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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) competition if consumers incur set-up costs. Set-up costs create a dynamic consistency problem: The monopolist cannot guarantee low future prices once customers have incurred those costs. We show that, if customers anticipate this problem, the monopolist's profits can be improved through ex-ante commitment to competition in the post-adoption market, if set-up costs are large. If set-up costs are small, the monopolist can typically achieve the same level of profits without price commitment as with.

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I. Introduction

In many markets, buyers must bear specific set-up costs in order to use a product. In such markets, there is often a problem of opportunism: the seller can in effect expropriate the returns to the buyer's specific investment by raising the price ex post. A recent literature[1] on "switching costs" has analyzed this problem for the case of competing sellers when each firm's product has its own set-up cost, and shows how opportunism leads to inefficient price or quality "gouging" once buyers have sunk their seller-specific investments. In this paper we analyze how the prospect of similar opportunism affects a monopolistic seller.

Buyers of a new product may be reluctant to incur set-up costs if they will be exploited ex post. This reduces the size of the market, to the detriment of sellers; in particular, a monopolistic seller might benefit from being able to commit to future prices. We ask when a monopolist would indeed (strictly) value that ability, and when voluntarily inviting competitors into the market, often called second-sourcing, is a profitable means of commitment.

An example of the opportunism and of the second-sourcing remedy we will study is the local-area-network product Ethernet. Xerox, the developer, offered open licenses at a nominal charge. Sirbu and Hughes [1986] suggest that had Xerox not thus opened the technology, semiconductor firms might not have made the specific investment to develop the dedicated semiconductor chip, fearing that customers 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." Once assured of open licensing, Intel and others developed the required chip.

As this example suggests, buyers commonly insist, before locking into a supplier's new product, "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."[2] We argue that one important reason a seller may "fail to perform" is simply the monopoly incentive to raise price. While there is often a conventional insurance motive for second-sourcing to avoid uncontrollable supply risks such as fires in the factory, we show that, even absent such risks, the seller may seek second sources in order to commit not to raise prices.

Why would a seller use second-sourcing rather than another form of price commitment, such as a long-term price contract? Much second-sourcing is in producer-goods markets, where we might expect such contracts to be feasible. However, long-term price contracts are distinctly imperfect implements. For instance, Farrell and Shapiro [1987b] show that when quality is not verifiable, long-term price contracts can be ineffective in preventing gouging ex post (or even harmful if carelessly conceived).[3] And when costs and demand parameters are unknown ex ante, the incentive-compatibility constraints combined with ex post individual rationality constraints impose inefficiency.[4] We will show below that in some circumstances second-sourcing can achieve first-best outcomes, and is thus superior to imperfect long-term contracts. More generally, second-sourcing makes for ex post competition, whereas sophisticated long-term contracts make for something more like ex post regulation. Thus, to the extent that competition is more efficient, more flexible, or otherwise better than bilateral contracts, second-sourcing is better than long-term contracts. For example, in the Farrell-Shapiro [1987b] model, where long-term contracts only sometimes achieve full efficiency, second-sourcing always does so. If, as in our model, the seller can collect ex ante the benefits from ensuring better ex post outcomes, then he has an incentive to use the efficient means of commitment.

Our model applies both to goods that are bought more than once, and to "components" of a system, such as VCR players and tapes, or computers and software. Our assumption of set-up costs makes first and second period goods complements, in the sense that expectations about the second-period price affects first-period demand. Similarly, expectations about the future availability (or price) of tapes or software affects the current demand for VCRs or computers. Indeed, acceptance of the VHS system as the standard was expedited by second-sourcing or open licensing to produce the second-period good (tapes or software), increasing the expected supply of the second period good, and increasing the demand for the VCRs (first period good)[5,6].

In an independent paper, Shepard [1986] analyzes a market in which an innovator licenses competition as a commitment to product quality (delivery time). Since both producer's costs and buyer's surplus increase in quality, it plays formally a similar role to price in our model. While our papers are similar in spirit, Shepard assumes that two-part royalty contracts are available to control competition and to redistribute profits back to the patent-holder. By contrast, we focus on an extreme, but common, form of second-sourcing, in which the manufacturer effectively gives away the technology with a lag.

In Section II we analyze a very simple model, and show that the seller cannot gain from price commitment if the set-up cost is not too large. When the set-up cost is larger, however, the seller gains from second-sourcing. In section III we relax our special assumptions of identical customers, inelastic consumer demands, and a single cohort of buyers; in each case, price commitment matters for sufficiently large adoption costs, and second-sourcing is a useful form of such commitment. Section IV concludes.

II. The Model

We consider a two-period model of a monopolist's pricing problem for a new product with adoption costs. We assume that marginal production costs are constant and equal to c, and prices must be nonnegative.[7] In addition to the price of the product, buyers incur a one-time cost, F, at the time of adoption.[8] Buyers have complete knowledge of the problem and are fully rational, so they correctly anticipate second-period prices. The monopolist can control entry through his licensing policy.

We focus on an extreme form of second-sourcing, known as open licensing, in which the monopolist gives away the technology and competitive pricing ensues. Obviously, second-sourcing of this type which enables other firms to compete with the innovator on equal terms immediately (and without royalty payments) is not profitable; we consider a less drastic form of second-sourcing, in which the technology is given away but with a lag. This requires that the monopolist can credibly commit to licensing future competition. There are two ways in which this may be possible. First, licensing agreements can specify a future effective date. Second, reverse-engineering a product and starting production take time; so if an innovator merely refrains from patenting, then he obtains precisely the temporary market power followed by competition that we model.

We begin our analysis under three further simplifying assumptions, which we will then relax in turn: (1) Each buyer is willing to pay up to v for each period's consumption. (2) Each buyer purchases either zero or one unit of the good in each period. (3) No new customers enter in period 2. Let δ be the discount factor. We assume that there are gains from trade:

(1) $$v(1+\delta) - F - c(1+\delta) > 0.$$

Given a price path (p_1, p_2), we can compare a buyer's payoff from his four possible strategies: buying in both periods, either, or neither. Calculation shows that he buys in both periods if

(2) $$p_1 + \delta p_2 \leq v(1+\delta) - F,$$

(3) $p_1 \leq v - (1 - \delta)F,$

(4) $p_2 \leq v.$

For the seller to extract the full social surplus, (2) must hold with equality, and (3) and (4) must hold. Since (2) fails when both (3) and (4) hold with equality, this is always possible (see Figures 1 and 2). So, <u>if the seller can commit himself to both prices in period 1, he can extract the full social surplus</u>. Indeed, a continuum of price paths (p_1, p_2), such as (v - F, v), do so.

Without a commitment, it is common knowledge that the seller will set $p_2 = v$. The effects of this depend on the relative sizes of v and F. If $F \leq v$, then as Figure 1 shows, this is consistent with extracting the full surplus; in fact, the price path (v - F, v) (point A in the Figure) suffices.

If F > v, however, there is a dynamic consistency problem. Buyers will never buy in period 1 at any non-negative price without a second-period price commitment, since to do so would give them negative surplus in the first period and they know that they would get nothing in the second. Therefore, the seller who cannot commit to a second-period price makes no sales! In this case, the seller will want to find a way to commit to future prices. Given the imperfections of long-term price contracts, second-sourcing may be a desirable commitment strategy. In this model and its generalizations in section III we have the following result:[9]

<u>Proposition 1</u>. There exists a two-part licensing contract (a per-unit royalty and a fixed fee) that extracts the whole social surplus.

Proposition 1 is immediate. The monopolist has two instruments (per-unit royalties and fixed fees) with which to achieve two targets: monopoly output and redistribution of profits. For instance, he can allow one or more licensee(s) to sell in <u>both</u> periods at a per-unit royalty of $R = v - F/(1+\delta) - c$. Since the price path $(R + c, R + c)$ satisfies (2) with equality and satisfies (3) and (4), the full social surplus becomes industry profits under price competition. The licensees make no profits; the original seller gets the whole surplus.

