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SECOND-SOURCING AS A COMMITMENT:
MONOPOLY INCENTIVES TO ATTRACT COMPETITION

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## Abstract

We show that a new product monopolist may benefit from
delayed entry into its market when consumers of the product
incur set-up costs.  Set-up costs create a dynamic consistency
problem:  the monopolist cannot guarantee that it will set low
future prices for the product once customers have incurred the
costs of product adoption.  We show that, if customers are aware
of this problem, the monopolist's profits can be improved through
ex-ante commitment to competition in the post-adoption market.
The most profitable post-adoption market structure depends on
the size of adoption costs and on future demand conditions.  For
sufficiently large set-up costs, an innovator of a product with
static demand is better off with perfect competition than as a
monopolist in the post-adoption periods.  For lower set-up costs,
first-best profits are achieved under monopoly in all periods.
If new demand is expected in the future, licensed competition
will improve the monopolist's profits.

## 1.  Introduction

The idea that a monopolist benefits by deterring potential rivals from entering a market is almost axiomatic in the economic theory of industrial organization.  A recent literature, following Spence (1977) and Dixit (1980)[1], has analyzed a vast array of instruments for protecting monopoly rents by excluding rivals.

This paper shows that for many products, a monopolist may benefit from _attracting_ competitors into its market.  In a market for a new product in which consumers incur a one-time cost of adoption,[2] a monopolist faces a dynamic consistency problem in its pricing policy. This problem arises when the monopolist cannot guarantee low prices for its product after customers have sunk the set-up cost and are "locked into" the product.  Anticipating high post-adoption prices, some customers will be reluctant to adopt the product; hence, demand and total profits are lower than they would be if the monopolist could make price commitments.  Under some conditions, this problem can be resolved by attracting competitors into the market.  Competition will guarantee low prices in the future, increasing initial demand for the product and profits to the innovator.

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[1]  See for example, Eaton and Lipsey (1981), Ware (1984), Bernheim (1984), Bulow (1985), Eaton and Ware (1986).

[2]  Examples of products with adoption costs are numerous.  New computer chips used by electronics firms often require replacement of old equipment by new compatible machines; rental of new word-processing equipment necessitates training costs; adoption of an innovative textbook requires preparation of new lectures and problem sets; use of a new tennis racquet may cause an initial decline in one's success in the sport.

We show in a two-period model that the privately optimal second-period market structure depends on the dynamic demand conditions in the market and on the size of set-up costs. With static demand and large set-up costs, the innovator is strictly better off with perfect competition in the second period than as a two-period monopolist; for small adoption costs, maximum profits can be achieved with a two-period monopoly. If demand is expected to grow over time, the monopolist can increase its profits by encouraging a limited number of competitors into its market.

The theory developed here provides a persuasive explanation for the second-sourcing policy commonly followed by new product firms. Where repeat purchasers become locked-in after adopting a supplier's new product, "buyers routinely insist, before incorporating a seller's componenet into equipment which the buyer manufactures, that the seller demonstrate the existence of at least one other substantial seller that can supply the product in the event the first seller should default -- go bankrupt, be subject to labor strife, or fail to perform for a variety of other reasons."[3] As argued in this paper, one reason that a seller may "fail to perform" is simply the monopoly incentive to raise price. Swann (1986) observes that "many manufacturers of microprocessors have actually sought second sources, or if not that, then they have not actually discouraged them."[4]

Innovators can encourage competition into the market by relaxing

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[3] Taylor (1984), p. 564.

[4] For example, in 1985, Intel had an average of 4 second source copies for each of its 11 own design products and in 1980 had 25 second sources for each of its 8080 and 8085 I/O chips.

patent restrictions, choosing not to patent the product, or providing open access to technological information at favorable license fees. Examples of open licensing practices provide additional support for the dynamic consistency motivation for encouraging competition. IBM's "open architecture" policy in personal computers is an example of the competitive strategy where the post-adoption products are complementary components. As a result of this policy, over 750 research groups produce software and complementary devices, increasing the demand for the IBM machines. Similarly, Xerox followed an open licensing policy for its Ethernet local area network technology (LAN). Sirbu and Hughes (1986) suggest that had Xerox retained a monopoly on the LAN technology, Intel might not have invested the up-front specific capital to develop the required semiconductor chip for the technology, believing that "competitors (might have been) reluctant to buy such a chip for fear that Xerox would (have) behave(d) opportunistically and cut off the supply sometime in the future, or charge(d) exorbitant prices once the chip had proved successful." As a result of open licensing, Intel and other chip manufacturers implemented the design and developed the required chip.

An alternative incentive may explain the second sourcing and open licensing policies followed in these examples. As argued by Swann (1986), these policies may expedite the acceptance of a product as the industry standard. In many of the above examples, important consumer networks may be exploited through standardization, as analyzed by Katz and Shapiro (1985, 1986) and Farrell and Saloner (1985, 1986), and those gains will be greatest for the firm whose product becomes the standard. Therefore, there could be an incentive for an innovator to commit to low

prices in order to become a de facto standard.[5]  This incentive is conceptually distinct from (although often present together with) the price commitment incentive analyzed in this paper:  Our analysis applies when there are no "network externalities" in the use of the good. However, price commitment may make a product more likely to be accepted as the industry standard, both through its effect on expectations of future buyers' willingness to buy it (as analyzed by Katz and Shapiro (1986)), and by making first-period buyers more willing to lock into it.[6]

The monopolist may want to commit itself to product characteristics other than future prices; for example, product quality or servicing of the product.  We consider only price commitments in this paper, as a proxy for the much larger set of product attributes that may affect current demand for the product.   In independent research, Shepard (1986) analyzes a market in which an innovator licenses competition as a commitment to product quality (delivery time).  Since both producer's cost and buyer's surplus increase in quality, it plays formally a very similar role to price in our model.

Consumer set-up costs are analyzed in several other recent papers.  Schmalensee (1982) shows that when consumers must incur a set-up cost to learn the quality of a new product, a pioneering firm in the

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[5]  See especially Katz and Shapiro (1986).  Besen and Johnson (1986) report such a strategy by Motorola in the battle for the AM stereo standard.

[6]  Another incentive for a firm to offer an attractive licensing contract to a competitor or potential entrant might be to dissuade the rival from developing a superior technology (Gallini (1984), Gallini and Winter (1985)).

market benefits from consumers' reluctance to switch to a competitor's product with unknown quality. A more closely related literature concerns competition with switching costs.[7] That literature assumes competition, and asks about the effect of switching costs on market prices. We consider the problem faced by a monopolist who can choose in advance whether to allow competition without switching costs or to exclude effective competition entirely. We show that entry often benefits an innovator. One interpretation of this is that where entry barriers reward a pioneering firm with a monopoly, we identify when its profits may be increased by eliminating these barriers (switching costs) through licensing.

