inefficient, $L \leq X - \Delta$. Then,*

(i) *for $w < 1 - L$, the incumbent is credit–rationed.*

(ii) *for $w \geq 1 - L$, the incumbent invests. At date 1,*

  (a) *in the high profit state, the entrant does not enter and the incumbent does not exit.*

  (b) *in the low profit state, the entrant enters if and only if the incumbent's investment cost is sufficiently sunk, $L < (1-w)/\lambda$. The incumbent is partially downsized.*

Proof. By inspection, the objective function (2) is decreasing in β. Therefore, if external finance is feasible, then $\beta = (1-w)/L \equiv \beta(L)$.[14] This is feasible if and only if $w \geq 1 - L$. From the binding break–even constraint (IR), we have $R = \beta(L)L = 1 - w < \Pi$ (by $\Pi > 1$). Entry in the low profit state occurs if and only if $\beta(L) > \lambda$, which reduces to $L < (1-w)/\lambda$. ■

The overall effect of sunk costs on the incumbent's ability to deter entry into its market is thus ambiguous. In the high profit state, sunk costs are beneficial for the purpose of deterring entry: as the incumbent's initial investment becomes more sunk, and hence the resale value

[13] That is, we assume that the net present value of investment is positive.

[14] It is straightforward to show that if the financier had full bargaining power in renegotiation, then the optimal liquidation right would be given by $\beta = (1-w)/(\theta X + (1-\theta)L)$. This is decreasing in L, which is all that is needed for the qualitative results.

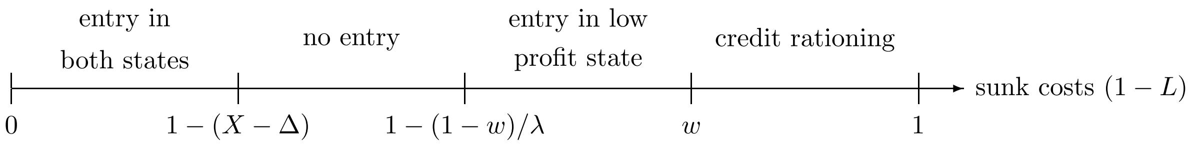

Figure 2: Sunk Costs and Entry Deterrence (case $w > 1 - \lambda(X - \Delta)$)

The figure illustrates the effect of sunk costs on the incumbent's ability to deter entry. For $1 - L < 1 - (X - \Delta)$, the entrant enters in both states. For $1 - L \in [1 - (X - \Delta), 1 - (1 - w)/\lambda]$, entry is completely deterred. For $1 - L \in (1 - (1 - w)/\lambda, w]$, the entrant stays out in the high profit state, but enters in the low profit state. For $1 - L > w$, the incumbent is credit–rationed.

of its assets decreases, it becomes less appealing to the incumbent to accommodate entry by liquidating assets and exiting the market. This makes entry by the prospective rival less profitable, and thereby facilitates entry deterrence. In the low profit state, however, the entry–deterring effects of sunk costs are less clear–cut. In our model, financiers are willing to provide funds only if they are given the right to liquidate part or all of the incumbent's assets in case of a default. This, in conjunction with the incumbent's inability to compensate lenders out of second period profits, implies that the incumbent will be partially liquidated in the low profit state, even if continuation would be efficient. This potentially creates room for profitable entry. Sunk costs exacerbate this effect: as the collateral value of assets decreases, lenders demand additional protection in the form of stronger liquidation rights. Consequently, a larger fraction of the incumbent's assets will be liquidated, and hence they will be more scope for profitable entry in the low profit state.

Figure 2 illustrates the effect of sunk costs for the case $w > 1 - \lambda(X - \Delta)$ (and $X - \Delta < 1$). In this case, the relationship between investment irreversibility and the incumbent's ability to deter entry is non–monotonic.[15] For low levels of investment irreversibility, the entrant

[15] For $w < 1 - \lambda(X - \Delta)$, the entrant enters in both states if $L > X - \Delta$ and enters in the low profit state if $L \leq X - \Delta$. Thus, in this case, the relationship between investment irreversibility and entry deterrence is monotonic.

enters in both states (and the incumbent exits). As investment becomes more irreversible, we reach the range where entry is completely deterred. As the level of investment irreversibility increases further, the incumbent eventually loses its ability to deter entry in the low profit state. Lastly, for very high levels of investment irreversibility, the incumbent is credit–rationed.

