Predation, Stock Prices and Financial Structure

Abstract

This paper provides a theory of predation based on the incentives of firms to affect the stock price of their rivals in order to make issuing equity capital more costly for them. Myers and Majluf (1984) demonstrate that a firm may forego a positive net present value investment when financing the project would require it to issue undervalued stock. In a similar setting where giving up the project benefits competitors, a firm's rivals may compete more aggressively in order to lower the firm's stock price. The analysis examines how the a firm's financial structure affects the extent to which it will be subject to predation when there is asymmetric information between firms and investors. This analysis should be contrasted with models of predation such as Bolton and Scharfstein (1990) which require the prey to be subject to agency conflicts.

paper number: 214

paper number: 214

1 Introduction

In recent years, a number of large technology companies, (e.g., Microsoft), were accused by their less established rivals of engaging in predatory behavior.[1] Perhaps, because technology companies are more dependent on the stock market for their capital, an issue that surfaced in these cases is the incentives of predators to take actions that can at least temporarily adversely effect their own, as well as their rivals' stock prices.[2] While actions that hurt a firm's own stock price may appear to be counterintuitive, such actions can make sense if a decline in the firm's rival stock price inhibits its ability to raise equity capital, making it a less formidable competitor in the future. This paper presents a model that explores this possibility.

The link between predation and financial markets has been considered in the economics literature at least since McGee (1958). The early discussion centered on what is known as the *long purse* theory of predatory behavior. To understand this theory, consider an industry with two competitors and high entry barriers. If one firm's internal funds and access to financial markets are limited, then its rival might decide to cut prices or take other aggressive actions that force the financially constrained firm to exhaust its funds and exit. The predator gains from such actions by increasing prices and reaping monopoly profits in subsequent periods. Although the argument is intuitive at first sight, as a theory, the long purse is incomplete in important ways. For example, Telser (1966) pointed out that the theory fails to justify predatory behavior, since it predicts that the weaker firm will exit the market immediately. In addition, the theory does not really address what prevents the prey from accessing financial markets in the first place.

[1] Firms such as Google in the U.S. or Wannadoo in France have been involved in notorious litigation cases. In July 2007 the European Commission accused Intel of "abuse of a dominant market position."

[2] Anecdotal evidence abounds. For instance, Business Week (03/08/00) reports that MarketWatch was accussed by TheStreet.com's James Cramer of sinking his company's stock price from a high of 71 1/4 when it started trading to 12 1/2 on 02/23/00. Also, Reuters (09/23/99) quotes Steven Ballmer as saying: '*There is such an overvaluation of technology stocks, it is absurd.*' (...) '*I could put our own company and others in that category.*' (Note: Microsoft shares fell 4.17% and the Nasdaq Composite fell 4.97% on September 23th and 24th.)

The more recent literature addresses explicitly these issues by showing how, in the presence of informational asymmetries that lead to capital market imperfections, a firm may predate to exclude a rival from access to capital. Specifically, Fudenberg and Tirole (1986) describe a situation in which a firm of unknown quality requires additional funds to continue its activities. Since investors use the current firm's performance to infer its future prospects, and provide funding only when performance is good, its rivals may be able to eliminate a competitor by taking actions that reduce the firm's performance.[3] In a seminal contribution, Bolton and Scharfstein (1990) examine financial predation in a setting where moral hazard plagues the relationship between a firm and its creditors. Because of this moral hazard problem, debt emerges as an optimal financial contract since it allows the creditor to cut off the firm's funding if the firm defaults on its obligations. However, with such a contract, the firm's rival has an incentive to take predatory actions that reduces the firm's ability to meet its obligations and can lead to its exit from the market.

The model developed in this paper is similar to Fudenberg and Tirole in that it assumes that there is asymmetric information between firms and investors. Specifically, we follow Myers and Majluf (1984) and consider situations where predation can increase the costs of equity financing and make firms to pass up otherwise profitable investments that require unattractive financing, i.e., underpriced stock. In addition, in contrast to Bolton and Scharfstein (1990), we explore a situation in which firms find it optimal to finance with equity rather than debt, which means that predation does not force the prey to default on its obligations. Hence, in contrast to both of these papers the objective of the predator is not to eliminate a competitor. Rather, consistent with Milgrom's (1988) observation that the objective of predation may be to weaken rather than to eliminate a competitor, in our model the predator seeks to reduce the ability of the rival to expand into new businesses.

Intuitively, predation in our model work as follows: In an industry with two competitors,

[3]In Fudenberg and Tirole's signal-jamming model, predation occurs to affect the perception about the prey's quality. In equilibrium, however, investors anticipate predation and, hence, predatory actions do not really affect the assessment of the prospects of the firm.

the predator takes actions when industry conditions are favorable to make investors believe that conditions are less favorable than they really are.[4] As a result, when investors observe that the prey's profits are low, they cannot tell whether this is because of unfavorable conditions or because of predation. What this means is that when predation does occur, the prey's stock will be undervalued relative to what the prey's management knows that it is worth. As a result, the prey may choose to pass up investments that require it to issue stock.

In addition to providing a novel economic rationale for predation, our model generates a number of implications that cannot be generated from existing models. First, since the benefits to predate arise because of asymmetric information, firms are subject to less predation if their stock trades in an efficient market with well informed investors and analysts. For similar reasons, a firm's disclosure policies can influence the incentives of its rivals to predate.[5] Second, our model suggests that a firm's capital structure influences its vulnerability to predation. In particular, a firm can eliminate the incentive of its rival to predate by holding sufficient financial slack to fund its investments without issuing equity. In this sense our model generates a result that is in the spirit of the early long purse literature. However, in our setting the incentives to predate are not necessarily monotonic in the prey's financial condition since a sufficiently small amount of slack can actually make the predator compete more aggressively. Third, our analysis suggests that predation is likely to occur in situations where predation can discourage the prey from growing by expanding into new business or by establishing an active product development strategy. These situations are likely to emerge in high-tech industries where firms rely on equity markets for a rapid growth.[6]

[4] The fact that predation is profitable when the prospects are high but not when they are low is a distinctive feature relative to Bolton and Scharfstein (1990) and Fudenberg and Tirole (1985) where predation happens unconditionally.

[5] Other studies that suggest an influence of equity financing on the intensity of competition are Poitevin (1989) who argues that equity finance can reduce a firm's exposure to predation and Rotemberg and Scharfstein (1990) who relate the intensity of competition in an industry to the effect that a firm's current profits can produce in its stock market valuation.

[6] This is consistent with allegations in the Netscape vs. Microsoft lawsuit that Microsoft's motive was to prevent Netscape from entering markets in which Microsoft already had market power.

