A Policy to Prevent Rational Test-Market Predation

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This article models the problem of designing predation policy as one of structuring incentives so that firms choose not to practice predation but to engage in nonpredatory competition. The government decides how intensively to search for possible predatory incidents, how thoroughly to investigate each incident, and how much to penalize convicted predators. We consider test-market "bluffing" predation in which incumbents with high costs can deter entry into a national market by pretending to have low costs. If fines are merely transfers, the optimal fine is the largest one that is feasible. Furthermore, the government should avoid injunctions against "continued predatory pricing."

1. Introduction

■ In discussing predation policy, economists have traditionally focused on developing appropriate definitions of predation.[1] Even with "correct" definitions, however, it is often difficult to determine in practice whether a firm's actions are predatory or merely competitive; marginal cost, for example, can only be observed inaccurately. Indeed, there may be significant welfare costs of falsely penalizing a firm for predatory behavior or of failing to penalize a truly predatory firm.

This article explicitly models the problem of designing predation policy as one of structuring incentives so that firms choose not to practice predation but, at the same time, are not discouraged from engaging in nonpredatory competition. The government decides how intensively to search for possible predatory incidents, how thoroughly to investigate each incident, and how much to penalize convicted predators. This approach differs from previous ones in its focus on the optimal administration of predation criteria, once the criteria have been established. Explicit account is taken of the fact that it is often difficult to identify possible predatory incidents and that, in general, investigations are inaccurate. The policy suggested here attempts to minimize the welfare costs of inaccurate investigations. Indeed, to the extent that fines are just transfers, these welfare costs are eliminated.

These points are illustrated with a somewhat stylized model of test-market "bluffing" predation (Salop and Shapiro, 1980) in which predation can emerge as the rational strategy

[1] Areeda and Turner (1975), Scherer (1976), and Williamson (1977) offer various definitions of predatory pricing. Ordover and Willig (1981) propose a general criterion, which is used to analyze predatory product innovation.

of the incumbent firm. Before entering a national market, a potential competitor often tests its product in a local market to predict, among other things, the ability of the monopolist to respond to entry. In general, entrants will fare worse against incumbents with low-cost technologies. But costs are both difficult and costly to determine from available documents and market behavior. If the incumbent simply maximized profits in the test market, the entrant would be able to infer the nature of his rival's costs by knowing demand and by observing the incumbent's price in the test-market duopoly game: low prices signal low costs; high prices signal high costs.

Thus, monopolists with high costs may wish to hide their true cost structure by charging a test-market price below the nonpredatory duopoly level. Although short-run profits will be lower, this strategy may lead to greater long-run profits by inducing the entrant to abandon production. If the greater profits from retaining the monopoly exceed the costs, predation—charging a test-market price below the duopoly level—will be the rational strategy of the incumbent. This pricing strategy is a special case of the general definition of predation proposed by Ordover and Willig (1981): a practice is predatory if it would be unprofitable if the entrant did not exit but is profitable if that exit occurs. On the other hand, the definition offered by Areeda and Turner (1975)—a price is predatory if and only if it is below marginal cost—may suggest that such a strategy is not predatory.

In general, it is desirable for the government to prevent predation if such behavior entails reduced social welfare, perhaps in the form of higher prices or less innovation. Again, the problem is that what appears to be bluffing predation may be a healthy response to competition or *vice versa*. Even with extensive auditing and investigations, the government, just like the entrant, is likely to be uncertain about the incumbent's costs. Excessive fines on firms that charge low test-market prices may not only prevent predation, but also lead firms with low costs to pretend they have high costs to avoid erroneous government penalty. But if a monopolist with low costs attempts to disguise his true costs, then the authorities have done nothing to facilitate entry. This is a case in which predation is discouraged, but so is healthy competition.

An effective government policy, therefore, eliminates the incentive to practice predation *and* maintains the incentive for monopolists with low costs to act competitively. The government's problem is to design mechanisms that, at minimum cost, induce firms to act honestly, i.e., to reveal their true cost structures.

In this article, the government's tools are search, investigation, and fine. *Search* is the process by which the government attempts to detect possible predatory incidents; *investigation* is the use of resources in litigation to discover the true cost structure of the suspected predator; *fines* are penalties levied against monopolists who are judged predators. By properly choosing the combination of search, investigation, and fines, the government induces the monopolist to reveal his true costs to the entrant, thereby encouraging entry only when profitable.

The article is organized as follows. Section 2 describes the equilibrium in the test market before implementing the optimal government policy. Section 3 outlines the government's policy instruments. In Section 4 we show that if all possible predatory incidents can be identified and if accurate investigations can be conducted, then a successful government policy always exists. Necessary conditions for the existence of such a policy are also derived. Further, we show that if firms are risk neutral and fines are merely redistributive, the optimal fine is the feasible maximum. Section 5 considers questions of how the optimal government policy varies across different industry configurations. Specifically, other things being equal, (i) the government should more carefully search and investigate firms in industries with large national markets; (ii) firms capable of paying higher fines should be investigated less frequently and at least as carefully; and (iii) in more monopolistic industries there are conditions under which the government should conduct investigations more frequently with at least as much accuracy.

2. Bluffing predation

■ The model follows closely that of Salop and Shapiro (1980). Consider a firm that is evaluating whether to enter a monopoly's national market but is uncertain about the incumbent's cost structure. The entrant believes the monopolist has low costs with probability, α, and high costs with probability, $1 - \alpha$. Let π_L^e and π_H^e be the present discounted value of the entrant's profits in the national market when competing against an incumbent with low and high costs, respectively. Denote by K the sunk costs of entering the national market. Assume that given his priors, the entrant's expected profits are negative, i.e.,

$$\alpha\pi_L^e + (1 - \alpha)\pi_H^e - K < 0. \tag{1}$$

Although (1) is neither necessary nor sufficient for test marketing,[2] it is necessary for the existence of a predatory equilibrium in this model.

Entry is profitable against an incumbent with high costs, but it is not profitable against one with low costs,

$$\pi_H^e - K > 0$$
$$\pi_L^e - K < 0. \tag{2}$$

Given his prior beliefs, the potential entrant will not enter the national market unless he learns that the incumbent has high costs.