3 Endogenous Sunk Costs

Up to now, we have taken the degree to which the incumbent's investment cost is sunk as exogenously given. We now allow for endogenous sunk costs. Suppose there are two types of inputs in which the incumbent can invest: physical capital (e.g., machines) and R&D (e.g., human capital), each costing \$1 per unit. The purpose of R&D is to enhance the efficiency of installed physical capital. Specifically, we assume that the inputs are perfect substitutes: a decrease in physical capital by x units can be offset by increasing R&D by x units. The incumbent needs precisely one unit of input, be it physical capital, R&D, or a combination thereof. One unit of physical capital has a salvage value $\bar{L} > 0$ at date 1 and zero salvage value at date 2. Investment in R&D is assumed to be firm–specific and nonrecoupable in liquidation.[16]

Now, letting α denote the amount invested into physical capital, the liquidation value of the firm's assets at date 1 is given by $L = \alpha\bar{L}$. In this context, the incumbent can effectively choose the liquidation value of its assets: as more physical capital is substituted for R&D, investment becomes more irreversible and the resale value of assets decreases. We assume that the capital allocation decision is made *ex ante*, cannot be reversed *ex post*, and is observable to the entrant and financiers. The incumbent may have to install at least some physical capital; let $\alpha^{\min}$ denote this minimum amount. To make the analysis interesting, we assume

$$\alpha^{\min}\bar{L} < X - \Delta < \bar{L} < X$$

In other words, if the minimum level of physical capital is installed, then exit following entry

[16]We could allow for partial recoupability of R&D expenses; the qualitative insights would stay the same.

is inefficient; if the maximum level of physical capital is installed, then exit following entry is efficient; and in the absence of entry exit is never efficient. The following lemma simplifies the analysis:

Lemma 1 *If not credit–rationed, the incumbent either chooses $\alpha = 1$ (henceforth, "exit strategy") or $\alpha = (X - \Delta)/\bar{L} < 1$ (henceforth, "entry deterrence strategy").*

Proof. As seen earlier, if $L > X - \Delta$, then the incumbent's payoff is $\theta\Pi + L - (1 - w)$ (absent credit rationing). This expression is increasing in L. Thus, if $\alpha > (X - \Delta)/\bar{L}$ is optimal, then the incumbent chooses $\alpha = 1$ (and, hence, $L = \bar{L}$). Conversely, if $L \leq X - \Delta$, then the incumbent's payoff is

$$U = \begin{cases} \theta\Pi + X - (1 - w) - (1 - \theta)\beta(L) \times (X - L) & \text{if } L \geq (1 - w)/\lambda \\ \theta\Pi + X - (1 - w) - (1 - \theta)\Big(\beta(L) \times (X - L) + (1 - \beta(L)) \times \Delta\Big) & \text{otherwise} \end{cases}$$

where $\beta(L) \equiv (1 - w)/L$. This expression is also increasing in L. Thus, if $\alpha \leq (X - \Delta)/\bar{L}$ is optimal, then the incumbent chooses $\alpha = (X - \Delta)/\bar{L}$ (and, hence, $L = X - \Delta$). ■

Under the exit strategy, the incumbent accommodates entry by exiting. The incumbent thus maximizes the resale value of its assets. Under the entry–deterring strategy, the incumbent aims at deterring entry. To minimize the agency cost associated with this strategy, the incumbent maximizes the resale value of its assets subject to the constraint that exit following entry is inefficient.

The next proposition characterizes the equilibrium with endogenous sunk costs:

Proposition 3 *(equilibrium with endogenous sunk costs)*

(i) *for $w < 1 - \bar{L}$, the incumbent is credit–rationed.*

(ii) *for $w \in \Big[1 - \bar{L}, 1 - (X - \Delta)\Big)$, the incumbent adopts the exit strategy.*

(iii) *for $w \geq 1 - (X - \Delta)$, the incumbent adopts the entry deterrence strategy if*

$$\theta \geq \begin{cases} 1 - \frac{X - \bar{L}}{\Delta} & \text{if } w \in \Big[1 - (X - \Delta), 1 - \lambda(X - \Delta)\Big) \\ 1 - \frac{X - \bar{L}}{\Delta}\frac{X - \Delta}{1 - w} & \text{if } w \geq 1 - \lambda(X - \Delta) \end{cases} \tag{3}$$

where $\lambda = (F - \underline{Y})/(\bar{Y} - \underline{Y}) \in (0,1)$. *Otherwise, it adopts the exit strategy.*