The rest of the paper is organized as follows. Section 2 introduces the model and discusses the possibility of predation in a simple, two-state world. This simple model illustrates the crucial assumption in the analysis that while an information asymmetry exists between investors and the managements of the two firms, but there is no information asymmetry between the firms. Section 3 endogenizes predation in the context of a Stackelberg game where, in order to lower the prey's profits and perceived value, the predator may choose a production quantity (or capacity) in excess of the quantity that would maximize its first period profits. Section 4 considers our extensions. Specifically, it discusses the implications on capital structure design (i.e., the effects of financial slack on predation), how predatory effects are related to the workings and the efficiency of the equity markets and, finally, how these effects are particularly relevant when there is additional feedback from stock prices to the real business of the firm. Section 6 present our conclusions.

2 A Simple Two-State Model of Predation

Consider two risk-neutral firms a and b that compete over two periods ($t = 0, 1$) and face a zero discount rate. Each period firms' profits can be either high (π_h) with probability p_h or low (π_l) otherwise. For simplicity, we consider the case of perfect correlation across profits between periods, i.e., second period profits equal first period profits.[7]

Firm a has sufficient financial slack to fund all its activities. Firm b has no cash on hand and it is assumed to have exhausted its "debt capacity" so it needs to raise equity to fund its activities. The value of its shares after the first period depends in part on its profits from its existing operations.

We assume that the state variable j is not observable by investors but that both firms a and b observe it. This information assumption is key for the results and intends to capture situations in which industry prospects are highly uncertain but where

At the beginning of the second period Firm b has an opportunity to invest $I > \pi_l$ in

[7] As it will be clear in the analysis below, the analysis can be extended to the case of positive correlation of profits.

a new project with value $v > I$. Firm a is already present in this market, and if Firm b implements the project, then Firm a's second period profits decline by X. We assume that v, I and X are common knowledge, and the new project and Firm b's current operations are related.[8] This assumption is essential because otherwise Firm b could avoid the threat of predation by spinning off the new project, or by selling the new investment opportunity to a firm in an industry where Firm a is not present. The model also assumes that managers act in the interest of current shareholders.[9] If, for example, Firm b is a young firm where the original founders still hold a suboptimally large ownership stake, then this assumption is not unreasonable.

Consider the case when the realization of the state variable at $t = 0$ was such that Firm b's profits are expected to be π_h. Also at time zero, but *after* the realization of the state variable is revealed, Firm a will make its decision whether or not to prey. Specifically, Firm a may want to prevent Firm b from investing I and entering the new market by taking predatory actions that are unobservable to investors (but observable to Firm b) and cause Firm b's profits drop to π_l.[10] Suppose that lowering Firm b's profits to π_l costs Firm a C. The predator is aware that the prey needs to issue equity to finance the investment, and its goal is to prevent the equity issue by lowering the prey's share price.

In order to finance the investment, the prey must raise $I - \pi_l$ in equity.[11] Suppose that investors believe that Firm b issues shares to raise $I - \pi_l$ and invests in the project only if there

[8] As an example, suppose that Firm b's existing assets are in the low end microprocessor market. These assets will generate Π_L or Π_H in profits, but the skills acquired while operating these assets also enable Firm b to invest I and enter the high end processor market in the future.

[9] This will be the case when managerial share ownership in the company is a non-trivial part of the management's compensation package, and it is not possible to eliminate the information asymmetry problem by forcing the manager to update her portfolio and purchase a pro rata allocation of any new shares issued. Hart (1993) and Dybvig and Zender (1991) demonstrated that such compensation contracts could eliminate the Myers-Majluf underinvestment problem.

[10] To achieve this, the predator could secretly lower the price of its output, increase production/capacity or boost advertising expenditures. No specific model of competition is introduced here, and it must be emphasized that predation of this sort could arise in a variety of competitive environments. In section 3 predation will be defined as a decision to produce (or build capacity) in excess of the amount that would maximize Firm 1's first period profits.

[11] Allowing Firm b to borrow Π_L against second period profits has the same effect as increasing available financial slack from $S = 0$ to Π_L. The effect of financial slack is discussed in Section 4.

was no predation and its second period profits are also expected to equal π_l. (Later we will argue that these are the only beliefs that can be supported in a pure strategy equilibrium.) When $j = h$ but Firm b's first period profits are low as a result of predation, the prey's problem is analogous to the underinvestment problem in Myers and Majluf (1984).[12] If Firm b decided to implement the project, it would have to issue undervalued equity. Investors value issuing firms as the sum of future profits and the present value of the project: $\pi_l + v$. In order to be willing to provide $I - \pi_l$ in funding for the new investment, equity investors will want to receive $(I - \pi_l)/(\pi_l + v)$ percent of the firm's shares.

If first period profits equal π_l as a result of predation but the firm still decides to issue, then the original shareholders are left with shares that are worth:

$$\left(1 - \frac{I - \pi_l}{\pi_l + v}\right)(\pi_h + v).$$

It is easily seen that given the above beliefs, Firm b will be undervalued by investors when Firm a preys. Note that Firm b's shareholders could get $\pi_h + \pi_l$ by simply foregoing the investment and the equity issue. For some parameter values investing and issuing undervalued equity will still make the original shareholders of Firm b better off than foregoing investment:

$$\left(1 - \frac{I - \pi_l}{\pi_l + v}\right)(\pi_h + v) > \pi_h + \pi_l. \tag{1}$$

For such parameter values Firm b will always implement the project, so predatory behavior will be unproductive and consequently there will be no predation. There will not be predation either when the cost of driving down Firm b's profits from π_h to π_l exceeds Firm a's benefits from preventing the investment, i.e. $X < C$.

The above arguments have eliminated the possibility of predation for certain parameter values. Under what conditions does predation occur in equilibrium? Notice that, given the above beliefs, Firm b is no longer better off issuing and investing when:

[12] The model is actually developed along the lines of a version of the Myers-Majluf model discussed in Daniel and Titman (DT, 1995).

$$\left(1 - \frac{I - \pi_l}{\pi_l + v}\right)(\pi_h + v) \leq \pi_h + \pi_l. \tag{2}$$

Proposition 1 *If (2) holds with strict inequality and $C < X$, then Firm a preys in equilibrium whenever the realization of the state variable is $j = h$. In a pure strategy equilibrium Firm b forgoes the equity issue and the new project. A mixed strategy equilibrium is also possible for some parameter values where Firm b takes the project with probability $1 > \delta > 0$. If (2) holds with equality and $C < X$, then predation will be one of the possible equilibria for $j = h$. There will not be predation when the realization of the state variable is $j = l$.*

Proof. *See Appendix.A* ■

The market is not entirely fooled by the predator's action, because Firm a's incentives to prey are known. What investors do not know is whether the observed low profits are the result of predatory behavior, or a decline in profitability due to market conditions. In a pure strategy equilibrium Firm b's decision to issue equity convinces investors that observed profits equal true profits and there has not been predation.[13] Figure 1 contains an outline of the model when (2) holds with strict inequality and $C < X$.