If the incumbent acts innocently in the test market (does not seek to hide his true costs), the entrant can infer the cost structure of the incumbent from the incumbent's response to test marketing. We assume that before test marketing, the entrant is ignorant about both demand and the monopolist's costs; the entrant is unable to infer cost from the observed monopoly price. After producing and selling the product in the test market, the entrant learns about production costs and test-market demand. The entrant can then infer cost from price, if the incumbent acts innocently and the entrant knows the kind of duopoly game (absent predatory considerations) that would be played.

The test-market profits of the incumbent, labelled 1 if low-cost and 2 if high-cost, are π_i^m under monopoly and $\pi_i^d(p)$ under duopoly when the price is p. Price p_i maximizes duopoly profits (absent strategic considerations) for a type-i firm, where $p_1 < p_2$ and $\pi_1^d(p_1) > \pi_2^d(p_2)$. This formulation does not commit us to a particular duopoly game such as Cournot or Bertrand.[3]

The strategic game is of the following form. After the entrant places his product on the test market, the incumbent responds with a price in the test market. Based on the incumbent's pricing response, the entrant either enters the national market or exits entirely. If there is exit, the incumbent retains his national monopoly and earns $\gamma\pi_i^m$ in the national market, where γ is a factor relating test-market to national-market profits. If there is entry, the entrant is committed by virtue of sunk costs, and the incumbent maximizes duopoly profits in the national market and earns $\gamma\pi_i^d(p_i)$.

The equilibrium concept used to solve the game is Bayesian (Harsanyi, 1967) and follows closely the recent work of Kreps and Wilson (1982) and Milgrom and Roberts (1982a, 1982b). An equilibrium (Nash) is a pair of strategies by the incumbent and entrant such that, given the other player's strategy, the strategy of each player maximizes its expected profits.

It is clear that if both types of incumbent set the same price, the entrant learns nothing from the test market. This is the case of "bluffing predation." Alternatively, the two types

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[2] There will be test marketing when γ is positive if the increase in expected profitability due to gaining more information about the incumbent's cost structure outweighs the cost of test marketing.

[3] In some cases, it makes sense to think of the strategic variables as quantities rather than prices. This is easily done without affecting the basic structure of the game.

may choose different prices. The entrant would then enter the national market if the observed price identified the incumbent as having high costs.

The extensive form of the game is depicted in Figure 1 below. The dotted lines represent the information set of players $\mathcal{J}$ (incumbent) and E (entrant); the ordered pair at the end of each branch represents the payoffs to the incumbent and entrant, respectively, for each set of moves. The incumbent's payoffs are test-market plus national-market profits, while the entrant's listed payoffs are only national-market profits (since test-market profits are irrelevant in deciding whether to expand production).

The entrant's strategy is denoted by (E_1, E_2) with $E_1, E_2 = 0$ for exit $= 1$ for entry into the national market; E_i is the action if p_i is observed. The incumbent's strategy is denoted by (p, p'), where p is the price if the incumbent has low costs and p' the price if the incumbent has high costs.

Proposition 1. The following pairs of strategies are equilibria of the game:

(i) Separating equilibrium. If $\pi_2^d(p_1) + \gamma \pi_2^m \leq (1 + \gamma)\pi_2^d(p_2)$,

Entrant: $(0, 1)$
Incumbent: (p_1, p_2).
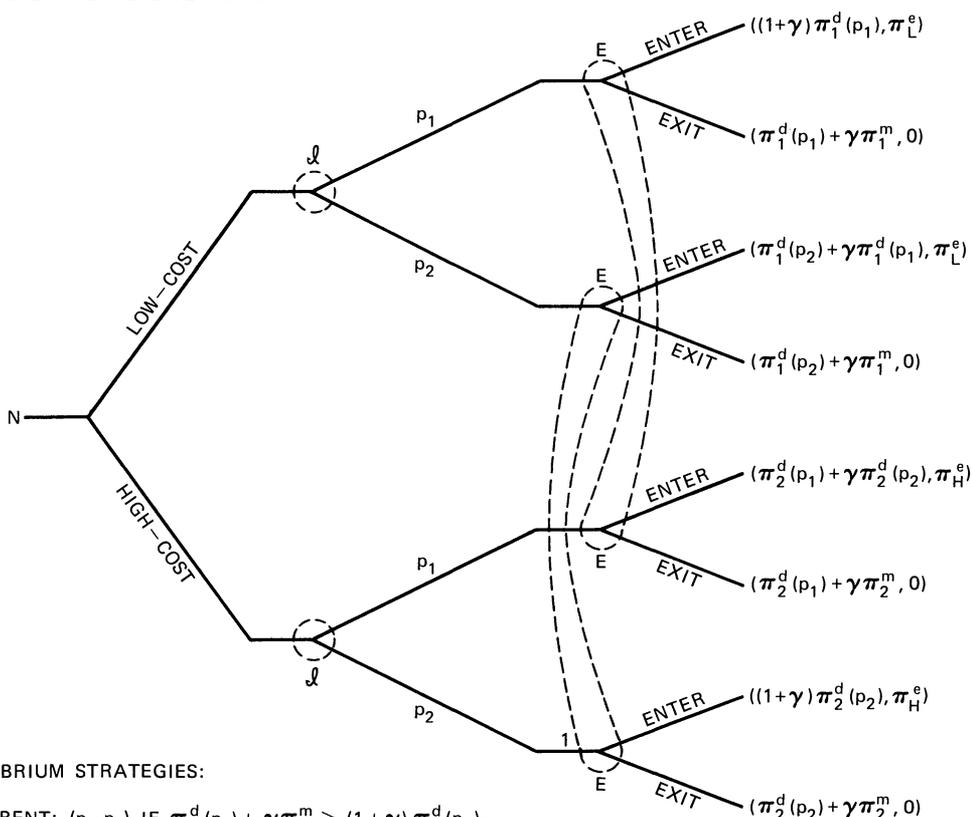
(ii) Pooling equilibrium. If $\pi_2^d(p_1) + \gamma \pi_2^m > (1 + \gamma)\pi_2^d(p_2)$,

Entrant: $(0, 1)$
Incumbent: (p_1, p_1).