The monopolist's dynamic inconsistency problem is reminiscent of the durable goods monopoly problem identified by Coase (1972), and analyzed by Bulow (1982) and Stokey (1981). There, the profit-maximizing price path of a monopolist seller of a durable good is dynamically inconsistent for the opposite reason than here: The monopolist cannot guarantee a <u>high</u> future price of a durable good; hence, first-period purchasers will refuse to pay as much as they would if the seller could so commit. Katz and Shapiro (1986) identify a related problem for products with network externalities. In this case, sellers would like to commit to <u>low</u> prices in the future since consumers care about the number of future buyers; inablility to do so may lead to biases in the technology choice. We analyze the effects of "consumer lock-in", a more direct way in which current buyers may care about future prices.

Before turning to the analysis, we disclose two critical

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[7] See for instance Klemperer (1986) and references therein.

assumptions of the model. First, we assume that the monopolist <u>cannot</u>
write contracts on future prices with its customers. The situation we
model, where buyers acquire relationship-specific capital, is one in
which contracts or vertical integration would seem particularly
appropriate.[8] These arrangements, however, are often absent. In
consumer goods, for example, vertical integration is infeasible and
future price contracts would be costly to write, given a large number of
customers. If future costs are uncertain, then contracts specifying a
fixed future price may be undesirable or unenforceable. Even if a
contract could be designed that solved satisfactorily the pricing
problem, other problems of opportunism could arise. The seller could
cheat on production quality (as in Shepard (1986)) or on developing
improved versions of the product: We do not model these problems here;
however, we believe that they demonstrate the difficulty in using
contracts for future price commitments. Just as competition is superior
to regulation in its flexibility to respond to changing market
conditions, so also it is superior to private contracts.

Our second crucial assumption is that a monopolistic seller <u>can</u>
commit itself to competition after a lag. There are two ways in which
this may be possible. First, licensing agreements can specify a date for
the technology to be transferred and production to begin. The second
mechanism, admittedly less capable of precise adjustment, uses the lag in
imitation. Reverse-engineering a product and commencing production take

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[8] Ferguson (1986) documents how the Japanese electronics industry
has used vertical integration to solve these problems, and encourages the
U.S. industry to do likewise. In fact, in the U.S., second-sourcing
seems to be the preferred arrangement.

time; so if an innovator does not license its technology but merely refrains from strong patent protection, then he obtains precisly the temporary market power followed by competition that we model here.

The paper is organized as follows. In section 2, we present a simple model for analyzing the pricing problem of a monopolist of a product with set-up costs. The model identifies a benchmark, in that it gives conditions under which commitment is not important to the monopolist. When a critical assumption of static demand is relaxed in section 3, price commitment is shown to matter. Increased future sales to new demanders could increase current demand; however, without price commitments, the monopolist cannot guarantee the optimal level of sales, unless competition can be encouraged into the market. The results of the paper are summarized and testable hypotheses of the theory are identified in Section 4. Implications for antitrust laws on licensing practices are discussed.

## 2. The Model

### 2.1 Assumptions and Notation

In this section, a monopolist's pricing problem for a new product with adoption costs is analyzed. We assume that each consumer purchases either zero or one unit of the good in each of two periods. In addition to the price, consumers also incur a one-time cost, F, at the time of adoption.[9] Each consumer has a "static" reservation price: the dollar

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[9] To encourage adoption of a new product, an innovator commonly attempts to transfer adoption costs from the consumer to itself. Attempts are made to make computers "user friendly"; computer companies give free training sessions on how to use their machines; textbook publishers provide detailed instructor's manuals and overheads for

value that he/she derives from each period of consumption. The distribution of these reservation prices is described by an inverse demand function, $v(n)$, where n is the number of consumers willing to pay v or more for a unit of the new product. All agents have the same discount rate r. We suppose that the monopolist can completely control entry. Marginal costs of production are constant and equal to c. Consumers have complete knowledge of the problem, and hence, perfectly anticipate future prices set by the monopolist. Two situations are considered: In the first, the monopolist can commit credibly to future prices; in the second case, by contrast, it cannot. We ask when a mechanism for price commitment can strictly improve profits.

## 2.2  The Unconstrained Path: Credible Price Commitment

In this section, we assume that the monopolist can credibly bind itself in period 1 to a period 2 price. With commitment, it turns out that the monopolist announces a price path $(P_1, P_2)$ that elicits purchases from the same consumers in each period. Since all consumers must incur the adoption costs F, whether they purchase in one or both periods, the innovator generates, and therefore extracts, maximum surplus by selling only to repeat customers. (Proof of this is in the appendix.)

This constant-sales policy implies that the difference between $P_1$ and $P_2$ will not exceed F. (For a price path with a large spread in $P_1$ and $P_2$, individuals with reservation prices in between the two prices

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lectures to complement a new innovative textbook. Adoption costs, however, are not likely to be transferrable; we assume that the innovator has reached the optimal allocation of adoption costs between itself and the consumer, and that this involves some set-up costs by the consumer.

would purchase only in the lower price period.)

(1)      $P_1 - F \leq P_2 \leq P_1 + F$ .

Moreover, to ensure that consumers do not wait until period 2 to buy the product, the surplus gained from adopting the product in both periods must exceed the surplus from adopting it in the later period only.  Let $\alpha=1/(1+r)$ and $\beta=\alpha(2+r)$. Then,

(2)      $v\beta - P_1 - \alpha P_2 - F \geq \alpha(v - P_2 - F)$
   $\Longrightarrow$    $P_1 \leq v - \alpha r F$ .

(The savings from postponing F until the second period are $\alpha r F$.)

  For an announced price path $(P_1, P_2)$ satisfying (1) and (2), a consumer with reservation price v buys the product in both periods if

(3)      $v\beta \geq P_1 + \alpha P_2 + F$ .

Since (3) holds with equality for the marginal consumer, the discounted monopoly profits are:

(4)      $V(n) = \beta[v(n) - F/\beta - c]n$ ,

and the first-order condition for n is:

(5)      $v(n) + v'(n)n - F/\beta = c$ .

Note that maximizing V(n) is identical to maximizing profits for a static monopoly facing demand curve $P = v(n) - F/\beta$ in each of two markets. Hence, a natural way for the unconstrained monopolist to achieve maximum profits is with a constant price path. The solution to the equivalent static monopoly problem is illustrated in Figure 1 for a linear demand curve. Profit-maximizing sales in each period are n* and the constant price is $P^* = v(n^*) - F/\beta$.

This constant price path is <u>not</u> dynamically consistent, but an infinite number of alternative price paths satisfying $P^*\beta = P_1 + \alpha P_2$ also yield n* repeat purchases and maximum profits. This result depends on customers having rectangular demand curves in each period, so that, at the time of adoption, they care only about the total price - the discounted sum of prices plus F - rather than the individual prices. The set of price paths that yield maximum profits is then given by:

(6)    (a)   $P_1 + \alpha P_2 = P^*\beta$

where  (b)   $P_1 \leq P^* + F\alpha^2/\beta$ [10]

and    (c)   $P_1 - F \leq P_2 \leq P_1 + F$ .


