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PREYING FOR TIME

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I. INTRODUCTION

THE RECENT antitrust policy literature which seeks to define predatory pricing contains a flood of proposals which have "pervasively transformed an entire body of law".¹ One theme of this literature is that a readily anticipatable standard should be established, so that firms will not fear being sued for normal competitive responses; another is that, since predation is presumed to be rare, the standard should be lax so as to minimize the possibility of stifling competition in the overwhelming majority of more competitive markets.

Perhaps the most striking feature of these arguments is the omission of any analysis of predatory behavior when business firms are sophisticated and "rational". McGee [1980, pp. 295-6], for example, points out that predation only pays if the present discounted value of future high prices exceeds the costs of suffering today's low prices. But if this is so for the monopolist, then why not for the competitor?

"It only *seems* paradoxical, therefore, that if a victim were sure this is a predatory campaign, rather than normal competition . . . , he would *surely* want to stick it out."

The argument that predation generally costs a predator more than it costs the prey (and other arguments) led McGee to conclude that predation is non-existent or rare, and that the best standard against predation would be no standard at all [p. 317].

To resolve whether some antitrust rule would work as desired requires analysis of an equilibrium with predation assuming that businessmen are reasonably intelligent. McGee points the way in qualifying his statements. His businessman is said to be "sure" the low price is not due to normal competition. This requires certainty: i.e., the businessman always knows exactly when a price is "predatory" versus when it is simply "competitive". If the process were so simple that businessmen could always be "sure", the difference between predation and competition should also be readily demonstrable to courts. But

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¹ Brodley and Hay [1981, p. 740]. Brodley and Hay review much of this literature as does McGee [1980]. Some other contributors are Areeda and Turner [1975], [1976], Baumol [1979], Greer [1979], Joskow and Klevorick [1979], Ordover and Willig [1981], Posner [1976], Schmalensee [1979], and Scherer [1976a], [1976b].

if businesses cannot always distinguish the precise point at which prices cease being "normally competitive", then predation may be both profitable and hard to detect by businessmen, courts or academic economists.

This paper develops a model of predatory pricing using the tools of incomplete information games. When the problem is seen as one of incomplete information, the standard reasons for saying predation is rare are not compelling. Further the lack of proof of predation is an unreliable empirical indicator of its prevalence. The model is designed to facilitate analysis of the efficiency of the various proposed antitrust rules when predation is rational. The result is that most of the rules may not prevent all instances of predation. For example the precise standard "Price must not fall below average variable costs" (Areeda and Turner [1975], [1976]), may in some cases serve as an instruction manual on how to avoid liability when preying.

II. AN INCOMPLETE INFORMATION GAME

II.1 *Entry with Imperfect Information*

The model is developed to analyse entry dynamics when the incumbent firm is a multimarket monopolist. An entrant who experiences a negative entry value in one market will analyse its cause prior to entry into another of the monopolist's markets. For example, if the entrant decides that the incumbent's production was more efficient than it had anticipated, it should consider whether the monopolist's other markets use the same or similar production processes and revise future anticipations accordingly. If negative entry value in one market slows or deters entry to other markets, the multimarket monopolist has an incentive to assure that an entrant is met with a negative entry value. This is true even if the Nash response of the monopolist, if it were only a single market monopolist, would yield positive entry value. Thus, if the cost of driving the entrant's value negative in one or a few markets is exceeded by the margin protected by forestalling entry into other markets, the multimarket monopolist has an incentive to "prey"—as long as this behavior actually inhibits entry.

From the monopolist's point of view, the success of this strategy depends upon keeping its identity hidden from potential entrants. If it were generally known that the single market Nash response would yield a positive entry value, entrants would rapidly enter the markets, predation would then be unprofitable, so a threat to prey would not be carried out. The dynamics of entrants' expectations and the monopolist's responses is critical. If an entrant knows, or believes, that predatory responses will never occur, it will conclude that a negative entry value resulted from inaccurate estimation of real competitive factors and will halt entry after a single episode: the expectation that predation will never occur makes it quite profitable. On the other hand, if entrants expected that all markets would be profitable absent predation they would be undeterred by initially negative entry values: the unprofitability of predation in that case would mean it would never occur. Where there is imperfect

information, entrants are not able to definitively attribute negative entry values to either misestimation or predation, and so some predation is liable to occur.

Two other models also analyse predation using incomplete information games. These models (Milgrom and Roberts [1982a] and Kreps and Wilson [1982b]) significantly restrict the strategies available to the players. In each period a new market appears. They require that predation, once it has begun *in any market* must continue in that market, so formally they have a series of one shot games. Since giving up is not permitted, predation, once started, is automatically credible for any market. The classical question (cf. Telser [1966], McGee [1980]), "How long can it pay to prey?" is swept aside.² This paper presents a model in which all prices are endogenous in all periods so that a richer strategy space appears: (a) entrants may now enter new markets to force a rise in profits in previously entered markets; (b) some monopolists may decide to prey only to gain extra time, with full knowledge that the predation will not preclude eventual entry of all of their markets. This adds three elements to the analysis: (1) the duration of predation in each market is endogenous; (2) entrants' abilities to cause predation to cease are modeled; (3) the anti-competitive potential of a type of predation which is ineffective in the longrun is also demonstrated. Each of these elements is important for antitrust analysis.