FIGURE 1

THE GAME IN EXTENSIVE FORM

EQUILIBRIUM STRATEGIES:

INCUMBENT: (p_1, p_1) IF $\pi_2^d(p_1) + \gamma \pi_2^m > (1 + \gamma)\pi_2^d(p_2)$

(p_1, p_2) IF $\pi_2^d(p_1) + \gamma \pi_2^m \leq (1 + \gamma)\pi_2^d(p_2)$

ENTRANT: $(0,1)$

Proof. Suppose first that $\pi_2^d(p_1) + \gamma\pi_2^m \leq (1 + \gamma)\pi_2^d(p_2)$ (Case (i)). If the entrant's strategy is $(0, 1)$, then p_1 is the best response of the incumbent with low costs since p_1 maximizes test-market profits and induces exit. If $\pi_2^d(p_1) + \gamma\pi_2^m \leq (1 + \gamma)\pi_2^d(p_2)$, an incumbent with high costs maximizes profits by charging p_2 in the test market, even though there is entry.[4] Since the entrant knows that $\pi_2^d(p_1) + \gamma\pi_2^m \leq (1 + \gamma)\pi_2^d(p_2)$ when he observes p_1, he knows he is facing an incumbent with low costs. In that case exit is the best response, since $\pi_L^e - K < 0$. Similarly, the entrant can infer that a firm charging p_2 has high costs; entry is the best response since $\pi_H^e - K > 0$. Thus, (i) is an equilibrium.

If $\pi_2^d(p_1) + \gamma\pi_2^m > (1 + \gamma)\pi_2^d(p_2)$, the best response of the incumbent with high costs to the entrant's strategy of $(0, 1)$ is p_1; the lower test-market profits are outweighed by the higher national-market profits due to exit. Likewise, p_1 is the best response of an incumbent with low costs. Now, if (p_1, p_1) is the incumbent's strategy, the best response of the entrant must be to exit if he observes p_1, since he cannot infer the incumbent's cost structure from the test-market price and $\alpha\pi_L^e + (1 - \alpha)\pi_H^e - K < 0$.

It is worth noting that strategies by the entrant that specify "entry regardless of the observed test-market price," $(1, 1)$, and "exit regardless of the observed test-market price," $(0, 0)$, cannot be equilibria of this game. In the former case, the incumbent's best response is to maximize test-market profits. The entrant's expected profits then are $\alpha\pi_L^e + (1 - \alpha)\pi_H^e - K < 0$. Clearly, $(1, 1)$ is not the best response to (p_1, p_2), and the pair is not an equilibrium. The same type of argument can be used to show that $(0, 0)$ is not an equilibrium strategy. There is, however, another equilibrium of the game, with the entrant's strategy $(1, 0)$, but it seems reasonable to dismiss it as implausible.[5]

It remains to specify the conditions for entry into the test market. Whether the entrant tests his product depends on his expectations about the possibility of predation. If the entrant knows that upon test-market entry the high-cost incumbent will engage in predatory behavior, the entrant will never enter the test market in the first place.[6] We assume that before test-market entry the entrant does not know with certainty whether predation is profitable. After entering the test market and learning about demand and production costs, the entrant knows whether Case (i) or Case (ii) holds. Since we assumed earlier that the entrant does not know the profit functions before test-market entry, it seems reasonable to assume that he does not know whether $\pi_2^d(p_1) + \gamma\pi_2^m \gtrless (1 + \gamma)\pi_2^d(p_2)$. Thus, let β be the probability that the price is revealing, i.e., that $\pi_2^d(p_1) + \gamma\pi_2^m \leq (1 + \gamma)\pi_2^d(p_2)$. We assume that the entrant's expectations about β are formed independently of those about α: in the entrant's prior, the event that price is revealing is independent of the event that the incumbent's cost is low.

Thus, the potential entrant tests his product if

$$\beta[\alpha\pi_L^e + (1 - \alpha)((1 + \gamma)\pi_H^e - K)] + (1 - \beta)\pi_L^e - T > 0, \tag{3}$$

where the profit functions now represent test-market profits and T denotes the sunk costs of test-market entry. With probability, β, the equilibrium is separating. Hence, with probability $\alpha\beta$ the entrant knows that the incumbent has high costs and then enters the national market; with probability $(1 - \alpha)\beta$ the entrant knows that the incumbent has low costs and

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[4] We assume that if the incumbent is indifferent between strategies, he chooses the "honest" one.

[5] The incumbent's best response to $(1, 0)$ is

$$(p_2, p_2) \quad \text{if} \quad (1 + \gamma)\pi_2^d(p_1) < \pi_2^d(p_2) + \gamma\pi_2^m.$$

Strategy $(1, 0)$ is a best response to (p_2, p_2) even though it yields zero profits. It seems unrealistic to expect the entrant to play a strategy that allows no hope for positive profits after making a costly commitment to test market its product. Indeed, one could argue that by entering the test market the entrant is signalling to the incumbent that he is hoping to earn positive profits and will play strategy $(0, 1)$. This argument, which is similar to one offered by Kohlberg and Mertens (1982), rules out the perverse equilibrium.

[6] This possibility could have been avoided by specifying more than two types of incumbents, but that would have complicated the model considerably.

then exits entirely. The equilibrium is pooling with probability $(1 - \beta)$. In this case the entrant is faced with a low price in the test market and abandons production. If (3) is negative, there can be a kind of predatory equilibrium in which the threat of predation is used to deter entry.[7] If (3) is positive, there can be test-market entry, predation, and exit. It is shown later that the government policy introduced here increases the expected profitability of test marketing.

Predatory behavior of the type described above may involve a welfare loss owing, for example, to high prices and to production by firms with higher costs than necessary. In the following sections, we consider a policy that deters such predatory behavior.

3. Government policy instruments

■ Consider a government agency charged with implementing a policy to prevent predation. The agency's objective is to encourage entry into industries that have incumbents with high costs and exit from those industries that have incumbents with low costs. Of course, it *may* be socially optimal to induce entry against incumbents with low costs as well. We place this issue in the background and assume that the welfare effects are such that it is optimal to pursue the stated objective.

As a fixed cost of designing the policy, the agency acquires information about the configuration of the industry, e.g., the existence of a competitive fringe, the availability of demand substitutes, and market concentration. Based on this information, the agency is able to infer the relevant data of the duopoly game. Once the agency has made the decision to design a policy to prevent predation and has acquired the requisite data on the incumbent's profits, it determines the least costly policy to achieve that goal.

