Spoiling the Market

May 2000 draft

S. Bucovetsky

Department of Economics, Faculty of Arts

York University

Toronto Ont. M3J 1P3

e–mail : < *sam@dept.econ.yorku.ca* >

Abstract

Low current prices for a product may induce some customers to purchase now, rather than in the future. This intertemporal substitution makes staying in the market in the future less attractive for firms, and may lead to a monopoly in the future if staying in the market is costly for some firms. Here the incentives are examined for an entrant to spoil the market, by inducing a price war which leads to the exit of the incumbent firm because of the reduction in future potential demand. An entrant will be able to predate successfully in this fashion only if it has some strategic advantage. If the incumbent has already committed to its capacity choice, and if the incumbent is less flexible in its ability to adjust its scale, the entrant may have such an advantage. Then entry on a large scale, driving down the current price, may be a credible way for the entrant to establish future monopoly power.

1. Introduction

This paper provides yet another analysis of rational predatory pricing, albeit in a model in which rationality is not exactly pervasive. It will indeed be the case that potential predator is making its choices optimally, that these optimal choices involve a phase in which price is set very low, and that this low price would establish a future monopoly position for the potential predator. It is also true that the victim of the predation, if it chooses to exit from the market, is responding rationally to the behaviour of its rival. However, the model presupposes a particular initial choice by the victim of the predation, a choice which would be sub–optimal if the victim had foreseen the possibility of predation.[1]

Why yet another model of predatory pricing? There are three reasons. One is that intertemporal substitution by buyers plays a major role here. The title of this paper refers to the possibility that a low current price induces an increase in current buying, at the expense of future buying, making the market less attractive in the future for the victim of the predation. This is by no means the first model of oligopoly in which durability or storability of the product plays a role. [2] But the number of such models is relatively small. The second reason is the identity of the firm which does the predation. In many (but certainly not all) models in the literature, predation is conducted by an established monopoly, in order to deter entry. Yet in many cases which get litigated or investigated, it is a new entrant which is accused of predatory pricing, presumably as a tactic to induce the established firm(s) to exit. Many of these cases may be instances in which accusations of predatory pricing are used to protect inefficient established firms from lower–cost entrants. But the classic *Standard Oil* and *American Tobacco* cases did involve the alleged predator doing its predation on established local firms. Here, being established first — and not having anticipated potential predation — helps put the incumbent at a disadvantage. The third reason is the most celebrated anti–trust case in recent years. In the recent *Microsoft* case, Justice Jackson concluded that Microsoft's decision to give away its Internet Explorer browser could not have been justified by potential profits in the browser market per se. He did however, note that

[1] In many "rational" models of predatory pricing, such as Benoit (1984) the presence of the victim of predation is taken as given, and this presence is irrational given what ensues.

[2] See, for instance, Bucovetsky and Chilton (1986), Bulow (1986), or Schmalensee (1974).

"the suspicion lingers.. that Microsoft's ambition is a future in which all or most of the content available on the Web could be accessible only through its own browsing software", although he found evidence of such a suspicion "insufficient".[3] Some of the features of the model presented here correspond, very loosely, to the features of the browser market in the late 1990's. This model does provide something of a framework to assess the possibility, and desirability, of an entrant achieving a future monopoly position in the browser market by selling browsers very cheaply in the present.

Now there is a pretty obvious reason, I believe, why a firm might want to distribute software very cheaply — network externalities. The logic behind this argument is both well–known and difficult to dispute.[4] If competing products have different standards, then the benefit to a buyer of buying a particular product increases with the number of units already sold of that particular product. Certainly then it may be optimal for Sony to sell Betamax very cheaply if the high current sales from the current low price drives down future demand for the competing VHS standard so much that VHS producers exit from the market.

In the model developed here there are no network externalities. The primary reason for this exclusion is that the above argument is well–known. This argument is also not the sturdiest buttress for an anti–trust case. When network externalities are present, there are benefits from monopoly. The plaintiff using this argument must demonstrate that the defendant is the "wrong" monopoly (as — allegedly — is the QWERTY keyboard standard), or that the harm to consumers from the plaintiff's monopoly power exceeds the benefit from the common standard.

Moreover, on the face of it, it is not that obvious that network externalities are that important for browsers. If a given web page can be read with either Internet Explorer or with Netscape Navigator, my benefit from using one or other of these browsers does not seem to depend very much on what browsers the rest of the population is using. Using popularity of one firm's browser to drive out another firm's browser seems to require some influence on the actual production of web pages. Of course, it does appear to be the case that Microsoft is doing exactly that, attempting to induce web designers to produce pages which are compatible with one browser but not the other. Yet this behaviour does not seem that central to the prosecution's arguments in the Microsoft

[3] *U.S. vs. Microsoft Corporation*, Findings of Fact, para. 384, pg. 69

[4] See, for instance, Katz and Shapiro (1986), Farrell and Saloner (1986), Cabral and Riordan (1994)

case, nor to Judge Jackson's conclusions. Besides, if the prosecution wanted to focus on network externality arguments, surely word processing software would be a better example? Certainly a case can be made that Microsoft Word superceded Word Perfect as the standard word processing package. The time period in which this change occurs appears to be a time in which Microsoft Word was available quite widely and cheaply. Subsequently, the price at which most potential customers could obtain a registered legitimate copy of Word seems to have risen sharply.

So the task here is to present a model in which a new entrant finds it optimal to introduce its product at a low price, even though there are no network externalities. Moreover, the new entrant has no cost advantage, and no informational advantage.

In the model presented here, the entrant does have two big advantages. One is the second–mover advantage of making its choices after the incumbent is locked into a policy which will turn out to be a very foolish policy in the face of the entry threat. The other is flexibility. While the incumbent actually has a cost advantage in my model, in producing a given level of output, the entrant is much better able to adjust its scale. This flexibility is crucial in explaining why it is the entrant, rather than the incumbent, which chooses to serve the market after it has been "spoiled".

Giving this flexibility advantage to the entrant certainly is somewhat contrived, and does drive the results. But if the purpose of predation is to drive out a rival, then there must be some reason why it is the rival, and not the predator which gets driven out. With sunk costs of entry, an incumbent can keep out future competition by spoiling the market, if it has already paid the entry cost. For a new entrant to drive out an incumbent, it must have some advantage. Greater flexibility by the predatory entrant does also may fit the Microsoft browser case. At the time the browser wars began Netscape was a relatively specialized firm. Microsoft produces a vast array of software products. It seems reasonable that Microsoft would be much better able to re–assign personnel among different software products. There are substantial quasi–fixed costs in hiring or firing workers by a firm. These costs mean that it can be expensive for a firm to adjust its scale if it must rely on the outside labour market to expand or contract output. By the same token, a multi–product firm can adjust production of a single product by using its internal labour market, avoiding many of the quasi–fixed costs of changing the firm's overall workforce. 5

5 Perhaps the strategic advantages of flexibility in this context why Netscape was purchased by

As mentioned above, intertemporal substitutability plays a key role in the model. It is essential that some buyers have this substitutability. For example, some potential buyers of browsers may not yet have internet access, and may be planning, other things equal, to purchase a browser in the future. If the current price of a browser is low enough, and if the future price of the browser is expected to be high, then these people will change their plans. Presumably even if the software is available only by download, they can download it using the computer of a friend who does have internet access. Or, if the cost advantage is significant enough, they may choose to purchase a modem and initiate internet service provision at an earlier date than they had originally planned, in order to download the cheap (or free) browser. The strategic significance of spoiling the market here is that a low current price leads to reduced future demand, other things equal.