The above discussion assumes that the prey is unable to send a credible signal about the true value of the company. Firm b's ability to signal that its second period profits will be π_h instead of π_l reduces the set of parameters for which predation is possible, but the results remain qualitatively similar.[14]

[13]In a mixed strategy equilibrum where Firm b takes the project with probability $1 > \delta > 0$, investors will believe that predation has occurred and true profits are higher than what they observed with probability $\delta / [1 - \Pr(H) + \delta]$.

[14]Price setting, project scaling, dividend payments and project delay have all been proposed as mechanisms to signal firm value by Giammarino and Lewis (1988), Krasker (1986) John and Williams (1985) and Choe, Masulis and Nanda (1993), respectively. In order to preserve space, results for the case when the prey is able to signal its value are not reported here but are available from the authors upon request.

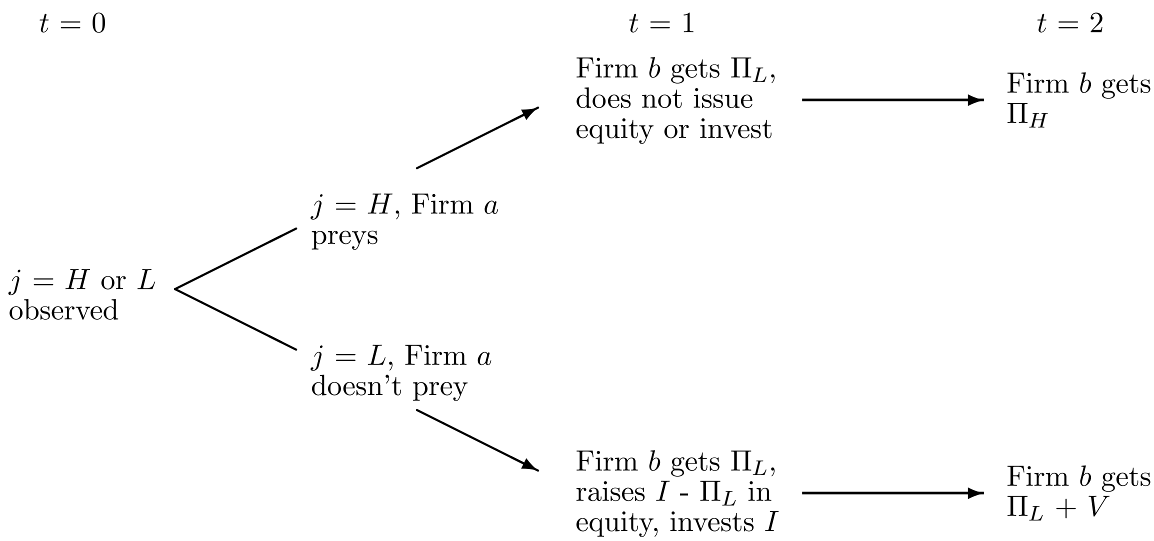

Figure 1: The Two-State Model

This simple model does not go into the details of how predation is actually implemented, and it only allows for two possible profit levels for Firm b. It is also unclear how the cost of predation, C is determined. To address these issues, the following section will develop a more detailed model of predation which allows for a continuum of possible profit levels for the prey. The model will assume that the two firms compete in a Stackelberg game where, in order to lower the prey's profits and perceived value, the predator may choose a production quantity (or capacity) in excess of the quantity that would maximize its first period profits.

3 Predation when the Predator's Costs are Endogenous

3.1 The Model

In this version of the model, the two firms compete in a Stackelberg setting over both periods of a two period game. The parameters v, I and X (the project's value, the investment and the decline in Firm a's second period profit if the project is implemented) are defined as before and again assumed to be common knowledge. The inverse demand function is $p = d - q_a - q_b$ in both periods, where p is the price, q_i is the quantity (or capacity) chosen by Firm i and d

represents the strength of demand. The choke price d is drawn from a distribution $F(d)$ over $[0, D]$ with $D > 0$, at time zero. While D and the distribution $F(d)$ are common knowledge, only the two firms observe the realization of d, investors do not. Still at time $t = 0$ but subsequent to observing d Firm a and then Firm b make their output decisions. Firm b observes its rival's output choice prior to choosing a production quantity.

For simplicity, we assume that the marginal cost of production is constant and it equals zero. In addition, as in the two-state model above, we assume that the predatory action is not observable to investors which in turn implies that - similar to Rotemberg and Scharfstein (1990) - investors are unable to observe equilibrium prices and quantities. While this assumption may be unrealistic when firms producing a homogeneous good compete in well established, transparent markets, the approach is chosen as a way of modeling competition in a (possibly newly emerging) industry where markets are relatively opaque and less well understood by investors. Product heterogeneity - while not modeled here - may also increase the difficulty of observing prices and production volumes. (Also, *true* prices may not be observable due to secret discounts off the list price and as a result of the impact of unobservable non-price competition such as increased sales efforts.)

Suppose first that the two firms ignore the impact of their first period decision on second period investment. In that case, Firm a will produce $q_a^* = d/2$, Firm b will produce $q_b^* = d/4$ and the equilibrium price will be $p^* = d/4$ in the first period of the game. Firm a and Firm b's equilibrium profits will be $\pi_a^* = d^2/8 = \pi_{SL}$ and $\pi_b^* = (d/4)^2 = \pi_{SF}$, respectively. The subscripts SL and SF stand for Stackelberg leader and Stackelberg follower. If $(d/4)^2 < I$ then Firm b will have to raise $I - \pi_{SF}$ in the equity market. From $I - \pi_{SF}$ investors can infer the Firm b's profits in periods 1 and 2, and value shares issued by the firm accordingly. In exchange for providing $I - \pi_{SF}$ in capital, investors will require shares representing s percent of the firm, where s is:

$$s = \frac{I - \pi_{SF}}{\pi_{SF} + v}.$$

3.2 The Decision to Prey

Firm a has zero funding needs therefore it is not affected by investors' perception of firm value at the end of the first period. It can reduce its rival's first period profits by producing more than the quantity produced by the leading firm in equilibrium in a Stackelberg game. If reducing the prey's current profits lowers the perceived value of its existing assets, then Firm b must issue undervalued shares to finance the investment. Predation prevents investment by reducing Firm b's perceived value to the point where losses from selling undervalued equity outweigh the net present value of the new investment. Since in this simple two period setting Firm a has no motivation to prey after the first period of the game, it will produce the Stackelberg equilibrium quantity $q_a^* = d/2$ in the second period and the two firms' profits will equal π_{SL} and π_{SF}.