The government knows whether predation could occur, but not whether it has actually occurred in a given test market. If bluffing predation is not profitable—$\pi_2^d(p_1) + \gamma\pi_2^m \leq (1 + \gamma)\pi_2^d(p_2)$—the optimal policy is to do nothing. This condition is likely to be met in industries in which the gains from deterring entry are small: either the monopoly is able to retain much of its monopoly profits under duopoly or the incumbent was originally strongly monopolistic. If the national market is small relative to the test market, the condition will also be met. Finally, if there are large differences in the types of incumbents—the costs of emulating an incumbent with lower costs are high—predation will not be profitable.[8]

If $\pi_2^d(p_1) + \gamma\pi_2^m > (1 + \gamma)\pi_2^d(p_2)$, there is scope for further government policy. The problem is that when the agency observes p_1 in the test market, it cannot, without an investigation into the costs of the incumbent, determine whether predation has actually occurred. The agency knows that predators would charge p_1 in the test market, but not whether a firm that charged p_1 was practicing predation. If the agency fines an incumbent for suspected predation, it may be erroneously penalizing healthy competitive behavior. In general, investigations into a firm's costs are inaccurate and will result in mistaken judgments about predation. Thus, indiscriminate fines may induce firms with low costs to charge p_2 in the test market to avoid erroneous government penalty. Consequently, there may be a pooling equilibrium in which both types of incumbents charge p_2, potential entrants never enter the national market when they observe p_2, and incumbents effectively deter national-market entry, even though test-market profits are positive.

The government must structure the expected fines so that each type of incumbent has

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[7] Of course, (3) can be negative, even if predation is not possible. If, for example, T is large, there will be no test-market entry, even without the possibility of predation.

[8] Determining whether the condition is satisfied is similar to administering the "structural tests" proposed by Joskow and Klevorick (1979) and Ordover and Willig (1981). The authors suggest that the courts (or government agency) conduct a preliminary investigation into the profitability of predation. Further investigation is required only when predation is highly profitable. This two-tier approach is aimed at minimizing the welfare costs that are incurred from mistakenly penalizing truly competitive firms or from not penalizing predatory firms.

an incentive to signal his true costs through his test-market price; incumbents must be discouraged from behaving in a predatory fashion, but not from competing. The government can do this by choosing the appropriate combination of search, investigation, and fine.

When the agency observes p_1 in the test market, it may launch an investigation into the costs of the incumbent.[9] If the agency finds that the incumbent has high costs, the incumbent is charged with having engaged in predation; if the investigation concludes the opposite, the incumbent is exonerated. Costs are observed with error, and the accuracy of the investigation increases with the expenditure on the investigation.[10]

Let I equal the agency's expenditure on an investigation. Denote by $\phi_i(I)$ the probability that a type-i firm is found to have *high* costs. The probability ϕ_2 is an increasing function of I, while ϕ_1 is a decreasing function of I. The more that is spent on the investigation, the greater probability that costs are correctly determined. If $I = 0$, the investigation is noninformative and $\phi_1 = \phi_2 = \frac{1}{2}$. We assume that the marginal returns to investigation (in terms of accuracy) are decreasing, i.e., $\phi_1'' > 0$, $\phi_2'' < 0$.

To reduce costs the agency investigates the incumbent with probability $\theta \in [0, 1)$. We assume that it is costly to detect an incumbent charging p_1. The agency "searches" local markets at cost, S, to determine whether, in response to test-market entry, the incumbent charged p_1.[11] The probability that a monopolist is detected charging p_1 increases with the extent of search. We assume that the marginal returns to search are decreasing, i.e., $\theta''(S) < 0$.

If an incumbent is detected charging p_1 and is found to be a firm with high costs (mistakenly or not), the government levies a fine, F, on the firm. Thus, the expected fine for a type-i monopolist charging p_1 is $\theta\phi_i F$. After the investigation, regardless of the outcome, the agency allows the incumbent to adopt any desired pricing policy in the national market.

Thus, the decision variables of the agency are the extent of search, the resources spent on the investigation, and the magnitude of the fine. A government policy is fully described by the vector $\Omega = (S, I, F)$. The agency chooses the Ω, which at minimum cost, induces a type-i firm to charge p_i in the test market and thereby reveals its true cost structure.

4. Optimal government policy: self-selection at minimum cost

■ Suppose that the equilibrium is pooling before the introduction of a government policy: predation is profitable. The government seeks to establish an equilibrium in which the entrant's strategy is $(0, 1)$ and the incumbent's strategy is (p_1, p_2). The agency starts by taking as fixed the entrant's strategy, $(0, 1)$, and calculates the set of Ω that induce an incumbent of type-i to charge p_i in the test market. Thus, the agency solves for the set of Ω that satisfy

$$\pi_1^d(p_1) + \gamma\pi_1^m - \theta\phi_1 F \geq \pi_1^d(p_2) + \gamma\pi_1^d(p_1) \tag{4}$$

$$\pi_2^d(p_1) + \gamma\pi_2^m - \theta\phi_2 F \leq (1 + \gamma)\pi_2^d(p_2).^{[12]} \tag{5}$$

Given strategy $(0, 1)$ by the entrant, the incumbent's best response is (p_1, p_2) by (4) and (5). But given strategy (p_1, p_2) by the incumbent, $(0, 1)$ is the entrant's best response. Hence, these strategies constitute an equilibrium.[13]

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[9] Incumbents that charge p_2 in the test market are not investigated. This has no effect on the results.

[10] It is assumed that the firm is unable to respond to the investigation by trying to convince the agency that it is a low-cost firm.

[11] In another view the agency must determine whether accusations of predation by firms that have test marketed are legitimate. The agency must decide whether the entrant has made a viable attempt at entry and whether the test-market price is actually p_1. Given the assertion that p_1 has been charged, θ rises with the extent to which the agency investigates the entrant and the test-market price.

[12] As with the entire literature on self-selection, we specify the self-selection constraints as nonstrict inequalities to avoid open-set problems. We assume that if the constraint is binding, the firm acts honestly.

[13] We rule out strategy $(1, 0)$ by the entrant on the same grounds as before. Actually, the case is even stronger since, owing to government policy, $\beta = 1$ and the expected profits of strategy $(0, 1)$ are even greater.