There must also be some potential buyers who cannot move forward their purchases. Presumably some people do not have friends who can download and make copies of software, some people do not have the technical knowledge even to know what to ask of their friends, some people do not have computers yet, and some people are too young currently to be willing or able to purchase the product. Others are so demanding of new technology that they will want to purchase a new version of their software, even if they already have purchased a perfectly functional older version.

The number of people who cannot substitute intertemporarily need not be large. In fact it is important that the number of new potential buyers coming on the market in future periods be somewhat smaller than the number of people who are able either to purchase today or to defer purchase. Again, this assumption about the size of the market in different periods does roughly fit the facts of the browser wars experience. In the United States at least, the peak period of growth has passed for computer and internet usage.[6]

Given the many strong assumptions underlying the model, the basic story can be told relatively simply. Imagine a monopoly makes its plans, assuming that no rival will enter. The monopoly

AOL.

[6] A BancAmerica Corp., Robertson, Stephens & Co. report estimated the number of home users of the web in the United States would rise by 7 million in 1997–98 and 1998–99, by 8 million in 1998–99 and then by 7 million in 1999–2000. Nua Internet Surveys estimated worldwide internet usage rose by 52 million in 1997–98, 55 million in 1998–99, and by 45 million in 1999–2000.

has little flexibility, so that it is locked into a scale. Once it has chosen its scale, its only choice in future is whether to stay in the market (at the already–chosen scale) or to exit. So in future there is a cost which may be avoided by shutting down, but the only way of saving in future is by shutting down completely ; a smaller scale of operation in future brings no cost savings. Imagine as well that there are many customers who are able to substitute intertemporarily, but that the number of potential buyers today exceeds the number of potential buyers who can only purchase tomorrow.

Given this pattern of demand, and given its cost structure, the monopoly will want to induce some of today's potential customers to defer purchase until tomorrow. Given its rigid cost structure, if it serves all of today's potential buyers today, then it will have excess capacity tomorrow. Shifting demand from today to tomorrow uses some of tomorrow's excess capacity, while enabling the firm to reduce its overall scale. (Of course, for demand to be shifted, all those who defer purchase today must do so because they prefer to defer purchase, given the monopoly's current price and given buyers' rational expectation of tomorrow's price.)

The cost of opening for business tomorrow may be relatively high, if the overall scale of operations is relatively high. The firm cannot adjust that scale tomorrow. If enough buyers have deferred purchase, the scale of tomorrow's market will be large enough that the firm finds it rational to open tomorrow. But if the firm had to rely only on demand of buyers who just came on the market tomorrow, then the market might be so small that the firm would be better off shutting down then.

Hence, if a new firm surprises the erstwhile monopoly by entering today, but after the erstwhile monopoly is locked into its scale decision, then the entrant can spoil the market. If the new firm's entry leads to a low enough price today, then no–one will choose to defer purchase. With all this deferred demand gone, the erstwhile monopoly will choose not to open tomorrow. Even with no future competition, opening would not be profitable. However, with the advantage of flexibility, the entrant can open tomorrow, on a small enough scale to serve profitably the new buyers. The entrant's monopoly leads to a high price. That means that today's buyers, observing the entry and rationally expecting the high future price, will indeed choose not to defer purchase. Spoiling the market is a credible threat, which actually is carried out, since the perception that predatory pricing leads to future monopoly causes today's buyers not to defer.

What is meant by "spoiling the market" in this paper is a level of first–period sales so large that the incumbent firm (the one with the rigid scale) will choose not to stay in the market in the second period. The bulk of the paper is devoted to showing that, under a large collection of assumptions, the following results hold : (1) it is rational for the incumbent not to stay in the market if total first–period sales are high enough ; (2) the entrant can induce those "high enough" sales by its choice of capacity in the first period ; (3) the entrant may find it profitable to do so.

Section 2 of the paper introduces the general model. Sections 3 through 8 prove the general results just stated. Section 9 presents 2 numerical examples, which perhaps demonstrate more succinctly what is going on than do the lengthy theoretical sections. Section 10 discusses briefly the welfare implications of spoiling the market, and offers the usual concluding remarks.

2. The Model

There are two firms, denoted the incumbent and the entrant. The firms produce an identical homogeneous product. The product is durable. The world is assumed to last for two periods.

In period 1, n_1 potential buyers are born. These buyers all live for two periods. If they buy the product in the first period, then they will own the product in the second period as well. There is no depreciation, and no change in the product between periods. So a one–period–old used unit is exactly the same as a new unit produced in the second period.

Each buyer can use at most one unit of the product. Buyers born in the first period have a discount factor δ. Buyers are distinguished by their valuation of the product. If a buyer has valuation v, then she gets utility

0 if she does not buy the product

$\delta(v - \pi_2)$ if she buys the product in the second period for a price of π_2

$(1 + \delta)v - \pi_1$ if she buys the product in the first period for a price of π_1

A fraction $q(v)$ of buyers born in each period have a valuation v or greater.

In the second period, n_2 buyers are born. The distribution of valuations among these people is exactly the same as the distribution in the first period. [7] The only differences among generations of consumers are that the first–period cohort lives for two periods, and that there are more people born in the first period.

$$n_1 > n_2 \tag{A1}$$

I will also be assuming that the underlying demand function (that is the distribution of people's valuation of the product) is elastic.

$$\epsilon(v) \equiv -\frac{q'(v)v}{q(v)} > 1 \quad \text{for} \quad \text{all} \quad v > 0 \tag{A2}$$

Firms have the same discount factor δ as do potential buyers.

The timing of the model is as follows (where the incumbent's choices in a period are denoted by upper–case letters, and the entrant's by lower–case):

0 : the incumbent chooses its capacity K, and pays a cost $F(K)$

1 : after observing K, the entrant chooses its first–period capacity k_1 and pays a cost $f(k_1)$

2 : the two firms choose simultaneously their first–period prices P_1 and p_1, and the maximum quantities $X_1 \leq K$ and $x_1 \leq k_1$ that they are willing to sell

3 : buyers born in the first period make their first period purchases ; if either firm's products are in excess demand, then those buyers with the highest willingness to pay get to buy

4 : the incumbent chooses whether to remain in the industry in the second period ; if it remains, then it incurs a cost of $F(K)$ again in the second period, and if it does not remain it incurs no second–period costs

5: the entrant observes the incumbent's second–period decision, and then chooses its own second–period capacity k_2, incurring a cost of $f(k_2)$

[7] So a person of type v born in the second period gets utility of 0 if she does not buy the product, and $v - \pi_2$ if she does buy the product for a price of π_2.

6 : the two firms choose simultaneously their second–period prices P_2 and p_2, and the maximum quantities $X_2 \leq K$ and $x_2 \leq k_2$ that they are willing to sell — if the incumbent indeed has chosen to remain in the industry at stage 4

7 : buyers born in the second period, and those who were born in the first period but did not buy in the first period, make their purchase decisions ; again, goods in excess demand are allocated to those with the highest valuation

Firms seek to maximize the present value of their profits.

