A Theory of Predation Based on Agency Problems in Financial Contracting

Patrick Bolton; David S. Scharfstein

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By PATRICK BOLTON AND DAVID S. SCHARFSTEIN*

By committing to terminate funding if a firm's performance is poor, investors can mitigate managerial incentive problems. These optimal financial constraints, however, encourage rivals to ensure that a firm's performance is poor; this raises the chance that the financial constraints become binding and induce exit. We analyze the optimal financial contract in light of this predatory threat. The optimal contract balances the benefits of deterring predation by relaxing financial constraints against the cost of exacerbating incentive problems. (JEL 610)

In this paper, we present a theory of predation based on agency problems in financial contracting. Our work is closest in spirit to the "long-purse" (or "deep-pockets") theory of predation, in which cash-rich firms drive their financially constrained competitors out of business by reducing their rivals' cash flow.[1] Although the existing theory is suggestive, it begs important questions. Why are firms financially constrained? And, even if firms are financially constrained, why don't creditors lift these constraints under the threat of predation?

We attempt to answer these questions. In Section I, we present a model (which is of independent interest) in which financial constraints emerge endogenously as a way of mitigating incentive problems. We argue that the commitment to terminate a firm's funding if its performance is poor ensures that the firm does not divert resources to itself at the expense of investors. This termination threat, however, is costly in a competitive environment. Rival firms then have an incentive to ensure that the firm's performance is

indeed poor. This increases the likelihood that investors cut off funding, and induces premature exit.

In Section II, we analyze the optimal contract when firms and investors take this cost into account. In general, the optimal response to predation is to lower the sensitivity of the refinancing decision to firm performance. There are two ways of doing this. One is to increase the likelihood that the firm is refinanced if it performs poorly; the other is to lower the likelihood that the firm remains in operation even if it performs well. Both strategies reduce the benefit of predation by lowering the effect of predation on the likelihood of exit. We identify conditions under which each of these strategies is optimal.

There is a tradeoff between deterring predation and mitigating incentive problems; reducing the sensitivity of the refinancing decision discourages predation, but exacerbates the incentive problem. Depending on the importance of the incentive problem relative to the predation threat, the equilibrium optimal contract may or may not deter predation.

We are by no means the first to present a theory of rational predation. In the existing models of rational predation,[2] one firm tries

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*Department of Economics, Harvard University, Cambridge, MA 02138 and Sloan School of Management, MIT, Cambridge, MA 02139.
[1]See, for example, John McGee (1958), Lester Telser (1966), Jean-Pierre Benoit (1984), and Jean Tirole (1988).

[2]See for example, Steven Salop and Carl Shapiro (1982), David Scharfstein (1984), and Garth Saloner (1987). These papers draw much from the early work of Paul Milgrom and John Roberts (1982) on rational limit-pricing.

to convince its rivals that it would be unprofitable to remain in the industry; predation changes rivals' beliefs about industry demand or the predator's costs. In our model, there is common knowledge that production in each period is a positive net present value investment. Thus, predation need not be effective by changing rivals' beliefs, but rather by adversely affecting the agency relationship between the firm and its creditors. Drew Fudenberg and Jean Tirole (1986) have also argued that agency problems between creditors and the firm can result in financial constraints that induce predatory behavior by rivals. Their model differs from ours in that they consider only a sequence of one-period contracts and do not consider optimal responses to predation.

Our paper is also related to the recent work on the interaction between product-market competition and the capital market. James Brander and Tracy Lewis (1986) and Vojislav Maksimovic (1986) are among the earliest papers. They point out that because equity holders receive only the residual above a fixed debt obligation, the marginal production incentives of managers who maximize the value of equity depends on the debt-equity ratio. Therefore, investors can use capital structure to induce managers to compete more agressively, in the process affecting product-market equilibrium. There are two drawbacks of their work. First, it restricts attention to a subset of feasible financial instruments; under a broader set of instruments, product-market equilibrium would be very different. Our paper, in contrast, derives the set of feasible contracts from first principles and analyzes optimal contracts within that set. Second, in these papers, financial structure plays no role other than through its effect on product-market strategy. In our analysis, financial policy also affects agency problems within the firm.

These papers are similar in spirit to the work of John Vickers (1985) and Chaim Fershtman and Kenneth Judd (1987a, b) who analyze the effect of managerial incentive contracting (rather than financial contracting) on product-market competition. Like Brander and Lewis's model, firms gain competitive advantage by altering managerial objectives. For example, by basing compensation on sales, shareholders can induce the manager to produce more output. This may have strategic value if firms compete in a Cournot environment. Unlike Brander and Lewis's model, but like ours, the latter Fershtman and Judd paper analyzes optimal contracts. These contracts serve the dual function of mitigating agency problems and affecting product-market competition.

On a formal level, our basic framework is similar to work by Roger Myerson (1982) and Michael Katz (1987). These papers consider incentive problems between a principal and an agent in which the agent's performance both influences and is influenced by other parties. Although Myerson's development is in an abstract principal-agent setting and Katz's main application is to bargaining, this framework seems particularly well-suited to analyze the interaction between product-market competition and the capital market.

An important implication of our approach is that financial structure affects firms' financing costs as well as their gross profitability. Information and incentive problems in the capital market can determine the structure of the product market. This is in contrast to most models, in which capital structure only affects financing costs.[3]

Finally, we note that the dynamic nature of our of financial contracting has some novel features. We assume that contracts cannot be made directly contingent on profits. To induce managers to pay out cash flows to investors, the firm is liquated when its payouts are low. Liquidation occurs although it is inefficient, and the threat of liquidation is credible. The optimal dynamic financial contracts that we describe resemble standard debt contracts in many ways.