II.2 *The Model*

The model will be developed as a dynamic game with "imperfect but complete information". In each period several potential entrants consider entry into the markets of an incumbent monopolist. The monopolist in turn selects market parameters (e.g., prices, rebates, advertising...) for each market at each time. Information is "imperfect" in the sense that the potential entrants do not know all the competitive aspects of the monopolist's markets. Despite the fact that entrants do not have a perfect description of the monopolist they face, they have "complete information" about the types of monopolists they may be facing.³ More specifically, they know that the monopolist is one of H possible monopolists and they know the probability that it is any individual type of monopolist. The formal game theoretic model structure and proofs are detailed in the Appendix.

(i) *Predatory Acts*

A definition of predatory behavior is a prerequisite to further analysis. For the purposes of this paper, predation will be defined as:

The selection of strategy in any *entered market* which does not maximize present value in that market when it is considered in isolation, but which

² In terms of Figure 1 their firms only play on the diagonal of each matrix. Once a monopolist reveals it will not prey, additional markets can only be entered at a rate of one per period. Further, unlike strategy (b), any predator which does not prey in an additional entered market has "failed".

³ If predation is rational with complete information, it may be rational with incomplete information. See, for example, Rosenthal [1981].

is selected for the purpose of *slowing or stopping* future entry of *equally efficient* firms.

It is at times convenient to think of this "strategy" as a low price. Unlike "limit pricing", predatory pricing is only used *in response* to entry. These acts serve to slow or stop entry and need not require elimination of an entrant. They are knowingly selected in a fashion that does not maximize the monopolist's present value in each market separately. They occur where the Nash equilibrium for each market in isolation would lead to a positive entry value and involve the monopolist sacrificing profits in order to create a negative entry value. Further, the potential for a positive entry value demonstrates that the result does not simply reflect competitive overcrowding. The equal efficiency assumption (which is not essential) assures that the results do not simply reflect superior efficiency on the part of the incumbent firm.⁴

(ii) *Basic Structure of the Model*

There are J potential entrants indexed by $j = 1, \dots, J$. They observe a monopolist which is operating in m identical markets indexed by $i = 1, \dots, m$. From their knowledge about technology, demand, prices, and other observable characteristics the potential entrants know that the monopolist must be one of only H possible monopolists, indexed by $h = 1, \dots, H$. They further know that of these H possible types, only for a "type 1" monopolist would these markets be "inherently competitive" (markets for which the form of the non-predatory post-entry Nash equilibrium for a single market monopolist would yield a negative present value to any of the potential entrants). They know that the other possible types of monopolists, $h = 2, \dots, H$, all operate in "beneficial markets" (ones for which single market Nash reactions would lead to positive entry values for any entrant).

The monopolist's type is indistinguishable pre-entry. Even the post-entry results do not necessarily reveal the monopolist's type. If entry leads to profits which indicate that the entry has a positive present value, then the monopolist will have revealed itself to be a beneficial type, i.e., not of type 1. But the converse is not true. If entry leads to the level of profits which would be expected from entering a market of a type 1 monopolist, this is not a reliable indicator that the monopolist is actually a type 1 monopolist. It could instead be a beneficial monopolist feigning the reactions of a type 1 monopolist. If this occurs, a type $h > 1$ monopolist may be said to "play as a type $h = 1$ monopolist" or more simply, this may be called a "predatory response" (if the entrant is as efficient as the monopolist). Type $h > 1$ has an incentive to play as a type 1 only if, by doing so, it can slow or stop entry.

The problem of not knowing whether a non-remunerative entry episode

⁴ As Brodley and Hay [1981] point out, successful entry of somewhat less efficient firms may raise welfare. Our standard is intended to be a non-controversial sufficient condition for predation. It allows the incumbents' fixed sunk entry costs, valued at either original cost or replacement value, to be as high as, or higher than, those of entrants.

occurs from a type 1 playing as a type 1 (competition) or a type $h > 1$ playing as a type 1 (predation) demonstrates how imperfect information creates the potential for strategic behavior. It is assumed that entrants have complete information about the distribution of possible monopolist types in two respects. Prior to any entry all potential entrants know exactly the probability that the monopolist is of each type. After entry, by observing monopolist behavior, entrants accurately revise their prior probabilities.

A simple numerical example can illustrate model dynamics. For notational ease the markets are modeled as having static demand. As a consequence, the flow profits for any market, divided by the interest rate, r , are the present value of flow profits for that market unless competitive conditions change. The monopolists' flow profits are assumed to be ΠM in any unentered market. Predation by any $h > 1$ yields monopolist flow profits of ΠP . To simplify notation, without altering qualitative results, heterogeneity is introduced in only one parameter. This parameter is Πh , the flow profits monopolist h would receive were it to react to entry by playing its Nash present value maximizing strategy for the market. It follows that $\Pi h < \Pi M$, and for $h > 1$, $\Pi h > \Pi P$.

There is little cost in the richness of qualitative results from introducing heterogeneity for the \mathcal{J} potential entrants through only one parameter—fixed sunk entry costs. The entry costs of entrant j are f_j . Again for notational ease there are only two entrant types, entrant 1 and all others, defined by $f_1 < f_2 = f_3 = \dots = f_j$. If an entrant enters a market of a type 1 monopolist it receives "competitive" flow profits of πC . These do not induce exit, $\pi C \geq 0$, but are non-remunerative in the present value sense that $\pi C/r - f_j < 0$ for all of the \mathcal{J} potential entrants. Similarly, if an entrant meets a predatory response it receives flow profits of πC because a predatory monopolist must act so as to be indistinguishable from a type 1 monopolist. If the monopolist is of type $h > 1$ and "plays as itself" (e.g., plays to receive Πh), then entrant flow profits are πB . These are "beneficial" in the present value sense: $\pi B/r - f_j > 0$ for all of the \mathcal{J} potential entrants.