If the incumbent chooses the exit strategy, then the entrant always enters. Conversely, if the incumbent chooses the entry deterrence strategy, then the entrant enters in the low profit state if and only if $w < 1 - \lambda(X - \Delta)$ *and stays out in the high profit state.*

Proof. Let $w_1 \equiv 1 - \bar{L}$, $w_2 \equiv 1 - (X - \Delta)$, and $w_3 \equiv 1 - \lambda(X - \Delta)$. External finance under the exit strategy is feasible if and only if $\beta(\bar{L}) \leq 1$, i.e., $w \geq w_1$. External finance under the entry deterrence strategy is feasible if and only if $\beta(X - \Delta) \leq 1$, i.e., $w \geq w_2$. Thus, for $w < w_1$, the incumbent is credit–rationed. For $w \in [w_1, w_2)$, only the exit strategy is feasible. Thus, the incumbent adopts the exit strategy. For $w \geq w_2$, both strategies are feasible. The incumbent adopts the entry deterrence strategy if and only if its payoff under the entry deterrence strategy is not smaller than its payoff under the exit strategy. This is equivalent to the agency cost under the entry deterrence strategy not being larger than the agency cost under the exit strategy. To derive the latter cost, notice that under the first best the incumbent would choose the entry deterrence strategy (since $X > \bar{L}$) and make a payoff of $\theta\Pi + X - (1 - w)$. The incumbent's payoff under the exit strategy is $\theta\Pi + \bar{L} - (1 - w)$. The agency cost under the exit strategy is thus given by $X - \bar{L}$. The agency cost under the entry deterrence strategy is in turn given by

$$C = \begin{cases} (1-\theta)\Big(\beta(L) \times (X - L) + (1 - \beta(L)) \times \Delta\Big)\Big|_{L=X-\Delta} = (1-\theta)\Delta & \text{if } w \in [w_2, w_3) \\ (1-\theta)\beta(L) \times (X - L)\Big|_{L=X-\Delta} = (1-\theta)\frac{1-w}{X-\Delta}\Delta & \text{if } w \geq w_3 \end{cases}$$

In sum, for $w \geq w_2$, the incumbent adopts the entry deterrence strategy if and only if $C \leq X - \bar{L}$. Solving this expression for θ gives (3). Lastly, under the exit strategy, the entrant obviously enters in both states. Under the entry deterrence strategy, the entrant enters in the low profit state if and only if $\beta(X - \Delta) \equiv (1 - w)/(X - \Delta) > \lambda$, which reduces to $w < w_3$. ■

Figure 3 provides an illustration.[17] Severely financially constrained incumbents are credit–

[17] Here, we assume $1 - \frac{X-\bar{L}}{\Delta}\frac{X-\Delta}{1-w_3} > 0$. Otherwise, all incumbents with $w \geq w_3$ adopt the entry deterrence strategy.