    To highlight the self-selection nature of the problem, suppose the government had set Ω such that (5) was satisfied, but the inequality in (4) was reversed. The best response to strategy (0, 1) by the entrant would be (p_2, p_2); but then (0, 1) could not be a best response to (p_2, p_2) since the entrant would earn negative expected profits. The only possible equilibria in which the incumbent plays (p_2, p_2) have the entrant playing (0, 0) and (1, 0). In both equilibria there is never entry into the national market. Thus, excessive fines and inaccurate investigations are counterproductive.

    If Ω is chosen properly, then the equilibrium is separating, and both the government and the entrant know the incumbent's cost structure with certainty once price is set. Thus, even if the incumbent is found guilty of predation, the entrant does not expand production, because he knows that only firms with low costs would charge p_1 in the test market.

    The agency also knows that only low-cost firms are convicted; nevertheless, it must investigate a firm charging the low price and fine it if it is found guilty. Otherwise, high-cost firms could charge the low price without fear of being forced to pay the fine, and the equilibrium would be broken. This is a property of all self-selection models. For example, in the insurance market model of Rothschild and Stiglitz (1976), once low-risk individuals have signalled that they are low risks by offering to purchase incomplete insurance, the firm would then like to offer a better contract to them; but it cannot for fear of attracting high-risk individuals. Similarly, in the labor market models of Guasch and Weiss (1980) and Nalebuff and Scharfstein (1984) only workers of a certain type are examined. Still, the test must be administered to uphold the equilibrium.

    In our context, these observations imply that if the investigation is not perfectly accurate—as it is likely not to be—the agency will mistakenly fine firms for predation when, in fact, predation is not an equilibrium strategy. To the extent that fines are merely transfers, there is no special cost of making such mistakes. For this scheme to be successful, the legal procedure must be somewhat myopic in the sense that it considers only the facts at hand and ignores the general considerations of upholding an equilibrium.

    Another important feature of this policy is that there is no need to impose the traditional injunctions against "continued predatory pricing." Since investigations are inaccurate, they will sometimes constrain competitive behavior and lead to higher prices. Indeed, this is one of the major costs that Joskow and Klevorick (1979) attempt to minimize by proposing a two-tier approach. (See footnote 8.) If firms are enjoined from "predatory pricing," then when the courts make a type-I error, i.e., convict an innocent firm, they constrain future competitive behavior. By not investigating firms in industries that are already fairly competitive, as suggested in the structural test, the costs of ordering inappropriate injunctions are reduced, but still exist. Under the policy proposed here, if the agency is able to deter predation, in equilibrium, the entrant and the government have perfect information about the incumbent's cost structure. Thus, there is no need for a further injunction against continued predatory pricing; indeed, such an injunction would only constrain future competitive behavior.

    Another property of the policy is that test-marketing is encouraged. Because the potential entrant knows that with the government policy the equilibrium is separating, the entrant test markets if

$$\alpha \pi_L^e + (1 - \alpha)[(1 + \gamma)\pi_H^e - K] - T > 0, \tag{6}$$

which is met more easily than the previous condition:

$$\beta\{\alpha\pi_L^e + (1 - \alpha)[(1 + \gamma)\pi_H^e - K]\} - (1 - \beta)\pi_L^e - T > 0.$$

    The agency chooses the Ω that satisfies constraints (4) and (5) at minimum cost to the government. Define the cost of a policy, $C(\Omega)$, as the sum of the agency's expenditures on search and investigation. We assume that the shadow price of government revenue is one, and ignore the revenue from fines in the cost function. This assumption is made to

separate the issue of finding a policy to deter predation at minimum cost from the redistributive question raised by incorporating fines into the cost function; while fines are merely transfers, search and investigation represent real costs.[14]

The agency, therefore, solves the following program:[15]

$$\operatorname*{Min}_{\Omega} C(\Omega) \equiv S + \theta(S)I, \tag{7}$$

subject to

$$\theta\phi_1 F \leq \rho_1 \equiv \pi_1^d(p_1) - \pi_1^d(p_2) + \gamma(\pi_1^m - \pi_1^d(p_1)) \tag{8}$$

$$\theta\phi_2 F \geq \rho_2 \equiv \pi_2^d(p_1) - \pi_2^d(p_2) + \gamma(\pi_2^m - \pi_2^d(p_2)) \tag{9}$$

$$F \leq \bar{F}. \tag{10}$$

Constraints (4) and (5) above are rewritten here as (8) and (9). They state that the expected fine must be less than (greater than) ρ_1 (ρ_2), the gain to the incumbent with low (high) costs of charging p_1 rather than p_2. Constraint (10) places a limit, $\bar{F}$, on the size of the fine: it must be feasible for both types of incumbents to pay $\bar{F}$.[16] We assume that $\bar{F}$ is greater than the F for which (9) holds with equality when θ and ϕ_2 are close to 1, i.e.,

$$\bar{F} > \rho_2. \tag{11}$$

While ρ_2 represents a stream of future profits, $\bar{F}$ is the fine that a firm can pay at any given moment. If the incumbent is a multiproduct firm or has many segregated markets, it seems reasonable to assume that (11) can be met.

Before solving for the optimal Ω, we prove the following proposition:

Proposition 2. Provided: (i) the investigation becomes perfectly accurate as $I \to \infty$, (ii) $\theta \to 1$ as $S \to \infty$, and (iii) $\bar{F} > \rho_2$, there always exists an Ω such that firms are induced to reveal their true cost structures.

Proof. The proof is trivial. As $I \to \infty$, $\phi_1 \to 0$, $\phi_2 \to 1$, and as $S \to \infty$, $\theta \to 1$. In the limit the expected fine on the high-cost incumbent approaches $\bar{F}$, which is greater than ρ_2 by assumption. The expected fine on the incumbent with low costs approaches zero in the limit, which is certainly less than ρ_1. Thus, both constraints are satisfied.

If the parameters are such that the only way to induce self-selection is with perfectly accurate investigations and search, and this is possible only at infinite cost, the government would not want to pursue such a policy. In general, there will be a set of parameter combinations that make inducing separation worthwhile. The greater is ρ_2 and the smaller is $\bar{F}$, the more expensive the policy and the less likely the policy is a welfare improvement. These points are considered in greater depth in the next section. Note that the conditions stated in Proposition 2 are also sufficient for full separation if there are more than two types of firms; however, it becomes increasingly difficult to devise accurate investigations as the number of firms becomes larger.

