Network Access Pricing and Deregulation

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The paper addresses the question of pricing access to the network facilities of an incumbent firm after deregulation. Network access pricing continues to be regulated in such industries as telecommunications, railroads, electric power and natural gas. We emphasize that access prices should be set such that they satisfy an individual rationality condition for the incumbent firm so that access is granted voluntarily. We examine the effects of the voluntary access condition on incentives for entry and show that properly chosen access prices provide incentives for efficient entry using several alternative competition models: Bertrand–Nash, Cournot–Nash and Chamberlin competition with differentiated products.

1. *Introduction*

Deregulation of network industries, including telecommunications, railroads, electric power and natural gas, raises an important question: how should access to the networks of the incumbent utilities be priced? If access is priced too high, efficient entry may be discouraged and duplicative facilities will be created to bypass the existing network. If access is priced too low, excessive entry and congestion may result, and the incumbent utility might fail to cover its costs. Because access pricing affects the market equilibrium after deregulation, the level of access prices also affects consumer welfare. As deregulation proceeds, regulators continue to regulate network access pricing. The key issue is how to balance the interests of consumers, incumbent firms and entrants with incentives for entry. Our analysis emphasizes that access prices should be set such that they satisfy an individual rationality

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condition for the incumbent firm so that access is granted voluntarily. We examine the effects of the voluntary access condition on incentives for entry and show that properly chosen access prices provide incentives for efficient entry.

The Telecommunications Act of 1996 mandated interconnection through unbundling of network elements and resale of services of the local exchange carriers. The Federal Communications Commission (FCC) interpreted these important provision of the Act in its *First Report and Order*. The US Court of Appeals for the Eighth Circuit in July 1997 vacated the pricing provisions of the *First Report and Order*, holding that 'the FCC exceeded its jurisdiction in promulgating the pricing rules regarding local telephone service' (1997 US Appl. LEXIS 18183 at *7). The court affirmed key provision of the order that did not concern pricing. Moreover, the court did not consider whether the FCC's unbundling rules effected a taking, because the court ruled the question not yet ripe for adjudication. It appears likely that property rights issues surrounding the pricing of unbundled network elements will be the subject of further negotiation and legal action between the FCC and local exchange companies.

In this context, the voluntary access condition plays a crucial role. If access pricing satisfies the voluntary access condition, as examined in the present paper, then it is reasonable to conclude that such pricing does not effect a taking. The *equivalence principle*, introduced by Sidak and Spulber (1996), shows that there is an equivalence between the regulated firm's opportunity cost and (i) damages for breach of the regulatory contract; (ii) just compensation for a regulatory taking; (iii) the change in investor valuation of the utility after deregulation; and (iv) pricing policies that promote efficient entry and interconnection in network industries opened to competition. Constitutional protections for private property and the regulatory contract support consideration of pricing when access to the incumbent's network is voluntary.

The question of whether voluntary access pricing allows efficient entry and downward pricing flexibility is controversial. If voluntary access pricing does not allow prices to fall or deter efficient entry then such pricing would contradict the stated intent to promote competition of the 1996 Telecommunications Act. Our analysis shows that voluntary access pricing is consistent with falling prices and competitive entry under several competitive scenarios.

We examine network access pricing using several alternative competition models: Bertrand–Nash, Cournot–Nash and Chamberlin competition with differentiated products. In each of these settings, some common points emerge. First, the access price that maximizes social benefits subject to the incumbent's individual rationality condition provides incentives for efficient entry. The access charge allows entry to take place if and only if the regulated output can be produced at a lower cost by more efficient competitors. Second, the access charge is consistent with price reduction and output expansion relative to the regulated price and output. By expanding output, entry lowers the incumbent's per-unit opportunity cost and thus lowers the access charge. Third, efficient entry strictly increases social welfare. Finally, the equilibrium access charge is compared with the well-known contestable markets benchmark case in which the regulated price does not change with entry and the access charge equals the regulated firm's mark-up. In each of the market structures considered in this paper, the equilibrium access charge is lower than the benchmark.

Our analysis allows an explicit specification of the access charge that can be used to evaluate incentives for entry and welfare effects. We consider an incumbent that offers a service that it produces itself and delivers over its own transmission network. Deregulation then takes a specific form. Regulatory entry barriers are removed and regulators set an access charge for the incumbent's network. Access refers to originating and terminating calls in telecommunications, trackage rights in railroads, retail and wholesale wheeling in electric power, and transmission in natural gas. Entrants supply a final service (such as local toll calling, rail transport, delivered bulk power or delivered natural gas) in competition with the incumbent and transmit the service over the incumbent's network. Selling access entails opportunity costs for the incumbent because more efficient competitors displace sales of the incumbent's final service. We derive an access charge as the price that maximizes social benefits subject to the incumbent's individual rationality condition.