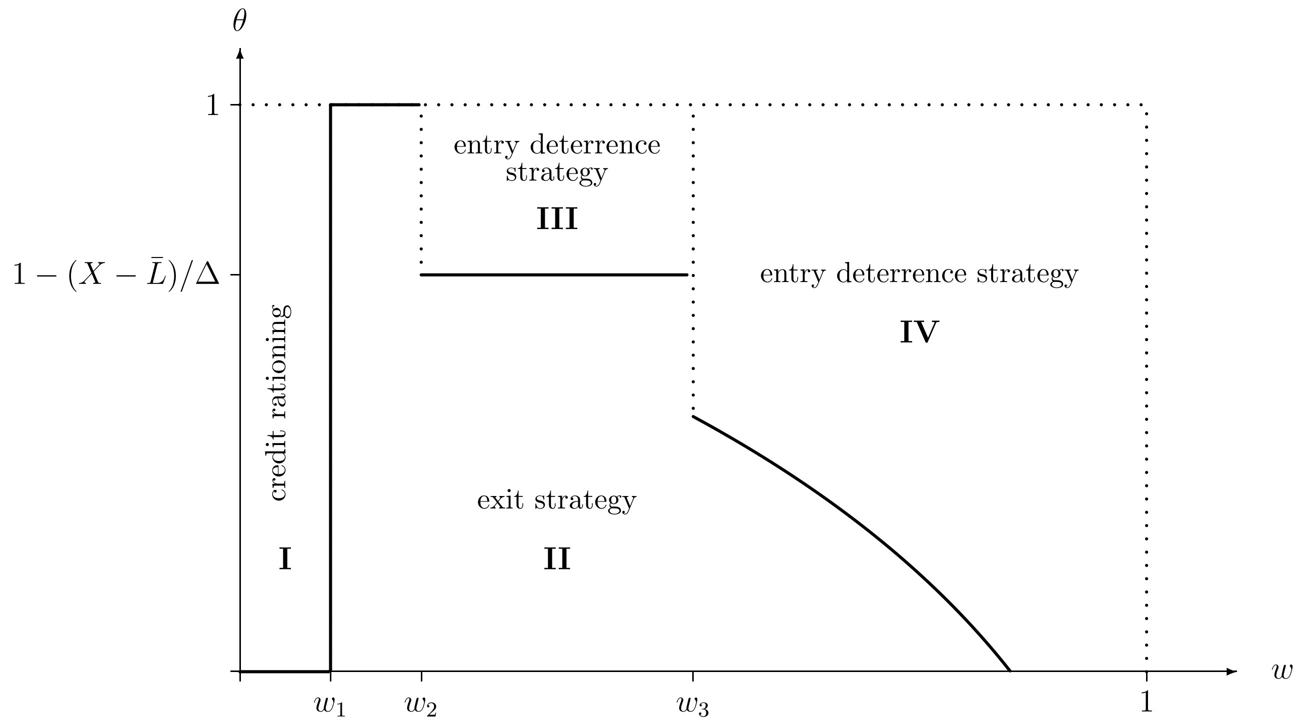

Figure 3: Equilibrium with Endogenous Sunk Costs

Severely financially constrained incumbents are credit–rationed (area I). Incumbents in area II adopt the exit strategy. Incumbents in area III adopt the entry–deterrence strategy. This enables them to deter entry in the high profit state. They do, however, experience entry in the low profit state. Incumbents in area IV adopt the entry–deterrence strategy and do not experience entry.

rationed (area I). Incumbents in area II adopt the exit strategy, i.e., they accommodate entry by exiting. Incumbents in area III adopt the entry deterrence strategy. This enables them to deter entry in the high profit state. They do, however, experience entry in the low profit state. Lastly, incumbents in area IV adopt the entry deterrence strategy and do not experience entry.

The comparative statics are as follows: as financial constraints become more binding (w decreases), the probability of the low profit state increases (θ decreases), or the cost of competition increases (Δ increases), the incumbent becomes more prone to choose the exit strategy. As the incumbent has less internal funds, it needs to borrow more. This forces the incumbent to give greater liquidation rights to its financier, which makes the entry deterrence strategy less attractive. As the probability of the low profit state increases, it becomes less likely that the incumbent can reap the benefit from deterring entry in the high profit state. Consequently, an increase in the probability of the low profit state makes the incumbent more prone to choose the exit strategy.

An increase in the cost of competition also makes the incumbent more prone the choose the exit strategy. The reason for this depends on whether or not entry in the low profit state can be avoided under the entry deterrence strategy. If entry in the low profit state cannot be avoided, then the agency cost under the entry deterrence strategy is given by the expected cost of entry, namely, $(1 - \theta)\Delta$. This is obviously increasing in Δ. Conversely, if entry in the low profit state is deterred, then Δ enters the agency cost via its effect on the resale value of the incumbent's assets under the entry deterrence strategy. Intuitively, to make exit following entry unattractive, the resale value of assets must be relatively low when the post–entry continuation profit $X - \Delta$ is low. An increase in Δ thus forces the incumbent to give greater liquidation rights to its lender, which makes the entry deterrence strategy less appealing.

4 Monitored Finance

We now extend the model towards monitored finance. Specifically, following Diamond (1984), we assume that the financier can resolve the moral hazard problem on the side of the incumbent by monitoring the firm. There is a fixed monitoring cost $K > 0$. For instance, one can think of monitoring as gathering hard evidence and making profits verifiable (as in the costly state verification literature; see, e.g., Townsend 1979 and Gale and Hellwig 1985), so that the incumbent could be severely punished if it defaulted strategically. Another interpretation of monitoring is that the financier visits the firm on a regular basis and prevents the incumbent from behaving opportunistically by being physically present. These activities are clearly costly for the financier; this is captured by the monitoring cost K. In making the choice between monitored and arm's length finance (i.e., the financing method considered above), the incumbent needs to trade off the inefficiencies of arm's length finance with the monitoring cost.