But such royalty payment schemes are often infeasible or costly to write or enforce. As a result, in many second-source agreements the developer simply gives away the technology[10]. It might seem that commitment to perfectly-competitive pricing (even with a lag) is going too far, from the point of view of the profit-maximizing monopolist. We will see below that this can be true when demand is elastic, but in our benchmark model, second-sourcing without royalties always achieves first-best profits when commitment is needed, i.e. when $F > v$. To see this, note that since the second-period price is just $p_2 = c$, a first-period price $p_1 = v(1 + \delta) - F - \delta c$ satisfies (2) with equality. As Figure 2 shows, when $F > v$, any (non-negative) price-path that satisfies (2) with equality automatically satisfies (3) and (4). Profits (which accrue entirely in period 1) are then $p_1 - c = (1 + \delta)(v - c) - F$ per buyer, which is the full social surplus.

For smaller F, second-sourcing (without royalties) need not be profitable. We have seen that, for $F < v$, it is unnecessary, since the seller can extract the full social surplus without it. If F is not too far below v, second-sourcing is neutral for profits: the seller extracts the whole surplus with or without it. But when $F < v - c$, second-sourcing strictly reduces profits. To see this, note that with $p_2 = c$, (4) is automatic. If (2) is the binding constraint on first-period price, then the seller can extract the full surplus; but if $F < v - c$, then (3) is the binding constraint, and the seller can get no more than

$$p_1 - c = v - (1 - \delta)F - c,$$

which is less than the full surplus (1) since $F < v - c$.

Proposition 2. For sufficiently large adoption costs, $F > v$, second-sourcing without royalties achieves first-best profits, while no profits are attainable without commitment. For lower set-up costs, $F \leq v$, the seller can extract the full surplus without commitment. When $v - c \leq F \leq v$, second-sourcing is neutral for profits; when $F < v - c$, it strictly reduces profits.

This benchmark model illustrates two principal results: (1) price commitment matters when set-up costs are large, and (2) second-sourcing can then be an effective form of price commitment. In the next section we show that these results continue to hold in somewhat more general models.

III. Relaxing the Assumptions

In this section we relax (separately) three assumptions of the benchmark model - identical customers, inelastic buyer demands, and just one cohort of buyers. First, we discuss the role that each assumption played above.

In the benchmark model, since buyers get no surplus with or without commitment, they do not gain from second-sourcing. Although second-sourcing is in fact often initiated by sellers[11], our stark result relies on our assumption of identical customers. In section III.A we relax this assumption to show how second-sourcing benefits buyers as well as the seller.

Second, as we have seen, the assumption of inelastic buyer demands often allows the seller to take his profits entirely in one period with no efficiency effects. This implies that price commitment matters only when $F > v$, and that second-sourcing extracts all the surplus whenever $F \geq v - c$. In section III.B, we analyze the sensitivity of our results to elastic demands.

Finally, the seller's incentive to exploit locked-in customers is strongest with our assumption of a single cohort of buyers, or no demand growth. With growing demand, not all customers at any time are captive, and so the seller may be less inclined to exploit those who are. In section III.C we allow for demand growth (a characteristic of most new product markets), and discuss when this ameliorates the commitment problem.

A. <u>Different Customers</u>

In this section we relax the assumption that buyers are identical. We consider a distribution of reservation prices described by a general inverse demand function, v(n), where n is the number of customers willing to pay v or more for a unit of the product. Since this model yields results very similar to those above, our discussion is brief.

First, consider a seller who can commit to future price. We show in the appendix that he sets a price path (p_1, p_2) that elicits purchases from the same buyers in each period. Since (2) holds with equality for the marginal buyer, discounted monopoly profits are:

$$M(n) = (1+\delta)[v(n) - F/(1+\delta)-c]n.$$

Maximizing M(n) is identical to maximizing profits for a (static) monopoly facing inverse demand curve $p(n) = v(n) - F/(1+\delta)$ in each of two markets. The solution to this problem is illustrated in Figure 3. Hence, one way to achieve maximum profits is with a constant price $p^* = v(n^*) - F/(1+\delta)$. An infinite number of alternative price paths - for instance, $(v(n^*) - F, v(n^*))$ - also satisfy (2) with equality and (3)-(4) (where v is replaced by $v(n^*)$), and so also maximize M.

If the seller <u>cannot</u> commit to a future price, then he faces two demand curves as in Figure 4: Before paying the set-up costs, buyers consider these costs in their purchase decision, and demand is given by AB. Once F is sunk, their demand shifts vertically up by F to CD.

In the Appendix, we show that the profit-maximizing strategy is to sell to the same buyers in both periods. In the second period, after n^* buyers have paid F, the marginal buyer is willing to pay $p_2=v(n^*)$. Hence, the first-period price will be $p_1=v(n^*)-F$. That is, as in Section II, a "penetration pricing" strategy is followed. For $F \leq v(n^*)$, the constrained monopolist can sell to n^* customers in each period and achieve maximum profits. For larger set-up costs, $F > v(n^*)$, that strategy would involve a negative first-period price, which we suppose is impossible. The seller therefore charges[12] $p_1 = 0$ and $p_2 = F$, selling to only n' customers, as illustrated in Figure 5. When the seller cannot bind himself to future prices and adoption costs are large, he will be better off under second-sourcing: he can set a first-period price $(1+\delta)v(n^*) - F - \delta c$, extracting the entire surplus.[13] Notice that all inframarginal customers, as well as the seller, benefit from second-sourcing.

B. Elastic Demand

In sections II and III.A we assumed inelastic individual demands, with the result that a price path that extracts all the profits in one period is quite satisfactory. Normally, however, p_1 and p_2 would have within-period efficiency effects, and so neither the no- commitment price path (v-F, v) nor the second-sourcing price path $(v(1+\delta)-F-\delta c, c)$ is fully efficient.

In this sub-section, we again assume that buyers are identical, but we allow for elastic demand (within each period) by each buyer. Let s(p) be the (per buyer) buyer surplus in a period at price p; and let $\pi(p)$ be the corresponding profits - in both cases, after F is sunk. We assume that $\pi(.)$ is concave, and write p^* for the price that maximizes π.

If $(1 + \delta)s(p^*) \geq F$ then commitment is unnecessary: if the seller sets his profit-maximizing price p^* ignoring set-up costs, buyers are happy to buy at that price. Also, if $(1 + \delta)s(c) < F$ then no gains from trade can be achieved. Accordingly, we assume that $(1 + \delta)s(p^*) < F < (1 + \delta)s(c)$ - that is, without commitment, profits are strictly less than with. Now, to analyze zero-royalty second-sourcing, we consider three cases.

First, suppose that $s(c) + \delta s(p^*) < F$ (we will write the left hand side, the total discounted consumer surplus from the price path (c, p^*), as $s(c, p^*)$). It follows that without commitment the seller must (to sell at all) set a first-period price $p^f < c$. Also, (since $\delta \leq 1$), $s(p^*, c) < F$ too, and therefore under second-sourcing the seller must set a first-period price $p^S < p^*$. These prices are determined by the equations (see Figure 6)

(5) $$s(p^f, p^*) = F = s(p^s, c).$$

Now since there are gains from trade, $p^s > c$. Thus $p^f < c < p^s < p^*$. This means that the price path without commitment, (p^f, p^*), is "more spread-out" than the price-path under second-sourcing, (p^s, c). We intuitively expect that, with elastic demand, such a "spread" is undesirable; since the buyers get the same payoff either way, we expect second-sourcing to be profitable. We can formalize this, using ideas from the theory of risk-aversion, as follows.