For predation to be optimal \mathcal{J} must be greater than 1, but the simplest case mathematically, $\mathcal{J} > m$, is selected. Also the presence of entrant adjustment costs leads to the most interesting equilibria. This is incorporated using a simple adjustment cost rule: each entrant can enter only one market in any period.⁵ Finally, no market can profitably absorb infinite entry. The simplest convention is to assume that no market can accommodate more than one entrant. Then to avoid the complications of modeling mistaken multiple entry, the extensive form of the game in each time period permits potential entrant \mathcal{J} to go first, $\mathcal{J} - 1$ goes second, and so on until entrant 1 chooses whether to enter. After all entry decisions are made, the monopolist responds for that time period.

⁵ With no adjustment costs the game collapses. For an airline to be certain not to face predation it must enter every city pair of every competitor in each entered market simultaneously. This might require entering on a single day virtually all U.S., European, Pacific, etc., city pairs. Leaving aside evidence of adjustment costs one should note that most entry is sequential. This fact should be instructive in terms of interpreting litigated predation cases as well.

(iii) *A Simple Example*

Suppose there are only three markets ($m = 3$),⁶ that there are only three monopolist types ($H = 3$), and that the monopolist is drawn from a sample composed of 49 type 1 monopolists, 50 type 2 monopolists, and a single type 3 monopolist. Direct solutions for equilibria are difficult, even for simple examples, but some equilibria can be constructed by working backwards. First, assume a behavior rule for each monopolist type and then derive optimal entrant reactions, "best replies". Second, assume an entry behavior rule and derive the best reply for each monopolist type. If the model parameters are selected such that: (a) the entrants' best replies are identical to the behavior rule assumed in solving for the monopolists' best replies; and (b) the monopolists' best replies are the behavior rules assumed in solving for the entrants' best replies, then a full game Nash equilibrium has been derived.

The first step is to analyse optimal entry. Suppose any of the 50 type 2 monopolists would always prey if only one market were entered, but would always play as type 2 if two or more markets were entered. Suppose that the type 3 monopolist's rule is to prey if one or two markets are entered but not if all three are entered. What is the optimal entrant response? One potential solution involves entrant J entering market 1 in period 1. Since $(J-1)$ is identical to J , then $(J-1)$ would enter market 2 in period 1, and similarly $(J-2)$ would enter market 3. The outcome of the first stage of the game would entail steady state flow profits of $(\Pi_1, \pi C)$ with probability 0.49; $(\Pi_2, \pi B)$ with probability 0.50; and $(\Pi_3, \pi B)$ with probability 0.01. Thus if J would enter there would be a flood of entry in stage 1. Neither predation nor sequential entry would be observed. Alternatively, if not even entrant 1 is willing to enter in period 1, no entry ever occurs. Again neither predation nor sequential entry would be observed.

One interesting case for predation occurs if there are entrant parameters which yield the following entry sequence:

- Time 1: Entrant 1 enters market 1.
- Time 2: Entrant 1 enters market 2.
- Time 3: If πB has occurred in markets 1 and 2 then entrant J enters market 3,
 and
 if πC has occurred in markets 1 and 2 there is no further entry.

Time 4-anon: No entry, the profit steady state is that of period 3.

Such parameters exist. The extremely low probability of type 3 monopoly relative to type 2 monopoly makes this intuitively clear. All that is needed is:

⁶ Predation is more likely to occur as m is increased, but it can occur with only three markets. Easley, Masson and Reynolds [1981] demonstrate this result in a decision theoretic version of this model. As m increases, the monopolist's value of markets protected goes up for any level of entry. But the entrant's breakeven point, assuming πB would be revealed upon its last entry, is unaltered.

(1) entrants $2, \dots, J$ do not find roughly even odds of πB to be attractive; (2) entrant 1 finds even odds to be attractive if it requires entering two markets sequentially; but (3) having entered 2 markets without observing πB , entrant 1 would not find entry of a third market to be attractive if the probability of πB were only 0.02 ($= 0.01/(0.49 + 0.01)$), the conditional probability that the monopolist is of type 3 if it has not played to yield πB in markets 1 and 2.

The technical statements of conditions (1)–(3) above are:

- (1) $[0.49\pi C/r + 0.51\pi B/r] - f_j < 0, \quad j > 1;$
- (2) $\{\pi C - f_1\} + \{[2(0.5\pi C/r + 0.5\pi B/r) - f_1]/(1+r)\} > 0;$
- (3) $\{3(0.98\pi C/r + 0.02\pi B/r) - f_1\} - \{2\pi C/r\} < 0.$

Conditions (1)–(3) are readily seen to be compatible (e.g., if $\pi C = 0$; $\pi B = 0.1$; $r = 0.1$; $J \geq 4$; $0.06 < f_1 < 0.3$; and $1 > f_2 = f_3 = f_4 > 0.51$, these conditions are met). This leads the entrants' best replies to be the behavior pattern described above in the sequence from time 1 to 4-anon.