Proposition 2 states sufficient conditions for the existence of an effective government policy. If $\rho_1 > \rho_2$, then all that is necessary for existence is that S and I can be chosen so

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[14] One could easily incorporate into this model the idea that fines have a welfare cost. There would then be a tradeoff between conducting more accurate investigations (which would reduce the welfare costs of fines but increase actual costs) and higher fines (which would have the opposite effects). It is possible to show that as long as the welfare costs from fines, $W(F)$, are a concave function of F, the optimal fine will be the same as in this model, namely the maximum feasible fine. If $W(F)$ is strictly convex, the optimal fine may be less than the maximum.

[15] Actually, $C(\Omega) = \alpha(S + \theta(S)I)$, but since the solutions would be the same with either cost function, for convenience we drop α.

[16] One might also view $\bar{F}$ as the maximum fine that society deems ethically defensible or as "treble damages."

that $\theta\phi_2 \geq \rho_2/\bar{F}$. If $\rho_2 > \rho_1$, it must also be possible to set $\theta\phi_1$ less than $\rho_1/\bar{F}$. The additional condition arises because, if the test is not accurate enough, low-cost incumbents will be deterred from acting competitively and charging the low price.

Proposition 3. The optimal fine is $\bar{F}$.

Proof. Consider the constraints

$$\theta F \phi_1 \leq \rho_1$$

$$\theta F \phi_2 \geq \rho_2.$$

FIGURE 2a

OPTIMAL POLICY WHEN $\rho_1 < \rho_2$
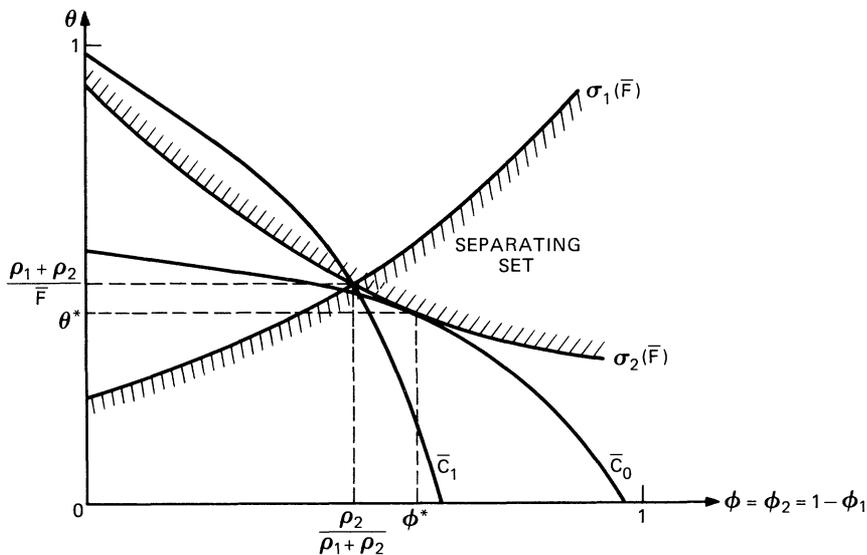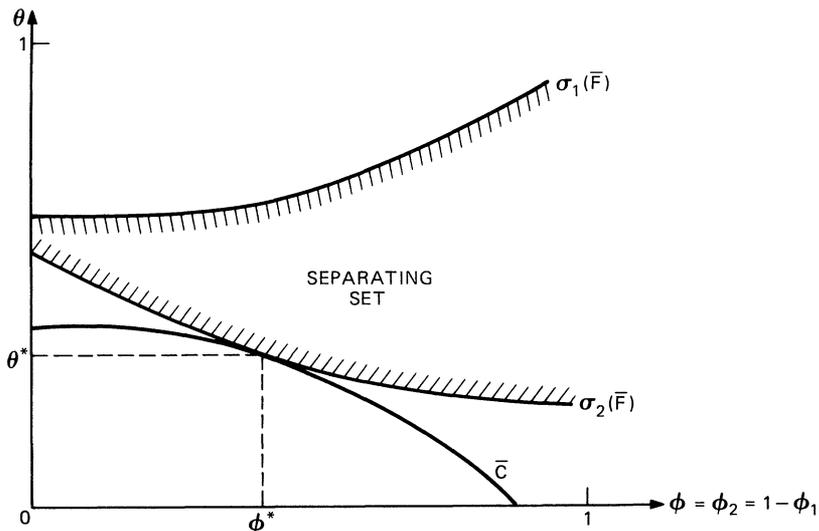

FIGURE 2b

OPTIMAL POLICY WHEN $\rho_1 > \rho_2$

Choose I and θF to satisfy the constraints above. Since $S + \theta I$ is increasing in θ, for a given θF, the greater F is the less costly the policy is. Thus, $F = \bar{F}$.[17]

It can also be shown that only the constraint on the incumbent with high costs is necessarily binding. To see this, suppose instead that $\theta \phi_2 \bar{F} > \rho_2$. Now, reduce θ (and, therefore, costs) until the constraint is binding. The other constraint is certainly met if it was met before, since the expected fine is now lower. Thus, at the optimum $\theta \phi_2 \bar{F} = \rho_2$.

The optimization problem is represented graphically in Figures 2a and 2b. Curves $\sigma_i(\bar{F})$ represent the combinations of θ and ϕ_i such that the type-i incumbent is indifferent between charging p_1 and p_2 in the test market when the fine is $\bar{F}$.[18] Points to the right of each curve are points at which a type-i incumbent prefers charging p_i rather than p_j, $i \neq j$. The gridded area represents the set of θ and ϕ_i that induces separation. The level curves, $\bar{C}$, are the agency's isocost curves.

In Figure 2a, $\rho_1 < \rho_2$ so that the curves, $\sigma_i(\bar{F})$, intersect. In this case it is possible that combinations of θ and ϕ_i which induce the high-cost firm to charge p_2 must be ruled out because they also lead the low-cost incumbent to charge p_2. Thus, we can get either a corner solution, $\bar{C}_0$, or an interior one, $\bar{C}_1$. If, on the other hand, $\rho_1 > \rho_2$, as in Figure 2b, all cost-minimizing θ and ϕ_i which induce the high-cost firm to charge p_2 do not distort the incentives of the low-cost firm. It is impossible to say whether $\rho_1 \gtrless \rho_2$ without specifying the nonpredatory duopoly game. This will be done in the next section.

