250

Price Caps, Deregulation and Bypass Efficiency

Michael Einhorn

Columbia Institute for Tele-Information
Graduate School of Business
809 Uris Hall
Columbia University
New York, New York 10027
(212) 854-4222

PRICE CAPS, DEREGULATION AND BYPASS EFFICIENCY

Michael Einhorn

Working Paper Series. Draft Copy, 1988. Do not cite or quote without permission of the author.

Center for Telecommunications and Information Studies. 809 Uris Hall, Graduate School of Business, Columbia University, New York, New York, 10027. (212) 280-4222.

PRICE CAPS, DEREGULATION, AND BYPASS EFFICIENCY

Michael A. Einhorn
Rutgers University
Newark, New Jersey

1. Introduction

In continuing to deregulate the telecommunications industry, the Federal Communications Commission (FCC) has begun to consider alternative approaches to traditional cost-based price regulation as means to encourage regulated-monopoly efficiency, promulgate technological innovation, and protect consumers (for more detail, see Federal Communications Commission (1987), Haring and Kwerel (1987)). Under current regulatory structures, customer prices are designed to recover the regulated utility's costs plus an allowed rate of return on its rate base; this strategy, which is very costly to administer, provides no incentives for utilities to pursue cost-efficiencies and technological improvements and may encourage both uneconomic expansion of the utility's rate base and cross-subsidization of deregulated services (for more detail, see National Telecommunications and Information Administration (1987)). The alternative approaches now being considered can be broadly classified as price-capping strategies; under price-capping, regulators would delimit a category of regulated core services and set either a maximum price for each individual service or a maximum level for a composite price

In the course of writing this paper, I have benefitted from conversations with Doug Conn, Bruce Egan, Jonathan Falk, David Sibley, Ingo Vogelsang, and Robert Willig. Funding has been provided by the Research Council of Rutgers University. All errors are mine.

index. (All price caps would be adjusted to allow for inflation and productivity change in the industry.) As long as no price exceeds its allowed maximum, the utility may price freely any service and may keep the profits that may result from any innovation that successfully lowers prices and costs; these profits are the incentives that should encourage utility efficiency.

The general idea of price-capping has been warmly endorsed by several telecommunications economists (Linhart and Radner (1986), Egan and Taylor (1987), National Telecommunications and Information Administration (1987)); however, certain significant benefits have, to date, gone unnoticed. Particularly, properly designed price caps on switched access usage may be sufficient to provide local exchange carriers (LECs) with proper incentives to design nonuniform usage price schedules that will eliminate all customer incentives to bypass uneconomically. If the price caps are based upon a prior tariff with constant access and usage prices, the resulting nonuniform price schedule will be weakly Pareto-improving relative to this tariff. Other than possible antitrust surveillance to protect against predatory pricing, no additional regulation is necessary to this end.

This paper extends in several meaningful directions an earlier article of mine (Einhorn (1987)), where I derived a nonuniform price schedule for profit-constrained, welfare-maximizing LEC that is faced with possible (large) customer bypass. Under certain circumstances, I demonstrated that the LEC should be permitted to price some usage (for heavily used switched access lines) at prices that are below the associated marginal cost; because low-level usage prices would continue to exceed marginal cost, each switched access line would still make a positive net revenue contribution toward recovering the company's fixed costs. Furthermore, only economic bypass would result in this tariff.

Despite its theoretical elegance, the paper suffered from several practical drawbacks. First, no limits were placed on small-user prices; as a consequence, small users could be made worse off compared with an earlier flat-rate tariff. Obvious political difficulties abound. Second, regulators needed to determine both utility and rival marginal costs as well as the distribution of customer intensities in order to set usage prices for the LEC. Since regulators cannot realistically determine the accuracy of reported marginal cost data, countless opportunities abound for LECs and rivals to distort their reported cost data in order to increase company profit. Since bypass costs should include, in a contestable market, the technologies of potential rivals, measuring rival costs might literally be impossible if entry has not occurred. If bypass rivals do exist, the utility may dispute their rivals' reports and drag regulators through administrative nightmares that may be impossible to adjudicate fairly; the same point holds with regard to customer intensity. Price-capping may be a workable alternative tactic that may eliminate many of these problems. As I shall show, price-capping provides a profit-maximizing LEC with the incentives to determine, as best it can, its own and rival costs.

The paper is organized as follows. Section 2 reviews other relevant theoretical papers and two practical applications. Section 3 develops the basic model and Section 4 derives the relevant basic results; Section 5 considers some additional complexities relevant to telecommunications pricing. Section 6 discusses two objections. Section 7 concludes the paper. Through the course of the paper, it will be necessary to refer to proofs of results in Einhorn (1987); where important, the proofs are included in footnotes.

2. Existing Literature and Applications

Several economists have explored the economics of price-capping in different contexts; this section reviews some prototype models. We also consider two applications of price caps.

Theoretical Results

Baron (1987) has extended his earlier work on incentive mechanisms to price caps. He recognizes that utilities that are regulated in the traditional cost-based manner have no incentive to reduce costs and may strategically distort reported cost data in order to increase profit. He designs alternative price-cost mechanisms that would permit the utility to earn positive profits; the allowed usage price P depends upon the utility's reported marginal cost C, which the utility may deliberately distort from its actual value C. Regulators do have a Bayesian prior on C; it ranges from minimum C^- to maximum C^+ with distribution F(C) and density f(C). To maximize social welfare, regulators allow a usage price P(C) and a lump sum transfer payment to the utility of $T(C)$; $P(C) = C + F(c)/f(C)$ and $T(C) = \int_{C^-}^{C^+} Q(P(c))dc$ ($Q(P(c))$ = total customer demand at price $P(c)$). Under necessary regularity conditions, $dP/dC > 0$; $P(C^+)$ is then the price cap. Under Baron's schedule, the utility has an incentive to report C accurately.

There are two difficulties with Baron's approach. First, regulators must estimate an accurate Bayesian prior regarding the distribution of C; this may be particularly difficult with telephone costs. Second, Baron has not explicitly considered the the possibility that P(C) may exceed a politically-constrained maximum.

Vogelsang (1987) extends earlier seminal work (Vogelsang and Finsinger (1979)) to develop non-Bayesian incentive mechanisms using two-part tariffs; as will be shown, these tariffs are implicitly price-capped in each period. In time t, let Q_t represent customer usage demand and P_t the respective prices; let N_t represent the number of customers and A_t its associated price. Let $C_t = C(Q_t)$ represent the utility's costs in time t; this includes a fixed component K. In time t, the utility may choose any prices P_t and A_t as long as $P_t'Q_{t-1} + A_tN_{t-1} \leq C(Q_{t-1})$; since C_{t-1}, N_{t-1}, and Q_{t-1} are easily monitored, this constraint can be readily checked. The utility then attempts to maximize discounted profits $\sum_{t=0}^{\infty}(P_t'Q_t + A_tN_t - C(Q_t))/(1 + r)^t$ subject to this price constraint. Vogelsang shows that P_t and A_t converge to profit-constrained optimal two-part tariffs (Schmalensee (1981)) in steady-state equilibrium. (Convergence to Ramsey prices of similar non-Bayesian mechanisms has been suggested by Brennan (1987) and Egan and Taylor (1987).)

Non-Bayesian adjustment procedures are important and one hopes to see more development; at present, there are two limits to Vogelsang's present approach. First, he has not yet incorporated the fact that LEC costs C_t depend upon both usage Q_t and customers N_t. Second, because his resulting optimal equilibrium prices are only profit-constrained, Vogelsang -- like Baron -- has not yet considered the political realities behind setting small-customer prices.

Linhart, Radner, and Sinden (1987) consider a third price-capping strategy. In their model, regulators determine a trajectory P(t) for price P over time t; $dP/dt < 0$. Because P(t) declines, management must reduce costs to keep net earnings at an acceptable level. The decline in prices may eventually squeeze utility profits below an acceptable level, at which point present management must be dismissed. Once this point is reached, regulators must reset P(t) at a higher level and begin a new downward trajectory. As with Baron and Vogelsang, the prime difficulty with this approach is that the resulting price level will be politically unacceptable.

Willig (1978) derives a profit-constrained nonuniform usage price schedule P(q) for a customer's usage q where no price P(q) may exceed an initial level P_o; although his resulting tariff is not profit- or welfare-maximizing, it weakly Pareto-dominates the initial flat-rate alternative. He demonstrates that P(q) should eventually fall to but not below marginal cost C. The ceiling price P_o then represents a price cap. His results invite two improvements. First, he does not derive the general shape of the best Pareto-improving schedule. Second, he assumes that large customers have no service alternatives (such as bypass) and are therefore captive to the utility.