There are parameters for a type 2 monopolist such that its reaction to the above entry behavior rule would be to prey in response to a period 1 entry, but to not prey in response to the second entry. There are also parameters such that a type 3 monopolist would prey in response to entry in both periods if it knew that by so doing its third market would not be entered. To demonstrate this it is useful to give the sequencing a visual representation in matrix form. The monopolist's flow profits can be represented for each of its three markets by the rows of the matrix; the columns represent time 1, time 2, etc. Since the profit steady state is reached after the last play in time 3, the additional infinite sequence of columns which replicate the time 3 profit outcomes can be suppressed. Using the entry rule above and recalling that if any monopolist $h > 1$ selects a response with profits of Π_h , then any remaining unentered markets will be entered, matrices (a) and (b) in Figure 1 show the profit sequences underlying a necessary condition for a type 2 monopolist to prey in the first time period. The only difference between matrices (a) and (b) are the "starred" profit levels in (b), elements (1, 1) and (3, 2). By foregoing period 1 profits in market 1, monopolist 2 gains by retarding entry into market 3 by one period. This condition is that profits from preying only one time exceed those from no predation.

$$(4) \quad (\Pi_2 - \Pi P) < (\Pi M - \Pi_2)/(1+r)$$

Further, monopolist 2 must not find it profitable to prey in period 2. A sufficient condition for this is that predation in the second period would not be remunerative even if it would stop all entry. This condition can be visualized by contrasting matrix (b) with (c): The difference is in those elements which are "starred" in matrix (c) (and for the continuing values of the third column elements in periods 4-anon). The condition for ceasing predation is found by the difference in present values between matrix (c) and (b). This difference is

Matrix (a)
No Predation

| market | time | | |
|--------|---------|---------|---------|
| | 1 | 2 | 3 |
| 1 | Π_2 | Π_2 | Π_2 |
| 2 | ΠM | Π_2 | Π_2 |
| 3 | ΠM | Π_2 | Π_2 |

Matrix (b)
Preying Only Once

| market | time | | |
|--------|-----------|-----------|---------|
| | 1 | 2 | 3 |
| 1 | ΠP^* | Π_2 | Π_2 |
| 2 | ΠM | Π_2 | Π_2 |
| 3 | ΠM | ΠM^* | Π_2 |

Matrix (c)
Preying Twice—
Stopping All Entry

| market | time | | |
|--------|---------|-----------|-----------|
| | 1 | 2 | 3 |
| 1 | ΠP | ΠP^* | ΠP^* |
| 2 | ΠM | ΠP^* | ΠP^* |
| 3 | ΠM | ΠM | ΠM^* |

FIGURE 1

composed of ΠP rather than Π_2 in two markets in perpetuity, and then starting one period later, ΠM rather than Π_2 in a third market in perpetuity. Rearranging terms this is:

$$(5) \quad {}_2(\Pi_2 - \Pi P)/r > (\Pi M - \Pi_2)/r(1+r)$$

Conditions (4) and (5) are consistent. By multiplying by r , the type 2 monopolist follows the conjectured strategy if

$${}_2(\Pi_2 - \Pi P) > (\Pi M - \Pi_2)/(1+r) > (\Pi_2 - \Pi P)$$

In order for a type 3 monopolist to behave as posited it must satisfy a condition similar to condition (4):

$$(6) \quad (\Pi_3 - \Pi P) < (\Pi M - \Pi_3)/(1+r)$$

Furthermore, it is necessary that it satisfy a condition which is the inverse of condition (5):

$$(7) \quad {}_2(\Pi_3 - \Pi P)/r < (\Pi M - \Pi_3)/r(1+r)$$

These conditions can be obtained by substituting Π_3 for Π_2 in matrices (a), (b) and (c). These are met for any parameters for which

$$(\Pi M - \Pi_3)/(1+r) > 2(\Pi_3 - \Pi P)$$

The type 3 monopolist has more to lose from a duopoly game ($\Pi_3 < \Pi_2$) than does the type 2. Generally, the more competitive is the non-predatory outcome, the greater the incentive to prey.

These conditions are sufficient for demonstrating the existence of an equilibrium with predation in the example. No monopolist can improve its profits given the entry decision rules and no entrant can improve its expected value given the monopolists' decision rules. In many discussions of predatory pricing the assumption is made that a predator's goal is either to eliminate a firm or attain submission (agreement or merger). Although the model can be used to illustrate these types of predation, the examples above demonstrate the existence of two other predatory strategies.⁷

The first strategy, used by monopolist 3, looks like classical "deep-pockets" predation, but it is not. The monopolist preys in some markets in perpetuity to protect others in perpetuity. In "deep-pockets" predation firms are alleged to use earnings from profitable markets to finance predation in others. That is certainly not the causality underlying this example. In fact the predatory markets may yield non-negative cash flows ($\Pi P \geq 0$). Thus, a "long purse" (see [Telser 1966]) is not required for predation to have anticompetitive effects in some markets in perpetuity.

The second strategy, used by the type 2 monopolist, involves the use of predation only to slow entry; it recognizes that it will subsequently cease its predation and face complete entry of its markets. Despite this fact, it can attain a greater present value by preying and retarding the rate of growth of competition. The fact that eventual entry is not stopped does not mean that predatory behavior has not occurred or that it has been unsuccessful. Profits can be made from slowing the inevitable.