I. Contracting Without Predation

There are two firms labeled A and B, who compete in periods 1 and 2. At the beginning of each period, both firms incur a fixed cost,

[3]This is also a feature of Robert Gertner, Robert Gibbons, and Scharfstein (1988). In that paper capital structure decisions can convey information to both the capital and product markets.

F. The firms differ with respect to how they finance this cost. Firm A has a "deep pocket," a stock of internally generated funds which it can use to finance this cost. In contrast, firm B has a "shallow pocket"; it must raise all funds from the capital market.

The first step in our analysis is to characterize the contractual relationship between firm B and its sources of capital. We assume that there is one investor who makes a take-it-or-leave-it contract offer to firm B at the initial date 0, which firm B accepts if the contract provides nonnegative expected value. The assumption that the investor rather than the firm has all the bargaining power may seem unrealistic. This is particularly so for a firm issuing public debt or equity in a well-functioning capital market with many competing investors. However, young companies requiring venture capital, or older ones placing private debt or equity, are likely to bargain with investors. In reality, neither side has all the bargaining power; our assumption simply sharpens our results without affecting their essential character. Indeed, it will become clear below that the termination threat must be part of any feasible contract regardless of the competitive structure of the capital market.

Firm B's gross profit (before financing costs) in each period is either π_1 or π_2, where $\pi_1 < \pi_2$. At the beginning of each period, all players believe that $\pi = \pi_1$ with probability θ. Thus, we are assuming that profits are independently distributed across periods. We make this assumption to distinguish our results from models of predation (based on the limit-pricing model of Milgrom and Roberts, 1982) in which the incumbent firm tries to convince the entrant that it would be unprofitable to remain in the industry. These models rest on the assumption that the entrant's profits are positively serially correlated. As we argue below, we would strengthen our results by assuming that profits are positively correlated.

For simplicity, we assume that the discount rate is zero. We also assume that $\pi_1 < F$: with positive probability the investment loses money. Later we analyze the model under the assumption that $\pi_1 > F$ and argue that in that case as well the termination threat is valuable (although the analysis

raises some other issues). In both cases, the expected net present value of the investment is positive:

$$\bar{\pi} \equiv \theta \pi_1 + (1 - \theta) \pi_2 > F.$$

The agency problem we analyze stems from the impossibility of making financial contracts explicitly contingent on realized profit. There are two alternative interpretations of this assumption. One is that at the end of each period, the firm privately observes profit. The other is that profit is observable but not verifiable; although both the firm and investor can observe profit, the courts cannot, and hence these parties cannot write an enforceable profit-contingent contract.[4]

We do assume that the investor can force the firm pay out a minimum of π_1 in each period. If the courts know that this is the minimum possible profit, then a contract of this form is feasible. This assumption amounts to the claim that π_1 is the verifiable component of profit and the residual $\pi_2 - \pi_1$ is the non-verifiable component.

There are at least three reasons for assuming that contracts cannot be made fully contingent on realized profit. First, it is often difficult to judge whether particular expenses are necessary; what look like justifiable expenses may really be managerial perquisites with no productive value. Thus, there is scope for managers to divert resources away from investors to themselves. A second, related reason is that the firm might be affiliated with another firm, thus providing some flexibility in the joint allocation of costs and revenues. Finally, from a methodological perspective, the assumption that profits are not observable generates simple and intuitive results that generalize to a wide variety of

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[4] In many situations, the latter interpretation is more plausible; an investor is often closely involved in the firm's operations, whereas the courts are not. Irregular accounting practices can make it difficult for outside parties to know the firm's true profitability. Although these assumptions have the same implications in the basic model we analyze, they will have different implications if renegotiation is possible. We discuss this in more detail in Section II, Part B.

realistic agency models. One such model is discussed in Section II, Part B.[5]

In a one-period model, the investor would not invest in the firm. To see this, let R_i be the transfer from the firm to the investor at date 1 if the manager reports that profit is π_i, $i = 1, 2$. Assuming limited liability protects the firm and its managers, and that the firm has no other assets, R_i can be no greater than π_i. Clearly, it will report the profit level that minimizes financing costs. Since $R_i \leq \pi_i$, at date 1 the investor can receive at most $\pi_1 < F$ and hence would always lose money. If instead the relationship lasts for two periods, the investor can control whether the firm receives financing in the second period. The investor can threaten to cut off funding in the second period if the firm defaults in the first. This threat induces the firm to pay more than π_1 in the first period. Note that this threat is credible; since $\pi_1 - F < 0$, no investor wishes to finance the firm in the second period.

Formally, we analyze the contract-design problem as a direct revelation game, in which the terms of the contract are based on the firm's report of its profit. In particular, suppose the investor gives the firm F dollars at date 0 to fund first-period production. As in the above one-period model, let R_i be the transfer at date 1 if the firm reports profits of π_i in the first period. Let $\beta_i \in [0,1]$ be the probability that the investor gives the firm F dollars at date 1 to fund second-period production if the firm reports π_i in the first period.[6] We assume that without this second-round financing the firm lacks the necessary funds to operate in the second period.[7] Finally, let R_{ij} be the transfer from the firm to the investor at date 2 if the first-period

report is π_i and the second-period report is π_j.