Consider the framework with endogenous sunk costs. The incumbent needs to choose a financing method (monitored or arm's length finance) and a business strategy (entry deterrence or exit strategy). Under monitored finance, the threat of termination is no longer needed to induce the incumbent to repay the financier. An optimal contract specifies repayments at date 1 and date 2 such that the financier just breaks even on his initial investment and the monitoring cost.[18] The incumbent adopts the entry deterrence strategy (since $X > \bar{L}$), and entry is fully deterred. Thus, monitored finance is equivalent to self–finance, except for the monitoring cost K. The incumbent's payoff under monitored finance is $\theta\Pi + X - (1-w) - K$, which we assume to exceed the incumbent's internal funds w (otherwise, monitored finance would never be the optimal financing choice).

The incumbent chooses monitored finance if and only if the monitoring cost does not exceed the agency cost under arm's length finance. The next lemma shows when monitored finance is the optimal financing choice (the wealth thresholds are defined in the proof of Proposition 3):

Lemma 2 *(choice between monitored and arm's length finance)*

(i) *for $w < w_1$, arm's length finance is not feasible. Thus the incumbent uses monitored finance.*

(ii) *for $w \in [w_1, w_2)$, the incumbent chooses monitored finance if and only if*

$$K \leq X - \bar{L} \tag{4}$$

(iii) *for $w \in [w_2, w_3)$, the incumbent chooses monitored finance if and only if*

$$K \leq \min[X - \bar{L}, (1-\theta)\Delta] \tag{5}$$

[18] It is worth noting that such a contract may well take the form of an equity claim.

(iv) *for $w \geq w_3$, the incumbent chooses monitored finance if and only if*

$$K \leq \min\left[X - \bar{L}, (1-\theta)\frac{1-w}{X-\Delta}\Delta\right] \tag{6}$$

If the incumbent chooses monitored finance, then entry is fully deterred. Conversely, if the incumbent chooses arm's length finance, then Proposition 3 applies.

Proof. Follows immediately from the preceding analysis. ■

We then have the following result:

Proposition 4 *The relationship between the incumbent's own financial resources and the extent to which entry is deterred may be non–monotonic. Specifically, very poor and very rich incumbents do not experience entry, while some incumbents with intermediate levels of internal wealth experience entry at least in the low profit state.*

Proof. From Lemma 2 we know that incumbents with internal funds $w < w_1$ use monitored finance, and hence deter entry. Clearly, very rich (w close to one) incumbents do not experience entry either. It remains to be shown that some incumbents with intermediate levels of internal wealth do experience entry. Notice that if $K > X - \bar{L}$, then all incumbents with internal wealth $w \geq w_1$ choose arm's length finance, and hence Proposition 3 applies. Conversely, if $K \leq X - \bar{L}$, then incumbents with $w \in [w_2, w_3)$ and $\theta > 1 - K/\Delta$ choose arm's length finance and the entry deterrence strategy, but experience entry in the low profit state. ■

Very poor incumbents are credit–rationed under arm's length finance, and hence they have no choice but to use monitored finance. Yet, given that they do so, entry will be deterred. Very rich incumbents do not experience entry either, regardless of their financing choice. Some incumbents with intermediate levels of internal funds may experience entry, however. Under arm's length finance, these incumbents either adopt the entry–deterrence strategy, in which case entry in the low profit state cannot be avoided, or they accommodate entry by exiting the market. At the same time, however, the inefficiencies under arm's length finance are not large