Investors' equilibrium beliefs resemble those in the pure strategy equilibrium of two state model: if Firm b's period 1 profits equal π_b (π_b simply stands for Firm b's observed first period profits) and it issues equity to raise $I - \pi_b$, then π_b must be Firm b's true profit i.e. there was no predation and the firm observed $d = 4\sqrt{\pi_b}$. If Firm b had observed $d > 4\sqrt{\pi_b}$ and its profits had been lowered by predation, then Firm b would not issue. (If Firm b issued even when the predator preyed then - since predation is costly - Firm a would not have preyed in the first place.) Investors will value Firm b's shares according to these beliefs.

Suppose that the predator reduces the prey's profits to $\pi_b < \pi_{SF}$, and the prey still decides to invest and issues stock to raise $I - \pi_b$. Investors will then believe that π_b equals Firm b's profits in the absence of predation and require

$$s = \frac{I - \pi_b}{\pi_b + v}$$

percent share of the firm.

How aggressively must Firm a prey in order to prevent Firm b from investing? Predation must ensure that for the prey's current shareholders, the value of the firm without the new investment is at least as great as the value of their share of the firm subsequent to stock issuance and investment:

$$\left(1-\frac{I-\pi_b}{\pi_b+v}\right)(\pi_{SF}+v) \leq \pi_{SF}+\pi_b. \tag{3}$$

How low must Firm b's profits fall for inequality (3) to hold? Solving (3) for π_b we get:

$$\pi_b \leq \bar{\Pi}_b = \frac{\pi_{SF}+v-\sqrt{(\pi_{SF}-v)^2+4(v-I)(\pi_{SF}+v)}}{2}. \tag{4}$$

Firm b will respond to Firm a's output choice along its reaction function, producing $R_b(q_a) = (d-q_a)/2$. Producing less or more than $R_b(q_a)$ will reduce Firm b's profits and its perceived valuation. When Firm a preys and produces $q_a > d/2$, Firm b's profits will equal $\pi_b = [(d-q_a)/2]^2$. Substituting π_b, it is easily seen that (4) will hold when Firm a produces:

$$q_a \geq \bar{q}_a = d - 2\sqrt{\bar{\Pi}_b}. \tag{5}$$

Differentiating with respect to v and I, it can be shown that $\bar{q}_a$ increases in v and decreases in I. In other words the predator will have to prey more aggressively when the value of the project increases or when the investment required to implement the project decreases. This result is intuitively appealing: the more attractive the investment, the harder it is to prevent it by predation.

In general, one would expect Firm a to increase its output above its Stackelberg equilibrium level in period 1 when the gain from predation is greater than the cost. The cost of producing $q_a > d/2$ is simply the difference between the profits of the leading firm in a Stackelberg game and those of the predator: $C(d) = (d^2)/8 - q_a[(d-q_a)/2]$. Note that $\bar{q}_a$ in equation (5) is itself a function of d, so the relationship between the cost of predation and the realization of d is not straightforward. Although the cost of predation may decrease in d for low values of the demand parameter, ultimately the cost of predation will increase in d because for high realizations of d the predator must reduce Firm b's profits just to ensure that the prey must raise outside equity in order to fund the project. Predation will not be observed in equilibrium when the realization of d is such that $C(d) > X$, i.e. when the gain from preventing Firm b's investment, is less than the decline in Firm a's first period profits caused by the predatory expansion of output.

Firm a can reduce the perceived value of Firm b's assets in place to zero by producing $q_a = d$ and causing the price and Firm b's output to drop to zero. If the realization of d falls below a certain level, then even producing $q_a = d$ and reducing the perceived value of the second company's existing business to zero will not be sufficient to prevent investment. Intuitively, the true value of the company's existing operations is so low relative to the net present value of the project, that current shareholders are better off investing and issuing even when investors believe that the existing assets are worthless. The deep pocketed firm will not prey for such low realizations, since predation would be fruitless.

Lemma 1 *Predation will not be observed when the realization of* d *is such that* $d < \underline{d}$ *(i.e. the value of Firm* b*'s existing business is very low).*

Proof. *See Appendix.A* ■

It is important to note a key implication of no predation for certain values of d (and the corresponding π_{SF} profits). Suppose the predator preyed at all possible profit levels of Firm b (i.e. all realizations of the demand parameter). Investors would always know that the profits they observed were not the true profits but the result of predation, and they could recover the value of Firm b by simply adding back profits lost due to predation. In this model, low realizations may or may not be observed because of predation. This differentiates the model from signal jamming models of predation where observers can recover the original signal from the distorted signal and the players' incentives.

Since the goal of the predator is to deceive investors about the value of the competing firm, predation becomes pointless when investors know that predation must have taken place. The predator must lower the profits of the prey to a level where predation would not occur, in order to keep investors in uncertainty about the value of the prey. In the limited strategy space of the model, Firm b can only avoid issuing undervalued equity by not issuing at all, because issuance is interpreted by investors as a signal that there was no predation. Figure 2 contains a simplified outline of the model.