It is clear from the argument presented above for the one-period model that $R_{i1} = R_{i2}$; the second-period transfer cannot depend on second-period profit because the firm would always report the profit level corresponding to the lower transfer. Thus, let R^i be the second-period transfer if the first-period reported profit is π_i. It follows from the limited liability assumption that $R^i \leq \pi_i - R_i + \pi_1$; the second-period transfer cannot exceed the surplus cash from the first period, $\pi_i - R_i$, plus the minimum profit in the second period, π_1.[8]

The optimal contract maximizes the expected profits of the investor subject to the following constraints: (1) the firm truthfully reveals its profit at dates 1 and 2 (incentive compatibility); (2) the contract does not violate limited liability; (3) the firm opts to sign the contract at date 0 (individual rationality). Formally, the problem is the following:

$$\underset{\{\beta_i, R_i, R'\}}{\text{Maximize}} - F + \theta \left[R_1 + \beta_1 (R^1 - F) \right]$$

$$+ (1 - \theta) \left[R_2 + \beta_2 (R^2 - F) \right],$$

subject to

$$(1) \quad \pi_2 - R_2 + \beta_2 (\bar{\pi} - R^2)$$

$$\geq \pi_2 - R_1 + \beta_1 (\bar{\pi} - R^1);$$

$$(2) \quad \pi_i \geq R_i,$$

$$(2') \quad \pi_i - R_i + \pi_1 \geq R^i, \quad i = 1, 2;$$

$$(3) \quad \theta \left[\pi_1 - R_1 + \beta_1 (\bar{\pi} - R^1) \right]$$

$$+ (1 - \theta) \left[\pi_2 - R_2 + \beta_2 (\bar{\pi} - R^2) \right]$$

$$\geq 0.$$

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[5]Robert Townsend (1979) and Douglas Gale and Martin Hellwig (1985) present models in which investors and firms can write profit-contingent contracts for some finite cost; this contrasts with our assumption of infinite costs. Below, we discuss the relationship between these models and ours.

[6]For now, we are assuming that there exists an enforceable randomization scheme. We discuss this assumption in greater detail below.

[7]One can show that this amounts to assuming that $\pi_2 - \pi_1 < F$.

[8]Implicit in this formulation is the assumption that the firm must keep profits (net of transfers to the investor) in the firm between dates 1 and 2, but that at the end of period 2 any profit left over can be consumed by the entrepreneur. This is consistent with the assumption that profits cannot be observed.

The incentive-compatibility constraint (1) ensures that when profit is high the firm does not report that profit is low. If profit is π_2, the firm receives some surplus in the first period if it reports π_1 since $R_1 \leq \pi_1 < \pi_2$; however, by setting $\beta_1 < \beta_2$ the investor makes it costly for the firm to report π_1, since the firm generally receives surplus in the second period.

We have omitted the incentive-compatibility constraint ensuring that the firm reports π_1 rather than π_2. We demonstrate later that this constraint is not binding. Note also that the limited-liability constraints (2) and (2') imply that the individual-rationality constraint (3) is not binding.

The following two lemmas, which we prove in the Appendix, simplify analysis of the optimal contract.

LEMMA 1: *The incentive compatibility constraint* (1) *is binding at an optimum.*

LEMMA 2: *There exists an optimal contract in which second-period transfers,* R^1 *and* R^2, *equal* π_1.

Lemma 1 is a typical feature of contracting problems. Lemma 2 establishes that the investor can receive at most π_1 from the firm in the second period because there is no termination threat at that time.

These two lemmas simplify the maximization problem to

$$(4) \quad \text{Maximize} - F + R_1$$
$$+ \beta_2 (1 - \theta)(\bar{\pi} - F)$$
$$- \beta_1 [\theta F + (1 - \theta)\bar{\pi} - \pi_1],$$

subject to the limited-liability constraint, $\pi_i \geq R_i$, $i = 1, 2$.

Let $\{R_1^*, \beta_1^*, R_2^*, \beta_2^*\}$ denote the optimal contract. It follows immediately that $R_1^* = \pi_1$ and $\beta_2^* = 1$. Moreover, because both F and $\bar{\pi}$ exceed π_1, the last bracketed term is positive. Thus, $\beta_1^* = 0$. It then follows from the incentive-compatibility constraint (1) that $R_2^* = \bar{\pi}$. Finally, this contract satisfies the limited-liability constraints and (given that

$R_2^* = \bar{\pi} > \pi_1$) the omitted incentive constraint.[9]

There are two reasons why the investor cuts off funding if the firm reports low profits. First, the investor avoids losing $F - \pi_1$ in the second period. Second, it induces the firm to report profits truthfully, enabling the investor to extract more surplus from the firm in the first period. To see this, note that the incentive constraint implies

$$(5) \quad R_2^* = \pi_1 + (1 - \beta_1)(\bar{\pi} - \pi_1).$$

The term $\bar{\pi} - \pi_1$, is the firm's expected surplus in the second period given it operates then. By reporting π_1 rather than π_2, the firm reduces by $(1 - \beta_1)$ the probability that it receives this surplus. A marginal reduction in β_1 therefore lowers by $\bar{\pi} - \pi_1$ the expected value of reporting π_1. Hence, it increases by $\bar{\pi} - \pi_1$ the amount the investor can require the firm to pay when it reports profit of π_2.

Finally, we must determine the conditions under which the investor earns nonnegative profit. Given the optimal contract, the investor's expected profits are $\pi_1 - F + (1 - \theta)(\bar{\pi} - F)$. Thus, for the investor to invest at date 0, F can be no greater than $\bar{\pi} - (\bar{\pi} - \pi_1)/(2 - \theta)$. As a result, some positive net present value projects may not be funded.

We summarize these results in the following proposition.

PROPOSITION 1: *The investor invests at date* 0, *if and only if* $F < \bar{\pi} - (\bar{\pi} - \pi_1)/(2 - \theta)$. *In this case,* $R_1^* = \pi_1$, $\beta_1^* = 0$, $R_2^* = \bar{\pi}$, $\beta_2^* = 1$; *the firm operates in the second period if and only if its first-period profits are* π_2.

The proposition implies that there is an *ex post* inefficiency; the firm is liquidated when first-period profit is π_1 even though

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[9] Note that the firm weakly prefers to announce the true profit, when first-period profit is π_1. If the firm reports π_2, it is unable to make its first-period payment. In this case, the investor is paid π_1 and does not refinance the firm. The firm is then indifferent between the profit reports, in which case we assume that it reports its true profit.