The expansion of output that occurs in the Bertrand–Nash case confirms Laffont and Tirole's (1994) observation that under certain conditions the initial price is irrelevant. If there is entry, entrants do not have market power and products are perfect substitutes, the incumbent should supply only access if entrants are more efficient, or the incumbent should supply no access if it is more efficient than entrants. The initial price matters in general, however. In the Cournot–Nash case, for example, the difference between the benchmark case and the equilibrium access charge is due to an adjustment for entry costs.

Our analysis extends research on the efficient component-pricing rule (ECPR), also known as the imputation requirement, the principle of competitive equality and the parity principle.[1] The ECPR, due to Willig (1979) and Baumol (1983), and elaborated on by Baumol and Sidak (1994a,b), specifies the access price as the sum of incremental costs and opportunity costs. Other proponents include Kahn and Taylor (1994), MacAvoy (1996) and Sidak and Spulber (1997). In a later section we examine criticisms of ECPR pricing (see Tye, 1994; Ergas and Ralph, 1994; Economides and White, 1995).

Our analysis differs from the existing literature because we consider a more general specification of market competition. Moreover, our model emphasizes efficiency of incentives for entry under voluntary exchange. In this regard, it differs from Laffont and Tirole (1994, 1995) and Armstrong *et al.* (1995), who examine Ramsey–Boiteux pricing as a means of carrying out a second-best allocation of network fixed costs between the incumbent's final output price, the access charge and the competitor's final output price. The Ramsey–Boiteux prices depend on elasticities of demand for the final output as well as for the network input. Laffont and Tirole (1994) select optimal access charges that depart from the marginal cost of access due to the cost of public funds needed to cover fixed cost. The Laffont and Tirole analysis considers a more general asymmetric information model, while information issues are beyond the scope of this paper. Armstrong *et al.* (1995) impose a standard break-even constraint and show that the second-best optimal access price involves a mark-up over the marginal cost of access only if the break-even constraint binds. They conclude that if the incumbent's technology has increasing returns to scale, the access charge is set in excess of marginal cost, assuming uniform pricing and ruling out lump sum transfers.

Our model addresses three useful 'quibbles' (their term) raised by Laffont and Tirole (1995) regarding access pricing. They suggest first that the contestable markets paradigm is of limited value in evaluating access pricing because it neglects the possibility of entrants having superior technology, or other factors that create benefits from competition. To address this issue, we allow entrant and incumbent technologies to differ and examine entry in Bertrand, Cournot and Chamberlin settings. Second, they state that the

[1] There has been some discussion of access pricing in regulatory proceedings. In 1995, the Judicial Committee of the Privy Council of the House of Lords held in *Telecom Corp. of New Zealand Ltd.* v. *Clear Communications Ltd.* that an incumbent local exchange carrier's use of the ECPR conforms with New Zealand antitrust principles concerning abuse of a dominant position. With the enactment of the Telecommunications Act of 1996, the Federal Communications Commission and every state public utility commission considered efficiency questions in evaluating the ECPR for the pricing of interconnection and unbundled access to network elements in local telephony. Similarly, the Federal Energy Regulatory Commission and the state public utility companies are examining whether the ECPR is appropriate for pricing the transmission of electric power.

ECPR is 'only a partial rule as it does not specify how to determine the telephone operator's prices on the competitive segment'. In our framework, the access pricing is not a 'partial' rule because competition determines prices of the final service endogenously. Finally, they question whether it makes sense to propose a general access pricing rule without consideration of the market environment—for example, without considering product differentiation and cost differences. Our analysis confirms the need to adjust the access charge to account for the effects of product differentiation and cost differences on the market outcome.

The paper is organized as follows. Section 2 sets out the basic framework. Section 3 examines access pricing with Bertrand–Nash competition. Section 4 considers access pricing with Cournot–Nash competition. Section 5 introduces competition with differentiated products. Section 6 compares our results with a benchmark case and examines criticisms of that benchmark case. Section 7 presents our conclusions.

2. *The Basic Framework*

This section presents a model of deregulation with network access. An incumbent utility provides a service that it delivers by means of a transmission or transportation network. Initially, the incumbent is the sole supplier of the service, which is sold as a bundle with transmission. After deregulation occurs, entrants obtain access to the incumbent's transmission network and supply the final service in competition with the incumbent. We do not consider competition between network providers, so that the incumbent remains the sole provider of transmission.