Practical Applications

There have been two efforts to institute some kind of price-capping. In Britain, the Telecommunications Act of 1984 price-capped British Telecom's monopoly services (business and residential exchange, local service, domestic toll usage); the weighted average of these prices could not increase faster, on an annual basis, than the rate of inflation (measured by the Retail Price Index) minus a fixed percentage (3%) to incorporate expected productivity gain (for the theoretical basis behind these strategies, see Littlechild (1983).) There are no constraints on any single price in the composite index; both company profits and the prices of competitive services (connection charges, international calls, operator services, pay phones, and private line services) were deregulated. For a criticism of this approach, see Vickers and Yarrow (1988).

In New York, the state commission instituted a rate moratorium (until 1991) on New York Telephone's basic monopoly services; the carrier could only pass along prespecified cost increases that included the effects of wage contract negotiations and changes in tax law, separation procedures, and depreciation rates. New and monopolized "discretionary" services (customer calling, remote call forwarding, optional calling plans, TOUCH-TONE, INTELLIPATH, and CENTREX) were not included in the moratorium; however, the commission must still approve price increases in the latter category. As an incentive to reduce costs, the LEC may keep 50% of all earnings that exceed its authorized rate of return on its intrastate rate base.

The Bypass Problem

None of the above papers explicitly deals with the problem of large customer exit (or bypass); this is an important problem in telecommunications and could become significant in electricity and natural gas as well. In telecommunication, each customer can access its long-distance carrier through the LEC's switched access facilities or through alternative bypass technologies. Because LECs must recover substantial fixed costs, at some point they must price a service above marginal cost. Because customer access may be relatively inelastic, the flat-rate access fee would seem to be the most-efficient price to raise to recover fixed costs; this strategy is not politically acceptable. If usage prices for long-distance access are raised above marginal cost, some customers may switch to the bypass alternative, with a consequent loss of revenue to the LEC. This bypass may or may not be efficient from an economic perspective.

3. A Mathematical Model: Pareto-Improving Nonuniform Tariffs

We derive the general shape of a price schedule where no customer's well-being can be reduced from a prespecified initial level that resulted under previous line and usage charges; i.e., the new schedule must be weakly Pareto-improving. Under price caps, the LEC will be profit-maximizing; for comparison, we also consider a profit-constrained, welfare-maximizing LEC. Assume that each customer has at most one switched access line; its only alternative is to forego utility service altogether. Section 5 relaxes both assumptions.

Variables, Definitions, and Assumptions

Customers vary in their usage intensities; we shall assume that customer demand curves do not cross one another (see Faulhaber and Panzar (1977); Spence (1977); Mirman and Sibley (1980); Goldman, Leland, and Sibley (1984)). Consequently, we may index each customer with an ordinal parameter $i \in [0, 1]$; i is continuously distributed. Let $F(i)$ and $f(i)$ ($= dF(i)/di$) represent the cumulative distribution and density functions respectively; let a (d) designate the infimum (supremum) of intensities i of LEC customers. Therefore, $[a,d] \in [0,1]$. In this section, we shall assume that both a and d are fixed; Section 5 will make both variables-of-choice.

At any usage level q, net welfare of consumer i can be written:

$$3.1) \quad W_i(q) = U_i(q) - R(q) - A$$

where:

$U_i(q) = U(i,q)$ = consumer i's willingness to pay for q.

$R(q_i)$ = usage-sensitive revenue paid for usage q_i

A = access fee per customer line

We assume that $dU_i(q)/dq > 0$, $d^2U_i(q)/dq^2 < 0$, and $d^2U(i,q)/didq > 0$. If q_i is the optimal usage of customer i,

$$dU_i(q)/dq\Big|_{q=qi} = dR(q)/dq\Big|_{q=qi} = P_i.$$

Assume that all relevant functions are continuous and differentiable over [a,d], we may define aggregate consumer welfare W:

$$3.2) \quad W = \int_a^d W_i(q_i)dF(i).$$

Utility profits are defined:

$$3.3) \quad X = \int_a^d [A + R(q_i) - Z - Cq_i]dF(i) - K.$$

In a Pareto-improving tariff, no customer can be made worse off than he was originally; i.e., $W_i(q_i) > W_{io}(q_{io})$ where the o subscript indicates initial levels of welfare and usage that prevailed under initial customer and usage charges A_o and P_o. If $W_i = W_{io}$, the customer is <u>original-indifferent</u>. We shall then term this constraint the original-indifference constraint. Throughout the paper, we shall assume that the price schedule is single-crossing at q_i[1]. As a result, second-order conditions for maximizing utility are always met and q_i increases with i at any fixed price (for more details, see Goldman, Leland, and Sibley).

<u>First-Order Maximizing Conditions</u>

The objective function can be expressed as follows:

$$3.4) \quad L = (1 - g)W + gX + \int_a^d h_i(W_i - W_{io})di$$

Eq. (3.4) is a straightforward profit- (welfare-) maximizing problem when g = 1 (1/2). If profits must be non-negative, 1/2 ≤

$g \leq 1$ for a profit-constrained welfare-maximizing problem (see Schmalensee (1981)). The last RHS term in (3.4) is the Kuhn-Tucker term needed to ensure that $W_i(q_i) \geq W_{io}(q_{io})$ for all customers i. The multiplier $h_i \geq 0$; if $h_i > 0$, customer i is original-indifferent.

A minor extension of two earlier derivations (Spence, Einhorn) shows:

3.5a) $P_i = P(q_i) = C + (2g - 1 - h_i)t(i)(\partial^2 U(i,q)/\partial i \partial q\Big|_{q=q_i})/g$

where:

$$t(i) = [F(d) - F(i)]/f(i) \geq 0.$$

3.5b) $X \geq 0;\ g \geq 0;\ gX = 0$

3.5c) $W_i(q_i) \geq W_{io}(q_{io});\ h_i \geq 0;\ h_i[W_i(q_i) - W_{io}(q_{io})] = 0.$

Following Spence, Figure 1a (1b) illustrates the shape of the optimal nonuniform price schedule for a profit-maximizing (profit-constrained welfare-maximizing) when the original-indifference constraint is not binding (i.e., $h_i = 0$ in (3.5a)). The schedule need not be monotonically increasing but we shall assume that it is; P(q) must exceed or equal C and eventually P(q) must fall to C.

4. An Pareto-Improving Nonuniform Price Schedule

We now consider the implications of adding the Pareto-improving constraint to an optimal nonuniform price schedule; four statements must first be proved.