$\bar{\pi} > F$ and it is efficient to operate.[10] It is natural to ask whether, at date 1, after first-period profit of π_1 is realized, the two parties wish to tear up the original contract and renegotiate a mutually beneficial arrangement. Note, however, that although it is efficient to produce, the most the investor can receive from the firm is $\pi_1 < F$. Thus, it is impossible to negotiate around the contractually specified inefficiency and no other investor would be willing to lend money. *Our results therefore do not depend on the assumption that renegotiation is impossible or that other investors are irrational.*[11]

A. *Discussion*

The main point of the analysis is that a firm's performance affects its financing costs *and* its access to capital. This result is quite general and captures an important feature of corporate-financing arrangements. For example, in venture-capital financing the venture capitalist rarely provides the entrepreneur with enough capital up front to see a new product from its early test-marketing stage to full-scale production. (See William Sahlman, 1986.) Instead, typical venture-financing arrangements take the form of "staged capital commitment." Initially, the venture capitalist provides enough money to finance the firm's start-up needs like research and product development. Conditional on the firm's performance in this early stage, the venture capitalist may provide further financing to fund test-marketing, and then full-scale production.

There are at least two reasons why such contracts are used. First, they mitigate adverse selection problems. Entrepreneurs who have confidence in the venture accept contracts of this form more willingly because they know that when they return for more funding it will be at favorable terms. This point is similar to Mark Flannery's (1986) explanation of short-term debt and Benjamin Hermalin's (1986) argument that more able workers will sign short-term contracts to signal their ability. Second, staged financing arrangements reduce incentive problems between entrepreneurs and financiers. Requiring the firm to return to the venture capitalist for further funding limits the extent to which management can pursue its own interests (like consuming excess cash) at the expense of the venture capitalist. Our model formalizes this second benefit of staged capital commitment.

The model applies to more than just venture capital. Any disbursement of corporate funds through, for example, debt payments, dividends, or share repurchases, increases the chance that the firm will be unable to finance investment internally and must return to the capital market for further financing. And, as argued above, the commitment to go back to the capital market can increase value either through the information it conveys or its effect on managerial incentives. Michael Jensen (1986) has made a similar point: forcing managers to pay out cash prevents them from spending free cash flow on unprofitable investment projects.

Joseph Stiglitz and Andrew Weiss (1983) have also argued that the termination threat is an effective incentive device. Their analysis, however, differs from ours in two ways: the contracts they consider are not optimal; and the incentive problem concerns the choice of project riskiness rather than the observability of profits.

Finally, the agency problem we analyzed is related to the one-period models of Townsend (1979) and Gale and Hellwig (1985). In these models, the investor has a costly inspection technology that enables him to make payments contingent on profits. The optimal contract specifies that if the firm reports low enough profits, then the investor inspects and confiscates all of the firm's profits. Thus, inspection in these models plays the same role as the termination

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[10] This result is reminiscent of Townsend (1982) where an inefficiency in the second period facilitates trade in the first period. Like our model, trade cannot be supported if there is only one period.

[11] A more subtle set of questions arise if the firm reports π_1, when profits are really π_2 and then tries to renegotiate the contract. We turn to this question in the next section.

threat.[12] There is one important difference, however. In the inspection models it is never optimal for the investor to inspect once the firm has reported low profits even though the contract calls for him to do so; at this point, the investor knows the firm's profits and need not inspect. Thus, the inspection threat is not credible. In contrast, the termination threat in our model is credible; since $\pi_1 < F$, the investor always prefers to cut off funds when the firm's profits are low.[13]

B. *Extensions*

Other Agency Problems. Our model focuses on a particular agency problem, which enables us to make our point in the simplest possible way. We believe that the termination threat is useful for a wide variety of agency problems. The following example exhibits how this basic idea extends to the familiar effort-elicitation model of agency. This model also shows that our results do not depend on the assumption that profits are privately observed.

Suppose there are two periods of production and that in each period the manager can "work" or "shirk." By working, the risk neutral manager increases the probability that profit is π_2, but he incurs a utility cost. If the manager has limited wealth or is protected by limited liability, investors cannot sell him the entire firm (which is otherwise the optimal solution to the moral-hazard problem when the manager is risk neutral). This implies that if there is only one period of production, the manager must receive some expected surplus to induce him to work. (See Sappington, 1983, for a result along these lines.) This is analogous to the result in the one-period model considered above in which the firm receives an expected surplus

of $\bar{\pi} - \pi_1$. The manager, therefore, bears a cost if the firm is not refinanced. Thus, the threat of not refinancing the firm raises the cost of shirking; the investor can then induce greater effort at lower cost.

Correlation in Profits. In this model, profits are independently distributed across periods. Thus, unlike many multiperiod agency models, the principal (investor) learns nothing about the agent's (firm's) profitability over time. We can extend the model to the case where profits are positively serially correlated. In fact, this strengthens our results.

Let $E(\pi|\pi_i)$ be expected second-period profits conditional on first-period profits, π_i. With positive serial correlation, $E(\pi|\pi_2) > \bar{\pi}$ and $E(\pi|\pi_2) > E(\pi|\pi_1)$. It is straightforward to establish that the optimal contract sets $\beta_1^* = 0$, $\beta_2^* = 1$, $R_1^* = \pi_1$, and $R_2^* = E(\pi|\pi_2)$. Since the firm's expected surplus in period 2 is greater when first-period profit is π_2, it loses more if it is not refinanced. This reduces the manager's incentive to underreport profits and enables the investor to extract more rent from the firm.[14]

Capacity Expansion. So far we have interpreted β_i as the probability of refinancing. Alternatively, we can interpret β_i as a capacity-expansion parameter; the investor commits to a staged capital-expansion plan contingent on the firm's first-period performance. By this we mean that if profits are π_i, the investor gives the firm enough money to increase capacity by an amount $\beta_i F$. We assume this increases expected profits by $\beta_i \bar{\pi}$.[15] Under this interpretation, we drop the constraint $\beta_i \in [0,1]$, and suppose that β_i lies in some interval $[\underline{\beta}, \bar{\beta}]$. These assumptions preserve the basic structure of our model. Thus, the investor sets $\beta_1 < \beta_2$ to mitigate incentive problems.