The Incumbent Firm

Let Q be the final service and assume that each unit of service requires exactly one unit of transmission, so that transmission is an input to the production of the service. The incumbent's unit cost of producing the service is c and the unit cost of producing transmission is b. Thus, the incumbent's total costs are $(c + b)Q$.

The price of the final service is P and $Q = D(P)$ is the market demand for the service. Let $R(P)$ represent the incumbent's net revenue or *quasirent* from the service,

$$R(P) = (P - c - b)D(P) \tag{1}$$

Assumption 1. Market demand, $Q = D(P)$, is twice differentiable and decreasing with inverse demand $P = P(Q) = D^{-1}(Q)$. Revenue is a concave function of output, $P''(Q)Q + 2P'(Q) < 0$.

Before deregulation, the price of the service is P_0 and the incumbent's output is $Q_0 = D(P_0)$, so that the incumbent's initial quasirent is $R_0 = R(P_0)$. The framework is sufficiently general to allow the initial price to take any value between the short-run competitive price, $P_C = c + b$, and the monopoly price, defined by $R'(P_M) = 0$.

After deregulation, the market price for the final service equals P. The total output of entrants is X and the incumbent's residual demand is $D(P) - X$. Thus, excluding the net returns from providing access, the incumbent earns quasirent $R_1 = R_1(P)$,

$$R_1(P) = (P - c - b)(D(P) - X) \tag{2}$$

The incumbent firm's *opportunity cost* of supplying access equals the change in the incumbent's quasirent as a consequence of entry, $\Delta = R_0 - R_1$.

Letting A be the price of access, the incumbent's net earnings from the sale of X units of access are $(A - b)X$. Entry affects the incumbent's earnings both through the market price and the displacement of sales. The incumbent will not accept a competitor's offer to purchase access unless the net access revenue equals or exceeds the opportunity cost of supplying access to the network.

Assumption 2. The incumbent access supply decision is voluntary.

Thus, for the incumbent to supply access, *individual rationality* requires that the access price satisfies the *voluntary access condition*:

$$(A - b)X \geq \Delta \tag{3}$$

The voluntary access condition can constrain the welfare-maximizing access price. If the opportunity cost of providing access is positive due to falling quasirents, the access price must exceed the unit cost of supplying access. In equilibrium, the incumbent firm's opportunity cost Δ depends on A through the market price and displacement effect.

Entrants

Entrants supply the final service by relying on access to the incumbent's network for transmission of the service to final customers. Entrants incur a cost of producing the final service equal to g, which differs from the incumbent's cost c due to differences in technology, input costs or regulations faced by the two types of firms.

If the post-entry equilibrium is well defined, the post-entry price and the sales of the incumbent and entrant will depend on the access charge, that is, $P(A)$ and $X(A)$. In what follows, the post-entry equilibrium will be defined for Bertrand, Cournot and Chamberlin competition. Entrants earn post-entry profits equal to

$$\Pi(A) = (P(A) - g - A)X(A) \tag{4}$$

We examine the consequences for access pricing of efficiency gains from entry. Entrants can provide the service at lower cost than the incumbent, $g < c$.

Regulators do not permit the price to rise above its initial level P_0, although entry can occur at the initial price by displacing the sales of the incumbent. Regulators further require that the incumbent supply the service through an independent subsidiary that pays the same access charge as entrants do for using the network.[2] The incumbent's deregulated affiliate can be one of the competitive entrants without affecting the analysis. Thus, it is reasonable to assume that if the equilibrium price is less than or equal to the regulated price, entry occurs and entrants fully displace the incumbent's sales.[3] If the equilibrium price exceeds the regulated price, then the market price is the regulated price P_0. If entry occurs at that price, entrants displace the incumbent firm's sales at the regulated price. If entry does not occur, the incumbent continues to supply the initial output, Q_0, that is demanded at the regulated price.

Regulation of the Access Charge

The sequence of events is a follows. Prior to deregulation, the incumbent sells the service at price P_0. Then, the regulator chooses the access charge A. Entry

[2] Deregulation may require the incumbent to supply access to entrants on the same terms as it does to itself (see, for example, Section 251 of the Telecommunications Act of 1996.