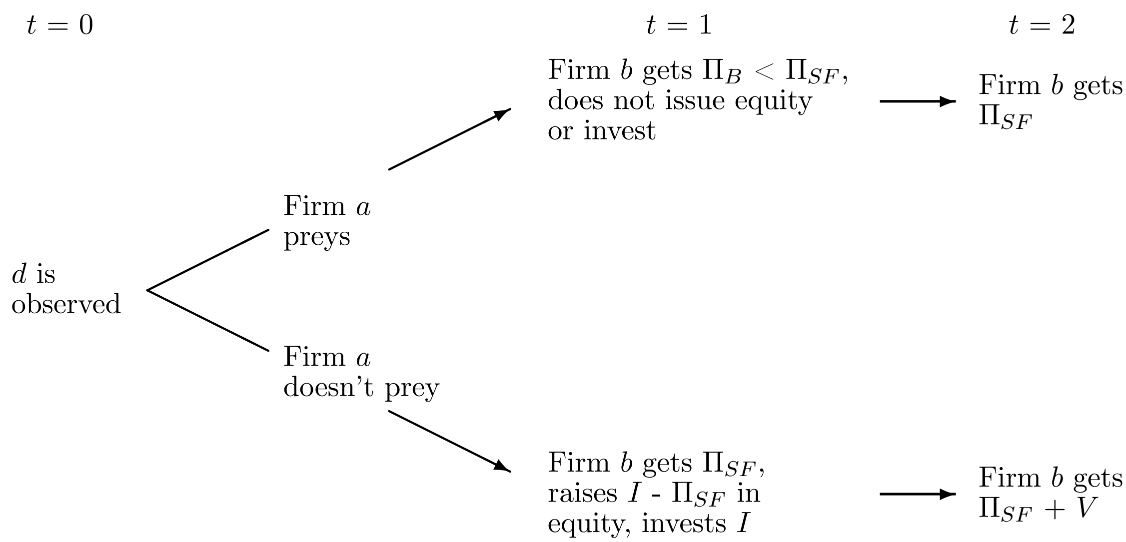

Figure 2: The Two-Period Stackelberg Model

The result in Lemma 1 also suggests that a core business that is not worth much may provide protection from predators, while a valuable core business may make a firm an attractive target. It is possible that small firms do not simply pass below predators' radar screen; it is the low value of their assets in place that makes them less vulnerable. Consider the following quote from Cusumano and Yoffie (1998), page 140: "In 1994, Netscape came into the world with very little baggage. Its history, revenues and installed base were too meager to give competitors enough of a handhold to bring the company down."

Proposition 2 summarizes the results from the above discussion.

Proposition 2 *In equilibrium, Firm a will prey (will produce at least $\bar{q}_a$) in period 1 if and only if i) such predatory action lowers Firm b's first period profits to a level where predation is not observed, ii) $d > \underline{d}$, and iii) the cost of predation, $C(d)$ is less than the benefit X of preventing its competitor from investing. Firm b will not issue equity and will not invest when predation has occurred in period 1.*

Proof. *See Appendix.A* ■

The assumption that the net present value of the project and the true value of the firm are unrelated may seem unrealistic, but similar results can be derived even when a positive relationship exists between the two. Assume for example that the present value of the project equals $I + \alpha + \beta\pi_{SF}$ instead of v, where $\alpha > 0, \beta \geq 0$. When $\beta > 0$, the change from the simpler version of the model is twofold: predation lowers the value of Firm b in the eyes of investors by both reducing the perceived value of its existing operations to π_b and that of its future project to $I + \alpha + \beta\pi_b$. At the same time, Firm b's incentives to invest are greater for high realizations of d, since besides increasing profits, high realizations also increase the project's net present value. As it turns out, the latter effect dominates.

The predatory production quantity can be derived analogously to the way we obtained $\bar{q}_a$, by simply substituting $I+\alpha+\beta\pi_C$ and $I+\alpha+\beta\pi_b$ for the parameter v (the former represents the project's true present value, while the latter is its value as perceived by investors). The resulting expression increases in β, implying that the greater impact the d demand parameter has on the project's net present value, the more aggressively the predator must prey.

3.3 Numerical Example

Consider the numerical example where $I = 100$, $v = 130$, $X = 40$ and $C = 50$. As we will see, in this case there will only be predation if the realization of d falls between 28.932 and 40.046. For some low realizations of d, predation can never achieve its goal. If the realization of the demand parameter is $d = 20$ for example, then Firm a would maximize its first period profits by setting its output at $q_a = 20/2 = 10$. Firm b's optimal output choice is given by $R_b(10) = (20 - 10)/2 = 5$ making $\pi_{SF} = 5(20 - 10 - 5) = 25$. Firm a could reduce the profits and perceived value of its competitor to zero by producing $q_a = 20$. If Firm b decided to issue shares to fund the new investment, investors would demand a 100/130 share of the firm (the firm's perceived value is simply the present value of the project). The original shareholders' holdings will be worth:

$$\left(1 - \frac{100}{130}\right)(25 + 130) = 35.769 > 25$$

so the prey is still better off issuing and investing. It is easily seen that predation will remain fruitless for all $d < \underline{d} = 24.98$.

Suppose that the realization of d is 28. If Firm a does not prey and produces 14, then Firm b's output will be $R_b(14) = 7$ and its profits will equal $\pi_{SF} = 49$. If Firm a increases its output to 23.195, then Firm b will reduce its output to $R(23.195) = 2.403$. Relative to the "Stackelberg price" $p_S = 7$, the price of the output falls to $p = 28 - 23.195 - 2.403 = 2.403$ and Firm b's profits drop to $(2.403)^2 = 5.773$. This reduces the perceived value of Firm b to $130 + 5.773 = 135.773$: the sum of the project's present value and the future profits investors expect based on current profitability. New investors will then demand $(100 - 5.773)/(130 + 5.773)$ share of the firm, and issuing shares and investing in the new project will no longer make current shareholders better off:

$$\left(1 - \frac{100 - 5.773}{130 + 5.773}\right)(49 + 130) = 54.733 = 49 + 5.773.$$

Note that Firm a's profits would be $14 \times 7 = 98$ if it choose its output to maximize current profits, while predation leads to current profits equalling $2.403 \times 23.195 = 55.729$. The cost of predation, $98 - 55.729 = 42.271$ is greater than the amount to be gained from predation, $X = 40$, so Firm a will not prey when $d = 28$.

Consider now the case when the realization of d is 36. If Firm a does not prey and produces 18, then Firm b's output will be $R_b(18) = 9$ and its profits will equal $\pi_{SF} = 81$. If Firm a decides to prey and increases its output to 26.566, then Firm b will in turn reduce its output to $R(26.566) = 4.717$. Relative to the "Stackelberg price" $p_S = 9$, the price of the output falls to $p = 4.717$ and Firm b's profits drop to $(4.717)^2 = 22.252$. This reduces the perceived value of Firm b to $130 + 22.252 = 152.252$: the sum of the project's present value and the future profits investors expect based on current profitability. New investors will then demand $(100 - 22.252)/(130 + 22.252)$ share of the firm, and issuing shares and investing in the new project will no longer make current shareholders better off:

$$\left(1 - \frac{100 - 22.252}{130 + 22.252}\right)(81 + 130) = 103.252 = 81 + 22.252.$$

Note that Firm a's profits would be $18 \times 9 = 162$ if it choose its output to maximize current profits, while predation causes first period profits to drop to $4.717 \times 26.566 = 125.315$. The cost of predation, $162 - 125.315 = 36.685$ is less than the amount to be gained from predation, $X = 40$, so Firm a will prey when $d = 36$.

The benefit of deviating from the predatory strategy is less than 40 for realizations when $d_l = 28.932 < d < 40.046 = d_h$, so Firm a will prey. There will be no predation when $d \leq 28.932$ or $40.046 \leq d$. Figure 3 illustrates the relationship between the realization of d and predation.