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[12] In our model, if inspection costs are finite, one can show that the investor would never simultaneously use both inspection and the refinancing threat. So if inspection costs are high enough, only the refinancing threat is used.

[13] We are grateful to Julio Rotemberg for pointing out this difference between the models.

[14] If the firm's profits are negatively correlated over time, it loses less if it is not refinanced and it is more difficult for the investor to extract rent from the firm. However, situations in which profits are negatively correlated over time seem rather implausible.

[15] The assumption that expected profits are linear in β is strong, but it could be relaxed without much difficulty.

Renegotiation. The model assumes that renegotiation is not feasible. Suppose instead that after profits are realized the firm and investor can renegotiate mutually beneficial changes in the contract. Further, suppose that profits are observable to both parties (although not verifiable).

If profits are π_2 but the firm reports π_1, under the terms of the contract the firm is not supposed to receive any further financing. However, the firm has leftover cash of $\pi_2 - \pi_1$. Thus, if $\pi_2 - \pi_1 > F$, the firm can finance second-period investment with its own funds. In this case, it is impossible to induce the firm to pay more than π_1 in the first period and thus no investor would finance investment.[16]

This result rests on the assumption that investors cannot enforce a covenant restricting further investment by the firm; however, if investment is verifiable, such a covenant is feasible. Thus, suppose the investor and firm agree on this covenant at date 0 and suppose the firm decides to report π_1 when its profit is π_2. Without permission from the investor, the firm is prohibited from further investment and is forced to liquidate.

Liquidation, however, is inefficient and we would expect the parties to renegotiate around this covenant. Thus, whether the firm is willing to deviate (by reporting π_1 rather than π_2) depends on the outcome of the renegotiation process. If the firm has none of the bargaining power, the most it stands to gain from deviating is $\pi_2 - \pi_1$, which is exactly what it would get if it did not deviate. Since the firm is indifferent between the two alternatives, we can assume it would report profits truthfully. If, instead, the firm has some of the bargaining power during renegotiation, it can extract some of the efficiency gains and thus will earn more than $\pi_2 - \pi_1$ from deviating. Thus, the contract is not "renegotiation-proof" and not incentive compatible.

A renegotiation-proof can be designed, however. Suppose that the firm stands to gain a fraction, α, of the efficiency gain from investing, $\bar{\pi} - F$. Then instead of requiring the firm to pay $\bar{\pi}$ if it reports π_2, a renegotiation proof contract requires the firm to pay $\bar{\pi} - \alpha(\bar{\pi} - F)$; this makes the firm indifferent between reporting π_2 truthfully and reporting π_1 and then renegotiating.

The more bargaining power the investor has (the greater is α), the less the investor can require the firm to pay when it reports profit of π_2. If α is large enough so that the firm has most of the bargaining power then the renegotiation-proof payment is so low that the investor cannot cover his financing costs. For example, if α equals one, the firm pays F when profit is π_2 and π_1 when profit is π_1; these payments are not enough to cover the investor's costs. In this case, the possibility of renegotiation at date 1 drives out investment at date 0. There is, however, a wide range of parameter values for which the threat of renegotiation does not affect investment behavior.

The same analysis essentially applies when $\pi_2 - \pi_1 < F$. The only difference is that in this case the firm need not write a covenant against further investment since the firm must return to the investor to raise additional funds. The investor may be willing to lend because the firm has collateral of $\pi_2 - \pi_1$. By reducing the required payment when profit is π_2, the investor can ensure that the contract is renegotiation proof. It may, also, be efficient to restrict the firm from borrowing funds elsewhere because such borrowing induces competition among creditors and transfers some of the bargaining power to the firm.

Other Extensions. The results are easily generalized to a continuum of profit levels. One can show that if first-period profits are greater than $\bar{\pi}$, $\beta = 1$ and the firm pays back $\bar{\pi}$ in the first period. If profits are below $\bar{\pi}$ the firm pays back all of its first-period profits and it is refinanced with some probability between zero and one; the greater the firm's profits the greater the likelihood it is refinanced. In many ways, this contract resembles a debt contract: the firm is supposed

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[16]Note that if profit is indeed π_1 there are no excess funds so that the firm cannot invest in violation of the prohibition.

to pay back $\bar{\pi}$; if it does not, all of its profits are paid over to the creditor and there is some chance that the firm is liquidated.

One can also extend the model to assume that there is competition among investors at date 0 so that effectively the firm has all the bargaining power initially. In this case one can show that the contract involves $\beta_2^* = 1$ and $1 > \beta_1^* > 0$. The termination threat will still be used, but to a lesser extent and the contract will be more efficient.

II. Predation and the Optimal Contract

In this section we model explicitly the interaction between the firm's financial policy and product-market competition. To begin, suppose the investor and firm B ignore the existence of firm A when designing an optimal financial contract; they assume that (stochastic) profits are exogenous. In this case, the financial contract is as described above. But, this makes it attractive for firm A to prey. If firm A can lower firm B's expected first-period profit (say, by reducing its price or increasing its advertising), then it can increase the probability that firm B exits. Firm A will do so if the costs of taking such actions are less than the expected benefits of becoming a monopolist.