As mentioned in the introduction, not everyone is fully rational here. In particular, the incumbent's capacity decision at stage 0 is not a profit–maximizing one, given what occurs subsequently. The game begins only at stage 1. What is being analyzed here is predatory pricing by an entrant, given that its entry is a complete surprise to the incumbent. [8]

The capacity K chosen by the incumbent in stage 0 is the value of K which would maximize the present value of its profits if there were no entry (that is, if k_1 and k_2 were set equal to 0).

$(A3)$

The price–setting procedures in each period are minor variations on the Kreps–Scheinkman (1983) model of capacity–constrained Bertrand competition. I have maintained their assumption of efficient rationing when there is excess demand. Further assumptions on the demand function will insure that firms will not wish to set prices so that there is any excess demand, regardless of the rationing rule.

In the model presented here, the capacity choice in each period is sequential, rather than simultaneous (as, for instance in Kreps and Scheinkman). As I have just mentioned, in the first period it is essential that the game start after the incumbent has already chosen its capacity.

[8] This behaviour could be made rational by assuming that there is some small positive probability that an entrant can enter. If the probability is reasonably small, then the incumbent's optimal initial choice of capacity would be the choice it would make if there were no entry threat. (Small changes in this level would buy it no strategic advantage if there were entry.) The game analyzed here is then the sub–game which occurs if the entrant actually does enter.

The reason that I have assumed sequential capacity decisions in the second period as well is to eliminate a possible source of multiple equilibria. If the market were spoiled by first–period price competition, then there might be two possible equilibria in pure strategies in the subgame starting in the second period : one in which the incumbent chose to enter, and in which the entrant reacted by choosing a low level of capacity, and one in which the entrant chose a relatively high level of capacity and in which the incumbent reacted by not entering. My assumption of sequential entry in the second period insures that there is a unique equilibrium in pure strategies to the second–period sub–game.

The incumbent is locked into a capacity before the start of the game here. Its first–period cost $F(K)$ is completely sunk at the start of the game. In the second period it cannot save any money by reducing the scale of its operations : its effective cost of producing y_2 units is 0 if $y_2 = 0$, $F(K)$ if $0 \leq y_2 \leq K$, and infinite if $y_2 > K$. [9]

The entrant's choice is assumed to be completely flexible in each period. That is, at the beginning of period 1, it can choose a capacity of k_1, at a cost of $f(k_1)$. At the beginning of the second period, it makes a new capacity choice, choosing a k_2 which need not equal k_1, and paying a cost of $f(k_2)$.

The entrant is assume to pay a price for its flexibility. It is assumed to have at least as high production costs (average and marginal) as the incumbent

$$F(K) \leq f(K) \quad ; \quad F'(K) \leq f'(K) \qquad \text{for} \quad \text{all} \quad K > 0 \tag{A4}$$

Consider now the demand faced by firms in the first period. A person will buy in the first period only if buying now is at least as good as the the other two options, not buying at all, or deferring purchase until the second period. If all buyers expected to be able to buy at a price [10] of

[9] A monopoly actually might want to adopt such an inflexible capacity, even at no cost advantage, if it wanted to convince first–period buyers that it would charge a low price in the second period, as might arise in the presence of network externalities (as in the "durable goods monopolist on his head" problem of Katz and Shapiro).

[10] I use π_1 and π_2 to denote the prices paid by the consumer, since it has not yet been established that the two firms will charge the same price in each period, or that quantity demanded equal

π_2 in period 2, then those who would be willing to buy at a price of π_1 in period 1 are those with valuations v such that

$$(1+\delta)v \geq \pi_1 \tag{1}$$

and

$$v \geq \pi_1 - \delta\pi_2 \tag{2}$$

Therefore, the total first–period demand at a price of π_1 will be

$$n_1 q(\frac{\pi_1}{1+\delta}) \qquad \text{if} \qquad \pi_1 \leq (1+\delta)\pi_2 \tag{3}$$

and

$$n_1 q(\pi_1 - \delta\pi_2) \qquad \text{if} \qquad \pi_1 > (1+\delta)\pi_2 \tag{4}$$

if all buyers expect that they will be able to buy at a price of π_2 in the second period.

3. The Monopoly Solution

The capacity K of the incumbent has been chosen prior to the game. This level of capacity must satisfy two properties in order for the entrant to be able to spoil the market. First of all, the monopoly must want to stay in the market in the second period if the market is not spoiled — otherwise predatory pricing is not necessary to get the incumbent to leave. Secondly, the monopoly must depend on deferred second–period purchases to make second–perod entry profitable. That is, it must lose money if it serves only those buyers born in the second period.

Now if the monopoly sold up to its full capacity K in the first period, then its residual demand in the second period if it charges a price of P_2 is

$$(n_1 + n_2)q(P_2) - K$$

since the K first–period buyers with the highest valuation will have chosen to buy in the first period. [11] So the second–period price is the solution to

$$(n_1 + n_2)q(P_2) - K = K$$

quantity supplied. If there were rationing, π_i would be the lowest price at which the given consumer actually could obtain the product in period i.

[11] provided that some buyers born in the first period do want to buy in the second period, that is provided that $n_1 q(P_2) > K$

or

$$P_2 = \phi[\frac{2K}{n_1 + n_2}] \tag{5}$$

if $\phi(\cdot)$ is the inverse function to the demand function $q(\cdot)$.

$$\phi[q(p)] \equiv p \tag{6}$$

Given the price P_2, those customers of valuation v such that

$$(1 + \delta)v - P_1 \geq \delta(v - P_2)$$

will want to buy in the first period, implying that first–period demand is

$$n_1 q(P_1 - \delta P_2)$$

so that

$$P_1 = \phi[\frac{K}{n_1}] + \delta\phi[\frac{2K}{n_1 + n_2}] \tag{7}$$

if the firm uses its capacity fully in the first period.

The monopoly would choose its capacity K so as to maximize discounted profits

$$P_1 K + \delta P_2 K - (1 + \delta)F(K)$$

where P_1 and P_2 are defined by equations (5) and (7) as functions of K. If K maximizes profits defined in this way, then consistency of the monopoly's plan requires it to want to open in the second period :

$$\phi[\frac{2K}{n_1 + n_2}]K - F(K) \geq 0 \tag{$A5$}$$

Assumption ($A5$) is the first condition alluded to above, that some first–period "predation" is necessary for the entrant to get the incumbent to exit.

If buyers born in the first period were not there to buy from the monopoly in the second period, then its best policy, if it had stayed in the market, would be to sell all its capacity to the available buyers, those born in the second period. This best policy will not be profitable if

$$\phi[\frac{K}{n_2}]K - F(K) < 0 \tag{$A6$}$$

Inspection of equations $(A5)$ and $(A6)$ shows that assumption $(A1)$, that there be more new customers in period 1 than in period 2, is necessary in order for $(A5)$ and $(A6)$ both to hold.

Assumptions $(A5)$ and $(A6)$ are stronger than assumption $(A1)$. They depend on the capacity chosen by the incumbent. Since condition $(A5)$ is necessary in order for the incumbent to exit from the market, a more farsighted incumbent could guarantee its ongoing presence by choosing a capacity level small enough that condition $(A6)$ does not hold. That such a capacity choice is possible is insured by the following assumption $(A7)$:

$$max_k[\phi(\frac{k}{n_2}) - f(k)] > 0 \tag{A7}$$

This assumption is needed to insure that the entrant, with its capacity flexibility, can find it profitable to produce in the second period, after its first–period sales have spoiled the second–period market for the incumbent.