Both of these strategies work despite the fact that potential entrants know these strategies and do their best to counteract them. For example, suppose that entrant one uses sequential entry to call the bluff. It continues to enter until it knows that accommodation is sufficiently unlikely that it is no longer profitable to enter. When it ceases to enter it knows that if it faces a predator it could force accommodation by yet further entry, and it knows it may be facing a predator. Despite this sophisticated entrant behavior, the model demonstrates that successful predation may stifle competition without either eliminating competitors or even stopping (some) competitors from entering!

⁷ Another interesting equilibrium pattern is not demonstrated. Suppose that if there had been only monopolists 1, ..., ($H-1$) that no entrant would have entered, but since type H was possible, entrant 1 did enter. It is possible that once behavior reveals that the opponent is not of type H , the entrant will continue to enter. This is because it has already invested the sunk costs in some markets and it may pay at the margin to try to force the monopolist to yield πB in these, and new, markets.

(iv) *Equilibria*

For any parameters the model generates a steady state within a finite horizon (see the Appendix).⁸ It is useful to note that entrants, $j > 1$, will enter at only one stage of any game. This will be either the first period or after a monopolist $h > 1$ plays as an $h > 1$ (see the Appendix).

It follows that there are equilibria of three generic types:

- (1) *Instantaneous Entry*: The probability of a type 1 monopolist is so low that all markets are entered in the first period.
- (2) *Zero Entry*: This has two subcases: (a) *Benign*: The probability of a type 1 monopolist is so great that even a type 1 entrant who expects no predation would not enter; (b) *Latent Deterrence*: Only a type 1 entrant would enter if all $h > 1$ monopolists would play their true types; it does not enter, however, in light of probabilities that type $h > 1$ monopolists would prey and it would be excessively costly to enter sufficient markets to force some of them to cease to prey.
- (3) *Sequential Entry*: This may involve pure or mixed strategy equilibria. There are three subcases: (a) *Competition*: The monopolist is of type 1. The type 1 entrant enters some markets and then ceases entry; (b) *Predation in Perpetuity*: The type 1 entrant enters only some markets, the monopolist is of type $h > 1$, but plays as type 1. The monopolist gains by initially slowing entry to only one market per period and then by halting all entry after that; (c) *Predation to Slow Competition*: The monopolist is of type $h > 1$, but plays as type 1 for some time. It later responds to entry by playing its own type and having all of its remaining unentered markets entered in the next period. Slowing competitive entry benefits the monopolist despite the fact that it knows it may not ("will not" in pure strategies) deter eventual entry to all of its markets.

One characteristic of sequential entry equilibria is worth stressing. Given the model structure, observed sequential entry of two or more markets can mean only one thing: there is a positive probability that the monopolist is a predator. The only possibilities are that πB is observed initially and a flood of entry precludes sequential entry or that πC is observed. Continued entry to the latter set of markets is only optimal if there is some chance that πC will be revised to πB . If πC may be revised to πB then this means that one possible reason πC is being observed is that the incumbent firm is a predator.

III. POLICY ISSUES

Since 1975 there has been "... a virtual explosion in the legal and economic literature dealing with predatory pricing [which] has rapidly and pervasively

⁸ A monopolist may be willing to prey longer if this would stop all future entry, than if it could only slow entry. When such a gap occurs the equilibrium may involve mixed strategies (within this gap). These equilibria are discussed more fully in Easley, Masson and Reynolds [1984] and a pure strategy decision theoretic solution is presented in Easley, Masson and Reynolds [1981].

transformed an entire body of [U.S. Antitrust] law, and within the briefest period of time" (Brodley and Hay [1981, p. 740]). The economic literature underlying this revolution has generally attempted to define predation without formally analysing its rationality. However, knowing when predation might work—the credibility issue—is an important step in knowing how and when to expect it. This issue is discussed in the policy literature, but its importance is not fully recognized. A closer examination of the role of imperfect/incomplete information in predatory pricing reveals fundamental infirmities in the current policy debate.

III.1. *Criteria for Policy Analysis*

The various proposals for predatory pricing rules have, either implicitly or explicitly generally contained the following points. First, some economic definition of predation is formulated. These vary by author depending upon numerous factors such as whether "fairness" is considered to be relevant. Next, a judicial definition is offered: How should courts define predation given the imperfect information that will be faced by courts? The policy goal can be seen as a rule which weighs the costs against the benefits from deterring or stopping predators. The costs are: (1) Enforcement costs; (2) Costs of type 1 errors (punishing the innocent); (3) Costs of type 2 errors (acquitting or not even detecting the guilty); (4) Costs from firms using alternative strategies to achieve the same ends; (5) Costs due to non-predatory firms acting to avoid being mistaken for predators. The potential for both benefits and costs from any rule against predation is highly dependent upon the incidence of predation. If predation is extremely rare, then costs (2) and (5) may easily outweigh the benefits. If it is very common (3) and (4) may be the primary costs, and the relative benefits from deterrence may be great.

III.2. *The Incidence of Predation*

Economists who opine that predation is rare have little evidence to go on.⁹ Predators are unlikely to admit to predation lest they lose their bluff or get prosecuted. Only if it does not expect to be detected will a monopolist prey.

⁹ If economists could definitively detect predation then; (1) it might not pay to prey if potential entrants could hire economists, and (2) predators could be easily brought to justice.

Koller [1971] examines the results of 123 cases since 1890. Only 26 out of 95 convictions have complete records. To be categorized as predatory by Koller an episode must pass three tests. The third test is that a competitor must be eliminated or merged or that there be "improved market discipline". The predators demonstrated in this model would never violate this criterion. Koller finds 5 total cases of predation by his standards.