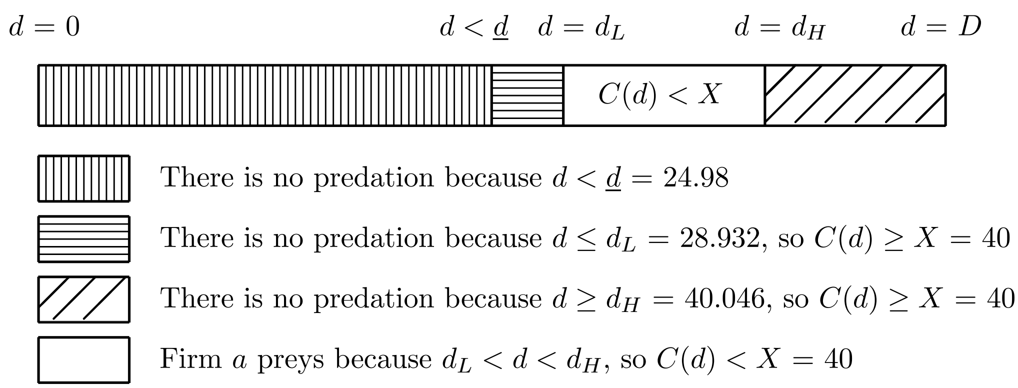

Figure 3: The realization of d and the decision to prey

4 Extensions of the Model

4.1 The Role of Financial Slack

First period profits need not be the only source of funding for new investment at the beginning of period two. Firm b may also have an amount S of financial slack at the beginning of the game. Assume that Firm b observes the realization of d and then - before the two firms make their output decisions - decides whether to continue to hold slack or make a distribution to shareholders.

The effect of holding slack is twofold: a neutral effect is raising the value of the firm under all realizations of d, since the value of S does not vary across the state space. Holding

S as slack will also have an effect similar to reducing I: Firm b will have to raise less at the end of the first period in order to fund the project. Consider equations (4) and (5): the analogous equations when the prey has S financial slack are quite similar:

$$\pi_b \leq \bar{\Pi}_b^S = \frac{\pi_{SF} + v - \sqrt{(\pi_{SF} - v)^2 + 4\,(v + S - I)\,(\pi_{SF} + S + v)}}{2} \tag{6}$$

$$q_a \leq \bar{q}_a^S = a - 2\sqrt{\bar{\Pi}_b^S}. \tag{7}$$

Just like in the "no-slack" case, there will be no predation for low realizations of d, because the predator would have to reduce the perceived value of its competitor below zero. Examining equations (6) and (7), it is easily seen that this will be the case whenever $d < \underline{d}^S = 3\sqrt{(v + S)\,(\frac{v}{I-S} - 1)} > 0$. Notice that $\underline{d}^S$ is greater than $\underline{d}$ in the previous subsection, i.e. adding slack increases the range of realizations where predation will not be feasible. Lemma 2 and Proposition 3 summarize the results from the above discussion:

Lemma 2 *When Firm b holds S in financial slack, predation will not be observed when the realization of d is such that $d < \underline{d}^S$ (the value of Firm b's existing business is very low).*

Proposition 3 *When Firm b holds S in financial slack, Firm a will prey in equilibrium (will produce at least $\bar{q}_a^S$) in period 1 if and only if i) such predatory action lowers Firm b's first period profits to a level where predation is not observed, ii) $d > \underline{d}^S$, and iii) the cost of predation, $C(d)$ is less than the benefit X of preventing its competitor from investing. Firm b will not issue equity and will not invest when predation has occurred in period 1.*

Differentiating with respect to S, it can be shown that $\bar{q}_a^S$ increases in the amount of financial slack. For any realization of d, the predator will now have to produce more (relative to the no-slack case) in order to sufficiently reduce Firm b's perceived value. The greater the slack, the more aggressive the predator must become.

There are two possibilities: first, given the realization of d, it may still be optimal for Firm a to prey even when Firm b has S in slack. In this case Firm a will increase production relative to the no-slack case and Firm b's profits will be lower. Firm b will then prefer to make a distribution to shareholders in order to reduce its financial slack to zero. Distributing all slack to shareholders will make the predator prey less aggressively. In other words Firm b will adopt a "puppy dog" strategy in order to reduce competition in its core business.

If S is sufficiently large, then predation will not be optimal for Firm a[15], and Firm b will either not distribute slack or it will distribute a portion of S such that the remainder will still deter predation. Of course if Firm b would have the option of increasing its slack to an arbitrarily large amount at no cost, then it would always start the game with financial slack sufficient to prevent predation. In this case however Firm b would not be financially constrained. Although not modeled here, it is probably not unreasonable to assume that - due to information asymmetry and resulting agency problems - investors want to limit the amount of financial slack a young firm has, therefore limiting its ability to deter predation.

Implicitly we have assumed so far that reducing the scale of the project is not part of the strategy space for Firm b. If Firm b can reduce the size of the project, then it may be able to prevent predation. Firm b's goal is to use project scaling as a signal and convince investors that the realization of the d demand parameter was in fact high and its next period profits will be high. When predation does occur however, Firm a may prey more aggressively to prevent Firm b from signalling its value by scaling down the project.[16]

5 Applications of the Model

5.1 Executive Compensation

Consider the situation when Firm b has an opportunity to hire a new executive. The reservation wage of the executive equals I^e, while the value of her services to the company equal $v^e > I^e$. Firm b has an opportunity to hire the executive at the end of period 1. The

[15] $S \geq I$ is the simplest case to consider, but increasing S may also prevent predation because both the cost of predation and $\underline{d}^S$ increase in S, and both $C(d) > X$ and $d < \underline{d}^S$ prevent predation.

[16] Results are not reported in detail in order to save space. A longer discussion of the impact of signalling is available from the authors upon request.

large majority of the executive's compensation will consist of Firm b stock. Firm a - a deep pocketed competitor - is concerned that its profits would be lower by X^e dollars if Firm b hires the new executive and starts competing more successfully.

The two firms compete in the same setting as in the earlier section, but now it is the executive to be hired who is unable to observe the realization of the d demand parameter. She assesses the value of Firm b's shares based on the firm's first period profits, so Firm a may prevent the hiring of the new executive by competing more aggressively and reducing the perceived value of the prey.

What should be emphasized here is that even if there is relatively little benefit to the predator from preventing Firm b from hiring key people, the existence of other parties that make their decisions contingent upon the perceived value of the firm will make predation more damaging through a feedback effect.[17] If the predator preys to prevent new investment, it may nevertheless prevent the hiring of the new executive as well. Thus the unconstrained firm does not need to compete more aggressively, but further benefits still accrue to the predator and the prey suffers additional damage.