Theorem 1: Let [b, c] represent the first band of customers who

Figure 1a: Unconstrained and Constrained Price Schedules: Profit-Maximizing Firm

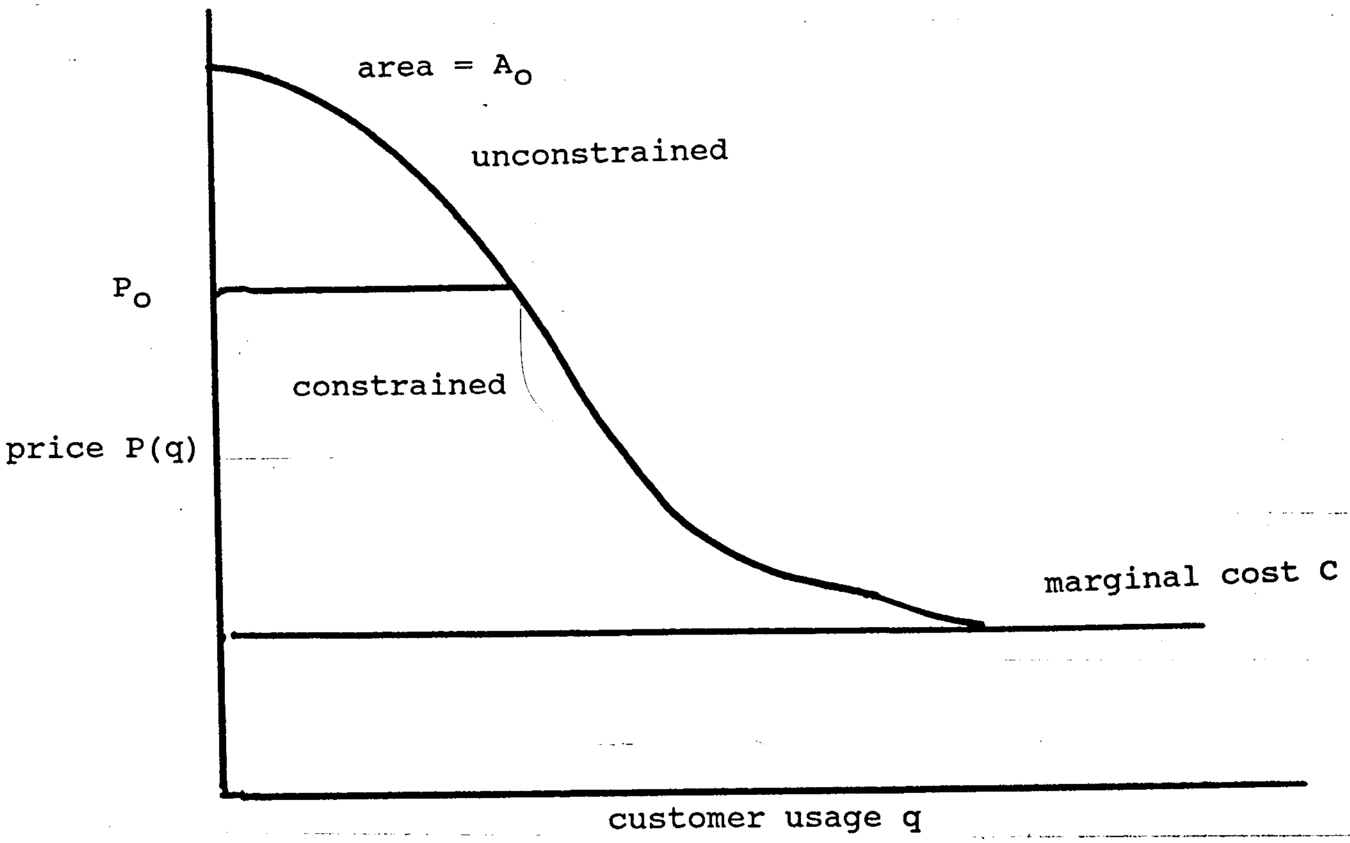
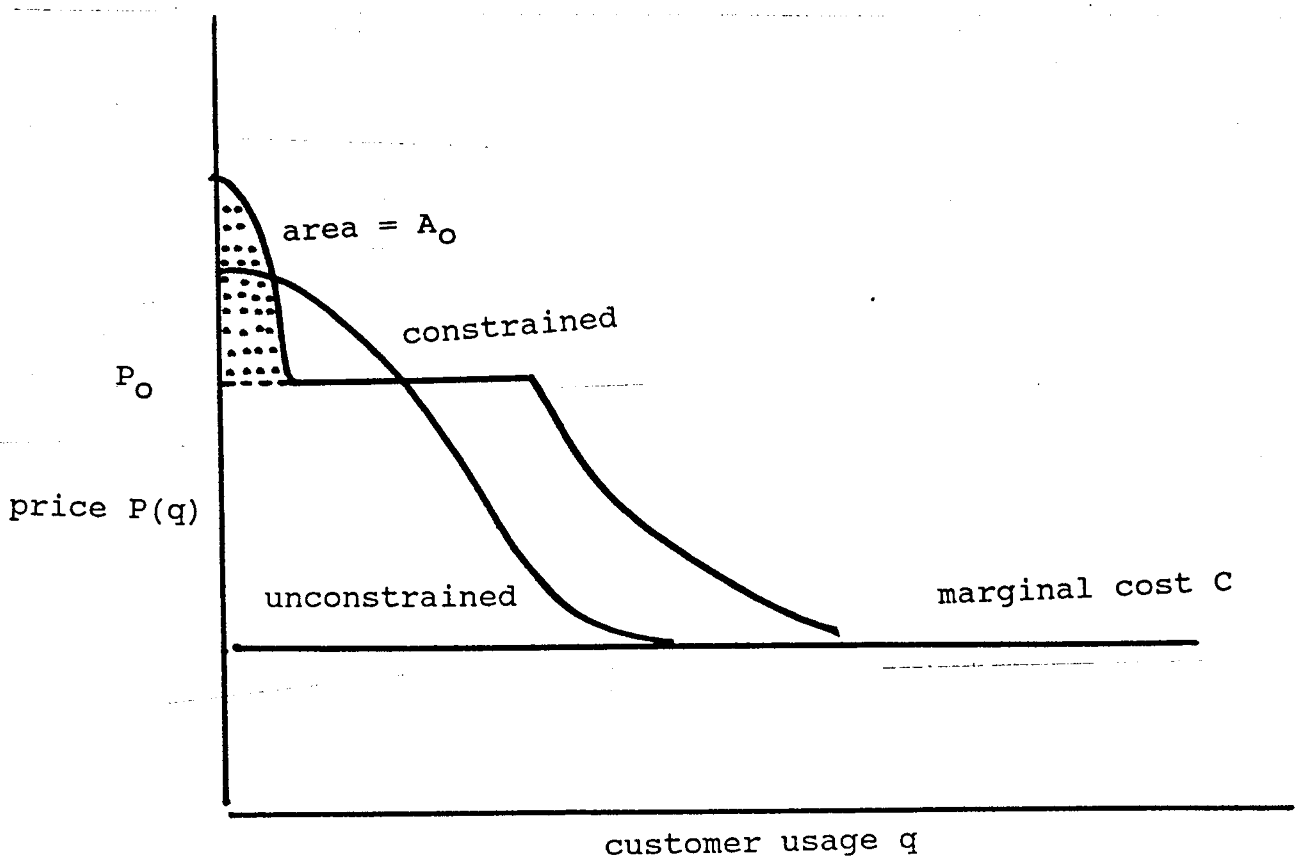


Figure 1b: Unconstrained and Constrained Price Schedules: Profit-Constrained Welfare-Maximizing Firm



are original-indifferent. Suppose that $P(q_i) > P_o$ for some $i \in (b, c]$. Then for some j (b, i), $P(q_j) < P_o$.[2]

Let q_{bo} represent the usage level of customer b if the marginal price of usage is P_o (i.e., point E in Figure 2). We now prove Lemma 2.1, which will be useful for proving Theorem 2.

Lemma 2.1: $A + R(q_{bo}) = A_o + P_o q_{bo}$.[3]

Theorem 2 establishes that the price schedule has a plateau at P_o over the interval (b, c]:

Theorem 2: $P(q_i) \geq P_o$ for $i \in (b, c]$.[4]

We can combine Theorem 1 and Theorem 2 to state a major corollary:

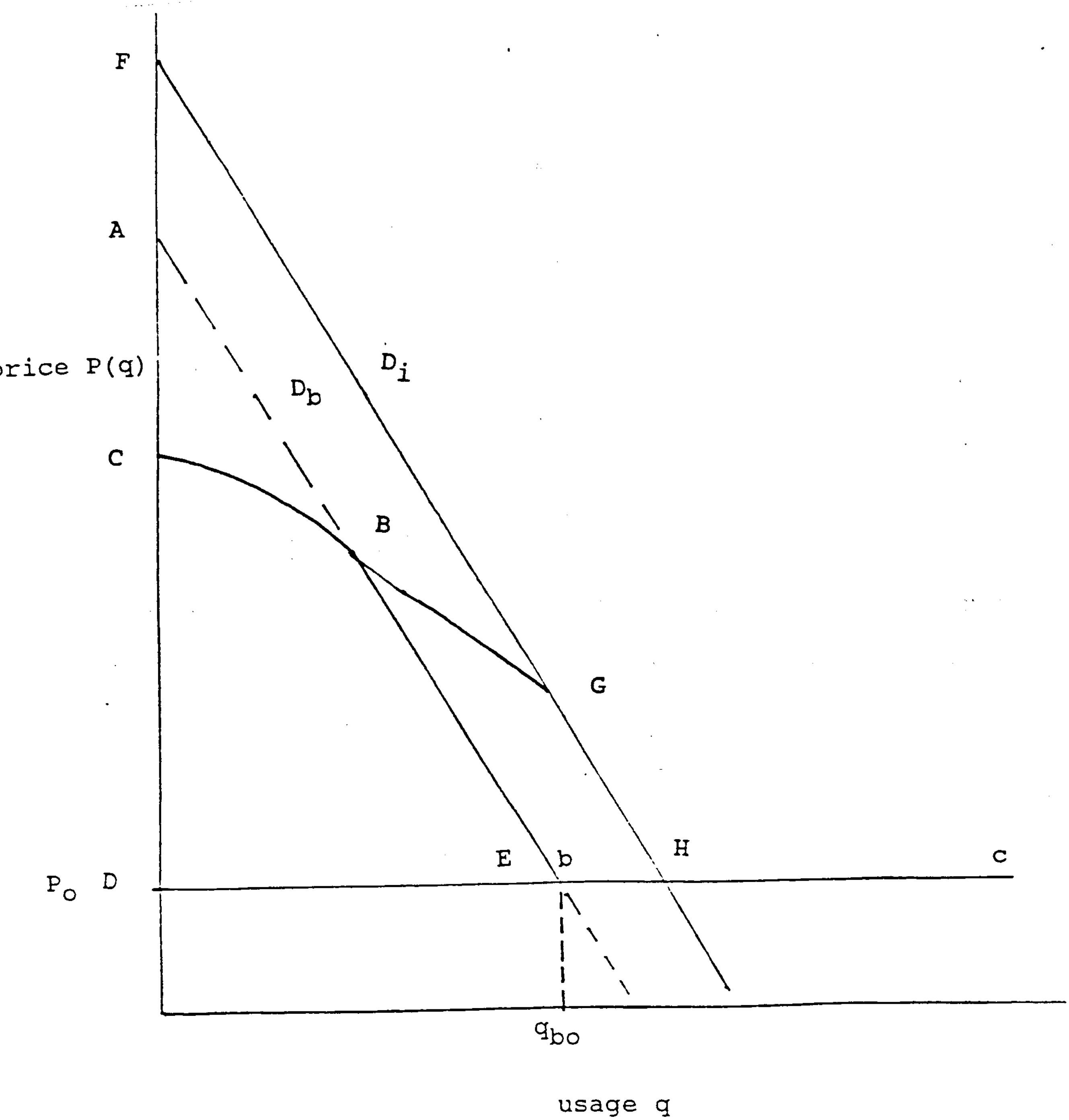
Corollary 2.1: $P_i = P_o$ for all customers $i \in (b, c]$.