A question arises about what types of investigations are more effective. If $\rho_1 > \rho_2$, any policy that deters predation (at minimum cost) does not distort the incentives of the low-cost incumbent. Thus, it is more effective to choose a type of investigation that reveals more about the costs of the high-cost incumbent than about those of the low-cost incumbent. As long as fines are merely transfers, the degree of inaccuracy in determining the costs of a low-cost firm are irrelevant. If $\rho_1 < \rho_2$, it is optimal (if possible) to choose a type of investigation that is more revealing about the high-cost incumbent's costs but ends up at the point at which, when $\phi_2 = \dfrac{\rho_2}{\theta \bar{F}}$, $\phi_1 = \dfrac{\rho_1}{\theta \bar{F}}$.

5. Comparative statics

■ This section considers how the optimal government policy varies across different industry configurations. In performing the comparative-statics analysis, there are two cases to consider: when only one self-selection constraint is binding, and when both are binding.

In the first case, we can express ϕ_2 as a function of θ,

$$\phi_2 = \frac{\rho_2}{\theta \bar{F}}. \tag{12}$$

The government's problem then is to

$$\min_{\theta} C = S(\theta) + \theta I\left(\frac{\rho_2}{\theta \bar{F}}\right), \tag{13}$$

where we have inverted the θ and ϕ_2 functions; $S'(\theta)$, $S''(\theta)$, $I'(\phi_2)$, and $I''(\phi_2)$ are all strictly positive for all θ and ϕ_2.

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[17] This is a standard result in the literature on punishment and fines (Polinsky and Shavell, 1979). If, however, the firm is globally risk-averse, it may be optimal to set the fine less than the maximum. For a proof in the context of labor markets, see Nalebuff and Scharfstein (1984).

[18] For graphical simplicity the curves are drawn for the case in which $\phi_2 = 1 - \phi_1$, i.e., when the investigation is symmetric.

Differentiating (13) with respect to θ yields the first-order condition for a minimum,

$$C_\theta = S'(\theta) + I\left(\frac{\rho_2}{\theta \bar{F}}\right) - \frac{\rho_2}{\theta \bar{F}} I'\left(\frac{\rho_2}{\theta \bar{F}}\right) = 0. \tag{14}$$

Differentiating again, we have the second-order condition,

$$C_{\theta\theta} = S''(\theta) + \frac{\phi_2^2}{\theta} I''(\phi_2) > 0. \tag{15}$$

To determine the change in the optimal θ, denoted θ^*, with an increase in a given parameter, t, we calculate

$$\frac{d\theta^*}{dt} = \frac{-C_{\theta t}}{C_{\theta\theta}}. \tag{16}$$

Since $C_{\theta\theta} > 0$, sgn $\dfrac{d\theta^*}{dt} = -$sgn $C_{\theta t}$; $\dfrac{d\phi_2^*}{dt}$ is then determined from the relation,

$$\frac{d\phi_2^*}{d\gamma} = \frac{d\phi_2}{d\gamma} + \frac{d\phi_2}{d\theta} \cdot \frac{d\theta^*}{d\gamma}. \tag{17}$$

In the second case, when both constraints are binding,

$$\frac{\phi_2}{\phi_1} = \frac{\rho_2}{\rho_1}. \tag{18}$$

Determining the effect of a parameter change on the optimal accuracy of the investigation reduces to calculating the effect of the change on the ratio ρ_2/ρ_1. Since both constraints are binding, the change in S is easily calculated by differentiating $\theta = \dfrac{\rho_1}{\phi_1 \bar{F}}$ with respect to the parameter, t, recognizing the dependence of ϕ_1 on t.[19]

In what follows we discuss the effect of the size of the national market, the size of the maximum fine, and the degree of monopoly power on the optimal policy.

□ **Size of the national market.** The larger the national market relative to the test market, the greater is γ. We assume that the size of the national market does not affect the ability of the incumbent to pay the fine; $\bar{F}$ is independent of γ.[20] When only one constraint is binding, straightforward differentiation yields

$$C_{\theta\gamma} = \frac{-\rho_2[\pi_2^m - \pi_2^d(p_2)]}{(\theta\bar{F})^2} I''(\phi_2) < 0, \tag{19}$$

which implies $\dfrac{d\theta^*}{d\gamma} > 0$, and

$$\frac{d\phi_2^*}{d\gamma} = \frac{[\pi_2^m - \pi_2^d(p_2)]}{\theta\bar{F}} \left\{ 1 - \left(1 + \frac{\theta}{(\phi_2)^2} \frac{S''(\theta)}{I''(\phi_2)}\right)^{-1} \right\} > 0. \tag{20}$$

Other things being equal, predation is more profitable in industries with larger national markets; the value to the incumbent of protecting its monopoly is greater.[21] Because the

fine is fixed at the maximum, the only way to deter predation is to increase the intensity of search and the accuracy of the investigation. In this case the low-cost incumbent strictly prefers charging p_1 to charging p_2, so that a small increase in his expected fine will not alter his pricing strategy.

When both constraints are binding, however,

$$\frac{d(\phi_2/\phi_1)}{d\gamma} = \frac{1}{\rho_1^2} \{[\pi_1^d(p_1) - \pi_1^d(p_2)][\pi_2^m - \pi_2^d(p_2)]$$

$$+ [\pi_2^d(p_2) - \pi_2^d(p_1)][\pi_1^m - \pi_1^d(p_1)]\} > 0. \quad (21)$$

Hence, $\dfrac{dI}{d\gamma} > 0$ and

$$\frac{d\theta}{d\gamma} = \frac{\pi_1^d(p_1) - \pi_2^d(p_2)}{\phi_1 \bar{F}} - \frac{\rho_1}{(\phi_1)^2 \bar{F}} \frac{d\phi_1}{dI} > 0. \quad (22)$$

The gains to both types of incumbents rise with an increase in γ, but those of the high-cost incumbent rise faster. Consequently, the accuracy of the investigation must increase. This reduces the expected fine on the low-cost incumbent. But, if the constraints are to remain binding, the expected fine for both types of incumbents must rise. Therefore, $\dfrac{d\theta}{d\gamma} > 0$.