It is noteworthy that many filed Sherman Act cases involve a multi-geographic market firm allegedly preying in a subset of markets, and many of the remaining cases involve a firm with several related products allegedly preying for only some of these products. Defendants and others argue that many allegedly threatening statements are the rhetoric of tough competition, but if threat-like statements come from type 1's they should also come from type $h > 1$. Finally, as noted above, markets more predisposed to competitive results are, *ceteris paribus*, more predisposed to predation.

Furthermore, predators will not wish to maintain evidence (e.g., incriminating memos) where it can be discovered. Although unambiguously incriminating evidence sometimes emerges, these firms have every incentive to settle the case out of court, leaving only the atypically ambiguous cases to go to court and become publicly reported. These cases are the bulk of the available evidence on the incidence of predation.¹⁰ It would thus seem risky to assume that predation is rare, and hence that costs (3) and (4) may be high.

III.3. *The Model and Proposed Antitrust Rules*

At the risk of oversimplifying numerous and varied analyses in the policy literature, the literature can be viewed as based upon the case of a single market industry with high entry barriers and long entry lags. Therefore, if an entrant can be swiftly eliminated, a monopolist may enjoy a long period of elevated profits. The role of conjectures in these discussions is generally implicit or simplistic. Multimarket considerations are then tacked on as an after-thought (cf. Brodley and Hay [1981, pp. 789–790] or McGee [1980, p. 326]).

Although the model presented here has no pretense of encompassing all possible types of predation, it demonstrates that previous analyses leave out many potentially important aspects of the problem. In contrast to one common view, predation need not imply economic murder (the elimination of an entrant) or coercion (to force conspiracy or merger upon an entrant). By simply making life tough for entrants the monopolist may intimidate future entry. By the same token, large entry barriers need not be present for predation to be an optimal strategy.¹¹ Indeed relatively low entry barriers and the threat of rapid mass entry may motivate a monopolist to artificially manufacture an additional entry deterrent through predation.

The new proposed “economic rules” against predation have had a profound effect upon legal decisions in the last decade. It is accordingly useful to see how these rules stack up against this model in which predation is in fact a rational strategy with sophisticated players. Several of the new rules propose “bright-line” standards, which describe precisely what is predatory and, by exclusion,

¹⁰ Of course additional circularity is added because if a particular predatory price does not fit the current legal precedent the case will probably not be filed. Conversely, the Robinson–Patman Act requires only the showing of injury, not predation, so there is a danger that loose use of judicial language could misbrand other cases.

¹¹ What courts have traditionally called monopoly is not needed either. Suppose every city has the same non-conspiring 4 grocery stores (A–D) located in a ring around the central city. An entrant entering near A (e.g., between A and B) might experience predation for precisely the reasons incorporated above, or because A (and/or B) attempt to induce it to try entering near C in the next city. If the entrant suspects all monopolists (A–D) are of the same type it may continue to enter A’s markets to attempt to force a shift to πB . If A may differ from B–D (e.g., product differentiation may lead to differences in perceived or actual cross elasticities of demand, or firm cost structures may differ) it may shift to entering near C. For this type of spatial oligopoly neither entry barriers nor large city market shares are required for predation to be effective. Finally, as discussed above, markets more prone to competitive results will, *ceteris paribus*, be more prone to predation.

what is not. Stripped to their essentials, the existing proposals can be summarized as follows.¹² "The courts should find it illegal for a dominant firm to ..." (1) "Set price below average variable costs"; or (2) "Set price below marginal costs"; or (3) "Eliminate a competitor by ..."; or (4) "Increase price following exit"; or (5) "Set price below average costs with intent to ..." or (6) "Increase output when experiencing entry".

One advantage of the "bright-line" approaches is that they let firms know exactly what they are not permitted to do, so that the fear of violating the law "by mistake" does not have a chilling effect on all activity. By the same token, a list of interdicted activities tells firms exactly what competition-stifling tactics they are permitted to employ. The parameters of the model in section II above were selected to demonstrate this. None of the predators described there could be held in violation of standards (1)–(4). Prices are not below AVC or MC and exit is not induced.¹³ Nor need they necessarily violate (5) using accounting costs. Measuring costs correctly (e.g., replacement value, learning effects) reduces the rule's precision (see Brodley and Hay [1981]). Also, depending upon technological and demand factors (some of which may be manipulated prior to entry) there is no logical necessity for the modeled firms to violate standard (6). Ironically, for the modeled firms, some bright-lines may constitute the instruction manual on how to prey with impunity.

Scherer [1976a], [1976b], Brodley and Hay [1981], and Schmalensee [1979] suggest using a Rule of Reason approach. Litigation may be more costly with this approach, but the unseen portion of the evidentiary iceberg, documents or admissions of intent,¹⁴ often come from the wider scope of inquiry. Many of the cases brought under the Sherman Act involve slashing prices by large margins (not infrequently by 50 %). It seems doubtful that many firms are inhibited from socially desirable competitive price cuts due to fear of Sherman Act litigation.¹⁵ The burden of proof is high, the number of cases filed as a proportion of price cuts is no doubt minuscule. But, to the extent that there is a small chilling effect, the by-product is that even non-predatory firms may be forced to keep pre-entry prices more closely aligned with costs in order to avoid the appearance of predation if there is entry.¹⁶ Thus if fear of litigation

¹² These standards are for predatory pricing. It is notable that most cases involve allegations of complementary coercion as well (e.g., bribing suppliers, threatening buyers). Standards (1)–(6) are simplified from their originals. They are respectively from: (1) Areeda and Turner [1975]; (2) Posner [1976]; (3) Ordover and Willig [1981]; (4) Baumol [1979]; (5) Greer [1979]; (6) Williamson [1977]. Joskow and Klevorick [1979] use a combination of (1), (4) and (5).