2.3   <u>The Constrained Path:   No Price Commitment</u>

Suppose now that the monopolist <u>cannot</u> credibly commit to a future price. As illustrated in Figure 2, the innovator faces two demand

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[10] Intuition for the upper bound on $P_1$ can be found by rewriting the right hand side of the inequality as $(P^* + F/\beta) - F\alpha$, where the first term equals v(n*), the gross surplus received in period 1, and the second term represents the savings in adoption costs from postponing adoption to the second period.

curves: Before paying the set-up costs, consumers will consider these costs in their purchase decision and demand is given by AB. Once those costs are sunk, their choices will be independent of the set-up costs and demand shifts vertically up by F to CD. As in the unconstrained case, the monopolist's optimal sales strategy is to sell to the same buyers in the two periods.[11]

In the second period, after n* consumers have sunk the set-up costs, the reservation price of the marginal consumer is $\hat{P}_2=v(n^*)$. Since the monopolist sells to the same consumers in both periods, condition (3) must be satisfied for all consumers. Substituting period 2 price into (3) implies that $\hat{P}_1=v(n^*)-F$. Hence, the dynamic consistent price path is a "penetration pricing" strategy consisting of a relatively low price in the first period to encourage adoption, followed by a higher, surplus-extracting price in period two: The condition for dynamic consistency is $P_2=P_1+F$.

We now come to the principal observation of this section. If $F \leq P^* \beta/\alpha$, then the constrained monopolist can still sell to n* customers in each period and achieve maximum profits, by setting prices $P_1=P^*-F\alpha/\beta$ and $P_2=P^*+F/\beta$. However, for large set-up costs, $F>P^*\beta/\alpha$, that strategy would involve negative prices, which we suppose are impossible. The monopolist therefore charges $P_1=0$ and $P_2=F$, selling to only $v^{-1}(F)$ customers.[12] In sum, the dynamically consistent price path of the

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[11] The formulation of this problem parallels the perfect foresight model by Schmalensee (1982). The optimality of a constant-sales policy is proved in his paper.

[12] Note that in this case, and possibly for smaller set-up costs, the price in period 1 will be less than the marginal costs of production.

constrained monopolist is:

(7)    (a)  $P_1 = P* - F\alpha/\beta$        for $P*-F\alpha/\beta \geq 0$ ,

            $P_1 = 0$                otherwise ;

       (b)  $P_2 = P_1 + F$ .

Thus, for sufficiently small set-up costs, the monopolist can achieve maximum profits <u>without</u> the ability to commit to future prices. It does this by setting a low first-period price to encourage customers to incur the set-up costs.

For products with large set-up costs $(F>P*\beta/\alpha)$, the monopolist cannot achieve first-best profits without price commitment. This is because the marginal consumer (in the optimum) incurs negative surplus in the first period; hence, he must be compensated with either a negative price in that period, or where negative prices cannot be set, a lower second period price. While the monopolist would like to commit itself to charge a low second period price, it cannot; and when period 2 arrives, it will maximize profits by charging a high price of F. This problem is illustrated in Figure 3. The demand curve for the equivalent static monopoly problem in the unconstrained case is EF; profit-maximizing sales and price in each period are n* and P*. AB and CD are the first and second period demands facing the constrained monopolist. Since $P_1$ would be negative at n*, the monopolist cannot sell n* in each period, and instead will sell $\hat{n}$ units of the product in each period at prices $P_1=0$

and $P_2 = F$.[13]

These results provide some insights into the nature of the

commitment benefits from competition. When the monopolist cannot bind

itself to future prices and adoption costs are large, it may be better

off to _encourage_ perfect competition into the market. To see this,

consider an alternative price path that achieves maximum profits for

large set-up costs, $P_1 = P^*\beta - c\alpha$ and $P_2 = c$.[14] If the monopolist follows an

open licensing policy (with zero royalties), and can successfully inform

consumers of future competition, it can set the optimal first-period

price while charging c with its competitors in the second period. This

policy extracts all the surplus from the marginal buyer in the _first_

period, in contrast to the penetration-pricing policy discussed above.

Alternatively, the monopolist might limit the number of licensees. Then,

given the price that results from the oligopoly in period 2, the

innovator can adjust $P_1$ according to (6) and redistribute the licensees'

profits back to itself through lump sum royalties. This strategy

achieves maximum profits without the need for possibly hard-to-enforce

per-unit royalties.

We summarize the effect of competition on profits with the

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[13] In addition to large set-up costs, low marginal costs will also
increase the importance of commitment. This is seen explicitly for a
constant elasticity specification of $v(n) = n^{-a}$, where a>1. In this case,
$P^* = (c - F/\beta)/(1-a)$. Hence, first-best profits are not attainable when
$c < F(1-2a-ar)/(2+r)$. This example reveals that low discount rates and
elastic demands tend to make the inability to commit to prices important.

[14] For this price path to yield the unconstrained profits,
$P_1 = P^*\beta - \alpha c$ must be sufficiently low to discourage customers from waiting
until period 2 to adopt the product; that is, $P_1$ must not exceed
$P^* + F\alpha^2/\beta$, the upper bound specified in (6b). This constraint on $P_1$ is
easily shown to be satisfied for the values of F corresponding to this
case $(F > P^*\beta/\alpha)$.

following proposition.


<u>Proposition 1</u>.  For sufficiently large user adoption costs and

non-negative prices, $F > P^* \beta/\alpha$, the monopolist of a new product is <u>strictly</u>

better off when faced with perfect competition or licensed competition in

future periods than when it retains a monopoly position; for lower set-up

costs, $F \leq P^* \beta/\alpha$, the monopolist can reach first-best profits without the

ability to commit to prices.


2.4  <u>Relaxing the Assumptions</u>

The model discussed above is the simplest framework for analyzing

the monopolist's pricing problem with consumer set-up costs.  Before

extending it, we comment on two features of the model.  First, because of

its simplicity, this model is not intended to be a general theory of

consumer adoption costs; rather, it identifies a set of conditions on the

technology and market for which commitment does <u>not</u> matter to the

monopolist.  As mentioned earlier, this result relies critically on the

assumption of static demand:  That is, no new buyers arrive in the second

period.  We relax this assumption in the next section and show that new

demand increases the incentive to commit to prices through competition.

Second, the results in this section are somewhat artificial since

they rely on an unrealistic consequence of our demand specification of

rectangular individual demands; namely that only the total discounted

expenditures, $P_1 + \alpha P_2$, matter, and not individual prices.  In general, $P_1$

and $P_2$ will have within-period efficiency effects, and the monopolist

will not be indifferent to replacing the static monopoly solution $(P^*, P^*)$

with the constrained monopoly solution (P*-Fα/β, P*+F/β) or the perfectly
competitive solution (P*β-cα, c).