Define a fictitious "utility" function as $u(p) = -s(p)$. This utility function is always increasing and concave in p, as is the profit function π for $p \leq p^*$, by assumption. Now observe that, by (5), the distribution with weight $1/(1+\delta)$ on p^f and $\delta/(1+\delta)$ on p^* is a <u>mean-"utility"-preserving spread</u>, in the sense of Diamond and Stiglitz [1974], of the distribution with weight $1/(1+\delta)$ on p^s and $\delta/(1+\delta)$ on c. Therefore the "expected value" of π under second-sourcing,

$$[1/(1+\delta)]\pi(p^s) + [\delta/(1+\delta)]\pi(c),$$

exceeds the "expected value" of π with no commitment,

$$[1/(1+\delta)]\pi(p^f) + [\delta/(1+\delta)]\pi(p^*),$$

if and only if the profit function $\pi(p)$ is more risk-averse in price than the "utility" function $-s(p)$. Thus <u>second-sourcing is profitable (relative to no commitment) if and only if profits are more risk-averse than is the negative of consumer surplus</u>. This is a somewhat unfamiliar condition, but a sufficient condition is that welfare, $\pi(p) + s(p)$, is concave in price.[14] Thus we expect that when F is large, second-sourcing will be profitable. Buyers, however, do not gain from it.

Our second case is that $s(p^*, c) \geq F$, implying that $s(c, p^*) \geq F$ also. In this case, the first-period price p^s under second-sourcing is p^*, and the first-period price p^f without commitment is above c. Buyers get positive net surplus under second-sourcing, but not under no commitment. In this case, we find that $c < p^f < p^* = p^s$. Thus the second-sourcing price path is a mean-"utility"-<u>reducing</u> spread of the no-commitment price path. In our standard case in which profits are more risk-averse in price than is "utility", it follows a fortiori that second-sourcing is unprofitable. Notice however that buyers would strictly like second-sourcing in this case.

The third, intermediate case is when $s(p^*, c) < F < s(c, p^*)$. Notice that this cannot happen for $\delta = 1$, and can happen only for a relatively small set of demand and cost parameters if δ is close to 1. The profit comparison is ambiguous here. For instance, suppose that demand is linear, $Q = 4 - p$, $\delta = 1/2$, and $c = 0$. Simple calculations show that second-sourcing is strictly unprofitable if F is close to the lower bound (which is 6) for this case; while if F is close to the corresponding upper bound (9) then second-sourcing is strictly profitable. This tends to support our general view that second-sourcing is most profitable when F is large, but we have been unable to prove general results for this case.

We sum up our results on elastic demand:

Proposition 3. When buyer demands are identical but elastic, and $F \leq (1+\delta)s(p^*)$, the seller can achieve first-best profits without price commitment. For larger set-up costs, price commitment matters. For most demand functions, profits are more concave than the negative of consumer surplus. In this case, second-sourcing without royalties is more profitable than no commitment when $F > s(c) + \delta s(p^*)$, and is less profitable when $F < s(p^*) + \delta s(c)$.

Our theme recurs. For small F, second-sourcing is unprofitable; for larger F, it is profitable.

C. New Demand

So far, we have assumed that all customers arrive in the first period. In fact, many new products experience gradual product diffusion, as customers learn about the product and inferior pre-existing substitutes wear out. When new customers arrive in the market, the monopolist may be less likely to "gouge" his captive customers (if he cannot discriminate). In this section we identify conditions under which new customers mitigate the commitment problem, and compare two alternative commitment strategies.

For simplicity, we consider a three-period model with two cohorts of buyers, each living two periods: cohort 1 (N_1 people) live in periods 1 and 2; cohort 2 (N_2 people) in periods 2 and 3. We assume that a customer who does not buy in his first period leaves the market. As before, we assume there are gains from trade: $F < (v-c)(1+\delta)$.

With price commitment, the monopolist can extract the full social surplus $(N_1 + \delta N_2)[(1 + \delta)(v - c)]$. As in Section II, a continuum of price paths work; an example is $(v-F(1-\delta), v-F, v)$.

In some cases, the monopolist can extract all the surplus even <u>without</u> price commitment. To see this, suppose that $F \leq v$, and that all N_1 first-cohort customers buy in period 1. Then in period 2, the monopolist can either sell only to those customers at their reservation price v, or sell to all N_1+N_2 customers at v-F.[15] He will do the latter if

$$N_1(v-c) \leq N_1(v-c-F) + N_2[(v-c)(1+\delta)-F]$$

or

$$N_2/N_1 \geq F/[(v-c)(1+\delta)-F]. \tag{6}$$

<u>Price commitment is not needed if new demand is large and set-up costs are small: $F \leq \min[v, \phi]$</u>, where ϕ is the critical value in (6):

$$\phi = [N_2/(N_1+N_2)](v-c)(1+\delta).$$

In Figure 7, the curve OA represents $F = \phi$. Thus commitment does not matter in the area above curve 0A and to the left of $F = v$. In this case, the large second cohort "commits" the seller to a low second-period price, increasing the first cohort's demand price in period 1. The monopolist can extract full surplus with a price path $(v - F(1-\delta), v - F, v)$.

In the remaining cases, when either $F > v$ or $\phi < F \leq v$, the monopolist cannot achieve first-best profits without price commitment. We now discuss what he might do about this.

Consider first the case $F > v$. As in Section II, the monopolist cannot sell to anyone without some commitment. No second-cohort customers will buy at any nonnegative second-period price, and so in the second period the monopolist will sell to any first-cohort customers at price v. But, anticipating this, first-cohort customers will refuse to buy in the first period at any nonnegative price.

As in Section II, the monopolist can increase his profits by second sourcing without royalties; that is, by committing to the price path $(v(1+\delta)-F-\delta c, c, c)$. No profits accrue in the second or third period, but the monopolist extracts the entire surplus from the first cohort, and earns

(7) $$\pi_S = N_1[(v-c)(1+\delta)-F].$$

Thus, second-sourcing (SS) strictly dominates monopoly when $F > v$, as illustrated in Figure 7.

When $\phi < F \leq v$ (below 0A and to the left of $F = v$ in Figure 7), the monopolist without price commitment will exploit the locked-in first-cohort buyers in period 2. This not only drives away second-cohort buyers but also reduces first-cohort buyers' willingness to pay in period 1. In this case, he can choose one of three strategies. First, he can follow a "no restraint" policy and sell to all N_1 first-cohort customers but to none of cohort 2. Or he can follow one of two commitment strategies. He can "restrain" first-period sales, and thus change the relative importance (come period 2) of old and new buyers. Since the "fat cat" (Fudenberg and Tirole [1983]) or "common margin" (Farrell and Shapiro [1987a]) effect makes the seller more willing to cut his price to sell to new buyers if there are not too many locked-in buyers, such restraint can constitute a commitment. Or, of course, he can engage in second-sourcing. We compare the profits of the three strategies below for $\phi < F \leq v$.

Under "no restraint," he sells to all N_1 first-cohort customers at prices $(v - F, v)$, earning

(8) $$\pi_N = N_1[(v-c)(1+\delta)-F].$$

If he restrains first-period sales, first-cohort customers are willing to pay a high price in the first period (anticipating a low second-period price) if and only if first-period sales are[16] no greater than

$$n_1 = N_2[(v - c)(1 + \delta)-F]/F.$$

Each first-period buyer is prepared to pay more for the good (in the first period) if there are no more than n_1 first-period buyers (see Figure 8). The price path under the restraint policy is $(v - F(1 - \delta), v - F, v)$, yielding profits:[17]

(9) $$\pi_R = N_2[(v - c)(1 + \delta) - F][(v - c)(1 + \delta)-F(1 - \delta)]/F.$$

Finally, profits under second-sourcing, given by (7), are identical to those under no restraint, since each extracts the full surplus from first-cohort buyers and no profit from the second cohort.