From footnote 4, P(q) and D_b must coincide from points B to E (Figure 2); therefore, $P_i = P_o$ from q_{bo} (point E) to q_c (see Corollary 2.1).

Figures 1a and 1b illustrate the effects of adding the original-indifference constraint. Unlike Spence's nonuniform price schedule, the new schedule reaches a plateau (b, c] along which $P(q) = P_o$. Lemma 2.1 makes sense; if $A + R(q_{bo}) = A_o + Pq_{bo}$ (or else, customer $i \in (b,c)$ could not be indifferent).

If more than one original-indifference constraint simultaneously existed, each customer must be no worse off than he would be under either of the two schedules, represented by A_o,

Figure 2: Two Demand Curves for Customers b and i



P_o and a_0, p_0). Because consumer demand curves do not cross, only one customer could be indifferent between A_o, P_o and a_0, p_0. Therefore, at most only one customer can be simultaneously indifferent between the two original price schedules and the nonuniform alternative. Let [b, c] ([b', c']) represent the spectrum over which customers are indifferent between A_o, P_o (a_0, p_0) and the nonuniform price schedule; from the above remarks, $c \leq b'$ is necessary.[5]

A Pareto-improving price schedule therefore would have two plateaus. If c = b', the schedule would jump from one plateau to the second by moving down the demand curve of customer c = b'. If b' > c, an interval of unconstrained customers would lie between the two plateaus; usage price P(q) would be constant over each plateau (see Figures 3a and 3b.) Obviously, additional plateaus can be added. Note that there is no reason why $P(q) \geq C$ at each plateau; as will be shown below, $P(q) < C$ is possible provided a necessary endpoint condition is added for d.

5. Important Extensions

This section introduces two important extensions to Section 3. First, both endpoints a and d may be variables-of-choice (d may be variable if large customers can bypass the LEC.) Second, each customer can have more than one access circuit; any mixture of bypass and switched access is possible.

Figure 3a: Two Original-Indifference Constraints

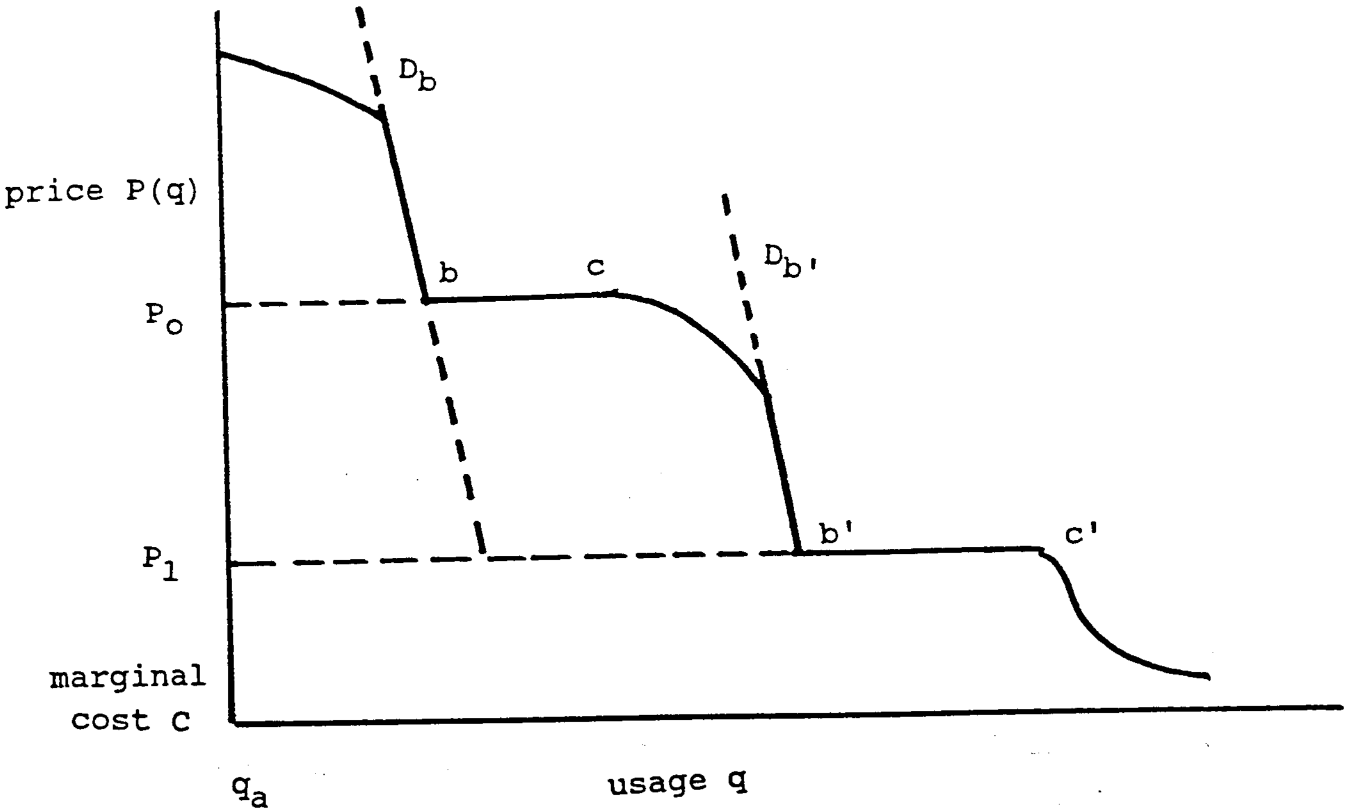
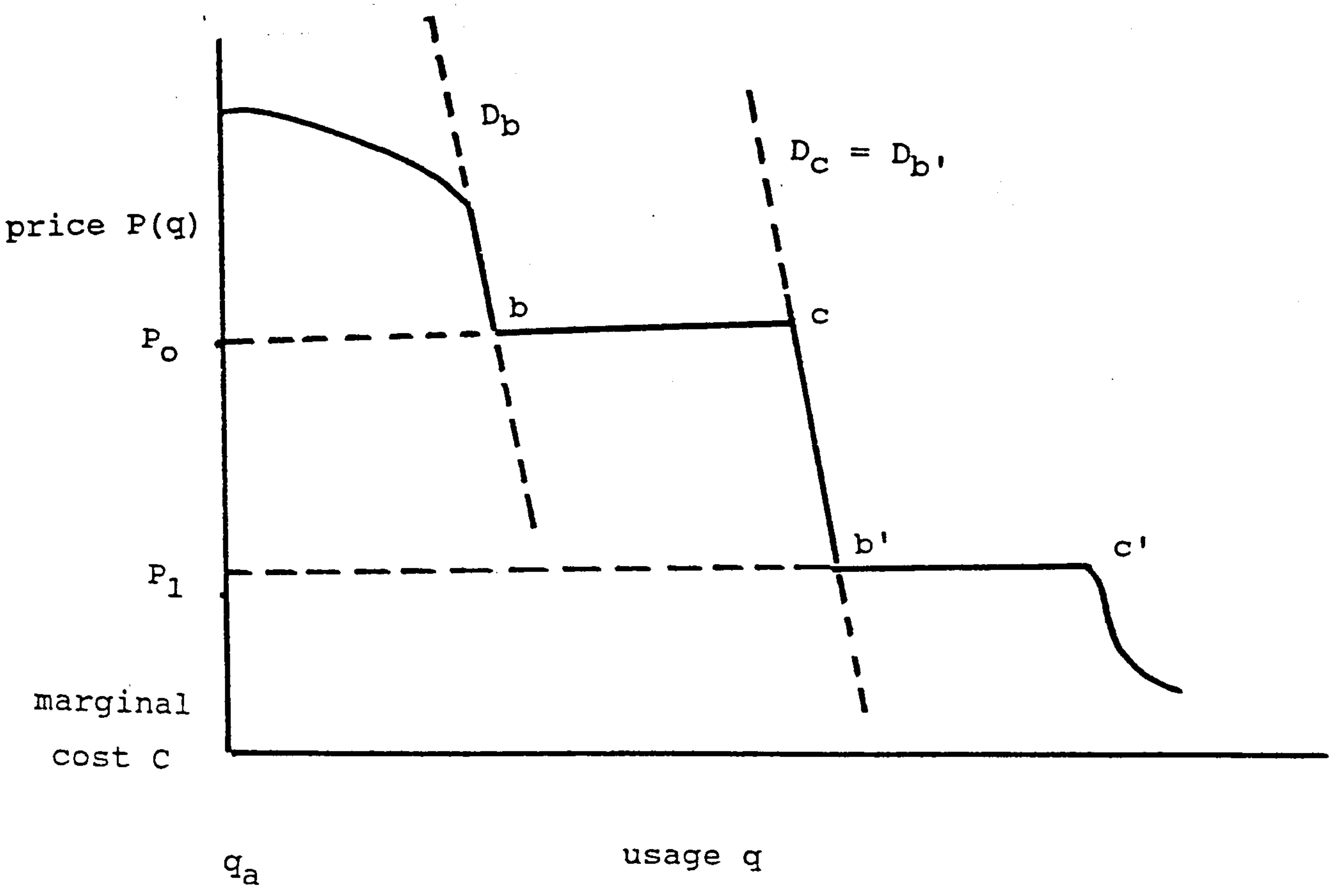