□ **Size of the maximum fine.**[22] When only one constraint is binding,

$$C_{\theta \bar{F}} = \frac{(\phi_2)^2}{\bar{F}} I''(\phi_2) > 0 \qquad \text{so that} \qquad \frac{d\theta^*}{d\bar{F}} < 0 \quad (23)$$

and

$$\frac{d\phi_2^*}{d\bar{F}} = \frac{\phi_2}{\bar{F}} + \left[\frac{\bar{F}}{\phi_2} + \frac{(\phi_2)^3}{\bar{F}^2} \frac{S''(\theta)}{I''(\phi_2)}\right]^{-1} < 0. \quad (24)$$

Both the intensity of search and the accuracy of the investigation should be lower in industries in which the maximum feasible fine is large. The expected fine remains the same, but the costs of the expected fine are lower because S and I are lower.

If both constraints are binding, an indiscriminately large fine and inaccurate investigation may distort the incentives of the low-cost incumbent. Indeed, inspection of (18) reveals that the optimal accuracy of the investigation is independent of $\bar{F}$. Thus, in this case, I does not vary with the size of the incumbent. The intensity of search, on the other hand, declines:

$$\frac{d\theta^*}{d\bar{F}} = \frac{-\rho_2}{\phi_2 \bar{F}^2} = \frac{-\rho_2}{\phi_1 \bar{F}^2} < 0. \quad (25)$$

As when only one constraint is binding, the larger maximum fine enables the government to reduce costs. But in this case, there is a critical level of expenditure, which must be exceeded or else the low-cost firm will be induced to charge the high price. Thus the level of search declines, and the accuracy of the investigation is invariant with $\bar{F}$. Note that the costs of deterring predation are a declining function of the size of the maximum fine.

□ **Degree of monopoly power.** We use the elasticity of demand as an index of monopoly power. Presumably, the incumbent has more "monopoly power," the less elastic is demand.

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[22] In some sense we can view the size of the maximum fine as a proxy for the size of the firm; *ceteris paribus*, large firms with access to greater resources can pay higher fines.

The question is how the elasticity of demand affects the profitability of predation. Does it increase the gains to predation by a greater extent than it increases the costs? Unfortunately, it is not possible to say very much about these questions without stating a more specific (and highly stylized) model of the nonpredatory test-market duopoly game. The following results should be interpreted more as an example than as definitive policy conclusions.

Suppose that: the inverse demand function is linear, $P = a - bQ$, with $a > 0$, $b > 0$; marginal costs of the type-i incumbent, c_i, and the entrant, c_e, are constant; and the innocent duopoly game is Cournot. Suppose further that $c_e = c_2$. This last equality is a sufficient condition for $\rho_1 > \rho_2$, and we need only consider the case in which just one constraint is binding. It can be shown that

$$C_{\theta b} = \frac{(\phi_2)^2}{b} I''(\phi_2) > 0 \qquad \text{so that} \qquad \frac{d\theta^*}{db} < 0 \qquad (26)$$

and

$$\frac{d\phi_2^*}{db} = -\frac{\phi_2}{b} + \left[\frac{b}{\phi_2} + \frac{\theta b}{(\phi_2)^3} \frac{S''(\theta)}{I''(\phi_2)}\right]^{-1} < 0. \qquad (27)$$

An increase in b—an increase in the elasticity of demand at each point on the demand curve—both increases the cost of predation and decreases the gain from predation. As a result, the expected fine needed to deter predation is lower. To reduce costs, therefore, S and I must both decline. Thus, given linear demand, constant marginal cost, and Cournot duopoly behavior, the intensity of search and the accuracy of investigation vary directly with the degree of monopoly power in the industry.

Suppose that instead of Cournot behavior, the duopoly game is Bertrand, i.e., incumbents cut prices to just below the cost of the entrant. Once again, assume that demand is linear and the marginal cost of the entrant is c_2. Then the low-cost incumbent sets $p_1 = c_2 - \epsilon$ and the high-cost incumbent sets $p_2 = c_2$. In this example $\rho_1 < \rho_2$, so that, depending on the shape of the cost function, both constraints can be binding. If this is so, (18) holds, the ratio of ρ_2 to ρ_1 is independent of b, and the accuracy of the investigation is the same for all elasticities of demand. Search, on the other hand, is decreasing in b:

$$\frac{d\theta^*}{db} = -\frac{1}{b} \frac{\rho_2}{\theta \bar{F}} < 0.$$

In this case, the gains from predation are smaller the greater is the elasticity of demand, whereas the costs of predation are independent of the elasticity of demand (and equal to zero). In sum, the profitability of predation is decreasing in b as is the expected fine needed to induce self-selection. Thus, even though both constraints are binding, the level of search is increasing with the degree of monopoly power of the incumbent. The expenditure on the investigation, however, is invariant in this case.[23]

6. Concluding remarks

■ One of the fundamental problems that arises in designing predation policy is that it is often difficult to distinguish between predatory and competitive actions. Even with appropriate definitions of predation, the judicial system is prone to make errors in applying criteria. Consequently, injunctions against the practices of innocent firms are likely to constrain competitive behavior unnecessarily. On the other hand, failing to regulate truly predatory behavior results in a welfare loss. This article addressed this problem by designing mechanisms that deter firms from practicing predation, but do not discourage nonpredatory competition. Account was taken of the fact that it is costly to identify possible predatory

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[23] The detailed calculations of this section are available from the author upon request.

incidents and that investigations into the actions of a firm are typically inaccurate. We solved explicitly for the optimal level of search, investigation, and the fine.

The policy suggested here performs better than previous proposals because it eliminates the welfare costs associated with inaccurate investigations. Under present practices, if the courts make a mistake in applying predation criteria, there is a welfare loss either because a firm is allowed to reap the benefits of predatory behavior or because a firm is constrained from acting competitively in the future. In this article the latter problem never arises, because the expected fine is chosen so that the incentives to act competitively remain. Indeed, there is no need to place injunctions on a convicted firm, because it is known that its actions are nonpredatory.

These points were developed in the context of a somewhat stylized model of test-market predation. One could, however, generalize the policy to address many types of predatory behavior. For example, under certain conditions, product innovation may be predatory. Whether any given innovation is predatory, however, is often unclear. Indiscriminate fines may deter firms from introducing new products that may be construed as predatory but that are, in fact, competitive by certain standards. The policy proposed here would be well-suited to contend with this problem.

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