4. Price Setting in the Second Period

The model will now be solved in the usual backwards fashion, starting with the pricing decisions of firms in the second period. The analysis here supposes that the incumbent has indeed chosen to stay in the market in the second period. Otherwise the entrant would simply choose a capacity k_2 so as to maximize its second–period profits, given its demand and its cost function.

In the second period, there are two sources of potential buyers to a firm, buyers born in the second period, and buyers born in the first period who have chosen to defer purchase.

Notice that eagerness to purchase in the first period is an increasing function of a buyer's willingness to pay.

LEMMA 1 : If $v' > v$, and if both types of buyer expect to be able to buy at the same price π_2 in the second period, then if the type–v buyer buys in the first period, so will the type–v' buyer.

PROOF : Equations 1 and 2 show that the higher–valuation buyer is at least as likely to want to buy in the first period. So if there is no rationing of purchasers in the first period, then the lemma must hold.

If there is rationing, it is efficient rationing, so that the higher–valuation purchasers are better able to buy at the lower price, reinforcing the previous effect. If x_1 units are available at a price π_1 from some firm in period 1, it is the x_1 buyers with the highest willingness to pay who will get to buy, proving the lemma.

The above lemma required both buyers to face the same price in the second period. If rationing is possible in the second period, then the lower–valuation buyer might be unable to buy from the lower–price firm, which means the higher–valuation period–1 buyer might face a lower second period price, making her less likely to buy in the first period.

The next lemma shows that this rationing in the second period cannot really affect demands.

LEMMA 2 : If one firm charges a strictly higher price than the other firm in the second period, its potential buyers born in the first period are those whose valuation is less than or equal to some cut–off level $\bar{v}$.

PROOF : Suppose the firm in question charges a higher price than its rival. Then it will only face any demand at all if the rival rations its sales.

The firm's potential demand from people born in the first period consists of those who did not buy in the first period, and who could not buy from the low–priced rival.

Define $\bar{v}$ as the highest valuation of these potential buyers. Consider a first–period buyer with a valuation $v < \bar{v}$. Efficient rationing means this person would be unable to buy from the low–priced firm in the second period, since the person of valuation $\bar{v} > v$ cannot either. So both types, $\bar{v}$ and v face the same price in the second period, namely the price charged by the higher–priced firm. (The higher–priced firm would never want to ration, since it can just raise its price to meet demand instead.)

Since both buyers face the same price in the second period, Lemma 1 applies. The type–v buyer does not buy in the first period, because the type–$\bar{v}$ buyer did not. Therefore, the type–v buyer is a potential buyer from the high–priced firm in the second period, completing the proof of the Lemma.

LEMMA 3 : A firm's demand in the second period will be elastic in the seond period, at all prices above the price set by its rival.

PROOF : Efficient rationing means that the people born in the second period who are potential buyers from the higher–priced firm are all those whose valuation is $\bar{w}$ or less, for some cut-off valuation level $\bar{w}$. Lemma 2 means that the people born in the first period who are potential buyers from the higher–priced firm are all those whose valuation is $\bar{v}$ or less, for some cut—off valuation level $\bar{v}$.

It also must be the case that $\bar{w} \geq \bar{v}$: buyers born in the first period will buy from the higher–priced firm only if they cannot buy from the lower firm, and if they choose not to buy in the first period.

Therefore, residual demand $d(p)$ for this firm in the second period has the following form, if p is greater than the price charged by the rival in the second period :

$$d(p) = 0 \quad \text{if} \quad p > \bar{w}$$

$$d(p) = n_2[q(p) - q(\bar{w})] \quad \text{if} \quad \bar{w} \geq p > \bar{v}$$

$$d(p) = n_2[q(p) - q(\bar{w})] + n_1[q(p) - q(\bar{w})] \quad \text{if} \quad \bar{v} \geq p$$

The underlying demand function $q(p)$ is assumed elastic (assumption $(A2)$). Adding these kinks to the demand function must reinforce this effect : $pd(p)$ must increase as p decreases, proving the lemma.

If a firm has an elastic residual demand curve, then its optimal Cournot reaction, if it had zero costs, and no capacity constraints, would be infinite, whatever is its rival's output level.

Therefore, Proposition 1 of Kreps and Scheinkman can be applied. Whatever capacity and/or entry choices are made at the beginning of the second period, there will be no rationing in the second period if both firms enter. Both firms will charge the price which clears the market, given the second–period capacity choices.

In fact, Lemma 3 shows directly that a firm will not want to raise its price above its rival's unless it (the potential price–raising firm) is constrained by its capacity, which more or less establishes the result.

If only one firm enters in the second period, then it certainly would not want to ration when it could raise its price instead. It certainly will face an elastic demand curve, and so will want to use all its capacity. Therefore, the following result has been established.

PROPOSITION 1 : Whatever occurs in the first period, and whatever entry and capacity choices are made in the second period, the second period price–subgame results in all potential buyers being able to buy at the same price $\pi_2 = p_2 = P_2$ the price such that total quantity demanded in the second period equals available capacity ($K + k_2$ if the incumbent stays in the market, k_2 if it does not).

5. Second Period Capacity Choice

Let S_1 denote the total sales in the first period. Since high–valuation people are more likely to want to purchase in the first period, and since any excess demand in the first period is rationed efficiently, it is the highest–valuation S_1 people who buy in the first period. The cut–off valuation $\bar{v}$ which separates those who buy in the first period from those who defer purchase is

$$n_1 q(\bar{v}) = S_1 \tag{8}$$

If both the incumbent and the entrant choose positive capacities for the second period, then the equilibrium to the subsequent price–setting sub–game must involve both firms choosing the market–clearing price (Proposition 1). The equilibrium prices $p_2 = P_2$ will solve

$$(n_1 + n_2)q(p_2) - S_1 = K + k_2$$

if $p_2 < \bar{v}$. If $p_2 < \bar{v}$ then assumption $(A6)$ implies that the incumbent will not enter. The previous condition can be re–written

$$p_2 = \phi[\frac{K + k_2 + S_1}{n_1 + n_2}] \tag{9}$$

where $\phi(\cdot)$ denotes the inverse function to $q(p)$.

If the incumbent chooses to enter, then the entrant will choose a second–period capacity k_2 to maximize its profits, given the subsequent price–setting game. It therefore chooses k_2 to maximize

$$\phi[\frac{K + k_2 + S_1}{n_1 + n_2}]k_2 - f(k_2)$$

This k_2 is the optimal Cournot reaction of a firm with cost function $f(\cdot)$, facing a total market demand function of $(n_1 + n_2)q(p)$, to rivals' output of $S_1 + K$.

Being a Cournot reaction function, k_2 need not in general be a decreasing function of S_1+K. If demand were iso–elastic, and the entrant's marginal cost were constant, for example, then k_2 would actually increase with S_1+K when the latter is small — up to the level at which $k_2=\epsilon(S_1+K)$.