Figure 3b: Two Original-Indifference Constraints



Bypass Alternatives

Let Z^* and C^* represent the respective access and usage costs for a bypass circuit. Assuming that bypass vendors constitute a competitive market, access and usage prices will be driven to associated costs Z^* and C^*.[6] Under bypass, the welfare of customer i would be:

5.1) $W_{i*}(q_{i*}) = U_i(q_{i*}) - C^* q_{i*} - Z^*$

where:

$q_{i*} = q_i(C^*)$

For any circuit, customers may then choose between bypass, LEC switched access service, and no service at all. If bypass is economic at a sufficiently high level of usage, $C^* < C$ and $Z^* > Z$ must hold. Therefore, $P_o > C > C^*$. Alternatively, bypass technologies can be a threat even if $Z^* > Z$ and $C^* > C$; this is because P_i may be above C^* since the LEC must capture fixed costs.

There are two groups of potential consumers. Without utility services, small consumers would prefer no service to bypass; i.e., $0 > W_{i*}(q_{i*})$. By contrast, large consumers would prefer bypass to no service; i.e., $W_{i*}(q_{i*}) > 0$. We shall assume that a is a small customer and d is a large one. At a, $W_a(q_a) \geq 0$; at d, $W_d(q_d) \geq W_{d*}(q_{d*})$. Strict equality holds at interior points a > 0 and d < 1. When a (d) is interior, consumer i < a (i > d) clearly would prefer having no service at all (bypass) to switched access even if the latter were available; i.e., $W_i(q_i) < 0$ $[W_i(q_i) < W_{i*}(q_{i*})]$.

The relevant welfare-maximand is then:

$$5.2)\quad W = \int_a^d W_i(q_i)dF(i) + \int_d^1 W_{i*}(q_{i*})dF(i).$$

Utility profits are defined as before:

$$3.3)\quad X = \int_a^d [A + R(q_i) - Z - Cq_i]dF(i) - K.$$

The objective function is now:

$$5.3)\ L = (1 - g)W + gX + \int_a^d h_i(W_i - W_{io})di + \int_a^d k_i(W_i - 0)di + \int_a^d m_i(W_i - W_{i*})di$$

The optimal conditions are given:

$$3.5a')\quad P_i = P(q_i) = C + (2g - 1 - h_i - k_i - m_i)t(i) (\partial^2U(i,q)/\partial i\partial q\big|_{q=qi})/g$$

$$3.5b)\quad X \geq 0;\ g \geq 0;\ gX = 0$$

$$3.5c)\quad W_i(q_i) \geq W_{io}(q_{io});\ h_i \geq 0;\ h_i[W_i(q_i) - W_{io}(q_{io})] = 0.$$

The k_i terms are Kuhn-Tucker constraints that require each customer to prefer or be indifferent between LEC service and no service at all; i.e., $W_i(q_i) \geq 0$. The m_i terms are Kuhn-Tucker constraints that require each customer to prefer or be indifferent between LEC service and bypass; i.e, $W_i(q_i) \geq W_{i*}(q_{i*})$.

We could derive formal optimizing conditions as in Section 3 but a less formal discussion neatly makes the basic points regarding P(q). We may conceive of the bypass alternative as being an additional original-indifference constraint with $A = Z^*$, $P = C^*$. As discussed in the previous section and illustrated in Figures 3a and 3b, a nonuniform price schedule with several original-indifference constraints must jump from plateau to plateau with gaps of strongly-preferent customers possibly in between; that is, there are constrained sections where customers on each plateau are indifferent. Figures 3a and 3b illustrate the general shape of P(q).

To determine optimal a and d, we differentiate (5.3) with respect to both:

5.4a) $(g - k_a - 1)W_a(q_a)f(a) - g(A + R(q_a) - Z - Cq_a) \leq 0; \; a \geq 0$

$a[(g - k_a - 1)W_a(q_a)f(a) - g(A + R(q_a) - Z - Cq_a)] = 0$

5.4b) $(1 + m_d - g)(W_d(q_d) - W_{d*}(q_{d*}))f(d)$

$+ g(A + R(q_d) - Z - Cq_d) \geq 0; \quad d \leq 1$

$(d - 1)[(1 + m_d - g)(W_d(q_d) - W_{d*}(q_{d*}))f(d)$

$+ g(A + R(q_d) - Z - Cq_d)] = 0$

If $a > 0$ and $d < 1$, $W_a(q_a) = 0$ and $W_d(q_d) = W_{d*}(q_{d*})$; eqs. 5.4a-b can be simplified (since g is positive):

5.5a) $A + R(q_a) - Z - Cq_a = 0$

5.5b) $A + R(q_d) - Z - Cq_d = 0$

If $a = 0$ $(d = 1)$, the endpoint customer may be indifferent or strongly prefer utility service. Under the former regime, eqs. 5.5a-b must hold. Under the latter, $k_a = 0$ and $m_d = 0$; eqs. 5.4a-b can then be simplified:

5.6a) $(g - 1)W_a(q_a)f(a) - g(A + R(q_a) - Z - Cq_a) \leq 0$

5.6b) $(1 - g)[W_d(q_d) - W_{d*}(q_{d*})]f(d)$

$$+ g(A + R(q_d) - Z - Cq_d) \geq 0;$$

To distinguish all possible scenarios, we shall assume that when a = 0 (d = 1), customer d strongly prefers the LEC. If a is indifferent, $k_a > 0$. Consequently, revenues from customer a should just cover his associated costs (see eq. (5.5a)). Because customer a is indifferent, $U_a(q_a) = Z + Cq_a$[7]. As noted, no customer i > a can be small-indifferent; i.e., $k_i = 0$ for i > a. Consequently, for small q_i, $P(q_i)$ is either at an unconstrained level somewhere above marginal cost C ($h_i = 0$) or it falls to P_o ($h_i > 0$); see eq. (3.5a')).