To formalize these ideas, we model predation as follows: for a cost $c > 0$, firm A can increase from θ to μ the probability that firm B earns low profit, π_1, in period 1. If firm B exits, firm A becomes a monopolist and its second-period expected profits are π^m. If, instead, firm B remains in the market, firm A's expected profits are π^d. Thus, given a contract in which the pair $(\beta_1, \beta_2) = (0, 1)$, the expected benefits of predation are $(\mu - \theta)(\pi^m - \pi^d)$. It preys provided $(\mu - \theta)(\pi^m - \pi^d) > c$, or defining $\Delta \equiv c / [(\mu - \theta)(\pi^m - \pi^d)]$, if $\Delta < 1$. If it does prey, the investor's expected profits are $\pi_1 - F + (1 - \mu)(\bar{\pi} - F)$.

More generally, given any financial contract of firm B, firm A preys if $(\beta_2 - \beta_1)(\mu - \theta)(\pi^m - \pi^d) > c$ or $(\beta_2 - \beta_1) > \Delta$. Hence, the benefits of predation depend on firm B's financial contract. Note that when the investors of firm B ignore the possibility

of predation, they maximize the benefit of predation to firm A, since $\beta_2 - \beta_1$ is largest when $\beta_2 = 1$ and $\beta_1 = 0$. *The contract that minimizes agency problems, maximizes the rival's incentive to prey.* To make the analysis interesting, we assume for the remainder of the paper that the parameters are such that if $\beta_2 = 1$ and $\beta_1 = 0$, it is optimal to prey, that is, $\Delta < 1$.

To analyze the effect of financial contracting on product-market equilibrium we need to make two further informational assumptions. First, we assume that the courts cannot observe firm A's predatory action. This is a reasonable assumption in light of the difficulties legal scholars and economists have encountered in defining predation. And, even if a reasonable definition of predation did exist, the information that the courts would need to use it could make enforcement unworkable. For example, the courts would need detailed knowledge of demand functions to know whether a firm's advertising and pricing policies were predatory.[17]

Given that the court cannot observe predation, firm B and the investors cannot make the contract contingent on the predatory action of firm A. Notice that we do allow firm B and its investors to observe firm A's predatory actions. This distinguishes our model from signaling (Milgrom and Roberts, 1982) and signal-jamming (Fudenberg and Tirole, 1986) models of predation which rely on the assumption that predation is not observable.

Our second informational assumption concerns the observability by firm A of the contract between firm B and its investors. If the predator can observe the contract, then the investor can use the contract to influence firm A's actions. By reducing the sensitivity of the refinancing decision to first-period profit, that is, reducing the difference be-

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[17]See, for example, Paul Joskow and Alvin Klevorick (1979) for one attempt at defining predation and a discussion of the difficulties in doing so. See Scharfstein (1984) for a model which takes account of the costs of detecting predation.

tween β_2 and β_1, the investor reduces the gains from predation. For small enough values of $(\beta_2 - \beta_1)$ he deters predation. He can do so by strengthening the commitment to refinance the firm, that is, increasing β_1. In the extreme, he can deter predation by setting $\beta_2 = \beta_1 = 1$. That is, the investor can give firm B a "deep pocket," a commitment of resources to finance investment in both periods. Alternatively, the investor can deter predation by refinancing the firm less often, that is, reducing β_2. We refer to this as a "shallow-pocket" strategy.

In many cases it is reasonable to suppose that contracts are observable; for example, the Securities and Exchange Commission requires all publicly held firms to disclose information on their financial structure. For privately held companies, however, there is no disclosure requirement. It may be more reasonable to assume that for these firms financial contracts cannot be observed. We therefore consider the two cases of observable and unobservable contracts.[18]

A. Observable Contracts

If contracts are observable, the investor can ensure that firm A does not prey by writing a contract that satisfies the following "no-predation constraint":

(6) $(\beta_2 - \beta_1)(\mu - \theta)(\pi^m - \pi^d) \le c$, or

(6') $(\beta_2 - \beta_1) \le \Delta$.

That is, the investor can deter predation by reducing the sensitivity of the contract to firm B's performance.

Recall that our formulation assumes that there exists a public randomization technology enabling the investor to set $\beta_i \in (0,1)$. Without such a technology, the investor is restricted to deterministic schemes. This means the only feasible contract in which the firm enters must set $(\beta_1, \beta_2) = (0,1)$. Thus, one cannot deter predation in this case. This strengthens our point that preda-

tion can occur as an equilibrium phenomenon.

To determine the efficient contractual response to predation if randomization is feasible (or if we interpret β as a capacity-expansion parameter), we first analyze the optimal contract that deters predation. We then compare this contract to the optimal contract given predation. The investor chooses the contract with the higher payoff, provided it earns nonnegative profit.

The optimal predation-deterring contract solves the following program:

$$\max_{\{\beta_1, R_i\}} -F + \theta[R_1 + \beta_1(\pi_1 - F)]$$
$$+ (1 - \theta)[R_2 + \beta_2(\pi_1 - F)],$$

subject to the incentive constraint (1), the limited-liability constraint (2), and the no-predation constraint (6').

This maximization problem is identical to the problem analyzed in Section I except for the constraint (6') which ensures that no predation occurs in the first period. At an optimum, this constraint is binding and $\beta_2 - \beta_1 = \Delta$; otherwise, the optimal solution would be $\beta_2 = 1$, $\beta_1 = 0$, firm A would prey, and the constraint would be violated. Observing that, as before, $R_1 = \pi_1$, the binding incentive constraint (1) becomes $R_2 = \Delta\bar{\pi} + (1 - \Delta)\pi_1$. Substituting these equalities into the objective function, we reduce the maximization problem to

$$\max -F + \beta_1(\pi_1 - F) + (1 - \theta)\Delta(\bar{\pi} - F).$$

It then follows that $\beta_1^* = 0$ and $\beta_2^* = \Delta$; *the investor optimally deters predation by lowering the probability that the firm is refinanced when its profits are high.* This deters predation because there is little incentive for firm A to pay a cost, c, to ensure that profits are low. But, why lower β_2 rather than increase β_1? A change in either of these two variables has the same effect on the no predation constraint and the incentive constraint. However, increasing β_1 is costly because it increases the probability that the investor loses $F - \pi_1$ in the second period, whereas lowering β_2 reduces this probability.