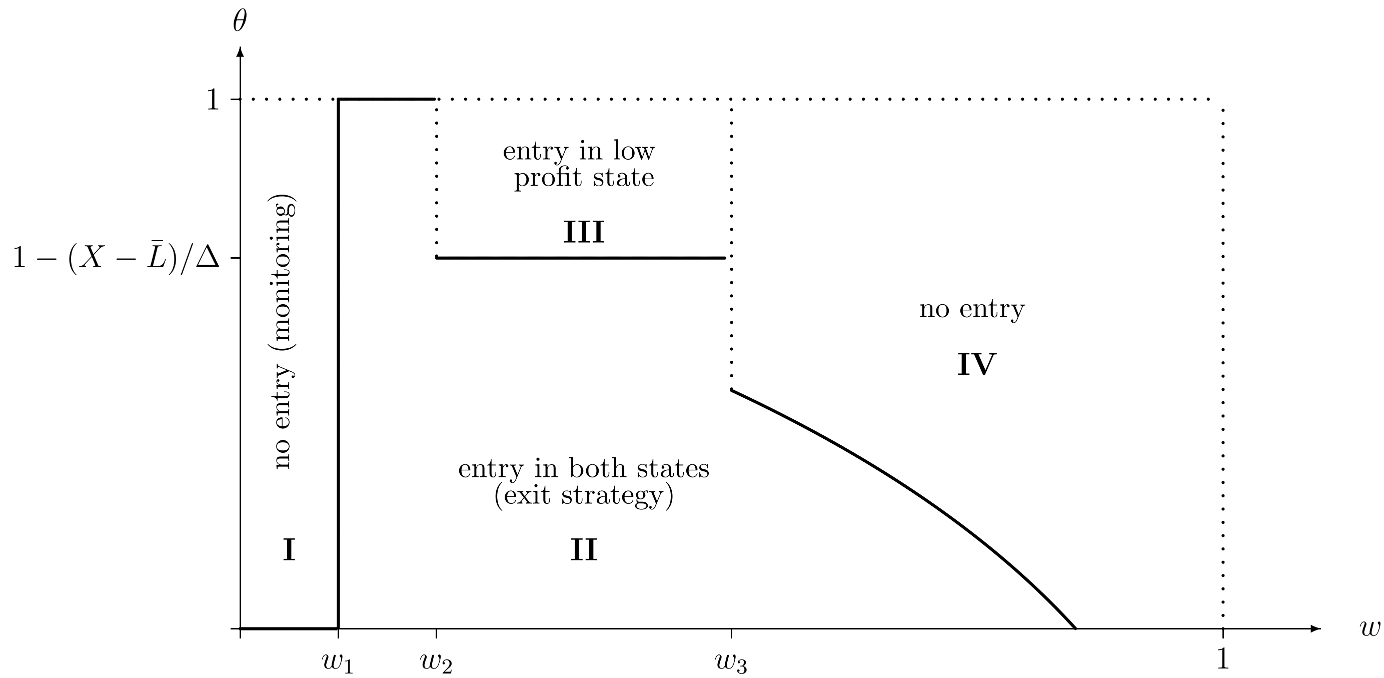

Figure 4: Equilibrium with Monitoring (case $K > X - \bar{L}$)

Incumbents in area I take monitored finance, and hence deter entry. Incumbents in areas II, III, and IV take arm's length finance, and hence Proposition 3 applies.

enough to justify choosing costly monitored finance. Thus, in equilibrium, these incumbents choose arm's length finance and experience entry at least in the low profit state.

Figure 4 illustrates the equilibrium with monitoring for the case $K > X - \bar{L}$. In this case, monitored finance is relatively expensive, as a result of which the incumbent chooses arm's length finance if feasible. Thus, Proposition 3 applies, except for those incumbents which are credit–rationed under arm's length finance. These incumbents use monitored finance, and hence deter entry. Figure 5 illustrates the equilibrium for the case $K \leq X - \bar{L}$. In this case, incumbents which adopt the exit strategy or are credit–rationed under arm's length finance use monitored finance (and hence deter entry). Some incumbents which adopt the entry deterrence strategy under arm's length finance but experience entry in the low profit state find monitored finance too costly. These incumbents choose arm's length finance and