If a = 0, the equality constraint from eq. 5.5a is not binding; if the original-indifference constraint were not binding, a profit-maximizing LEC could price A as high as it wished and a profit-constrained, welfare-maximizing LEC could recover its fixed cost requirements from A alone. However, when the original-indifference constraint is binding, the upward limits on A and small-level usage prices are given by Lemma 2.1.

If d < 1, revenues from customer d just cover its costs (see eq. 5.5b). Since $C^* < C$, the LEC must extend its C^* plateau until eq. (5.5b) holds on usage q_d of the largest customer. For usage above q_d, the LEC must dissuade large customers from staying with switched access; this can be done by raising P(q) (for usage q_i beyond q_d) above C^* (see Einhorn). Figure 4a illustrates the resulting price schedule. If d =

Figure 4a: Constrained Price Schedules with Bypass Threat: d < 1

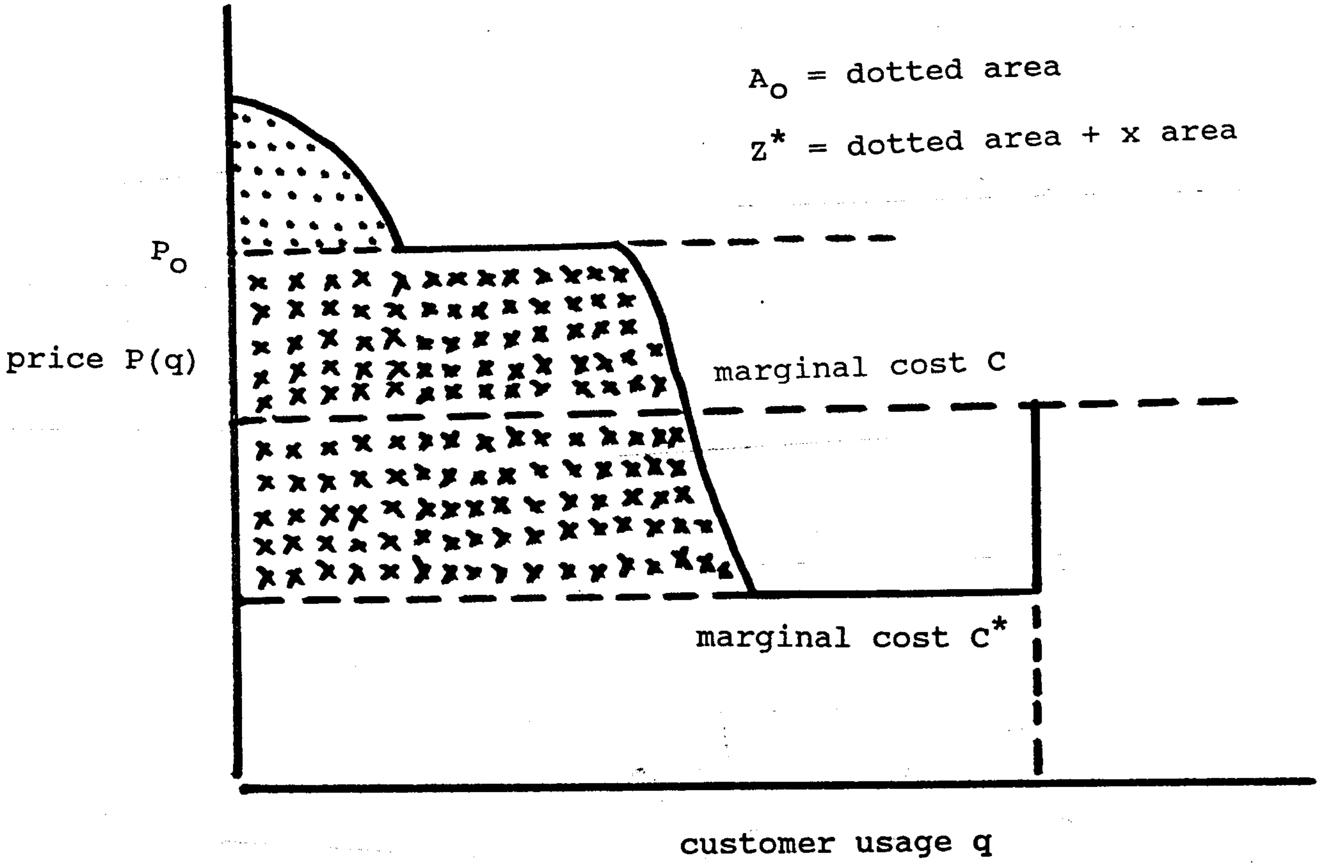
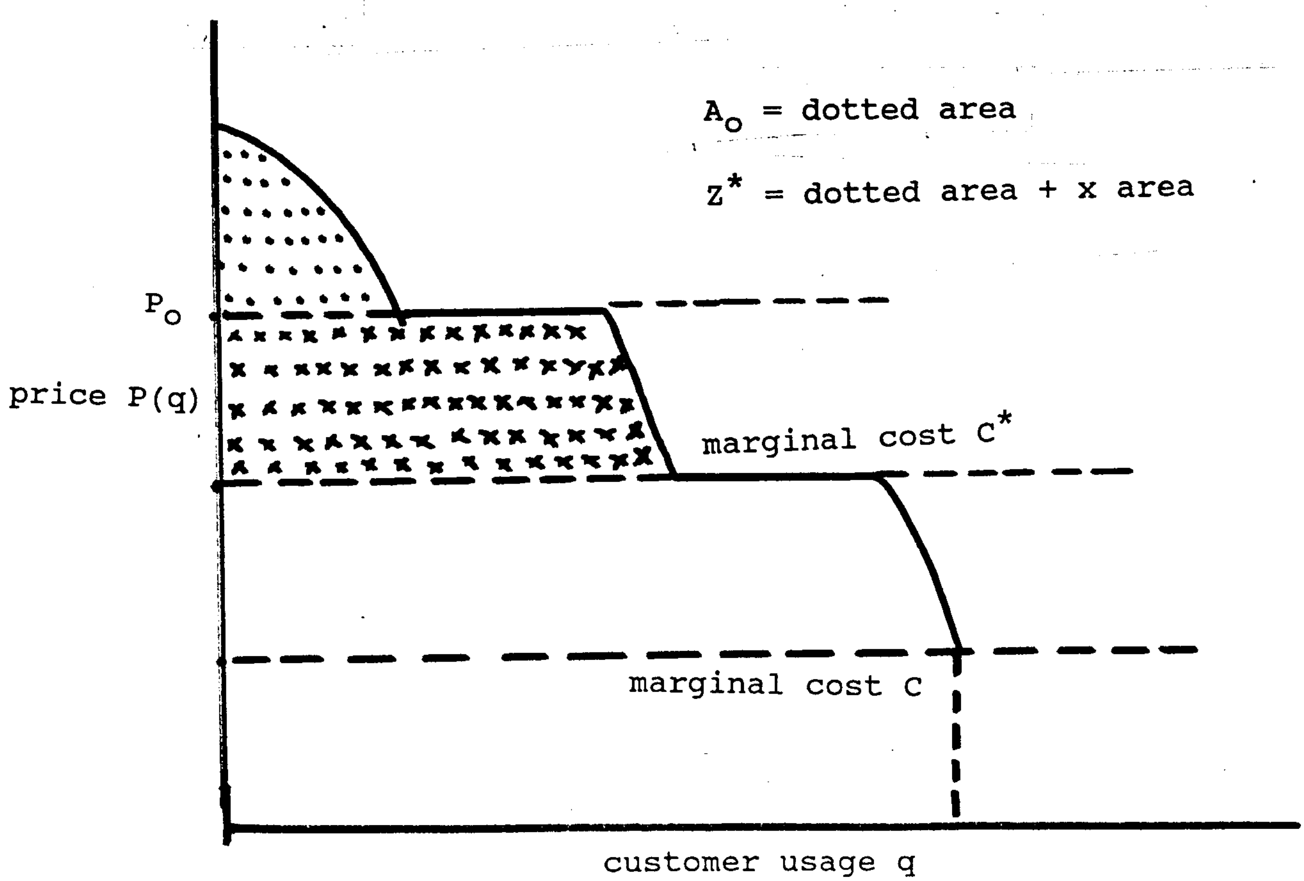


Figure 4b: Constrained Price Schedules with Bypass Threat: d = 1



1, eq. (5.5a) is not binding. Since the largest customer d = 1 strongly prefers LEC service, all customers i < d must do so as well. Assuming that no other original-indifference constraint imposes $P_o < C$, there is no reason for the LEC to price usage below C. Figure 4b illustrates the resulting price schedule.