In what follows, however, it will be useful if the reaction function eventually slopes down. More specifically, assumptions will be imposed which imply that if the incumbent stays in but is on the verge of shutting down, then the entrant will not wish to produce.

$$\frac{d}{dK}[\frac{F(K)}{K}] \leq 0 \tag{A8}$$

The incumbent would be on the verge of shutting down if its second– period price just covered its costs. With no production by the entrant in the second period, this price is

$$\phi(\frac{S_1+K}{n_1+n_2})$$

if this price is low enough to induce some purchases by buyers born in the first period.[12] If the incumbent is on the verge of shutting down, then

$$\phi(\frac{S_1+K}{n_1+n_2}) = \frac{F(K)}{K}$$

Assumption $(A8)$ then implies that the entrant cannot enter profitably :

$$\phi(\frac{S_1+K+k_2}{n_1+n_2}) < \frac{f(k_2)}{k_2} \qquad \text{for} \quad \text{all} \quad 0 < k_2 \leq K \tag{10}$$

which means that its optimal reaction $k_2(S_1+K)$ must drop towards zero as S_1 approaches the level which would induce the incumbent to leave.[13]

---

[12] And if this price were not low enough to induce these purchases, then assumption $(A6)$ says the incumbent cannot enter profitably.

[13] The non–increasing average costs also give rise to the possibility that the entrant might consider entering on a very large scale, $k_2 > K$. But the incumbent's cost advantage (assumption $(A1)$), and the optimality of K for the monopoly incumbent, mean that this is not a profitable possibility. If it were, than the incumbent would have chosen a larger capacity in the "pre– initial" stage 0.

Result (10) also helps concentrate the attention on the strategic role on spoiling the market in the first period. Were it possible to produce on a small scale at low average cost, then the entrant could be able to credibly drive out the incumbent by entering on such a scale, even in a one–period model. Assumption ($A8$) means that the inflexibility of the incumbent alone does not allow the entrant to drive out the incumbent. The result just obtained will also be used in a subsequent section, in demonstrating that the incumbent will not withhold production in the first period.

The outcome of the price setting and capacity choices in the second period mean that for low levels of first–period sales S_1, the incumbent will stay in the market in the second–period, and the entrant will produce a positive amount as well. For intermediate levels of S_1, the incumbent may stay in, and the entrant stay out.[14] For higher levels of S_1 , the incumbent will be deterred from staying in. The next section specifies the level of first–period sales necessary to keep the incumbent out.

6. "Incumbency Deterrence" in the Second Period

In this section, a sufficient condiiton is derived for the incumbent to choose not to enter the market in the second period.

PROPOSITION 2 : If total first period sales S_1 were $(n_1/n_2)K$ or greater, then the incumbent firm will choose not to stay in the market in the second period.

PROOF : From assumption ($A6$), the incumbent cannot cover its second period costs $F(K)$ if the second period price is $\phi(K/n_2)$ or less.

So it is sufficient to demonstrate that first period sales of $(n_1/n_2)K$ or more must lead to a price of $\phi(K/n_2)$ or less in the second period.

Given the first–period sales, and given that the product is always allocated to the buyers with the greatest willingness to pay, the valuation of the marginal buyer in the first period is

$$\phi(\frac{S_1}{n_1})$$

If

$$S_1 \geq \frac{n_1}{n_2}K$$

[14] if the incumbent's cost advantage is strict, or if its average cost is strictly decreasing

then this valuation must be at most $\phi(K/n_2)$. The only first–period shoppers who deferred purchase, and are available as potential buyers in the second period are those with valuations below this marginal level.

So if the second period price P_2 is above this marginal valuation, then only those born in the second period will buy, the price will be $\phi(K/n_2)$ (or less, if there is production by the entrant), and the incumbent cannot make a profit.

If the second period price P_2 is low enough to result in purchases by some buyers born in the first period, then

$$P_2 \leq \phi(\frac{K}{n_2})$$

so that production by the incumbent again is unprofitable.

An immediate implication of the Proposition is that the entrant can force the incumbent out (in the second period) if it produces a level of output $k_1 \geq \frac{n_1 - n_2}{n_2} K$ in the first period — provided that neither firm withholds output in the first period.

COROLLARY : If both firms sell all they can in the first period, then a sufficient condition for the entrant to spoil the market is that its first period capacity k_1 obeys condition (11) below

$$k_1 \geq \frac{n_1 - n_2}{n_2} K \tag{11}$$

The incentives to use capacity to the fullest will be discussed in the subsequent section.

7. Capacity Use in the First Period

Efficient rationing in the first period means that the buyers with the $X_1 + x_1$ highest demands will buy the good, if the two firms choose to make X_1 and x_1 units available when they set prices. Since only quantities sold affect the second period market, and since the underlying demand is elastic, neither firm will want to ration. That is, even if firms chose to withhold output, by selling quantities x_1 and X_1 strictly less than k_1 or K respectively, they would want to set prices such that there was no excess demand.

In this section, it will be demonstrated that both firms will want to sell all the output they can in the first period, at least when the capacity of the entrant is sufficiently large.

That is, if the entrant picks a high enough level of capacity in the first period, then the best reaction of the incumbent is to help the entrant spoil the market. It chooses to aid and abet its own “incumbency deterrence”, because to do otherwise would sacrifice too much first–period revenue.

PROPOSITION 3 : In any equilibrium in which

$$k_1 \geq \frac{n_1 - n_2}{n_2} K \tag{11}$$

first period sales will be large enough to spoil the market.

PROOF : The entrant will certainly want to use all its capacity, at least in the equilibrium. Otherwise it would have chosen a lower level k_1 of first–period capacity. (To this firm, excess capacity serves no strategic purpose.)

Suppose next that the incumbent chooses to sell some $X_1 < K$ in the first period, and that the market is not spoiled.

In this case, the second period price will be

$$P_2 = \phi(\frac{X_1 + k_1 + K + k_2}{n_1 + n_2}) \tag{12}$$

the first period price will be (from equation (4))

$$P_1 = \phi[\frac{X_1 + k_1}{n_1}] + \delta P_2 \tag{13}$$

and the present value of the incumbent's revenue will be $P_1 X_1 + \delta P_2 K$. This revenue can be written

$$R = \phi[\frac{X_1 + k_1}{n_1}]X_1 + \delta\phi[\frac{X_1 + k_1 + K + k_2}{n_1 + n_2}](X_1 + K) \tag{14}$$

The effect of an increase in X_1 on revenue can then be decomposed into three parts : the effect on the first term in equation (14), the direct effect on the second term, and the indirect effect on the second term through changes in the entrant's future capacity k_2.

The first effect is

$$\phi[\frac{X_1 + k_1}{n_1 + n_2}] + (\frac{X_1}{n_1})\phi'[\frac{X_1 + k_1}{n_1}]$$

which must be positive from the assumption ($A2$) that underlying demand is elastic. The second effect is

$$\delta\big(\phi[\frac{X_1 + k_1 + K + k_2}{n_1 + n_2}] + (\frac{X_1 + K}{n_1 + n_2})\phi'[\frac{X_1 + k_1 + K + k_2}{n_1 + n_2}]\big)$$

which also must be positive, and for the same reason. The indirect effect will be positive if and only if the entrant's reaction function $k_2(X_1 + k_1 + K)$ in the second period slopes down. As discussed in section 5 above, this need not be the case in general. But assumption $A8$ implied that the entrant would not be able to enter profitably in the second period if the incumbent were on the margin of entering. This means that increasing X_1 up to the point that the incumbent is just on the margin of entry in the second period must lower k_2 to zero. Therefore, the incumbent's present value of revenue must be increased if it increases first–period sales just up to the point at which its return to second period production is zero.