¹³ If (4) did not require an exit, the rule would lower an entrant's incentive to enter a potential predator's markets because it could not achieve πB in its infra-marginal markets for a quasi-permanent time period.

¹⁴ Good documentary evidence is seldom made public because when it is available the case is typically settled before trial.

¹⁵ The Robinson-Patman Act does not require a showing of predation. Any effect it has on pricing should not be attributed to a predation standard.

¹⁶ Contestable market theory depends upon an incumbent not being able to respond to match the entry price for a finite period of time. If sunk costs are non-zero this time period expands. Although this limits the applicability of contestability to a general curiozum (cf. Schwartz and Reynolds [1983]), its basic elements might come into play if firms feared litigation if they cut prices in response to entry.

has any effect at all upon non-predators, whether this leads to on average higher or lower prices, is itself an open question.

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APPENDIX: STRATEGIC PLAY AND EQUILIBRIUM

The model has a "sequential equilibrium" as defined by Kreps and Wilson [1982b]. All players know that the monopolist's markets are ordered in an entry sequence of $1, 2, \dots, m$. At stage "0" of the game, nature selects the monopolist. The probability of type h is p_h , where $\sum_{h=1}^H p_h = 1$. These and all other parameters are in the entrants' stage 1 information set. At stage 1, entrant j has the first move, an entry decision (on market 1). Then entrant $j-1$ moves. It can infer j 's move from the model structure. If it infers that j entered 1, it decides whether to enter 2; if it infers j did not enter, its decision is on market 1. This sequence of, in effect, simultaneous moves continues until 1 has moved. Then the monopolist selects its move given the information set derived from knowing its type and knowing all entry moves. (A type $h > 1$ will clearly play only 1 or its own type in equilibrium.) The stage 2 entrant information set includes all parameters and the revealed knowledge of all moves in stage 1. The game is then infinitely repeated.

Sequential equilibria exist for finite games. The game can be made finite by imposing a finite duration on the markets. Alternatively, suppose that once entry ceases there will be no future entry (certainly no new information would be generated if the monopolist changes its play only in response to entry). In this case the model has at most m stages before reaching a steady state which defines terminus values, for a finite game.

The information of entrant j is represented as a partition, Γ^j , of the nodes of the game tree at which j must move. At time t the possible nodes are denoted S_t^j and the partition is Γ_t^j with its elements the information sets I_t^j . These indicate which monopolist(s) entrant j may be playing at time t . A monopolist's information set at any time is the individual node associated with its identity. The set of possible nodes for a monopolist at t is denoted S_t^m , and this is partitioned into individual nodes, s_t , the information sets for the monopolist at time t .

A strategy for entrant j is a sequence of functions $g^j = \{g_t^j\}_{t=1}^m$, where the function $g_t^j: \Gamma_t^j \rightarrow \{x \in R_+^m: \sum_{i=1}^m x_i \leq 1\}$ assigns a probability to entering each market as a function of entrant j 's information at stage t . A strategy for monopolist h is also a sequence of functions $G^h = \{G_t^h\}_{t=1}^m$. The monopolist's possible information sets are S_t^h , so $G_t^h: S_t^h \rightarrow \{x \in R_+^H: \sum_{h=1}^H x_h = 1\}$ assigns the probabilities the monopolist will play as any type h in $\{1, \dots, H\}$ in any entered market. (A type 1 must play as type 1, so $G_t^1(s_t) = (1, 0, \dots, 0)$ for all t .) A monopolist of type $h > 1$ may assign positive probabilities to any play, but optimal behavior leads to zero probabilities always being assigned to all but the first and h^{th} element of the vector.

Let $g \equiv \{g^1, \dots, g^J; G^1, \dots, G^H\}$ describe the vector of entrants' and monopolists' strategies. Nature selects the monopolist's type using probabilities (p_1, p_2, \dots, p_H) . This

probability vector and any strategy vector g induces a probability p^g on the nodes of the game. The probability of reaching any node s is denoted $p^g(s)$ and the probability of reaching any set of nodes, for example I^j , is denoted $p^g(I^j)$.

Define $\mu^j(s)$ as the probability j assigns to being at node $s \in I^j$ if it arrives at information set $I^j \in \Gamma^j$. (Note $\mu^j(s)$ is implicitly conditioned upon I^j .) For any strategy vector, g , and expectation, μ^j , entrant j can assign probabilities to the terminal nodes, conditional upon any information set during the play of the game. Define $\rho^{\mu^j, g}(s | I^j)$ as the conditional probability entrant j assigns to terminal node s given the information set I^j . Then expected payouts are $E^{\mu^j, g}[\cdot | I^j]$. (For the monopolist, expected payouts are $E[\cdot | s]$ for any node.) Let $\mu = (\mu^1, \dots, \mu^J)$ be the vector of entrants' expectations.

Then (μ^*, g^*) is a *Sequential Equilibrium* if three conditions are met.