In a profit-constrained, welfare-maximizing problem, g will increase once the original-indifference constraint is added; customers i who are not indifferent would consequently face higher prices than they would without the constraint (see eq. (3.5a)). In a profit-maximizing problem, g = 1; therefore, prices to customers who are not indifferent do not change as a result of the constraint (see eq. (3.5a)). However, prices for customers who are not indifferent will be higher in a profit-maximizing problem (with g = 1) than in a constrained welfare-maximizing problem (when g < 1). Clearly, any customer who is indifferent will be as well off under either schedule.

If g = 1, $A + R(q_d) \geq Z + Cq_d$ (see eqs. 5.5b-5.6b). Although profit-maximizing LECs may decrease prices below marginal costs, each customer i < d would always contribute a positive amount of net revenue.[8] If d < 1 (i.e., $P_d = C^* = C$) the LEC could not profitably retain any line i > d.[9] Appendix A demonstrates that bypass will occur if and only if it is economic.

Multiline Customers

The model can be easily generalized to allow for multiline customers. Einhorn shows that the basic results from a profit-constrained, welfare-maximizing schedule for switched access line usage (with large customer bypass) can be extended immediately to a multiline model if we assume that each bypass circuit has a flat-rate line (usage) cost of Z^* (C^*), switched access on each line has a usage-sensitive price schedule $P(q)$, $P(q)$ is the same for each switched access line, and $dP(q)/dq \leq 0$ for usage q on each switched access line.[10] The parameter i now represents line intensity instead of customer intensity, all installed switched access lines can be unambiguously designated by an ordinal demand intensity parameter i with cumulative distribution function $F(i)$ and density $f(i) = dF(i)/di$. Since intensity of circuit usage is now ranked as was intensity of customer usage before, previous theoretical results remain unchanged.

To consider Pareto-improving schedules in a multiline model, we must add the requirement that net willingness-to-pay for usage on any switched access line i must not be less than willingness-to-pay for usage on the same line under the original tariff A_o, P_o; i.e., $W_i(q_i) > W_i(q_{io})$ where $q_{io} = q(P_o)$. This requirement is sufficient, but not necessary, for weak Pareto-improvement for any multiline customer since it guarantees, for any fixed level of usage q_i on any owned switched access line, that the perceived level of well-being of its owner will increase. Under this requirement, the equations and results established above for single-line customers can be extended to multiline customers as well. For each switched access line, $P(q)$ declines (possibly through one or more plateaus) to C or C^* depending upon whether d is equal to or less than 1. Plateau and endpoint conditions are the same. As before, bypass will occur if and only if it is economically efficient.

A well-known result in the literature (Willig (1978)) establishes, for deterministic demand[11], that an n-block nonuniform price schedule is equivalent to offering to each customer a menu of n two-part tariffs. Therefore, we can consider the price-capping game in a different manner. Regulators get to set the access and usage prices A_o, P_o for one tariff; the LEC may then design a menu of alternative two-part tariffs. For each switched access line that it owns, each customer may choose any tariff in the menu. Clearly, A_o, P_o serve as a price-cap to ensure that no customer is made worse off as a result.

6. Practical Considerations

We now consider two possible objections to this approach. First, a reseller might take advantage of the utility's declining block tariffs by installing a group of switched access lines and charging prices that are between the customer's price and its own cost. By providing resellers with an arbitrage opportunity, the LEC would lose its own customers. Second, when the LEC can price usage below marginal cost, it may have an incentive to attempt to price service in a predatory manner to destroy current competition.

Regarding resale, if resellers can legally enter the market, they always have the option of concentrating calls over bypass circuits. If the LEC does not implement a nonuniform price schedule (or a menu of two-part tariffs), resale may just as easily result over bypass circuits. By implementing a nonuniform price schedule, the LEC captures as much of the resellers' outgoing circuits as is economically efficient. The issue then is not whether resale will or will not occur; rather, the real issue is whether the resellers that will emerge will use bypass or switched access circuits.

Regarding the predatory pricing issue, the LEC enjoys a positive net contribution from all lines $i < d$; one then should not infer that the utility engages in predatory pricing merely because $P(q) \leq C$ as shown. However, predatory pricing would result if $A + R(q_i) < Z + Cq_i$; this may occur for $i > d$. Although predatory pricing is not profitable if employed indefinitely, a short-run application can nonetheless be profitable if it destroys existing competition. We then must assess whether predatory pricing is a more serious threat under price-caps/deregulation than under regulation.

First, note that if the bypass market were contestable, predatory pricing could never work; once the LEC relaxes its predatory strategy, competitors would immediately reappear. To eliminate competition, the LEC must maintain predatory pricing indefinitely; this is clearly nonprofitable. Since each long-distance carrier would be a potential vendor of bypass technologies, the market for bypass may indeed be contestable.

Second, if predatory pricing is a danger, it is, realistically speaking, just as profound a danger under traditional regulation. Under traditional economic regulation, LECs must report their marginal costs to regulators; regulators may determine whether predatory pricing exists based on these reported costs. If a short-run predatory strategy seems profitable, the LEC can easily distort its reported costs downward; in so doing, it can secure lower usage prices which may effectively stifle competition. It will be next to impossible for regulators to confirm that these reports are fallacious; while believing that they have eliminated predatory pricing, their security will be illusory.

In a different context, Noll and Owen (1987, p. 10) confirm this point:

> The FCC could not determine AT&T's costs, nor could it settle on a sensible cost-based method for pricing. One set of AT&T prices, the Telpak tariff, went through nearly two decades of hearings without a final determination of its lawfulness. It was apparent that evenwith a fully informed regulatory policy and the best will possible, the FCC could not cope successfully within available administrative procedures with AT&T's control of the information necessary to regulate prices effectively.

The problem of predatory pricing does not then depend upon whether traditional regulation or price-capping exists; the nature of the problem arises whenever any firm, regulated or not, has marginal costs that are exceptionally difficult to determine.

7. Conclusion

We can conclude the paper by noting how close the suggested scheme approaches free market competition. Regulators set the prices for one set of tariffs; the regulated utility designs as many alternatives as it chooses. With the exception of the regulators' tariff, the company may set its prices in a manner to maximize profits. In so doing, it will attract only those customers whom it can efficiently serve. Since no prices are cost-based, the utility has the incentive to adopt any cost-reducing innovation in access design if it is profitable; furthermore, because profits are deregulated, the utility has no incentive to cross-subsidize its competitive services with its regulated monopoly services.

ENDNOTES

[1]A price schedule is single-crossing at q_i if, for any i such that $P(q_i) \leq dU_i(q)/dq \big|_{q=q_i}$, $P(q_j) \leq dU_i(q)/dq \big|_{q=q_j}$ for $q_j \leq q_i$ (Goldman, Leland, and Sibley).

[2]Proof by contradiction. Suppose that $P(q_j) \geq P_o$ for all j $\in$ (b, i) and that $P(q_i) > P_o$. Figure 2 displays the relevant demand curves for customers b and i (D_b and D_i), one possible price schedule P(q), and the original usage price P_o. Area ABC (FGC) represents the net consumer surplus that customer b (i) enjoys with utility service; with bypass, customer b (i) would enjoy a net consumer surplus of area ADE (FDH) minus the flat-rate fee Z^*. Since b is original-indifferent, area ADE - A_o = area ABC; therefore, A_o = area BCDE. Since i is original-indifferent, area FDH - A_o = area FGC; therefore, A_o = area GCDH. But area GCDH = area BCDE + area GBEH; unless area GBEH = 0, this equality cannot hold. Area GBEH cannot equal zero if $P(q_j) \geq P_o$ for j $\in$ (b, i). E.O.P.

[3]Proof: From Theorem 1, $P(q_i) \leq P_o$ for some customer i > b. Since the single-crossing assumption implies that P(q) cannot cross D_b twice, P(q) and D_b must coincide from B to E; see Figure 2. At E, consumer b can purchase usage at price P_o, the same as

originally. Since consumer b is original-indifferent, inframarginal payments prior to q_{bo} must be the same under the two alternatives; therefore $A + R(q_{bo}) = A_o + P_o q_{bo}$. E.O.P.