The question, then, is whether the results on commitment are
robust to more general specifications of demand. In fact, the
<u>qualitative</u> results that commitment does not matter for products with low
set-up costs and that <u>some</u> form of competition is desirable for large
adoption costs do <u>not</u> depend on the elasticity of individual demands
(although the quantitative results on the critical value of F that makes
commitment desirable and the degree of desired competition do depend on
this assumption).

To see this, consider a slight variation on the model. Define
v(n) as the inverse <u>individual</u> demand curve, identical for all consumers,
where n is the amount of the good purchased by a consumer. Assume that
income effects are zero and that the discount rate is zero for all
agents. Finally, assume that the monopolist is unable to set a two-part
price. Then, the optimal price path is <u>unique</u> and has constant prices.
For sufficiently small set-up costs - F/2 less than the shaded area in
Figure 4 - the constrained and unconstrained monopolist will set the
static monopoly price of P* in both periods to achieve maximum profits.
For larger set-up costs, for example, where the consumer surplus equals
F/2 at $\hat{P}$, the unconstrained monopolist will set $\hat{P}$ in both periods to
maximize profits; however, the unconstrained monopolist cannot credibly
follow this price path. After consumers incur the adoption costs, the
monopolist will set a second-period price equal to P*; knowing this,
consumers will be willing to pay only P' in the first period, where the
sum of consumer surplus at P' and P* equals F.

Thus, when the assumption of inelastic consumer demands is relaxed, two results of the previous analysis change. First, the optimal price path is unique and constant. Second, when commitment matters, the monopolist will prefer not to confront perfect competition that forces the second period price down to marginal cost, if some more moderate form of commitment is available. Nevertheless, the qualitative results in Proposition 1 are preserved: For small set-up costs, commitment does not matter; for large set-up costs, some form of competition is desirable; although the desired competition will be generally less intense.[15] We turn now the model with growing demand.

## 3. The Importance of Growing Demand

### 3.1 Assumptions and Notation

Consider a simple extension of the previous model. In the second period, a group of new potential buyers enter the market.[16] Assume that

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[15] Another effect of the demand specification on the solution should be noted. For inelastic demands, the constrained monopolist is expected to extract the total surplus of the marginal consumer in the second period and therefore, this consumer is willing to pay a first period price no greater than the surplus generated in that period, net of F. If the model were extended to more than two periods, this would not change and hence, the result on commitment in Proposition 1 is preserved. For elastic individual demands, the importance of commitment is not independent of the length of the consumption horizon. In this case, the marginal consumer receives positive surplus in the second period at the constrained monopoly price; therefore, he is willing to pay a price in the first period for which the sum of the surplus generated in all periods exceeds F. The longer the consumption period, the more likely the constrained monopolist can set the optimal price path without the ability to commit.

[16] A more realistic extension would include new demand over time, where the stock of "locked-in" customers at any time increases with the flow of new adopters. Since our intention is to identify possible benefits from competition arising from the dynamic consistency problem, we present the simplest model that illustrates this point.

the distribution of reservation prices by new demanders is given by

$v(n_2/\delta)$, where $n_2$ individuals are willing to pay a maximum price of $v$ and

$\delta$ is a parameter measuring the size of new demand.[17]

In period 2, the market demand is given by the horizontal

summation of demands by repeat customers (those who have already incurred

the set-up costs) and new customers. Since we wish to examine the effect

of new demand on the monopoly pricing problem, we assume that $v(0)-F-c>0$;

that is, the surplus, net of adoption and production costs, generated

from a sale to the new customer with the highest reservation price, is

positive.

As shown in the appendix, the unconstrained and constrained

monopolists will set prices that encourage all first period customers to

make purchases in <u>both</u> periods. This implies that the first and second

period prices do not differ by more than F, as in the case of static

demand.


3.2  <u>The Unconstrained Solution</u>

To solve the unconstrained monopoly problem, consider first the

demand facing the monopolist in each period. As in Section 2, since first

period customers purchase in both periods, they must have reservation

prices satisfying (3). In the second period, new demanders will purchase

the product only if their reservation prices satisfy:


(8)      $v_2 \geq P_2 + F$ .

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[17]  Changes in $\delta$ correspond to isoelastic shifts in $v(n)$.

The objective function of the unconstrained monopolist, given the demand curves implied by (3) and (8) is:

(9)     $V_u = [\beta v(n_1)n_1 - F - \beta c]n_1 + \alpha[v(n_2/\delta) - F - c]n_2$ .

The profit function in (9) is maximized with respect to <u>simultaneous</u> choice of $n_2$ and $n_1$ to yield the two first-order conditions:

(10)     (a)   $\beta v(n_1) - F + \beta v'(n_1)n_1 = c\beta$

         (b)   $v(n_2/\delta) - F + v'(n_2/\delta)n_2/\delta = c$ .

Note that the condition in (10a) is identical to that for the unconstrained monopolist facing static demand (see condition (5)). Moreover, the optimal sales to early and late adopters are independent of each other. That is, the monopolist simply determines the optimal sales to each set of buyers; then, given the price resulting in period 2, it adjusts the first period price to extract the surplus from early adopters. Hence, the first-period price is unique, and depends on the solution to $n_2$ in (10b). Furthermore, since $v(0) - F - c > 0$ (by assumption), $n_2 > 0$ for all positive values of $\delta$. As will be shown below, this is not necessarily the case for the constrained monopolist.

## 3.3  The Constrained Solution

As before, the optimal pricing strategy for the constrained monopolist can be solved in two stages:  First, we find the optimal solution in period 2; second, we solve the first period problem, given

the optimal policy in period 2.

From (8), monopoly profits in period 2 can be written as

$$(11) \qquad V_2 = [v(n_2/\delta) - F - c](n_1+n_2) \ .$$

Maximization of (11) with respect to $n_2$, given the choice of sales in the first period, $n_1$, yields the interior solution for $n_2$:

$$(12) \qquad v(n_2/\delta) - F + v'(n_2/\delta)(n_1+n_2)/\delta = c \ .$$

Let the interior solution to (12) be $\hat{n}_2(n_1)$. If $v(0)-F-c+v(0)n_1/\delta \leq 0$, or $n_1 \geq -\delta(v(0)-F-c)/v'(0) = \bar{n}$, then $n_2$ is set optimally to zero. Hence, the optimal solution to the second period maximization problem, given $n_1$, is

$$(13) \qquad n_2^*(n_1) = \begin{cases} \hat{n}_2(n_1) & \text{for } n_1 < \bar{n} \\ 0 & \text{for } n_1 \geq \bar{n} \ . \end{cases}$$

We turn now to the first period decision. Discounted monopoly profits in period 1, upon substitution of the demand implied by (3) and (8) are

$$(14) \qquad V_1 = [\beta v(n_1)-F-c\beta]n_1 + \alpha[v(n_2^*/\delta)-F-c]n_2^* \ ,$$

where $n_2^*$ is given by (13) ($n_1$ is suppressed for notational convenience). The profits in (14) are then maximized with respect to $n_1$

to yield the first order condition:

(15) $\quad \beta v(n_1) - F + \beta v'(n_1)n_1 - \alpha v'(n_2*/\delta)(n_1/\delta^2)(dn_2*/dn_1) = c\beta$ .