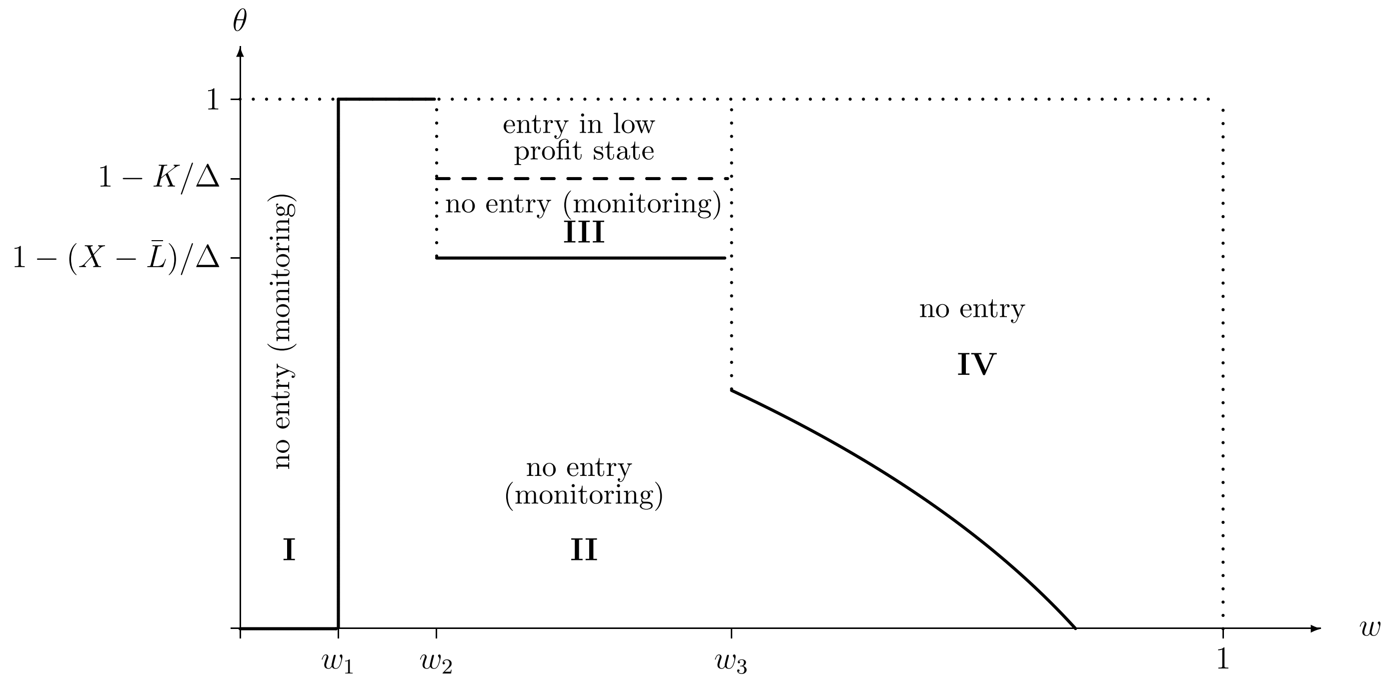

Figure 5: Equilibrium with Monitoring (case $K \leq X - \bar{L}$)

Incumbents in areas I and II take monitored finance, and hence deter entry. Incumbents in areas III take arm's length finance if and only if $\theta > 1 - K/\Delta$, in which case they experience entry in the low profit state. Otherwise, they take monitored finance and do not experience entry.

experience entry in the low profit state.

An interesting question which we now address is how the threat of entry shapes the choice between monitored and arm's length finance. Clearly, if the incumbent did not face the threat of entry (e.g., because it could effectively protect its market lead with a patent), then, under arm's length finance, it would maximize the liquidation value of its assets (i.e., $L = \bar{L}$) and derive a payoff of

$$\theta\Pi + X - (1 - w) - \underbrace{(1 - \theta)\frac{1 - w}{\bar{L}}(X - \bar{L})}_{\text{agency cost}}$$

Arm's length finance would be feasible if and only if $w \geq w_1$. Thus, in the absence of the entry threat, the incumbent would choose monitored finance if and only if $w < w_1$ or if $w \geq w_1$ and

$$K \leq (1-\theta)\frac{1-w}{\bar{L}}(X-\bar{L}) \tag{7}$$

We have the following result:

Proposition 5 *The threat of entry widens the set of parameter values for which the incumbent chooses monitored finance.*

Proof. We show that if the incumbent chooses monitored finance in the absence of the entry threat, then it will also choose monitored finance in the presence of the entry threat, and that the reverse is not true. For $w < w_1$, the incumbent chooses monitored finance regardless of whether it faces the threat of entry nor not. For $w \in [w_1, w_2)$, the incumbent chooses monitored finance in the presence of the entry threat if and only if (4) holds, i.e., $K \leq X - \bar{L}$. Yet,

$$(1-\theta)\frac{1-w}{\bar{L}}(X-\bar{L}) \leq X - \bar{L} \tag{8}$$

and hence (7) implies (4). For $w \in [w_2, w_3)$, the incumbent chooses monitored finance in the presence of the entry threat if and only if (5) holds. Yet,

$$(1-\theta)\frac{1-w}{\bar{L}}(X-\bar{L}) \leq \min[X-\bar{L}, (1-\theta)\Delta]$$

since $X - \bar{L} < \Delta$, and hence (7) implies (5). Lastly, for $w \geq w_3$, the incumbent chooses monitored finance in the presence of the entry threat if and only if (6) holds. Yet,

$$(1-\theta)\frac{1-w}{\bar{L}}(X-\bar{L}) \leq \min\left[X-\bar{L}, (1-\theta)\frac{1-w}{X-\Delta}\Delta\right]$$

since $X - \bar{L} < \Delta$, and hence (7) implies (6). Thus, if the incumbent chooses monitored finance in the absence of the entry threat, then it will also choose monitored finance in the presence of the entry threat. To show that the reverse is not true, it suffices to note that (8) holds with strict inequality for $\theta < 1$. ■