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[18]For more discussion of the different implications of contract observability, see Katz (1987).

Finally, note that the expected profit from following this predation-deterring strategy is $\pi_1 - F + (1 - \theta)\Delta(\bar{\pi} - F)$. Thus, conditional on entering, firm B chooses to deter predation provided $(1 - \theta)\Delta > 1 - \mu$. And, if $\pi_1 - F + \max\{(1 - \theta)\Delta, 1 - \mu\}(\bar{\pi} - F) > 0$, it will be profitable to enter. We summarize these results below.

PROPOSITION 2: *Firm B enters if and only if*

$$\pi_1 - F + \max\{(1 - \theta)\Delta, 1 - \mu\}(\bar{\pi} - F) \geq 0.$$

If B enters, and $(1 - \theta)\Delta \geq 1 - \mu$, the optimal contract deters predation. In this case, $\beta_1^* = 0$, $R_1^* = \pi_1$, $\beta_2^* = \Delta$, and $R_2^* = \Delta\bar{\pi} + (1 - \Delta)\pi_1 < \bar{\pi}$. If firm B enters and $(1 - \theta)\Delta < 1 - \mu$, the contract is as given in Proposition 1 and firm A preys.

The striking result that the shallow-pocket strategy optimally deters predation depends on the assumption that $\pi_1 < F$. Suppose instead that $\pi_1 > F$. By setting $\beta_1 = 0$, the investor is able to extract more surplus from the firm in the first period, but he foregoes positive surplus of $\pi_1 - F$ in the second period. Provided π_1 is not too large, the optimal contract still sets $(\beta_1, \beta_2) = (0, 1)$.[19]

In the presence of a predatory threat, however, $\beta_2 - \beta_1$, must equal Δ to deter predation. But, here the investor earns positive profit in the second period. So rather than reduce β_2, β_1 should be increased; this increases the probability that the investor earns a profit of $\pi_1 - F$ in the second period. In this case, a deep pocket is the optimal response to the predatory threat.

Note, however, that if $\pi_1 > F$ it is inefficient for firm B to exit in the second period. Thus, if the contract calls for the firm to be liquidated in the second period when its first-period profits are low, the investor and the firm may be able to renegotiate a more efficient arrangement in which the firm re-

mains in operation and the two parties split the surplus $\pi_1 - F$. If bargaining is efficient, firm B would never exit and firm A has no incentive to prey.

There are reasons to believe, however, that efficient renegotiation may not always occur. First, it can be in the investor's interest to ensure that such renegotiation is infeasible even though it encourages predation. By doing so, he may be able to extract more surplus from the firm in the first period. One way of committing not to renegotiate is to bring in other investors to finance the firm. If each has only a small stake and there are costs of negotiation, then none will have an incentive to renegotiate even though it would be efficient to do so if there were only one investor.[20] Second, our model assumes symmetric information about future profitability. A more realistic model would allow for the possibility of asymmetric information in which case bargaining is more likely to break down.

B. *Unobservable Contracts*

The assumption that contracts are observable may be inappropriate in some circumstances. There are no financial disclosure requirements for privately held firms, so it may be impossible for outsiders to observe a firm's contractual relationship with its creditors. Thus, we also investigate the case in which firm A cannot observe the contract signed by firm B and the investor. Instead, firm A must make a rational conjecture about the chosen contract.

When contracts are unobservable, it is as if the investor and the predator play a simultaneous move game.[21] (We can ignore firm B

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[19] The precise condition, discussed in more detail in an earlier version of our paper, is that $\theta F + (1 - \theta)\pi - F > 0$. This can be seen from inspection of (4) in the text.

[20] For example, small bondholders do not typically participate in financial renegotiations. Bankruptcy law recognizes this difficulty and provides a mechanism for facilitating renegotiation through the Chapter 11 reorganization process.

[21] Note, however, that we continue to assume that firm B signs the contract before firm A decides whether to prey. It might be argued that if the contract is signed first it would be in the interest of firm A to reveal its contract. But, as Katz points out in a related context, if the observed contract is not efficient, the two parties

because its actions follow trivially from the contract the investor chooses.) Firm A's strategy set is composed of two pure strategies: "prey," which we denote by P, and "do not prey," which we denote by NP. The investor's strategy set is essentially a choice of a pair $(\beta_1, \beta_2) \in [0,1]^2$. (We can ignore R_1 and R_2 since firm A is only concerned with the probabilities of refinancing, β_1 and β_2.)

We now establish that if firm B enters, in equilibrium $(\beta_1^*, \beta_2^*) = (0,1)$ and firm A preys. Given any strategy by firm A (and hence any probability of π_1, μ or θ) it is optimal to set $(\beta_1, \beta_2) = (0,1)$, $R_1 = \pi_1$, and $R_2 = \bar{\pi}$; this is a dominant strategy. Firm A's optimal response is then to prey. This forms the unique Nash equilibrium if firm B enters.

With observable contracts, firm B can credibly precommit to a contract that deters predation. But, when contracts are not observable, so that A must conjecture what contract B signed, firm B always wishes to set $(\beta_1, \beta_2) = (0,1)$; no precommitment is possible.

Thus, if contracts are not observable, firm B will enter provided its profits upon entry, $\pi_1 - F + (1 - \mu)(\bar{\pi} - F)$, are positive. Note that firm B enters (weakly) less often when contracts are unobservable. These results are summarized in the following proposition.