When $\phi < F \leq v$, all three strategies yield positive profits. Comparison of (7) - (9) implies that a policy of restraint strictly dominates no restraint (and second-sourcing) if[18]

(10) $$N_2/N_1 > F/[(v-c)(1+\delta)-F(1-\delta)],$$

or

$$F < [N_2/(N_1 + N_2(1 - \delta)](v - c)(1 + \delta) = \tau.$$

(The curve OB in Figure 7 represents $F = \tau$.) When (10) does not hold (for small N_2/N_1 or large F), the seller is indifferent between no-restraint and second sourcing. Hence, for $\phi < F \leq v$, second-sourcing is (at least weakly) unprofitable.

Profit-maximizing strategies for the monopolist - second-sourcing (SS), restraint (R) and no restraint (NR) - are illustrated in Figure 7 for all values of N_2/N_1 and F. Notice that, when $F \leq v$, a no-restraint policy is favored when the relative size of the second cohort is either large or small. The reason is that when N_2/N_1 is large, first-cohort customers are relatively unimportant in period 2, even when all N_1 customers buy in the first period; so price commitment does not matter. In contrast, when N_2/N_1 is small, the second cohort is unimportant, and the seller prefers to ignore it rather than to lose first-cohort profits in serving it.

Proposition 4 summarizes these results:

Proposition 4. If N_1 and N_2 customers enter a new product market in two cohorts, a monopolist can achieve first-best profits without commitment to prices when $F \leq \min[v,\phi]$. For larger set-up costs, price commitment matters and the following strategies will be followed: For $\phi < F < \min[v, \tau]$, the monopolist strictly prefers to retain his monopoly and practice restraint than to second-source. For $\tau \leq F \leq v$, the monopolist is indifferent between second-sourcing and a policy of no restraint. If $F > v$, then second-sourcing without royalties is strictly preferred to the other options.

IV. Conclusions

With product-specific set-up costs, current demand depends on anticipated future prices. As a means of commitment to lower future prices, an innovator may choose to attract limited competition into the market by offering generous licensing arrangements or permitting or facilitating imitation of his product. This is particularly likely to be profitable if the set-up costs are large.

We focused on an extreme, but surprisingly common, form of second-sourcing in which the monopolist gives away the technology with a lag. When identical customers have inelastic demands, this policy achieves first-best profits. For elastic demands, second-sourcing of this type will be profitable for sufficiently large set-up costs if (as we expect) profits are more concave in price than consumer surplus is convex. When new customers are expected to enter the market, the commitment problem is less severe since new customers may prevent the seller from exploiting locked-in customers; moreover, the seller can also (imperfectly) commit to low future prices by reducing first-period sales. Here too, our analysis supports our theme that even without royalties, second-sourcing is often profitable when set-up costs are large.

A monopolist often benefits by keeping rivals from his market; and recent literature has analyzed a vast array of ways to do so. This paper shows how a monopolist may benefit by attracting competitors. In addition to the obvious application to competitive strategy when we take market structure as given, our analysis has implications for vertical integration, which has recently been widely viewed as a response to problems of opportunism.

Appendix

Proof that it is optimal to sell to the same buyers each period

A. With Price Commitment.

We write the profits from selling to n_1 and n_2 buyers in periods 1 and 2, and show that it is optimal to set $n_1 = n_2$.

If $n_1 = n_2$, then the seller (with price commitment) can extract the full surplus, so that profits are

(A1) $$(1 + \delta)n(v(n) - c) - nF.$$

Now, if $n_1 < n_2$, then every buyer who buys in period 1 also buys in period 2, but not vice versa. Consequently, $p_2 = v(n_2) - F$, and p_1 is determined by equation (3) of the text. Therefore profits are

(A2) $$n_1[v(n_1) - c - (1 - \delta)F] + \delta n_2[v(n_2) - c - F].$$

Finally, if $n_1 > n_2$, then $p_2 = v(n_2)$ and $p_1 = v(n_1) - F$. Hence profits are given by

(A3) $$n_1[v(n_1) - c - F] + \delta n_2[v(n_2) - c] \quad .$$

Now we can rearrange (A2) to give

(A4) $$n_1[v(n_1) - c - F] + \delta n_2[v(n_2) - c - F] + \delta n_1 F,$$

and rearrange (A3) to give

(A5) $$n_1[v(n_1) - c - F] + \delta n_2[v(n_2) - c - F] + \delta n_2 F.$$

From (A1), (A4), and (A5), we see that the cases can be unified by writing profits as

(A6) $$M(n_1, n_2) = G(n_1) + \delta G(n_2) + \delta F \min[n_1, n_2],$$

where G(n) is defined as $n[v(n) - c - F]$. But (A6) makes it clear that M is maximized by setting $n_1 = n_2$.

B. Without Price Commitment.

We assume that $G(n)$ is concave in n. Without price commitment, and by our concavity assumption, n_2 will be set ex-post according to:

n_2 maximizes $G(n)$ if n_1 is sufficiently small;

$n_2 = n_1$ for intermediate n_1;

n_2 maximizes $G(n) + nF$ for large n_1.

We must show that, when n_1 is chosen optimally, only the middle case occurs. The argument is essentially the same as above. If n_1 is below that value of n that maximizes G, then profits are

$$n_1[v(n_1) - (1 - \delta)F] + \delta n_2[v(n_2) - c - F]$$
$$= n_1[v(n_1) - c - F] + \delta n_2[v(n_2) - c - F] + \delta n_1 F,$$

so that it pays to increase n_1 (n_2 being already optimal and not affected by marginal changes in n_1). Similarly, if n_1 exceeds the value that maximizes $n[v(n) - c]$, then profits are

$$n_1[v(n_1) - F - c] + \delta n_2[v(n_2) - c]$$
$$= n_1[v(n_1) - F - c] + \delta n_2[v(n_2) - F - c] + \delta n_2 F,$$

so that (n_2 being optimal) n_1 should be reduced; again, no effect of the change on n_2 need be considered.

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REFERENCES

Diamond, P., and J. Stiglitz, "Increases in Risk and In Risk Aversion," Journal of Economic Theory 8 (1974) 337-360.

Farrell, J., and C. Shapiro, "Dynamic Competition with Switching Costs," University of California and Princeton University working paper, 1987a.

_______ and ________, "Optimal Contracts with Lock In," University of California and Princeton University working paper, 1987b.

Fudenberg, D., and J. Tirole, "The Fat Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look," American Economic Review LXXIII (1983) 361-366.

Gallini, N.T. "Deterrence by Market Sharing: A Strategic Incentive for Licensing", American Economic Review, LXXIV, (1984), 931-941.

Green, J., and S. Scotchmer, "Switching Costs as an Explanation for Price Dispersion," Harvard mimeo, 1986.

Hart, O., and B. Holmstrom, "The Theory of Contracts" in Advances in Economic Theory, T. Bewley, editor, Cambridge University Press (1987).

Horstman, I. and Markusen, J., "Licensing versus Direct Investment: A Model of Internalization by the Multinational Enterprise", University of Toronto Working Paper, (1986).

Katz, M. and C. Shapiro, "On the Licensing of Innovation", Rand Journal of Economics 16 (1985) 504-520.

Klemperer, P. (1987a), "The Competitiveness of Markets with Consumer Switching Costs", Rand Journal of Economics, XVIII (Spring 1987) 138-150.

_____________ (1987b), "Markets with Consumer Switching Costs," Quarterly Journal of Economics 102.

Lovell, E. B. Domestic Licensing Practices, The Conference Board, Experiences in Marketing Management, XVIII, (1968).