For low values of $\delta$, there may be two solutions to (15). To see this, consider the profit function in Figure 5 for small $\delta$. The profit function consists of two parts: First, for $n_1 > \bar{n}$, $n_2* = 0$ and $dn_2*/dn_1 = 0$; note that this segment is identical to that for the static demand case in section 2. Second, for $n_1 \leq \bar{n}$, sales will be made to new demand when the second period is reached; hence, profits are larger than if $n_1 (\leq \bar{n})$ sales were made in both periods. As illustrated in Figure 5, (15) may be satisfied at two values: $n*$, the solution to the static demand case, and $\hat{n}$. Since $\hat{n}$ yields only a local maximum in this example, the constrained monopolist will ignore new demand when it is low, selling to the same $n*$ customers in both periods. As established earlier, the unconstrained monopolist will always sell to new demand; therefore, the constrained monopolist is unable to achieve maximum profits without commitment.

For larger values of $\delta$, sales to new customers will be profitable; nevertheless, the tendency towards suboptimal second period sales remains.[18] The first-order conditions for period 2 in (10b) and (12) reveal that the monopolist will set a lower price and have larger sales in the second period when it is able to make binding price commitments. Since $v' < 0$, the last term on the left-hand side of (12) is negative. Hence, $n_2^u > n_2^c$. In choosing $n_2$, the constrained monopolist

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[18] This can be seen by totally differentiating the profit function in (14) and employing the envelope theorem. Then, $dV_1/d\delta = -v'(n_2/\delta)^2 > 0$.

considers the negative effect that higher second period sales (and lower

prices) have on profits from the repeat customers. It would like to

ignore this effect, and simply maximize profits from new demand,

adjusting first period price to capture the surplus from early adopters.

Without binding price commitments, a promise of low future prices would

not be credible.

For the first period decision, the unconstrained and constrained

first order condtiions differ by the last term on the left-hand side in

(15). Since this term is negative, $n_1^u > n_1^c$.[19] When the monopolist

cannot commit itself to a future price, it takes into account the effect

of first period sales on its optimal price in the second period. Large

first period sales mean that there are many "locked in" buyers in the

second period; consequently, the monopolist will be reluctant to set a

low second-period price in order to increase sales to new customers since

this will lower revenues from sales to locked-in customers. Each buyer

in the first period is prepared to pay _more_ for the good (in the first

period) if there are fewer first-period buyers. As a result, it pays the

monopolist to reduce $n_1$ below the unconstrained level, thus publicly

changing its second-period incentives and thereby committing itself to a

lower second-period price. Because this commitment is costly, the

monopolist has a clear incentive to find a "cheaper" commitment

strategy.

Competition may be such a strategy, but not if taken too far:

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[19] Total differentiation of the first order condition in (12) with
respect to $n_2$ and $n_1$ reveals that $dn_2^*/dn_1 < 0$.

<u>Proposition 2</u>. A new product monopolist facing demand growth, may prefer limited competition to monopoly in the second period, but can be no better off under perfect competition or an open licensing policy (with zero royalty payments) in the second period. If the monopolist can control entry through license contracts with flexible royalties, maximum profits can be achieved with any number of licensees. Moreover, the monopolist may be better off to accommodate rivalry in the <u>first</u> period (as well as the second).

Under perfect competition or an open licensing policy (with zero royalties) in the second period, sales would be excessive. The profits in this case would be no larger, and generally lower than under monopoly in both periods. This is because the monopolist would earn profits only in the first period, given a second-period price equal to $c$; and those profits would be equal to the constrained monopoly profits with no demand growth. As established earlier, the constrained monopolist can be no worse off, under demand growth; hence, it would prefer a two-period monopoly to perfect competition in the second period.

Nevertheless, the monopolist may be willing to encourage some form of competition, since unconstrained profits exceed constrained profits. For example, the following arrangement yields maximum profits: The monopolist enters into a license contract with another firm and sets a per-unit royalty that yields $n_2^u$ sales in period 2; he then sets the optimal first-period price to achieve maximum industry profits. Through lump-sum royalty payments, the monopolist can redistribute the rents from the licensee(s) back to itself. Hence, it earns profits that are

strictly greater than the constrained profits without competition.[20]

This competitive strategy requires that the monopolist can commit credibly to licensing future competition. This does not seem to be a problem, as discussed in the Introduction. However, a more direct commitment to competition is to license rivals immediately. For sufficiently flexible royalty payments, maximum profits for the industry can be achieved with _immediate_ competition. For example, if the innovator can specify different royalties for periods 1 and 2 in the license contract, then it will set per unit royalty rates which elicit $n_1^u$ and $n_2^u$ sales in the oligopoly game that ensues.[21] If the license agreement leaves the licensee with a significant portion of the rents, the innovator can simply redistribute some of the rents back to itself through a lump sum payment. Where a constant royalty must be set, the decision to license depends on the tradeoff between larger industry profits from lower future prices and decreased profits from a less concentrated market.

Proposition 2 provides an explanation for the common practice of second sourcing. As mentioned earlier, electronics firms often license new products to one or a few competitors, but not to all, as a second source assurance to customers. Proposition 2 shows that both producers and consumers can benefit from this competitive strategy. Moreover, when

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[20] When entry costs are positive, industry costs are minimized (and royalty payments are maximized) when the number of licensees is limited to 1. For sufficiently large entry costs, the constrained monopolist may prefer not to license at all.

[21] Alternatively, the licensor may set a "sliding royalty", which declines in the amount of output produced, to encourage sales in the second period when new demand arrives.

new demand is expected to be large, the innovator has the incentive to control entry into the market, especially if per unit royalty rates are not feasible.[22] The costs of more intense competition - the decline in industry profits and royalties to the innovator - more than offset the benefits from attracting current demand through lower future prices. Therefore, a prohibition on selective licensing may lead to no licensing.

## 4. Conclusions

In this paper we examine markets in which an innovator may benefit from imitation of its product. With product-specific set-up costs, current demand depends on the anticipated future prices of the product. As a means of commitment to lower future prices, the innovator may choose to attract competition into the market by offering generous licensing arrangements or facilitating imitation of the product.