PROPOSITION 3: *Firm B enters if and only if* $\pi_1 - F + (1 - \mu)(\bar{\pi} - F) > 0$. *If the firm enters, the contract is as given in Proposition 1 and firm A preys.*

This result, like Proposition 2, is sensitive to the assumption that $\pi_1 < F$. If instead $\pi_1 > F$, in general the optimal (β_1, β_2) pair is a function of the probability of π_1 and hence whether firm A preys. Therefore, $(\beta_1, \beta_2) = (0,1)$ is not necessarily a dominant strategy. Given that firm A preys and the probability of π_1 is μ, the optimal response by firm B may be to set $\beta_1 = \beta_2 = 1$. But if this is true, it is not in the interest of firm A to

prey. Similarly, if firm A does not prey, it may be optimal to set $(\beta_1, \beta_2) = (0,1)$; but then firm A has an incentive to prey. As a result, there may be no pure strategy equilibrium. One can show, however, that there is a mixed strategy equilibrium in which firm A preys with positive probability and firm B sets $\beta_1 = 1 - \Delta$ and $\beta_2 = 1$.[22] Thus, in equilibrium, the investor partially deters predation.

III. Concluding Remarks

The central argument of this paper is that agency problems in financial contracting can give rise to rational predation. The financial contract that minimizes agency problems also maximizes rivals' incentives to prey. As a result, there is a tradeoff between deterring predation and mitigating incentive problems: reducing the sensitivity of the refinancing decision to the firm's performance discourages predation, but exacerbates the incentive problem. In equilibrium, whether financial contracts deter predation depends on the relative importance of these two effects.

Our theory of predation departs from the existing literature which views predation as an attempt to convince rivals that it would be unprofitable to remain in the industry. In our model, everyone knows it is profitable for the rival to remain in the industry. Nevertheless, predation induces liquidation and exit because it adversely affects the agency relationship between the rival's investors and manager.

Although our model narrowly focuses on predation, we believe that the model provides a useful starting point to analyze a broader set of issues concerning competitive interaction among firms with agency problems and financial constraints. For example, our model suggests that an important determinant of product-market success is the degree to which firms can finance investment with internally generated funds. This is in

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will have an incentive to privately annul the advertised contract and write a new one.

[22] More details of this argument can be found in an earlier version of our paper issued as a Sloan Working Paper No. 1986–88.

contrast to standard models of dynamic competition in which the only relevant consideration is the total capital stock and not the way in which it was acquired. The implictions of our model are consistent with Gordon Donaldson's (1984) findings that one reason managers prefer internal sources of funds is that it enhances their ability to compete in product markets.

In addition, our model suggests that certain types of product-market competition can increase managerial incentive problems within the firm. As implied by our model, the reliance on external financing exposes the firm to cutthroat competition. This may force the firm to rely more on internal sources of capital than on external ones. But, this reduces the extent to which outside investors monitor the firm and increases the possibility of managerial slack. Thus, external financing comes with costs and benefits: on the one hand, it disciplines management, but on the other, it makes the firm vulnerable in its product markets.

APPENDIX

LEMMA 1: *The incentive-compatibility constraint* (1) *is binding.*

PROOF: Suppose to the contrary that (1) is slack and that the only constraints are (2) and (2′). We establish that the optimal solution to this relaxed program violates (1).

First note that since (1) is slack, we need not be concerned with the effect of $\{\beta_1, R_1, R_1\}$ on the optimal choice of $\{\beta_2, R_2, R_2\}$ and vice versa. Thus, the maximization problem can be written:

$$\underset{\{\beta_t, R_t, R^t\}}{\text{Maximize}} \ R_t + \beta_t R^t - \beta_t F$$

subject to

(A1) $R_t \leq \pi_t$

(A2) $R_t + R^t \leq \pi_t + \pi_1.$ □

At an optimum to this program, $R_t = \pi_t$ and $R^t = \pi_1$. This is true in the case where $\beta_t < 1$ because given the constraint on the total payments (A2), it is optimal to shift more of the payment to the first period when it will be received with certainty. If $\beta_t = 1$, any division of payments satisfying $R_t + R^t = \pi_t + \pi_1$ is optimal and we may as well set $R_t = \pi_t$ and $R_t = \pi_1$. (Note that given $\beta_t = 1$ the division of payments between R_t and R^t has no effect on the incentive-compatibility constraint.)

The incentive constraint (1) therefore simplifies to

$$\beta_2(\bar{\pi} - \pi_1) \geq \pi_2 - \pi_1 + \beta_1(\bar{\pi} - \pi_1).$$

It is easily seen that for all feasible values of β_1 and β_2 the inequality cannot be satisfied. Thus the incentive constraint is violated at the optimum of the relaxed program, establishing the contradiction.

LEMMA 2: $R^1 = R^2 = \pi_1$ *is a part of an optimal contract.*

PROOF: Substituting the incentive constraint (1) into the objective function yields the new objective function:

$$- F + R_1 + \beta_1 \left[R^1 - \theta F - (1 - \theta)\bar{\pi} \right]$$

$$+ (1 - \theta)\beta_2(\bar{\pi} - F).$$

It follows that $\beta_2 = 1$. Hence only the sum, $R^2 + R_2$, and not the individual values R^2 and R_2 affects the objective function and the incentive constraint. Thus we can set $R^2 = \pi_1$. If $\beta_1 = 1$ the same can be said for R_1 and R^1. If $\beta_1 < 1$, R_1 and R^1 will be chosen to maximize $R_1 + \beta_1 R^1$ since it simultaneously maximizes the objective function and relaxes the incentive constraint. This expression is maximized subject to the limited-liability constraints by setting $R_1 = R^1 = \pi_1$. This completes the proof.   □

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