If it increases its first period sales X_1 a very small amount more at this point, so that it will not produce in the second period, then its profits must increase discontinuously. The present value of profits is

$$P_1X_1 + \delta i_2(P_2K - F(K))$$

where i_2 is an indicator function which takes the value 1 if the incumbent stays in the market in the second period and 0 if it doesn't. So increasing X_1 just beyond the point at which i_2 goes from 1 to 0 has no effect on second period profits, since those profits were 0 anyhow. However, it must increase P_2 discontinuously, as the entrant must produce on a lower scale than K in order to make a profit. Therefore, this increase in X_1 must increase the first period price discontinuously, as buyers anticipate the low level of production by the entrant after it has chased out the incumbent.

Therefore, the incumbent is best off increasing its first period sales, at least to the point where it chooses not to stay in the market in the second period.

The above Proposition did not assert that the incumbent must produce up to capacity in the first period. If $k_1 \geq \frac{(n_1-n_2)}{n_2}K$, and if the incumbent produced up to capacity in the first period, then no first–period buyers would purchase in the second period. Given that the entrant's optimal second–period sales must then be less than K,

$$\frac{K + k_1}{n_1} \geq \frac{K}{n_2} > \frac{k_2}{n_2} \tag{15}$$

so that the marginal first–period buyer must have a lower valuation than the marginal second–period buyer.

However if the incumbent sells somewhat less than K in the first period, it might be the case that the entrant chooses to sell to some deferred first–period purchasers in the second period. That means that the entrant would be choosing a second–period capacity k_2 so as to maximize $\phi[(S_1 + k_2)/(n_1 + n_2)]k_2 - f(k_2)$, and the resulting k_2 need not be a decreasing function of S_1 : increasing first–period sales might actually increase k_2 as well, serving to lower further the first–period price.

However, since the marginal first–period buyer must derive non–negative surplus from purchasing, it must be the case that

$$P_1 \leq \phi[\frac{S_1}{n_1}] \tag{16}$$

with strict equality if no first–period buyers choose to defer purchase.

Inequality (15) and equation (16) are sufficient for the following

COROLLARY : If k_1 satisfies inequality (11), then in the first period neither firm will withhold output.

PROOF : If the incumbent sold to capacity in the first period, so that $X_1 = K$, then inequality (15) implies that there will be no deferred purchase, and that

$$P_1 = (1 + \delta)\phi[\frac{K + k_1}{n_1}]$$

The assumed elasticity of demand means that

$$(1 + \delta)\phi[\frac{X_1 + k_1}{n_1}]X_1$$

is an increasing function of X_1. If X_1 is less than K, but still high enough that the incumbent will not enter in the second period, than the incumbent's present value of revenue is simply $P_1 X_1$. Inequality (16) then implies that this revenue is no greater than $(1 + \delta)\phi[(K + k_1)/n_1]$, proving the result.

8. The Incentives to Spoil the Market

Propositions 2 and 3 show that the entrant can, under the assumptions of this model, guarantee itself a future monopoly position by choosing a high enough level of capacity in the first period.

Spoiling the market as a strategy seems to present a familiar trade–off : the entrant's aggressive pricing sacrificing first–period profits in order to achieve future monopoly profits.

But in this model, neither the loss in current profits, nor the gain in future profits, are necessarily sure things.

I turn first to the effect of spoiling the market on future profits. High sales in the first period will lead to a monopoly in the second period for the entrant. But the monopoly is achieved only because the market is so unprofitable. Suppose for example that n_2 were very small in relation to n_1. Then, if the entrant's average cost curve were flat (and intersected the vertical axis above the second period demand curve $n_2 q(\cdot)$), it could earn positive monopoly profits in the second period by entering on a suitably small scale. But it might conceivably earn even higher profits in the second period by producing on a small scale in the first period, allowing the incumbent to continue, and sharing in the rich market of deferred puchases by the numerous first–period buyers.

The above possibility cannot occur if the number of new buyers in the second period is not so small. That is, considering only the profits earned in the second period

$$\pi_2 \equiv p_2 k_2 - f(k_2)$$

these profits will be higher if the incumbent is not present if the following assumption is made.

$$n_2 > 2n_1 \tag{A9}$$

PROPOSITION 4: If $n_1 < 2n_2$, then a first period capacity of $k_1 = K$ yields the entrant higher second–period profits than any k_1 which leads to the incumbent staying in the market in the second period.

PROOF : If $n_2 > 2n_1$, then

$$K > \frac{(n_1 - n_2)}{n_2} K$$

so that Proposition 3 shows that a capacity choice of $k_1 = K$ will lead to the incumbent withdrawing from the market in the second period.

If $k_1 = K$, then in the second period the entrant will pick a capacity k_2^* so as to maximize $\phi(\frac{k_2}{n_2}) - f(k_2)$. Since the monopoly cannot make a profit with a capacity of K serving second–

period customers alone, this k_2^* is less than K. First–period buyers rationally anticipate a high second–period price, and there are no second–period purchases by people born in the first period.

Now could the entrant make a higher profit in the second period if instead it chose some small k_1 in the first period, so that the incumbent stayed in the market in the second period, and some people born in the first period deferred purchase (anticipating the low prices due to competition in the second period)? Since second–period profits will be declining in first–period sales, the level of k_1 which yields highest second–period profit for the entrant is $k_1 = 0$. Given the incumbent stays in, the second period price is

$$\phi[\frac{2K + k_2}{n_1 + n_2}]$$

if $k_1 = 0$ and if some first–period buyers defer purchase. On the other hand, if the entrant deterred entry by setting $k_1 = K$, and then chose the capacity k_2, it would face a second–period price of

$$\phi[\frac{k_2}{n_2}]$$

This second price will be higher than the first as long as

$$\frac{k_2}{n_2} < \frac{2K + k_2}{n_1 + n_2}$$

or

$$k_2 < 2\frac{n_2}{n_1}K$$

So if $k_2 < 2\frac{n_2}{n_1}K$, the entrant can make higher second–period profits by choosing $k_1 = K$, forcing exit of the incumbent, and serving only second–period customers in the second period, than by choosing such a low k_1 such that both firms remain in the market in the second period.

What if $k_2 \geq 2\frac{n_2}{n_1}K$? In that case,

$$P_2 = \phi[\frac{2K + k_2}{n_1 + n_2}]$$

and

$$\frac{2K + k_2}{n_1 + n_2} \geq \frac{2K}{n_1} > \frac{K}{n_2}$$

from assumption ($A9$). So the second period price will be less than $\phi[\frac{K}{n_2}]$. By assumption ($A6$), the incumbent cannot meet the cost of its capacity if it faces a price of $\phi[\frac{K}{n_2}]$ or less. Therefore, if k_2 were going to be this large, the incumbent would not have stayed in the market.

Under assumption $A8$, spoiling the market does increase the entrant's future profits. Even so, it may not constitute predatory pricing, under either the Areeda–Turner or Ordover–Willig definitions. If the demand curve is fairly elastic, and if the entrant's average cost curve is fairly flat, then it certainly is possible that the first–period price is well in excess of the entrant's average or marginal cost. Assumption $A5$ means that the incumbent's second–period monopoly price exceeds its average cost :

$$\phi[\frac{2K}{n_1+n_2}] > \frac{F(K)}{K} \tag{A5}$$

If the entrant spoils the market by choosing a capacity of $k_1 = K$ in the first period, then the first period price will be

$$P_1 = (1+\delta)\phi[\frac{2K}{n_1}] \tag{17}$$

The assumption ($A4$) that demand is elastic means that

$$P_1 > (1+\delta)(\frac{n_1}{n_1+n_2})\phi[\frac{2K}{n_1+n_2}]$$

so that $P_1 > f(K)/K$ if δ is not too small, and if the incumbent's cost advantage is not huge. For example, if $\delta = 0.9$, the first period price P_1 defined in equation (17) would certainly cover average cost if the incumbent's cost advantage at an output level of K was no more than 25%. Unless it has an extreme cost disadvantage, the entrant can spoil the market while still pricing above average and marginal cost.