Shepard, A. (1986), "Licensing to Enhance Demand for New Technologies", Yale University and MIT, mimeo.

Sirbu, M. and K. Hughes, "Standardization of Local Area Networks", Carnegie Mellon University Working Paper (1986).

Swann, G.M.P., "The Emergence of Industry Standard Microprocessors and the Strategy of Second Source Production", in Product Standardization as a Tool of Competitive Strategy, H.L. Gabel (ed.), forthcoming, North-Holland (1987).

Taylor, R., "Licensing in Theory and Practice: Licensor-Licensee Relationships", Antitrust Law Journal, vol. LIII, (1984), 561-609.

Teece, D., "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy," Research Policy 15 (1986) 285-305.

von Weizsäcker, C.C., "The Costs of Substitution," Econometrica 52 (1984) 1085-1116.

Endnotes

1. See for instance von Weizsäcker [1984], Klemperer [1987a,b], Green and Scotchmer (1986), and Farrell and Shapiro [1987a,b].

2. Taylor [1984], p. 564.

3. This problem is especially acute in the semiconductor industry. Since technological change is rapid and customers' needs are often learned after the product is used, the "quality" of a product, for example, a software package or microprocessor chip, may be difficult for the courts to ascertain. The inability to commit to the price of an <u>effective</u> unit of the product (adjusted for quality) makes contracts that specify only price inadequate.

4. See for instance Hart and Holmstrom [1987]. We think that individual rationality ex post is a necessary feature of such a contract because quality problems make it essential that the buyer be able to walk away (otherwise the seller would cheat on quality). Given that, the seller too can always escape the contract by deliberately cutting quality to such a point that the buyer exercises his escape option. Of course, this does not rule out penalties for leaving (Farrell and Shapiro [1987b]), but such penalties seem to be relatively unusual.

5. The commitment problem would disappear if the two components could be sold at the same time. In the case of VCRs (or computers), the entire set of tapes, based on future movie productions (or software), could not have been sold simultaneously with the durable good. IBM's "open architecture" policy for the PC is an example of the analogue to second-sourcing, where the post-adoption products are complementary components. As a result of this policy, over 750 research groups have produced software and complementary devices, increasing the demand for the PC. Of course, this effect is confounded with a network-externalities effect in this case.

6. For components of a system available at different times, the monopolist can benefit from second-sourcing the component available in the second period. Swann [1986] observes that "partial" second-sourcing in only some components of a system is common in the

semiconductor industry.

7. Demand for the purpose we have in mind would not become ill-behaved when the price is negative but above (-F), but spurious "buyers" might be a problem: people could take computers at a negative price and use them for landfill.

8. Innovators often try to bear part of the buyer's adoption costs. For instance, computer companies give free training sessions; publishers provide manuals to complement a new textbook. Adoption costs, however, are not likely to be fully transferable, because of the cost of time and other unobservable costs borne initially by the user. For an analysis of contracts where setup costs are unobservable, see Farrell and Shapiro [1987b]. Here, we simply assume that the equilibrium allocation of adoption costs between seller and buyer involves some set-up costs by the consumer, as it often does.

9. This result is analogous to Shepard [1986], who allows flexible licencing contracts involving royalties and fixed fees. In her paper, the per-unit royalty is used to achieve first-best quality and the fixed fee is used to redistribute rents back to the licensor.

10. Empirical evidence shows that many licensing contracts specify royalty rates of only 3-5% of sales (Lovell [1968]). Several explanations are given for low royalty rates. For example, the licensor may have to specify low royalty rates to prevent a licensee from imitating the licensed product. Inability to monitor output or product quality or a strong bargaining position of the licensee may also necessitate low royalty rates. (See Gallini [1984], Horstman and Markusen [1986], and Teece [1986].)

11. Swann [1986] notes that "many manufacturers of microprocessors have actually sought second sources, or if not that, then they have not actually discouraged them."

12. Assuming that profits are concave as a function of price.

13. As before, when $F > v(n^*)$, p_1 satisfies (3).

14. Suppose welfare $\pi + s$ is concave in p, i.e. $\pi''(p) + s''(p) < 0$. Divide by $\pi'(p) > 0$ to get $\pi''(p)/\pi'(p) < - s''(p)/\pi'(p)$. Now notice that $-s'(p) = x > \pi'(p)$, so we can deduce that $\pi''(p)/\pi'(p) < - s''(p)/[-s'(p)]$, which says that the "coefficient of risk aversion" of π, $-\pi''/\pi'$, exceeds the corresponding coefficient for $u(p) = - s(p)$.

15. This is the second cohort's reservation price in period 2 because they rationally expect to be charged v in period 3.

16. One may ask how buyers can condition their first-period demands on first-period sales. In a more general model with heterogeneous buyers (as in Section III.A), buyers would infer both the equilibrium sales level and their own willingness to pay from the first-period price.

17. Profits under the restraint policy are

$$\pi_R = (n_1+\delta N_2)((v-c)(1+\delta)-F).$$

Substituting the expression for n_1 into π_R gives (9).

18. The policy of restraint strictly dominates no restraint and second-sourcing if

$\pi_R = N_2[(v-c)(1+\delta)-F][(v-c)(1+\delta)-F(1-\delta)]/F > N_1[(v-c)(1+\delta)-F] = \pi_S$,

which gives the expression in (10).

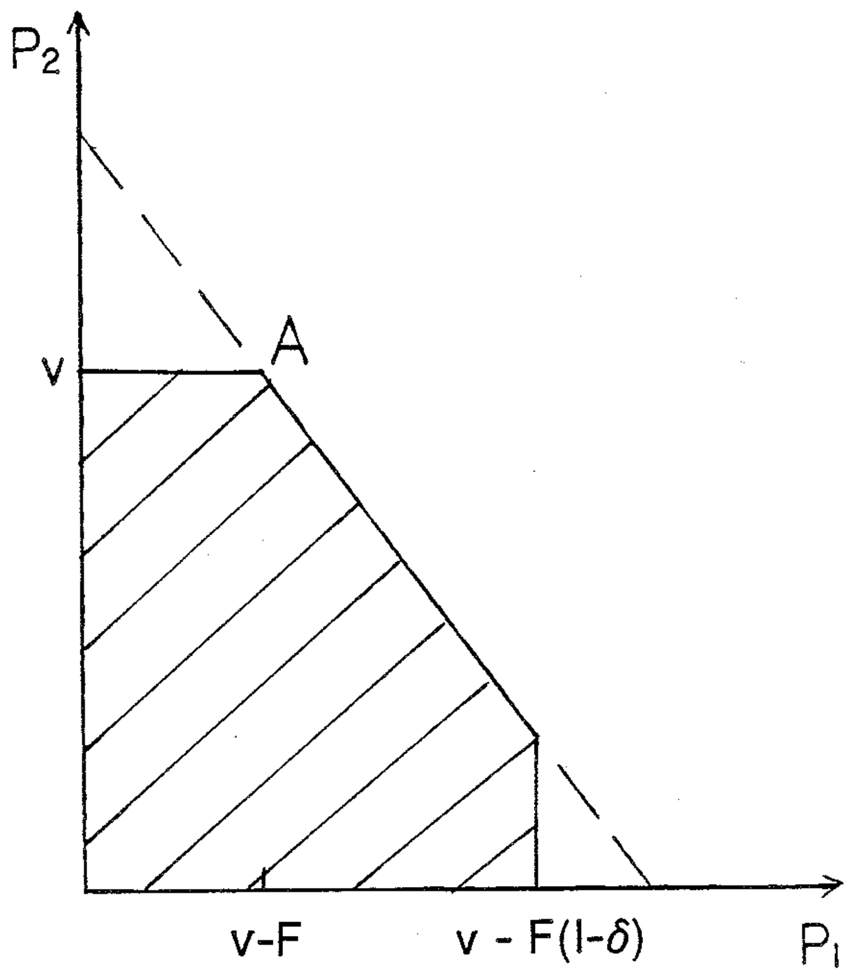

Figure 1

Prices that Induce Purchase in Both Periods:

The Case $F < v$

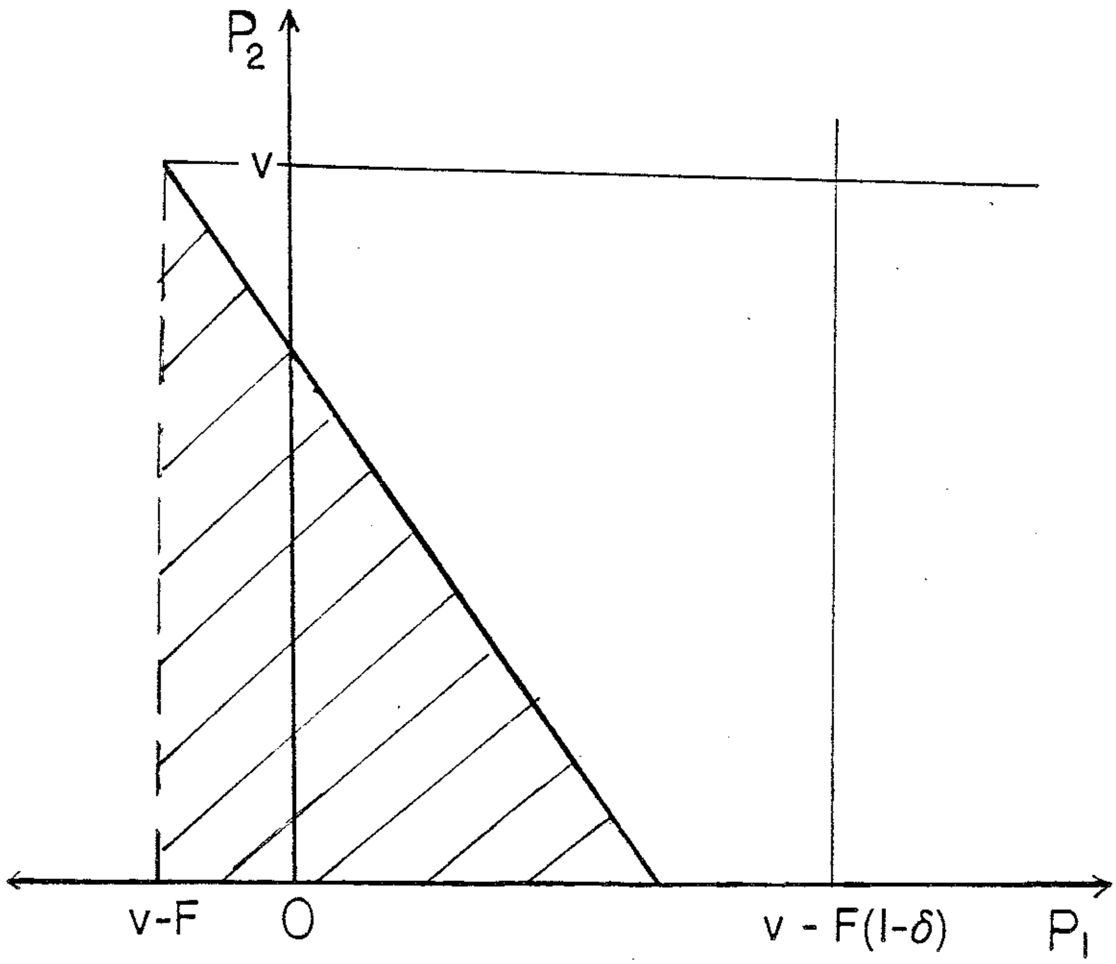

Figure 2

Prices that Induce Purchase in Both Periods:

The Case F > v

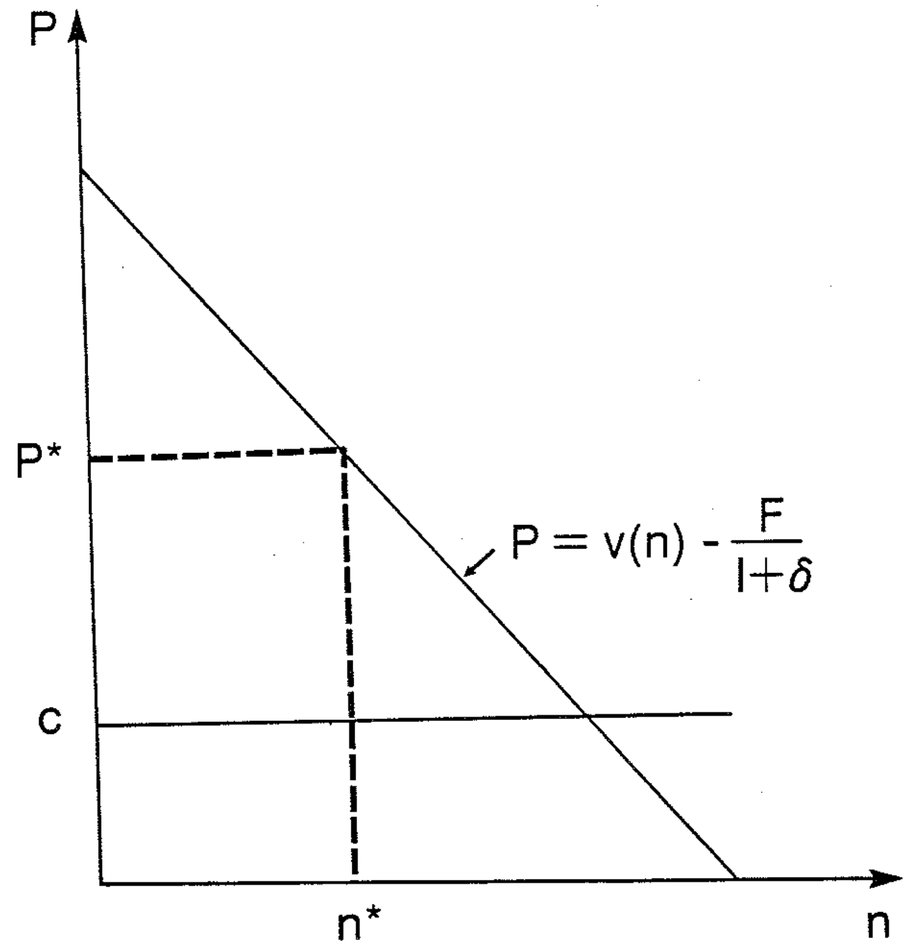

Figure 3
Profit-Maximizing Solution for the Unconstrained Monopolist

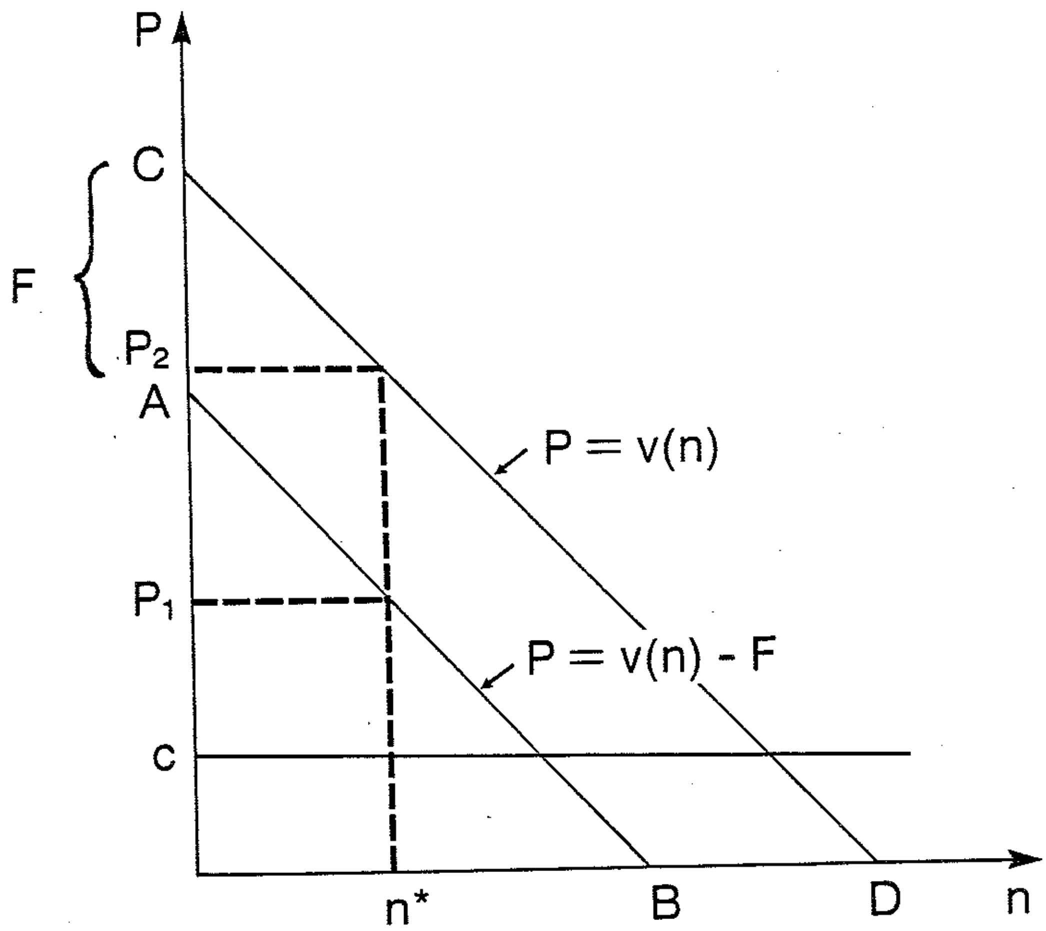

Figure 4
Demands Faced by Constrained Monopolist

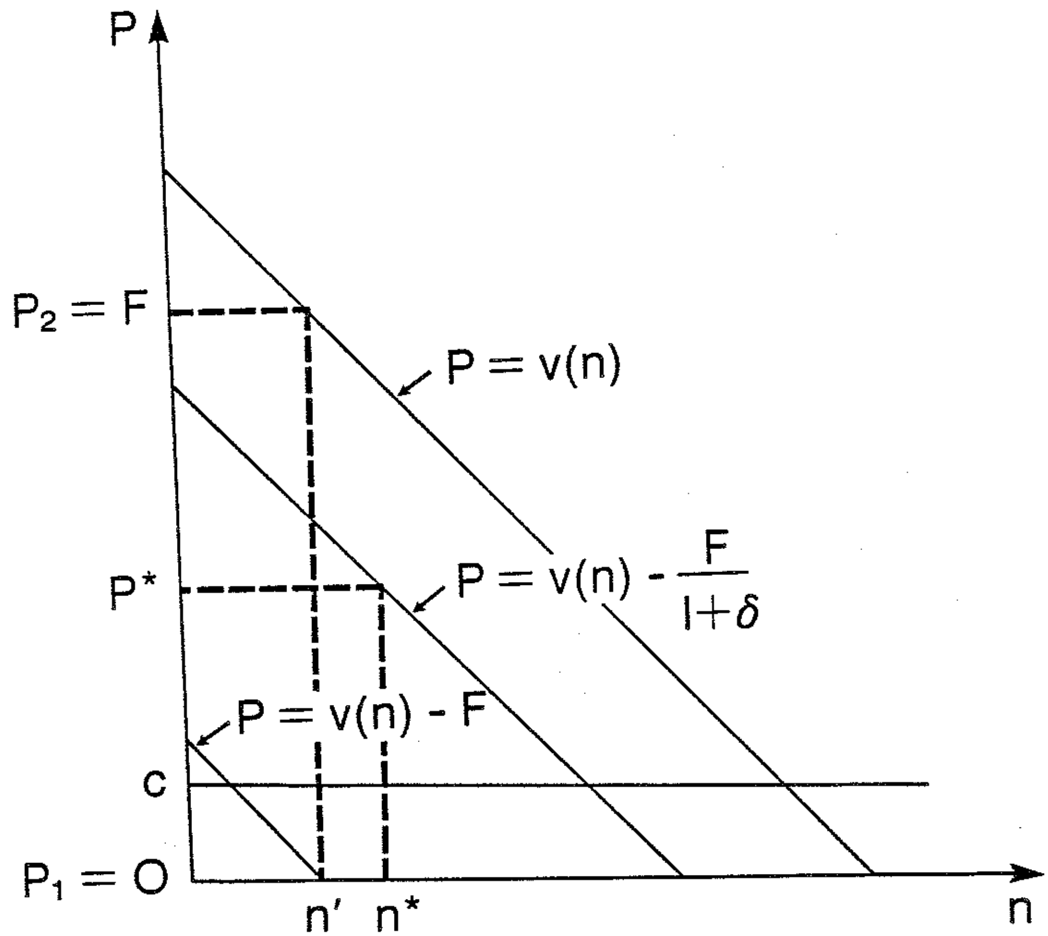

Figure 5
Constrained Monopoly Pricing for Large Adoption Costs

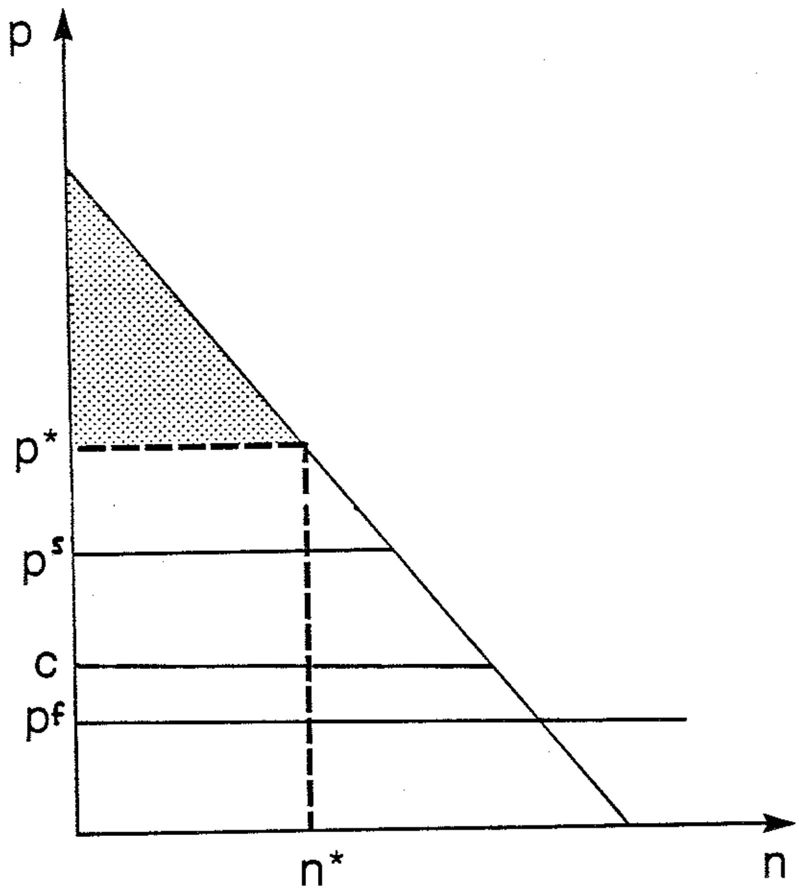