We explored the influence on the innovator's preferred second-period market structure of the size of the set-up costs and the nature of demand. For large set-up costs and static demand, the innovator can achieve first-best profits through perfect competition in the post-adoption market; if set-up costs are low, any form of competition is inferior to pure monopoly. When new demand for the good is expected in the future, then only moderate competition can yield first-best profits to the innovator.

The analysis in this paper is supported by the observation that

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[22] For example, Katz and Shapiro (1985) suggest that lump sum royalty rates are reasonable when output is difficult to monitor. Alternatively, the monopolist may want to set a low royalty rate per period of time to discourage imitation of the new product.

producers of new products often attempt to convince customers of good intentions to set low future prices. Commonly, consumers require evidence that the firm will not go bankrupt or the product line will not be discontinued after they incur the large set-up costs of adopting the product.[23] The inability to commit, at the time of product adoption, to the price for repeat purchases may keep the monopolist from achieving maximum profits unless competition for its product is encouraged.

While our model is simple, it does capture characteristics of markets where "second sourcing" of new products or favorable licesning policies are practiced. The efficiency of this policy has implications for antitrust laws towards licensing, specifically for the legal treatments of exclusive licensing. For large new demand or low set-up costs, the innovator may want to practice selective licensing of its product, especially when there are constraints on the structure of royalty payments or economies of scale in production. Under restrictions on exclusive licensing, the firm may simply refuse to license its product, and a Pareto-inferior outcome would result.

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[23] Titman (1984) examines the commitment problem in a financial setting. Titman suggests that the firm will hold lower levels of debt as a means of commitment that the firm will stay in the market (not go bankrupt).
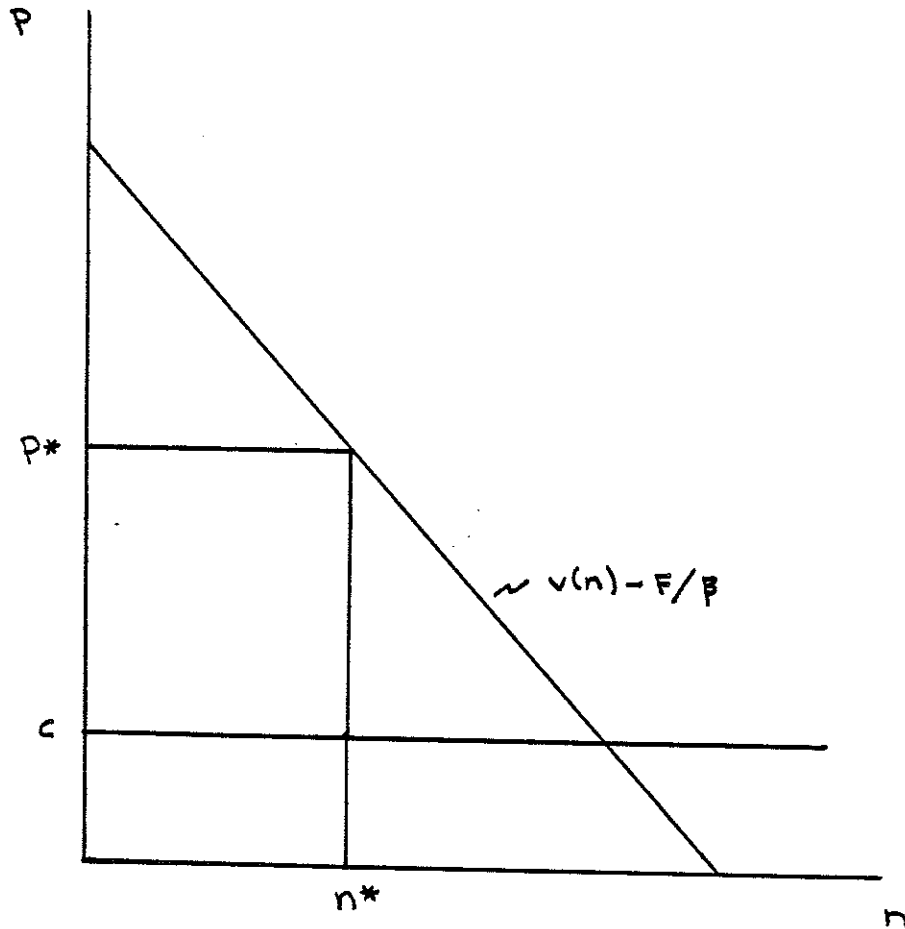
Figure 1

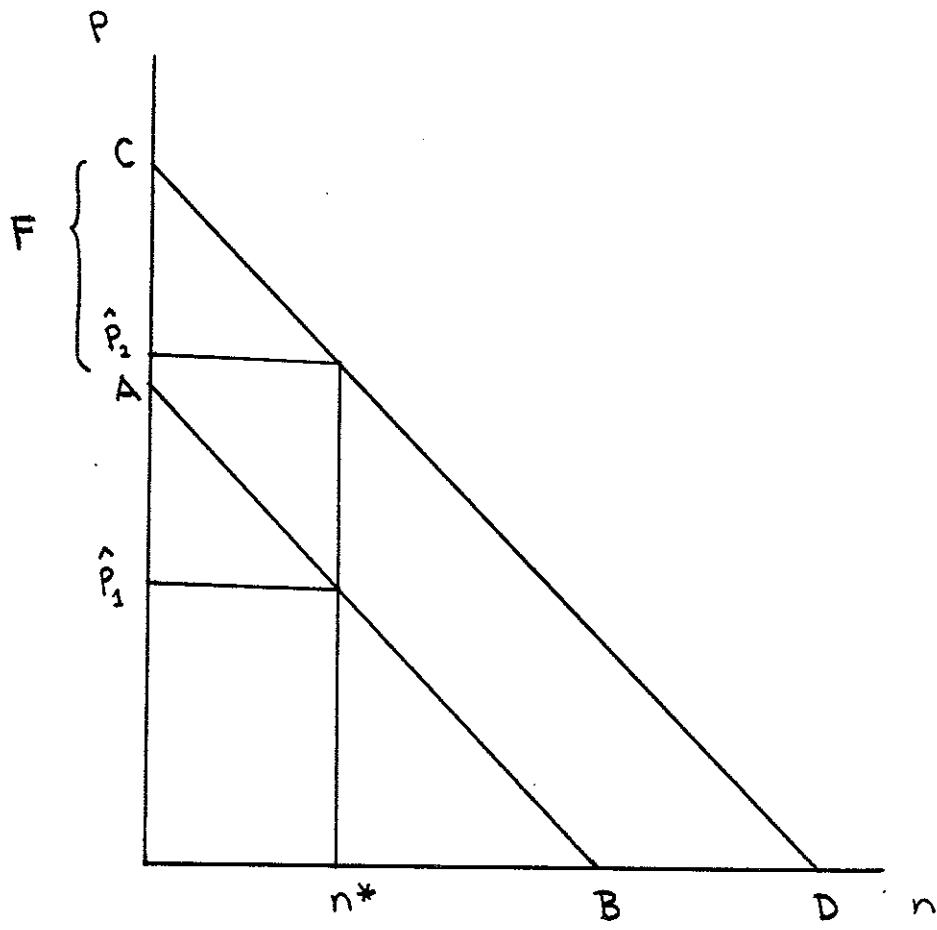Profit-Maximizing Solution for the Unconstrained Monopolist