One possible interpretation of the Ordover–Willig notion of predation in this model is to examine the effect of first period capacity k_1 on the entrant's first period profits, assuming that this capacity did not affect the second period decisions by firms. This profit is

$$\phi[\frac{K+k_1}{n_1}]k_1 + \delta\phi[\frac{2K+k_1+k_2}{n_1+n_2}]k_1 - f(k_1)$$

If this profit is maximized at some k_1 which actually does lead to the incumbent leaving, then spoiling the market would not be considered predatory under this definition ; it can be justified on the grounds of current profitability. In keeping with this notion of profitability if strategic affects on the future are ignored, I am ignoring effects of k_1 on the firm's own future capacity k_2 as well in this hypothetical exercise. The derivative of this "hypothetical" profit with respect to k_1 is

$$\phi'[\frac{K+k_1}{n_1}](\frac{k_1}{n_1}) + \delta\phi'[\frac{2K+k_1+k_2}{n_1+n_2}](\frac{k_1}{n_1+n_2}) + P_1 - f'(k_1) \tag{18}$$

The incumbent's capacity K was chosen so as to maximize the present discounted value of monopoly profits, so that

$$\phi'[\frac{K}{n_1}](\frac{K}{n_1}) + 2\delta\phi'[\frac{2K}{n_1+n_2}](\frac{K}{n_1+n_2}) + P_1^M + \delta P_2^M - (1+\delta)F'(K) = 0 \tag{19}$$

where P_i^M denotes the price in period i when the incumbent is an unthreatened monopoly. If the elasticity of demand were a constant $\epsilon > 1$, then equation (19) could be written

$$\frac{\epsilon - 1}{\epsilon}[P_1^M + \delta p_2^M] = (1+\delta)F'(K) \tag{20}$$

Now suppose that both entrant and incumbent had the same constant marginal production costs c. Suppose further that $k_2 = 0$, an assumption which actually biases the case against expression (18) being positive. Then, using equation (20) and the iso–elasticity assumption, expression (18) becomes proportional to

$$r_1\big[(1+\delta)(1-\frac{\eta}{2}) - (1-\eta)2^\eta\big] + \delta P_2\big[(1+\delta)(1-\frac{\eta}{3}) - 2(1-\eta)(1.5)^\eta\big] \tag{21}$$

when $k_1 = K$, where r_1 is the first–period marginal valuation

$$r_1 \equiv \phi(\frac{(K+k_1)}{n_1})$$

and where

$$P_2 = \frac{(n_1+n_2}{n_1)}(1.5)^\eta r_1$$

If expression (21) is positive, then the entrant's first–period profit is increasing in its first–period k_1 at $k_1 = K$, meaning that spoiling the market would not be predation, in the Ordover–Willig sense. In this isoelastic case (when $k_1 = K$ and when $k_2 = 0$), expression (21) depends only on three parameters δ, n_1/n_2 and *eta*. If the discount factor is sufficiently small, then the expression may be negative. But, for example, when $\delta \geq 0.7$, expression (21) must be positive for all admissible values of the other two parameters.

9. Two Numerical Examples

The following numerical example illustrates the possibility of an entrant profitably spoiling the market, provided that the incumbent has already locked itself into a scale which is appropriate for a monopoly, but not in the face of entry, and provided the entrant is able to vary its scale. The example involves a step function for each period's demand, consisting of three types of buyer. The crucial features of the demand function are that there be a large number of low willingness–to–pay consumers, to make it possible for the entrant to spoil the market in the first period, that there be some high willingness–to–pay consumers, to make second–period entry on a small scale possible, and that demand be shrinking.

Since the demand function is a step function, it does not satisfy the elasticity assumption $A2$. It will not always be true here that the incumbent will want to sell to its full capacity. However, it will be the case in the equilibrium, when the entrant has chosen its first period capacity optimally.

The table below shows the numbers of consumers of each type born each period. Note the distribution of buyers by valuation is the same each period ; there are 50% more buyers of each type born in the first period.

number of buyers, by birth year and by valuation

period	*valuation* 20	10	7
1	12	30	30
2	8	20	20

The discount factor, for both buyers and firms, is $\delta = 0.9$.

The cost per period to the incumbent, F, given the inflexible technology, is

$$F(K) = 10 + 8K$$

per period if it chooses a capacity K. Recall that this technology involves picking a scale K beforehand, and being able to produce up to K units at a cost of $F(K)$ in each period — or no units if it chooses not to produce in that period.

The entrant has a flexible technology, which enables it to produce k_i units in period i, at a cost of

$$f(k_i) = 20 + 9k_i$$

per period.

If the incumbent were a monopolist, then its best policy would be to choose a capacity of

$$K = 35$$

and to charge prices of 19 and 10 in periods 1 and 2 respectively. In the first period, all 12 of the high–demand buyers choose to purchase. The medium–demand buyers are indifferent among buying in the first period, buying in the second period, and not buying at all. Assuming, as is usual, that ties are broken in favour of the firm, 23 of the 30 medium–demand buyers choose to purchase in the first period, and the remaining 7 choose to purchase in the second period.

Given the three–step form of the demand function, it can be checked that the above policy ($K = 35$, $P_1 = 19$, $P_2 = 10$) yields higher profits than any other alternative. [15] It also is the case that the monopoly's policy is dynamically consistent : given its first period sales, opening for business in the second period earns it positive profits (of 60).

However, the monopoly needs some deferred purchases from the first period in order to open in the second period. Its total costs are 290 ; it needs at least one medium–valuation buyer from the first period to get it the 29 buyers needed to cover those costs at a price of 10. [16]

If a second firm enters, after the incumbent has committed to a capacity of 35, then that entrant can spoil the market by inducing total sales of 41 or more in the first period.

In this example, total sales need not equal the total capacity, in general. However, they will if k_1 is high enough. For example, suppose that $k_1 = 30$. It is then a Nash equilibrium to the first–period price–setting game for both firms to charge a price of 13.3 (which is the present value of the surplus received by the low–valuation buyers) and for both firms to sell to capacity. Here the incumbent gets revenue of 465.5 by selling 35 units at a price of 13.3 ; if it charged a price of 19 and sold only to medium–valued buyers, its revenue would be 228. Since second period profits

[15] The other obvious contender for the best policy is to sell only to the high–demand types, with $K = 10$, $P_1 = 38$, $P_2 = 20$, and that policy yields profits of only 390 in present value, compared with 430 for the "medium–valuation" strategy.

[16] If it sells only to high–valuation buyers born in the second period, it cannot cover its costs, and the only way it could get high–valuation buyers to defer purchases from the first period would be to sell fewer than 12 units in the first period.

were 60 under monopoly, no policy of withholding output will yield enough future profit to justify the foregone current revenue.