In other words, the threat of entry makes monitored finance more valuable. This can be explained as follows. Under the entry deterrence strategy, the incumbent chooses a relatively high level of investment irreversibility. Conditional on choosing arm's length finance, this comes at the expense of having more liquidation in the low profit state (relative to the no–entry scenario) and, potentially, entry in this state. Under the exit strategy, the incumbent maximizes the resale value of its assets and exits the market after the first period. If the incumbent did not face the threat of entry and chose arm's length finance, then it would continue in the high profit state (and hence reap the continuation profit X, rather than the liquidation value $\bar{L} < X$) and only partially exit in the low profit state. The threat of entry thus enlarges the agency cost under arm's length finance, thereby making monitored finance more valuable.

5 Conclusion

We developed a simple framework to analyze how sunk costs affect a financially constrained incumbent's ability to deter entry into its market. In the absence of financial constraints, sunk costs are unambiguously beneficial for the incumbent. Sunk costs make it less appealing to accommodate entry by liquidating assets in place. This may render entry by a prospective rival unprofitable, and thereby deter entry. With financial constraints, the entry–deterring effects of sunk costs are less clear–cut. In our model, financiers are willing to provide funds only if they are given the right to liquidate part or all of the incumbent's assets in case of a default. This, in conjunction with the incumbent's inability to commit to compensate financiers out of long–term profits, implies that the incumbent will be downsized in low profit states when it must default for liquidity reasons. This potentially creates room for profitable entry. Sunk costs exacerbate this effect: as the collateral value of assets decreases, financiers demand additional protection in the form of stronger liquidation rights. This entails more liquidation in low profit states, and hence more scope for profitable entry in these states. The overall effect of sunk costs on the incumbent's ability to deter entry may then turn out be non–monotonic: an initial increase in the degree to which investment costs are sunk may help to deter entry, but a further increase may give rise to more entry.

We endogenized sunk costs within a framework where fixed assets (physical capital), which have some salvage value, can be substituted for investment in firm–specific R&D. We showed that if the menu of financing options is restricted to arm's length finance, then there is a positive relationship between the incumbent's internal funds and the extent to which entry is deterred: cash–rich firms choose relatively high levels of investment irreversibility in an attempt to deter entry, while firms with more binding financial constraints prefer to maximize the resale value of their assets and accommodate entry by exiting the market. That is, as incumbents' own financial resources decrease and hence financial constraints become more binding, we should observe more exit (by incumbents) and more entry (by rivals). This implication is broadly in line with Kovenock and Phillips (1997) and Zingales (1998), who provide empirical evidence suggesting that, in concentrated industries, less leveraged firms (i.e., firms whose financial constraints are arguably less binding) tend to exit the product market less often. The implication is also consistent with Baskin (1987), who detects a positive relationship between firms' internal funds and their ability to earn *future* above–average profits.

However, casual empiricism also suggests that younger and smaller firms (i.e., firms whose financial constraints are arguably more binding) are often highly innovative and able to earn above–average profits. This seems to be in conflict with the previous observation. Extending the menu of financing options to monitored finance allows us to reconcile these observations. Once monitored finance is allowed for, the relationship between internal funds and entry deterrence may turn out to be non–monotonic. Firms with little internal funds use monitored finance, which allows them to deter entry. Cash–rich firms do not experience entry either. Firms with intermediate levels of internal funds may experience entry, however. Essentially, this is because for these firms, the inefficiencies of arm's length finance are not large enough to justify using costly monitored finance. Yet, under arm's length finance, these firms will experience entry at least in low profit states.

We also showed that the threat of entry makes monitored finance more valuable. In other words, if the incumbent could protect its market lead with a patent, then it would have less of an incentive to choose monitored finance. This suggests that in infant industries in which patent protection is not readily available, firms should have a relatively strong incentive to choose monitoring–intensive financing sources, such as venture capital. This may shed light on the role of venture capitalists in helping innovative firms to sustain their competitive advantages, as documented by Hellmann and Puri (2000). Consistent with their findings, our model suggests that the monitoring function of active financiers is particularly valuable when first mover advantages are to be protected.

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