Figure 2

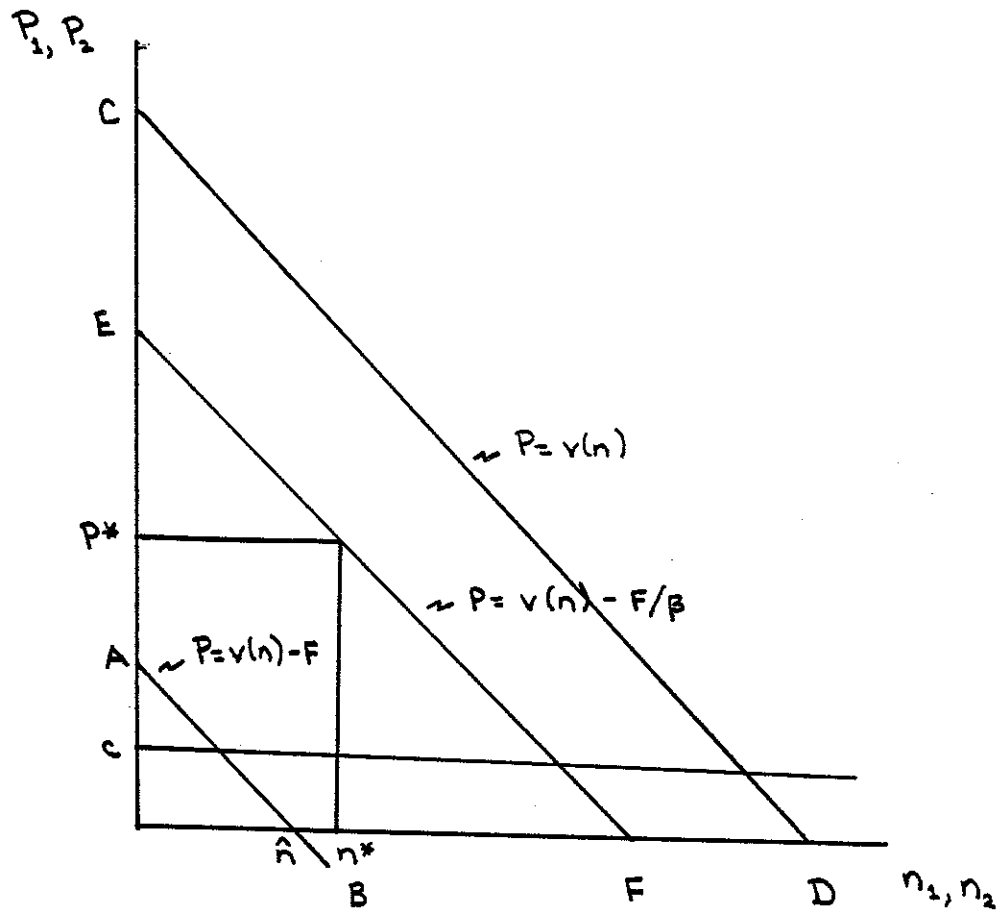Demands Faced by Constrained Monopolist

Figure 3

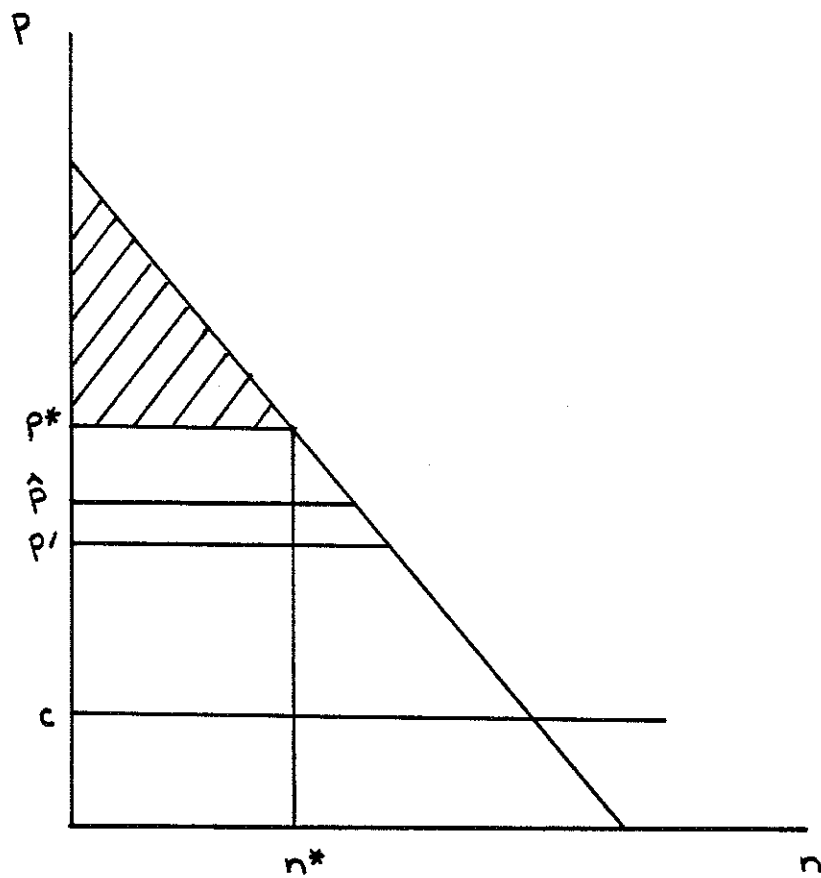Monopoly Pricing for Large Adoption Costs
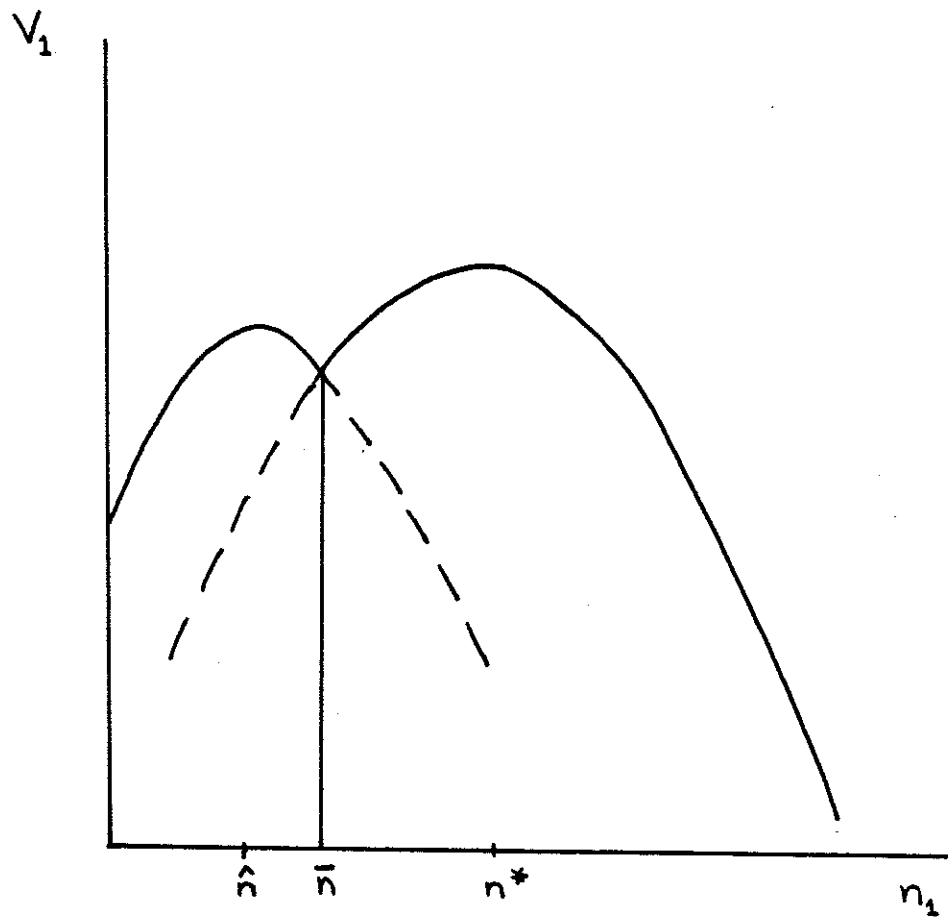
Figure 4