- (i) For all $j \in \{1, \dots, J\}$ and $I^j \in \Gamma^j$,

$$E^{\mu^{*j}, g^*}[\pi^j(s) | I^j] \geq E^{\mu^{*j}, g}[\pi^j(s) | I^j] \text{ where}$$

$$g \equiv (g^{*1}, \dots, g^j, \dots, g^{*J}; G^{*1}, \dots, G^{*H}), \text{ for all strategies } g^j.$$
- (ii) For all $\bar{s} \in S^h$ and all $h \in \{1, \dots, H\}$

$$E^{g^*, \mu^*}[\Pi^h(s) | \bar{s}] \geq E^g[\Pi^h(s) | \bar{s}] \text{ where}$$

$$g \equiv (g^{*1}, \dots, g^{*J}; G^{*1}, \dots, G^h, \dots, G^{*H}), \text{ for all strategies } G^h.$$
- (iii) There exists a sequence (μ_n, g_n) with $\lim_{n \rightarrow \infty} (\mu_n, g_n) = (\mu^*, g^*)$ such that for each n :
 - (a) $1 \gg g_n^j(I^j) \gg 0$ for all $I^j \in \Gamma^j$,
 - (b) $G_n^h(s) \gg 0$ for all s for each $h \in \{2, \dots, H\}$ and
 - (c) $\mu_n^j(s) = p_n^{s_n}(s) / p_n^{s_n}(I^j)$ for any $s \in I^j$, for all $I^j \in \Gamma^j$, and all j .

Conditions (i) and (ii) are simply that all entrants and the monopolist maximize expected profits given the equilibrium strategies of all other players. Condition (iii) is the "consistency condition". One heuristic interpretation is that (a) and (b) force positive probabilities on all possible outcomes. Condition (c) requires that expectations be derived from Bayes rule where applicable. The positive probabilities in (a) and (b) allow for expectations to be defined when attaining information sets which are logically possible, but off any equilibrium path. The limit assures that this assignment rule accurately presents expectations along any equilibrium path.

With these definitions, Proposition 1 follows directly from Kreps and Wilson's Proposition 1:

Proposition 1. The extensive form game of section II and this Appendix has at least one sequential equilibrium.

The model generates at most two truly strategic players, entrant 1 and the monopolist, if the monopolist is of type $h > 1$. This vastly simplifies constructing examples like those in the text.

The intuition is simple, if any $j > 1$ is willing to enter at stage 1, then all are willing at stage 1, so the game ends. Further, unless πB is observed in some later stage, entrants $j > 1$ have only "bad news", so they will not enter. Hence types $j > 1$ can be treated as "exogenous", entering all unentered markets only at stage 1 or at the stage after observing πB . Proposition 2 demonstrates these two entry equilibria for $j > 1$ in sections (i) and (ii) respectively.

Define: p_1 as the initial probability of a type 1 monopolist; $h(I_t^j)$ as the monopolist type played in stage $t-1$ (which entrant j observes at stage t); $n(I_t^j)$ as the number of markets entered at information set I_t^j ; and $\|g_t^j\|$ as the norm of g_t^j . (Note that $\|g_t^j\| = 1$

only if j chooses to enter some market with probability one and $\|g_t^j\| = 0$ if j chooses not to enter.)

Proposition 2. There exists an equilibrium where:

(i) *If $(p_1\pi C + (1-p_1)\pi B)/r \geq f_2$ then:*

$$\|g_1^j\| = \{1, \text{ if } j \in \{J, \dots, J-m\}; 0, \text{ otherwise}\} \text{ and}$$

$$\|g_t^j\| = 0 \text{ for all } t > 1, \text{ for all } j.$$

(ii) *If $(p_1\pi C + (1-p_1)\pi B)/r < f_2$ then for all $j > 1$ and all t :*

$$\|g_t^j\| = \{1, \text{ if } h(I_t^j) > 1 \text{ and } j > J - (m - n(I_t^j)); 0 \text{ otherwise}\}.$$

Proof

(i) If $(p_1\pi C + (1-p_1)\pi B)/r \geq f_j$ for all j then entry is profitable if there will be no predation (if $h > 1$ yields πB). From Proposition 1, condition (ii), if all m markets are entered h will play its true type. Entrants $J, \dots, J-m$ will enter sequentially, as for any $j' > J-m$ to delay for one period would lead to pre-emption by the entry of $J-m-1$.

(ii) If $(p_1\pi C + (1-p_1)\pi B)/r < f_j$ for $j > 1$ then the optimal stage 1 strategy for $j > 1$ is $\|g_1^j\| = 0$. This results because j 's payoff from entry, even with the most favorable strategies for its opponents, is negative. Thus no entrant $j > 1$ will enter in stage 1.

At any information set I_t^j , j will enter ($\|g_t^j\| = 1$) if there is an unentered market, that is, $j > J - (m - n(I_t^j))$ and if $\mu(s) = 1$ for any node $s \in I_t^j$ on a branch of the tree following a selection by nature of $h > 1$ (that is, if Πh is played and πB received). This strategy is optimal for the same reason as in (i) above.

At any information set I_t^j , $j > 1$ will not enter ($\|g_t^j\| = 0$) if $h(I_t^j) = 1$ because $\sum \mu(s) \leq (1-p_1)$ for $I_t^j \subset I = \{s : s \text{ is on a branch following selection by nature of } h > 1\}$.