Figure 6
Price Paths for Elastic Demands

$s(c) + \delta s(p^*) < F$

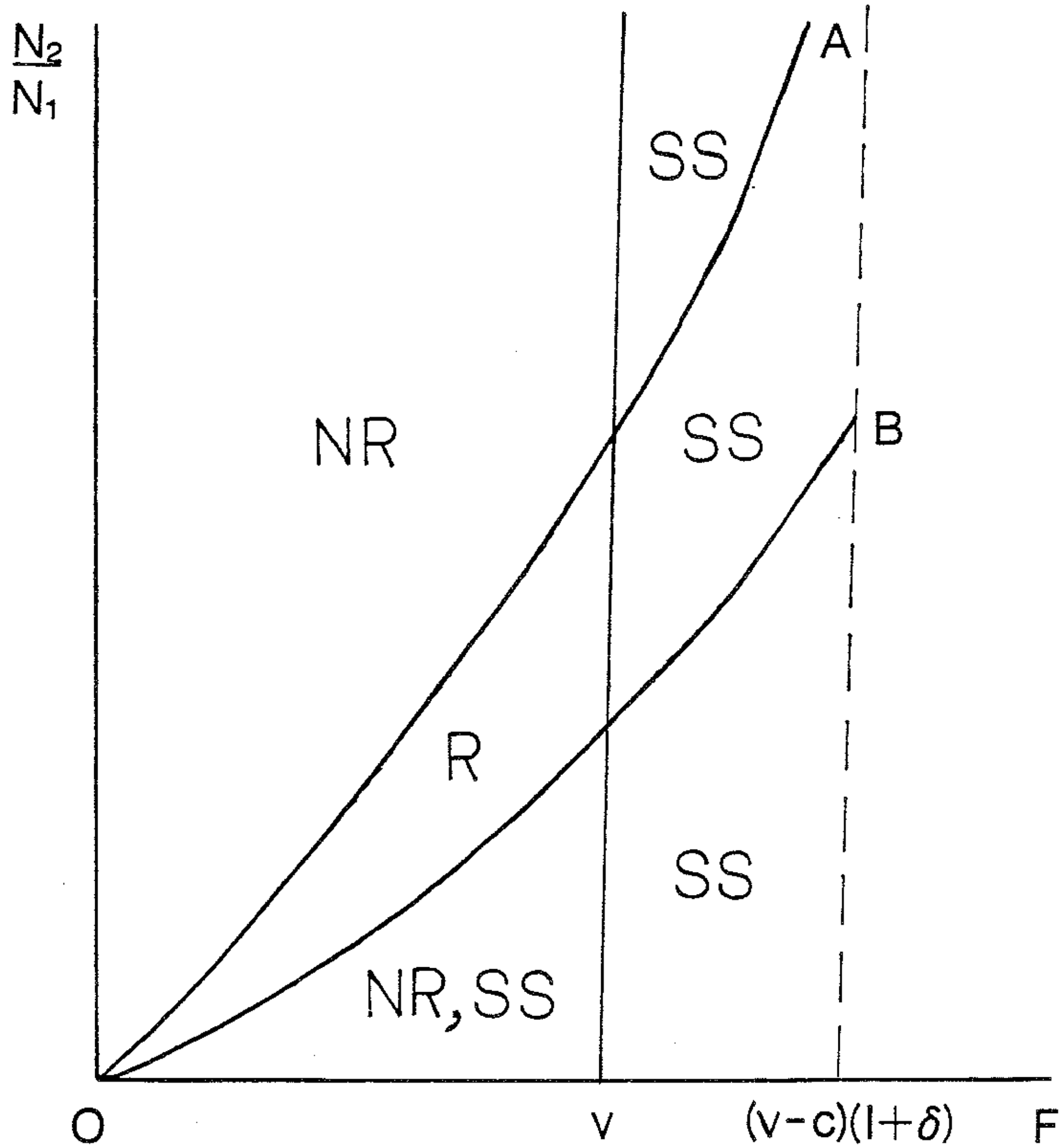

Figure 7

Monopoly Pricing Strategies under Growing Demand

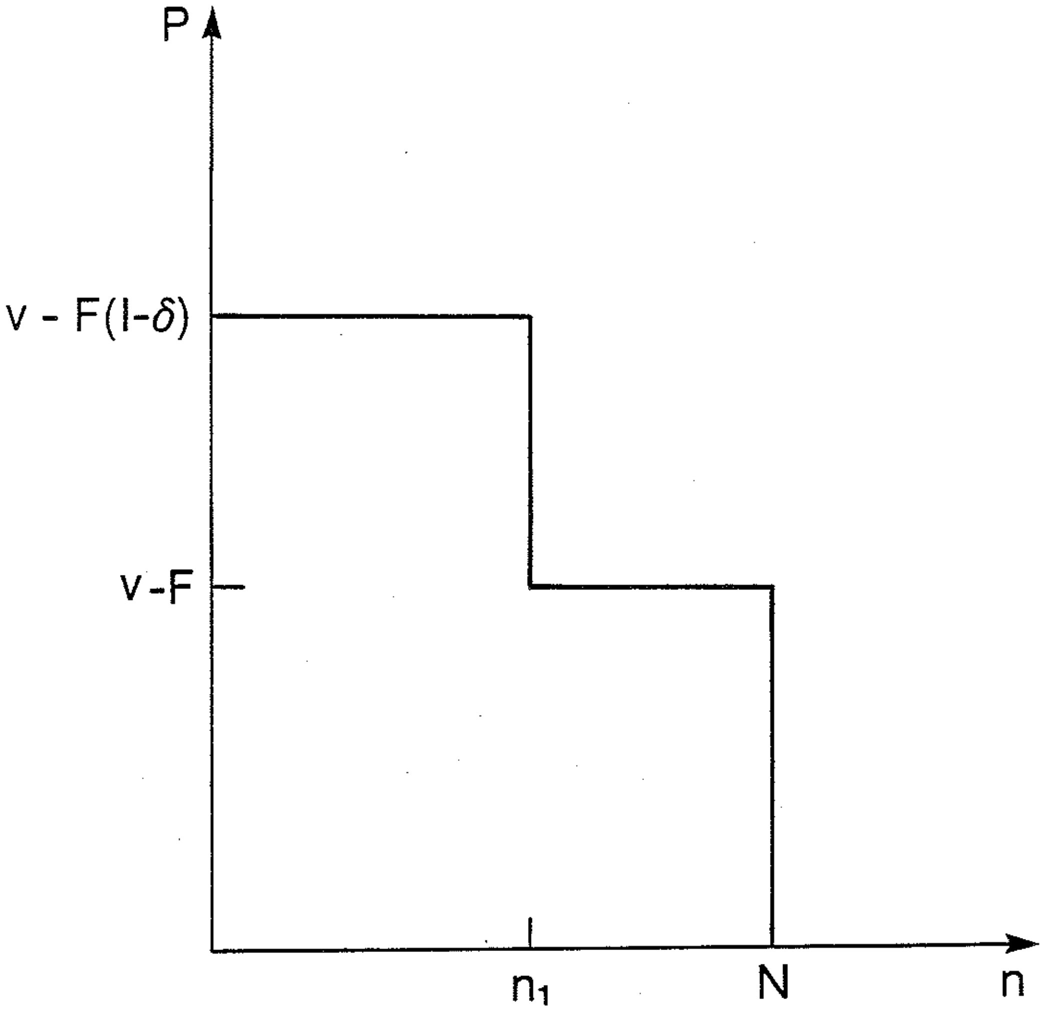

Figure 8
First-Period Demand Faced by
Constrained Monopolist

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