Price Paths for Elastic Demands

Figure 5

Profit Function when Demand is Growing

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## Appendix

### 1. Proof of constant sales policy for static demand.

Let $n_1$ be the number of customers buying in both periods and $\Delta n_1$ the additional customers who buy in only one of the two periods. We show that a price path resulting in $\Delta n_1 > 0$ is not optimal. Two cases must be considered: (1) the additional $\Delta n_1$ customers buy in period 2; and (2) the additional $\Delta n_1$ buy in period 1.

First consider case (1). Let $n_1$ and $N_1$ be the number of customers who buy in periods 1 and 2, respectively, where $N_1 = n_1 + \Delta n_1$ ($\Delta n_1 > 0$). Then, overall profit is given by

$$V = (v(n_1) - c)n_1 + \alpha(v(N_1) - F - c)N_1 ,$$

since the marginal ($N_1$th) second-period buyer <u>did not</u> pay the set-up cost in period 1 (by assumption). It is clear that the optimum involves $n_1 > N_1$; hence, sales to one-time buyers in period 2 is not optimal.

A similar demonstration shows that sales to one-time buyers in period 1 is not optimal (case (2)).

2.  <u>Proof that first period customers buy in both periods under growing</u>

   <u>demand</u>.

   Let $n_1$ be the number of first period customers who buy in both

periods and $\Delta n_1$ be the additional first period customers who buy in

only one of the two periods.  We show that a sales path resulting in

$\Delta n_1 > 0$ is not optimal.  Two cases must be considered: (1) The additional

$\Delta n_1$ customers buy in period 2; (2) the additional $\Delta n_1$ customers buy in

period 1.


(i)  Consider (1) first.  Let $N_1 = n_1 + \Delta n_1$ $(\Delta n_1 > 0)$ be the number of first

period customers buying in the second period and $n_2$ be the number of

sales to new demand in period 2.  Second-period profit is given by:

(a)     $[v(N_1) - F - c]N_1 + [v(n_2/\delta) - F - c]n_2$,

since the marginal ($N_1$th) second-period buyer who was present in period 1

<u>did not</u> pay the set-up cost in period 1 (by assumption).  Moreover,

$v(N_1) = v(n_2/\delta) = P_2 + F$, so $N_1 = n_2/\delta$.  Define $y = N_1 = n_2/\delta$.  Therefore, (a)

becomes

(b)     $(1+\delta)[v(y) - F - c]y$,

and overall profit is

   $[v(n_1) - c] + \alpha(1+\delta)[v(y) - F - c]y$.

But now it is clear that the optimum involves $y < n_1$, or $N_1 < n_1$; hence,

$\Delta n_1 > 0$ in period 2 is not optimal.


(ii)  Next consider the case when $\Delta n_1$ additional first-period customers

buy only in period 1.  In this case, $N_1 = n_1 + \Delta n_1$ represents total sales to

first period customers in period 1; where $n_1$ customers are repeat

customers in period 2.  First note that $P_1 = v(N_1) - F$, since the marginal

($N_1$th) first period customer buys only in period 1. Hence, the optimal number of sales in period 1, $N_1^*$, is given by:

(c)    $v(N_1^*) + v'(N_1^*)N_1^* - c - F = 0$ .

Next, consider the change in period 2 profits due to a change in $n_1$, the sales to repeat customers in period 2. There are two effects on profits from an increase in the number of repeat purchases in period 2. First, since repeat customers have already incurred F, profits from <u>repeat</u> sales change according to:

(d)    $v(n_1) + v'(n_1)n_1 - c$ .

Second, an increase in $n_1$ lowers $P_2$, resulting in a change in profits from sales to <u>new</u> customers. Since these customers have not incurred F, this change in profits is:

(e)    $[v(n_2/\delta) + v'(n_2/\delta)(n_2/\delta) - F - c](dn_2/dn_1)$ .

First, note that (d), evaluated at $n_1 = N_1^*$, is positive. If we can establish that (e) is also positive at $n_1 = N_1^*$, then $N_1 > n_1$ cannot be optimal.      Consider the expression in (e). Since $dn_2/dn_1 > 0$ (an increase in repeat sales decreases $P_2$, increasing the number of new sales), the sign of the expression in (e) depends on the sign of the term in []: the marginal profit from an increase in the number of <u>new</u> sales in period 2. Since the inverse demand of <u>new</u> customers is an isoelastic shift of the first-period demand, the marginal revenues of the two demands are equal at the same price. But, if some first period customers do not buy in period 2, it must necessarily be the case that $P_1 < P_2$; hence, the value of the [] term in (e) is positive, when $n_1 = N_1^*$. Since both terms in (d) and (e) are positive when $n_1 = N_1^*$, $N_1 > n_1$ (or $\Delta n_1 > 0$ in period 1) cannot be optimal.

Parts (i) and (ii) of the proof imply that or $\Delta n_1 = 0$.

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