Were the entrant's capacity very low, then there would be no pure–strategy Nash equilibrium. For example, if $k_1 = 15$ and $p_1 = 13.3$, then the incumbent would do better by selling only to medium–value buyers (27 units at a price of 19) than selling to capacity. [15]. As long as $k_1 > 629/38$, then there is a unique Nash equilibrium to the price–setting stage, and it involves $p_1 = P_1 = 13.3$, with both firms selling to capacity.

The entrant also wants to increase capacity, well above this threshold level for full use of capacity. Its marginal cost is less than the price, and as long as $k_1 + K$ is less than 72, the first–period price is 13.3, independent of k_1.

In this example, whether or not the incumbent will be prevented from staying in the market in the second period, the entrant's optimal strategy is to choose $k_1 = 37$. This capacity leads to the market being spoiled. In the second period the incumbent does not stay in, and the entrant makes a positive proift by entering on a small scale (of $k_2 = 8$), and selling only to the high–valuation buyers born in the second period.

In this example as well, the entrant is not practicing predatory pricing, in either the Areeda–Turner or the Ordover–Willig senses. The first period price is above its marginal and average costs, and its first period actions would be optimal even if it had no idea of what would ensue in the second period, or even if it had no prospect of dislodging the incumbent.

However, the numbers can be changed somewhat, to make the entrant's best strategy to be predation, in either of the above senses.

Suppose now that there are only two types, with the following distribution of valuations.

number of buyers, by birth year and by valuation

	valuation	40	10
period			
1		2	38
2		1	19

[15] Here future considerations don't really affect the withholding decision in the first period. Better to sell a unit today for 19 than tomorrow for 10.

with cost functions

$$F(K) = 1 + 9K$$

$$f(k_i) = 1 + 20k_i$$

Here, given the large number of medium–valuation buyers, the incumbent's best policy if it were a monopoly would be $K = 30$, $P_1 = 19$, $P_2 = 10$. The incumbent will want to stay open for business in the second period. But it needs at least 7 (lower–valuation) buyers to defer purchase from the first period to make second–period operation profitable.

The entrant cannot cover costs in the first period, given the scale of the incumbent. It also cannot cover costs in the second period, if the incumbent stays in.

However, suppose it enters in the first period, with a capacity of $k_1 = 3$. This capacity choice leads to a first–period equilibrium in which both firms sell to capacity (at a price of 19). Since $S_1 = 33$, then the incumbent would have revenue of 270 in the second period, less than its costs of 271. It will not stay in. Given the incumbent's departure, the entrant can produce 1 unit in the second period, earning profits of 19. The present value of those profits exceed the value of the losses (4) it incurred in the first period.

Therefore, in this second example, the entrant has to sell at a loss in the first period in order to spoil the market. Its behaviour appears to be predatory pricing in every sense of the term.

10. Concluding Remarks

Spoiling the market is presented here as an alternative strategic motivation for predation. It may present something of an answer to Judge Jackson's challenge : can flooding the market in the present bring about a profitable future monopoly position?

Whether or not spoiling the market constitutes predation, the welfare implications are ambiguous. In the second example in the previous section, the implications are pretty consistently negative. If the alternative to allowing the entrant to spoil the market is to allow the incumbent to maintain its monopoly position, the latter alternative looks much better in that example. Spoiling the market reduces the incumbent's profits (in present value) by 26.1, while increasing the entrant's profits by only 13.1. No buyers are better off, and the high–demand buyer born in the second period loses 27 (in present value).

In the first example, some buyers gain. In this example, spoiling the market reduces the first period price, yielding benefits of 239.4 to high– and medium–valuation buyers born in that period. The higher second–period price yields losses of 80 to high–demand buyers born in the second period. The incumbent's profits fall by 253.5 in present value, and the entrant earns 200.3. In this case there is a welfare gain from allowing the entrant to spoil the market, if we simply aggregate benefits among all parties. Moreover, if only the buyers' well–being is considered, the benefit is still positive in aggregate.

Given the ambiguity of the numeric examples, the general theoretical model of sections 2–8 of the paper cannot yield strong welfare prescriptions. By its very nature, allowing the entrant to spoil the market will benefit the entrant, harm the incumbent, make buyers born in the second period worse off, and make buyers born in the first period better off. Even that last statement may not hold : although spoiling the market increases first period production, and the implicit first–period rental price on the good, it also increases the second period price, so that the first–period price might actually go up.

The analysis in this paper depended on a key asymmetry : that the entrant had more flexibility than the incumbent. This advantage was needed to explain why it is the incumbent and not the entrant which leaves when the market is spoiled. But other (perhaps equally contrived) advantages would have the same effect. Suppose for instance that the world lasted for more than two periods. Then an entrant with deeper pockets than the incumbent might be better equipped to survive the intermediate periods of negative profits induced by high first–period sales. (This story would require the incumbent be unable to exit during the lean and then re–enter further in the future.) If the entrant chose its second–period capacity before the incumbent, and if both firms had high fixed costs (which could be avoided by shutting down in the second period), then again the entrant would have an incentive to drive the incumbent out by spoiling the market. Alternatively, if the entrant could contract in advance to pay its second–period fixed costs, and if the incumbent had not done so, this advantage would be sufficient. Each of these advanatages seems rather adhoc in specification ; but the main point is that spoiling the market will enable a firm with such an advantage to drive out its rival.

The durability of the product is also crucial. But again, the assumption can be relaxed. What is critical is that there be some intertemporal subsitutability. Presumably an airline fare war can reduce future demand, as some buyers respond to low current fares (and a rational expectation that they will not last) by changing their vacation plans. Predation by its very definition involves a situation in which there currently are more than one firm in the market, and in which at least one of the firms can choose to leave. Shifting demand from the future to the present may be a way for one firm to get its rival(s) to choose to exit.

References

Benoit, J.–P. (1984) : "Financially Constrained Entry into a Game with Incomplete Information", *Rand Journal of Economics*, 15, 490–499

Bucovetsky, S., and J. Chilton (1986): "Concurrent Renting and Selling in a Durable Goods Monopoly under Threat of Entry", *Rand Journal of Economics*, 17, 261–278

Bulow, J. (1986) : "An Economic Theory of Planned Obsolescence", *Quarterly Journal of Economics*, 51, 729–750

Cabral, L., and M. Riordan (1994) : "The Learning Curve, Market Dominance and Predatory Pricing", *Econometrica*, 62, 1115–1140

Farrell, J., and G. Saloner (1986) : "Installed Base and Compatibility : Innovation, Product Preannouncements, and Predation", *American Economic Review*, 76, 940–955

Katz, M., and C. Shapiro (1986) : "Technology Adoption in the Presence of Network Externalities", *Journal of Political Economy*, 94, 4, 822–841

Kreps, D., and J. Scheinkman (1983) : " Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes", *Bell Journal of Economics*, 14, 326–337

Schmalensee, R. (1974) : "Market Structure, Durability and Maintenance Effort", *Review of Economic Studies*, 41, 277–287

Computer World (1998) : "Commerce by Numbers – Internet Population", accessed at http://www.computerworld.com/home/Emmerce.nsf/All/pop

Nua Internet Surveys (1999) : "How Many Online Worldwide", accessed at http://www.nua.ie/surveys/analysis/graphs_charts/comparisons/how_many_online.html

U.S. vs. Microsoft Corporation, Findings of Fact (2000)