[4]Proof by contradiction. Let i represent the first point ($i > b$) where $P(q_i) < P_o$. Because customer i is original-indifferent:

$$1) \quad U_i(q_i) - R(q_i) - A = U_i(q_{io}) - P_o q_{io} - A_o.$$

We may express:

$$2) \quad R(q_i) = R(q_{bo}) + [R(q_i) - R(q_{bo})]$$
$$= A_o + P_o q_{bo} - A + [R(q_i) - R(q_{bo})],$$

where the second equality follows from Lemma 2.1. Substituting (2) into (1) and rearranging terms yields:

$$3) \quad U_i(q_i) - [R(q_i) - R(q_{bo})] = U_i(q_{io}) - P_o(q_{io} - q_{bo}).$$

Since $P(q_i) < P_o$, $U_i(q_i) > U_i(q_{io})$. Since $P(q) = P_o$ for all q between q_{bo} and q_i, $R(q_i) - R(q_{bo}) \leq P_o(q_{io} - q_{bo})$. But then equality cannot hold in (3), which means $P(q) < P_o$ is not possible. Q.E.D.

Note: If $P(q_i) = P_o$, $U_i(q_i) = U_i(q_{io})$ and $R(q_i) - R(q_{bo}) = P_o(q_{io} - q_{bo})$; (3) would hold.

[5]If $c > b'$, there would be more than one customer intensity that is indifferent between the three alternatives; if customer demand curves do not cross one another, this makes no sense.

[6]Because bypass technologies display increasing returns at some usage levels, we assume that consortia of users can form to exploit optimally any possible economies of scale; alternatively,

users may purchase bypass service from optimally-scaled resellers.

[7] $W_a(q_a) = U_a(q_a) - R(q_a) - A = 0$; therefore, $U_a(q_a) = Z + Cq_a$.

[8] If $d = 1$, $P(q_i) \geq C$ for all q_i; therefore, the statement clearly holds. If $d < 1$, let b represent the first customer i where $P(q_i) < C$. Since $P(q_i) > C$ for all lines $i < b$, $A + R(q_i) > Z + Cq_i$. For lines where $b \leq i \leq d$, $P_i < C$; for the largest of these (d), $A + R(q_d) \geq Z + Cq_d$. Therefore, for all lines i with $b \leq i < d$, $A + R(q_i) > Z + Cq$.

[9] To retain customer $i > d$, the LEC would have to set $P(q_i) = C^* < C$ for all $q_i > q_d$. Since $A + R(q_d) = Z + Cq_d$, $P(q_i) \geq C$ is necessary for all $q_i > q_d$ in order for the utility to break even. This is clearly impossible if $P(q_i) = C^*$.

[10] Because of the last assumption (which is not necessary in a single-line model), the marginal usage price on any switched access line monotonically decreases as more calls are routed over it; consequently, a profit-maximizing customer should always concentrate usage by routing calls over his available circuits in an unchanged order. He can then unambiguously rank his circuits by his intensity of usage. Each customer would then convert the most heavily used circuits to bypass.

[11] When customers choose from a menu of two-part tariffs, they must do so based on expected line usage. When demand is stochastic, usage on a line in a particular time period may be above or below its expected value; consequently, the selected two-part tariff might not "fit" the usage pattern. Nonuniform price schedules have the benefit of automatically "switching" the line to the appropriate tariff based on ex post usage.

APPENDIX A

This appendix demonstrates that bypass will occur if and only if it is economically efficient.

Customer i will strongly prefer switched access (bypass) if:

1) $U_i(q_i) - A - R(q_i) > (<) U_{i*}(q_{i*}) - Z^* - C^* q_{i*}$.

To be economically efficient, customer i should choose switched access (bypass) if:

2) $U_i(q_i) - Z - Cq_i > (<) U_{i*}(q_{i*}) - Z^* - C^* q_{i*}$

a. Suppose that $d < 1$. For all customers $i < d$ who prefer switched access, $A + R(q_i) > Z + Cq_i$ (see footnote 8). Therefore, $U_i(q_i) - Z - Cq_i > U_i(q_i) - A - R(q_i)$. Since eq. (1) must hold with a > sign for these customers i, $U_i(q_i) - Z - Cq_i > U_{i*}(q_{i*}) - Z^* - C^* q_{i*}$. From eq. (2), this is socially optimal.

To retain customers $i > d$, the LEC must price usage above q_d at C^* ($< C$). Since these customers will be large-indifferent,

3) $U_i(q_i) - A - R(q_i) = U_{i*}(q_{i*}) - Z^* - C^* q_{i*}$.

Since $P_i = C^*$ for $i > d$, $q_i = q_{i*}$ and $A + R(q_i) = A + R(q_d) + C^*(q_i - q_d) = Z + Cq_d + C^*(q_i - q_d) < Z + Cq_i$; the second equality follows from eq. (5.5b). Therefore, $U_i(q_i) - Z - Cq_i < U_i(q_i) - A - R(q_i)$. From (3), $U_i(q_i) - Z - Cq_i < U_{i*}(q_{i*}) - Z^* - C^* q_{i*}$. Consumers $i > d$ should then choose bypass (see eq. (2)).

b. When $d = 1$, if $P(q)$ hits a plateau, it will do so at $C^* > C$; $P(q)$ then falls to marginal cost C. From footnote 8, $A + R(q_i) > Z + Cq_i$. Therefore, $U(q_i) - A - R(q_i) < U(q_i) - Z - Cq_i$.

Since customer i voluntarily foregoes bypass, eq. (1) holds with a > sign. It immediately follows that eq. (2) holds with a > sign as well; each customer's decision to bypass is economically efficient.

BIBLIOGRAPHY

Baron, D.P. (1987), "Information, Incentives, and Commitment in Multiperiod Regulatory Mechanisms", Stanford University, Palo Altoc, California, unpublished manuscript.

Brennan, T.J. (1987), "Capping 'Average' Prices of Regulated Multiproduct Firms", George Washington University, Washington, D.C., unpublished manuscript.

Egan, B.L., and W. E. Taylor (1987), "The Economics of Ceiling Price Regulation", Bell Communications Research, Livingston, New Jersey, unpublished manuscript.

Einhorn, M.A. (1987), "Optimality and Sustainability: Regulation and Intermodal Competition in Telecommunications", Rand Journal of Economics, forthcoming, Winter, 1987.

Faulhaber, G.R., and J.C. Panzar (1977), "Optimal Two-Part Tariffs with Self-Selection", Bell Laboratories Economic Discussion Paper #74.

Federal Communications Commission (1987), In the Matter of Policy and Rules Concerning Rates for Dominant Carriers, Notice of Proposed Rulemaking, CC Docket No. 87-313.

Goldman, M.B., H.E. Leland, and D.S. Sibley (1984), "Optimal Nonuniform Prices", Review of Economic Studies, pp. 305-19.

Haring, J., and E. Kwerel (1987), "Competition Policy in the Post-Equal Access Market", FCC Docket DA 87-211, Issued: February 11, 1987, Released: March 11, 1987.

Linhart, P.B., and R. Radner (1986), "Relaxed Regulation of AT&T, Reconsidered", AT&T Bell Laboratories, Murray Hill, New Jersey, unpublished manuscript.

Linhart, P.B., R. Radner, and F. W. Sinden (1987), "A Sequential Mechanism for Direct Price Regulation", AT&T Bell Laboratories, Murray Hill, New Jersey, unpublished manuscript.

Littlechild, S.C., (1983), Regulation of British Telecommunications Profitability: A Report to the Secretary of State for Trade and Industry.

Mirman, L.J., and D. S. Sibley (1980), "Optimal Nonuniform Pricing for Multiproduct Monopolies", Bell Journal of Economics, pp. 659-70.

National Telecommunications and Information Administration, (1987), Regulatory Alternatives Report, U. S. Dept. of Commerce, July, 1987.

Noll, R. G., and B. M. Owen (1987), "United States v. AT&T: An Interim Assessment", Stanford University, Palo Alto, California, Working Paper.

Spence, A.M. (1977), "Nonlinear Prices and Welfare", Journal of Public Economics, pp. 1-18.

Schmalensee, R. (1981), "Monopolistic Two-Part Pricing Arrangements", Bell Journal of Economics, pp. 445-66.

Vickers, J., and G. Yarrow (1988), Privatizaton in Britain, MIT Press, Cambridge, Mass., forthcoming.

Vogelsang, I. and J. Finsinger (1979), "A Regulatory Adjustment Process for Optimal Pricing by Multiproduct Monopoly Firms", Bell Journal of Economics, pp. 157-71.

Vogelsang, I. (1987), "A Non-Bayesian Incentive Mechanism Using Two-Part Tariffs", Rand Corportion, Los Angeles, California, unpublished manuscript.

Willig, R., (1978), "Pareto-Superior Nonlinear Outlay Schedules", Bell Journal of Economics, Spring, 1978, pp. 56-69.