5.2 Mergers and Acquisitions

This paper emphasizes the point that share prices have an impact on a firm's ability to invest in a new project. As we have seen above, a firm's market value has an impact on the firm's ability to accomplish other goals as well. If a predator with deep pockets lowers share prices in an industry, then a financially constrained firm in the same industry may have a hard time making a successful takeover bid for a firm that the predator would also like to acquire. Even though their true value may be the same, the predator's cash offer will appear more favorable than the shares offered by its cash-strapped rival..

[17] See Subrahmanyam and Titman (2000) for a detailed analysis of how feedback from prices to cash flows increases the potential for stock market manipulation.

5.3 Innovation

An oft repeated charge against aggressive competitors in high technology industries is that their hardball tactics stifle innovation. This model is similar to other models of predation in the finance literature in that the predator may be able to reduce competition by blocking the prey's access to new financing. a somewhat unique feature of this model however is that a company's existing business becomes a potential victim because the firm has a positive NPV project in another industry or market segment, and it is this new project that threatens an existing monopoly.

It is conceivable that firms with valuable core businesses would adopt a "puppy dog" strategy and try to prevent predation by committing not to implement the future project.[18] This could be achieved by divesting the resources necessary to develop the project in the first place. If firms divest resources vital for innovation in order to avoid predatory action (and these resources are redeployed elsewhere, less efficiently), then the threat of predation indeed reduces innovation.

6 Conclusion

This paper proposes a model of predation which relies on the information asymmetry between management and potential equity investors. The underinvestment problem caused by this information asymmetry was analyzed in Myers and Majluf [1984]. Under certain conditions predators with deep pockets will benefit from strategically reducing a competitor's share price, in effect inducing a Myers-Majluf type underinvestment problem.

Firms with projects that require relatively little investment and have a large net present value are more difficult to prey on. Sufficiently large financial slack will prevent predation, however the presence of slack which is not sufficiently large will only make the predator prey

[18] In an online chat forum, MIT professor Michael A. Cusumano suggested that aspiring software entrepreneurs should "find a niche in which Microsoft does not compete and is not likely to compete for a few years. This is the only way to avoid becoming roadkill." (Source: "Chat with Michael Cusumano," *ABCNEWS.com*, 11/12/1998)

more aggressively. Hence, financially constrained firms will want to hold a large amount of financial slack or no slack at all. This result has implications for capital structure choice and cause a discontinuity in the firm's capital structure decision.

Some firms which are vulnerable to predation will follow a "no (or low) leverage" strategy because this strategy will ensure their ability to invest even when their equity is undervalued. Other firms will find that the "no leverage" strategy cannot prevent predation. These firms will increase their leverage in order to make sure that the predator does not prey very aggressively. The "high leverage" strategy will minimize the damage the predator must cause in the prey's core business in order to prevent new investment.

References

[1] Benoit, J-P., 1984, "Financially Constrained Entry in a Game with Incomplete Information," *Rand Journal of Economics*, 15, pp. 490-99.

[2] Bittlingmayer, G. and T W. Hazlett, 2000, "DOS Kapital: Has antitrust action against Microsoft created value in the computer industry?" *Journal of Financial Economics*, vol. 55, no. 3, pp. 329-359.

[3] Bolton, P., and D S. Scharfstein, 1990, "A theory of predation based on agency problems in financial contracting," *American Economic Review*. 80, 93-106.

[4] Brander, J.A. and T.R. Lewis, 1986, "Oligopoly and Financial Structure: The Limited Liability Effect," *American Economic Review*, v76 n5, pp. 956-70.

[5] Cho, I.-K. and D.M. Kreps, 1987, "Signaling Games and Stable Equilibria," *Quarterly Journal of Economics*, v102 n2, pp. 179-221.

[6] Choe, H., R.W. Masulis, and V. Nanda, 1993, "Common stock offerings accross the business cycle: Theory and evidence," *Journal of Empirical Finance*, 1, pp. 3-31.

[7] Cusumano, M.A. and D.B. Yoffie, 1998, *Competing on Internet Time: Lessons from NetScape and Its Battle with Microsoft*, New York, The Free Press.

[8] Daniel, K. and S. Titman, 1995, "Financing Investment Under Asymmetric Information," in Jarrow, R., Maksimovic V. and W. Ziemba, (eds.), *Finance (Handbooks in OR & MS, Vol. 9)*, North-Holland.

[9] Diamond, D., 1984, "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies*, v51 n3, pp. 393-414.

[10] Dybvig, P. H., and J. F. Zender, 1991, "Capital Structure and Dividend Irrelevance with Asymmetric Information," *Review of Financial Studies*, v4 n1, pp. 201-19.

[11] Fudenberg, D. and J. Tirole, 1986, “A ”Signal-Jamming” Theory of Predation,” *Rand Journal of Economics*, 17, 366-376.

[12] Fudenberg, D. and J. Tirole, 1985, “Predation without Reputation,” *Working Paper 377*, MIT

[13] Gale, D., M. Hellwig, 1985, “Incentive-Compatible Debt Contracts: The One-Period Problem,” *Review of Economic Studies*, v52 n4, pp. 647-63.

[14] Gelman, J. and S.C. Salop, 1983, “Judo Economics: Capacity Limitations and Coupon Competition,” *Bell Journal of Economics*, 14:2, pp. 315-325.

[15] Gertner, R., R. Gibbons, D. Scharfstein, 1988, “Simultaneous Signalling to the Capital and Product Markets,” *Rand Journal of Economics*, v19 n2, pp. 173-90.

[16] Giammarino, R.M. and T. Lewis, 1988, “A Theory of Negotiated Equity Financing,” *Review of Financial Studies*, Vol. 1, No. 3., pp. 265-288.

[17] Hart, O, 1993, “Theories of Optimal Capital Structure: A Managerial Discretion Perspective,” in Margaret Blair (ed.), *The Deal Decade: What Takeovers and Leverage Buyouts Mean for Corporate Governance*, Washington: Brookings Institution.

[18] John, K. and J. Williams, 1985, “Dividends, Dilution, and Taxes: A Signalling Equilibrium,” *Journal of Finance*, 40(4), pp. 1053-1070.

[19] Krasker, W.S, 1986, “Stock Price Movements in Response to Stock Issues Under Asymmetric Information,”. *Journal of Finance*, 41(1), pp. 93-105.

[20] Maksimovic, V., 1995, “Financial Structure and Product Market Competition,” in Jarrow, R., Maksimovic V. and W. Ziemba, (eds.), *Finance (Handbooks in OR & MS, Vol. 9)*, North-Holland.

[21] Milgrom, P, 1988, "Predatory Pricing," J. Eatwell, J., M. Milgate, and P. Newman (eds.), *The New Palgrave: A Dictionary of Economic Theory and Doctrine*, London: MacMillan Press Ltd., 1988.

[22] Milgrom, P. & J. Roberts, 1982a, "Limit Pricing and Entry under Incomplete Information," *Econometrica*, 50, 443-60.

[23] Milgrom, P. & J. Roberts, 1982b, "Predation, Reputation and Entry Deterrence," *Journal of Economic Theory*, 27, 280-312.

[24] Miller, M.H. and K. Rock, 1985, "Dividend Policy under Asymmetric Information," *Journal of Finance*, v 40 n4, pp. 1031-1051.

[25] Myers, S.C., & N.S. Majluf, 1984, "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have," *Journal of Financial Economics,* v13 n2, pp. 187-221.

[26] Ordover, J. & G. Saloner, 1989, "Predation, Monopolization and Antitrust," in R. D. Willig & R. Schmalensee (eds), *Handbook of Industrial Organization*, Vol. 1.

[27] Poitevin, M., 1989, "Financial signaling and the "deep-pocket" argument," *Rand Journal of Economics*, 20, 26-40.

[28] Roberts, J., 1986, "A Signaling Model of Predatory Pricing," *Oxford Economic Papers*, v38 n0 Suppl., pp. 75-93.

[29] Rotemberg, J. and D.S. Sharfstein, 1990, "Shareholder Value Maximization and Product Market Competition," *Review of Financial Studies*, 3, 367-91.

[30] Saloner, G., 1987, "Predation, Mergers and Imperfect Information," *Rand Journal of Economics*, 18, pp. 165-186.

[31] Subrahmanyam, A and S. Titman, 2001, "Feedback Effects of Financial Market Trading," *Journal of Finance*, v 56 n6, pp. 2389-2413.

[32] Telser, L. G,. 1966, "Cutthroat Competition and the Long Purse," *Journal of Law and Economics*, 9, pp. 259-277.

[33] Tirole, J., 1988, *The Theory of Industrial Organization*, Cambridge, MIT Press.

[34] Townsend, R, 1979, "Optimal Contracts and Competitive Markets with Costly State Verification," *Journal of Economic Theory*, 21, 265-93.

A Appendix

Proof of Proposition 1 First consider the possible pure strategy equilibria. Suppose that investors believe that predation occurs if $j = h$ but Firm b issues equity for both realizations of j. This is clearly not part of an equilibrium: predation is costly so Firm a will not prey unless predation prevents investment. In an equilibrium where Firm a does not prey, investors would have to believe that observed profits equal true profits. These beliefs will not be confirmed in equilibrium since, given these beliefs, Firm a could gain $X - C > 0$ by misleading investors and reducing Firm b's profits to π_l when $j = h$. Since (2) holds with strict inequality, Firm b will then choose to forgo the investment. Investors' beliefs will be confirmed in a pure strategy equilibrium if and only if they believe that Firm b will issue when $j = l$, there was no predation and observed profits equal true profits, and forgo the project otherwise. If (2) holds with equality, then the prey will be indifferent between investing and foregoing the project when predation has occurred. There will be two equilibria: one with investment and no predation, and a second with predation and no investment.

When parameter values are such that

$$\left(1 - \frac{I - \pi_l}{\pi_l + p_h (\pi_h - \pi_l) + v}\right)(\pi_h + v) > \pi_h + \pi_l,$$

a mixed strategy equilibrium may exist in which Firm b takes the project with probability $1 > \delta > 0$ when the predator preys, and δ is chosen to ensure that the payoff to Firm b remains the same whether or not it invests:

$$\left(1 - \frac{I - \pi_l}{\pi_l + \delta \cdot p_h (\pi_h - \pi_l) + v}\right)(\pi_h + v) = \pi_h + \pi_l.$$

Since the predator will only prey if its expected gains exceed the cost of predation, a mixed strategy equilibrium will not exist unless $(1 - \delta) X > C$.

Predation cannot deceive investors when it reduces Firm b's profits below π_l, because investors will realize that profits lower than π_l could only occur as a result of predation.

Proof of Lemma 1 From equation (4) it is easy to obtain $\underline{d}$, the value of the demand parameter where $\bar{\Pi}_b = 0$: $\underline{d} = 4\sqrt{v (v/I - 1)} > 0$. (Remember that $\pi_{SF} = (d/4)^2$.) For

$d < \underline{d}$ - or equivalently, $\pi_{SF} < v\,(v/I - 1)$ - the predator would have to reduce π_b and the perceived value of the prey below zero in order to prevent investment. Since this is not possible, there will be no predation when $d < \underline{d}$.

Proof of Proposition 2 Points *ii)* and *iii)* follow directly from Lemma 1 and the preceeding discussion. To see point *i),* consider the case when the predator observes the realization $\hat{d} > \underline{d}$ and therefore knows that - in the absence of predation - the prey's period 1 profit will equal $\hat{\Pi}_{SF} = [\hat{d}/4]^2 > \underline{\Pi}_{SF} = [\underline{d}/4]^2$. Suppose also that $C(\hat{d}) < X$, so the predator gains more by preying and preventing the investment than by maximizing current profits. If the predator increases its output to $q_a > d/2$ then the prey's profits drop to some $\pi_b < \hat{\Pi}_{SF}$. π_b might occur also as a result of a lower realization of the demand parameter: $\pi_b = \left[\tilde{d}/4\right]^2 = \tilde{\Pi}_{SF}$ where of course $\tilde{d} < \hat{d}$. Note however that if the predator finds it optimal to prey when the demand parameter equals $\tilde{d}$, then $\pi_b = \tilde{\Pi}_{SF}$ will only be observed as a result of predation so investors will know that predation must have taken place as soon as they observe π_b. (Investors know that when the two firms observe $\tilde{d}$, Firm b's first period profits will actually be lower than $\tilde{\Pi}_{SF}$.) In order for Firm a to successfully prey by lowering 2's profits to $\pi_b = \tilde{\Pi}_{SF}$, there must be no predation when $d = \tilde{d}$, implying that either $\underline{d} > \tilde{d}$ (predation is impossible even by reducing the value of the competitor's existing business to zero) or $C(\tilde{d}) > X$ (the cost of predation is too great).

The same reasoning can be applied as in the proof of Proposition 1 in order to show that investors' beliefs will be confirmed in equilibrium when they believe that Firm b will issue if there was no predation and observed profits equal true profits, and forgo the project otherwise.