[3] In the market for interstate natural gas, the major interstate pipelines became transporters of natural gas almost exclusively after the spot and contracts markets for gas displaced their merchant services (see Doane and Spulber, 1994). The interstate pipelines have continued to provide some merchant services through marketing affiliates. The case of full displacement is also consistent with the case of partial deregulation, with the incumbent being displaced only from the deregulated or 'noncore' portion of the market while it continues to serve regulated or 'core' customers. The incumbent's subsidiary has the same operating cost as entrants, presumably because the incumbent avoids costly regulatory constraints and can employ the same technology as entrants.

takes place and the market price is P. When products are homogeneous, social benefits after entry equal

$$W(A) = \int_{P(A)}^{\infty} D(z)\,dz + R_1(P(A)) + (A-b)X(A) + \Pi(A) \tag{5}$$

The policy-maker's problem is to select an access price that maximizes social benefits subject to the incumbent's voluntary access condition (3). The policy-maker's problem is therefore

$$\max_A W(A) \text{ subject to } (A-b)X \geq \Delta \tag{6}$$

In what follows, we will characterize the solution to the policy-maker's problem for both homogeneous and differentiated products. We contrast the unconstrained welfare maximum with the constrained problem, and show that the voluntary access constraint is binding.

In addition to determining the welfare-maximizing network access charge, we examine the welfare effects on entry at the constrained-optimal access charge. The social welfare effect of entry equals the change in consumer and producer surplus. Because regulation caps the price at the initial price level P_0, the post-entry price must be less than or equal to the initial price. Initial welfare is

$$W_0 = \int_{P_0}^{\infty} D(z)\,dz + R_0 \tag{7}$$

Define $G = W(A) - W_0$ as the welfare effect of entry with a binding access constraint,

$$G(A) = \int_{P}^{P_0} D(z)\,dz + \Pi(A) \tag{8}$$

Since entry only occurs if the entrant's profit is non-negative, it follows that if the voluntary access constraint is binding, the welfare gain from entry is non-negative. In what follows, we show that the welfare gains are strictly positive if entry occurs.

3. *Bertrand–Nash Competition*

The Bertrand–Nash case has *not* been examined before in the literature. The contestable markets case that has been the standard approach has generally assumed that prices remain at the pre-existing regulated price (see the discussion of the benchmark case in Section 6). In contrast, in the model considered here, the price falls to the entrant's unit cost. We assume that there are multiple entrants who engage in Bertrand–Nash price competition with the incumbent. Entrants thus are able to displace fully the incumbent's sales of the service when their operating cost g plus the network access charge is less than the incumbent's unit cost, $c + b$. Price competition then reduces the final output price to the unit cost for an entrant,

$$P^{B} = A + g \tag{9}$$

Entry occurs if the Bertrand–Nash price in equation (9) falls below the initial regulated price. Entrants sell total output equal to $X^{B}(A) = D(P^{B}) = D(A + g)$ and earn zero profit.

Since the incumbent's sales are displaced, the incumbent's quasirent is zero and opportunity cost exactly equals the initial quasirent, $\Delta = R_0$. Therefore, the regulator chooses the access charge A to maximize welfare,

$$W(A) = \int_{P^{B}}^{\infty} D(z)\mathrm{d}z + (A - b)D\left(P^{B}\right) \tag{10}$$

subject to the voluntary access condition $(A - b) \geq R_0$.

Proposition 1. (i) Under Bertrand–Nash price competition with entry, the unconstrained welfare-maximizing access charge is equal to marginal cost, b. (ii) Under Bertrand–Nash price competition with entry, the voluntary access constraint is binding for the regulator's problem (10), so that the unique constrained optimal access charge solves

$$A^{B} = b + R_0/D(A^{B} + g) \tag{11}$$

The proof is given in the Appendix.

The proof of Proposition 1 shows that the inverse demand $P(Q)$ crosses the average net revenue R_0/Q from above. We apply this result to establish the following.

Proposition 2. If the market equilibrium is Bertrand–Nash with entry and the access charge maximizes welfare subject to the voluntary access condition, the following hold. (i) Entry occurs if and only if the entrant's operating costs are lower than those of the incumbent, $g < c$. (ii) The welfare effects of entry are strictly greater than zero,

$$G = \int_{P^B}^{P_0} D(z)\mathrm{d}z > 0$$

To establish Proposition 2, note that $P^B < P_0$ if and only if

$$g + b + R_0/D(P^B) < c + b + R_0/D(P_0)$$

Since demand cuts the average revenue curve from above, the same inequality holds if and only if the entrants unit cost is less than the incumbent's unit cost, $g < c$. Thus, if entry occurs the price falls. The welfare gain equals G because the voluntary access condition is strictly binding. Thus, the welfare gain is positive.

Proposition 2 shows that the access price satisfies the efficient entry condition and entry enhances social welfare because the market price of the service falls. The proposition is illustrated in Figure 1.

From equations (9) and (10), the access price equals the margin of the entrant,

$$A^B = P^B - g \tag{12}$$

Notice that it is the *entrant*'s cost rather than the incumbent's cost that is subtracted from the equilibrium price. This contrasts with the benchmark case in the literature that we examine later on. Alternatively, the efficient access price can be represented as a weighted average of the cost of access and the regulated margin,

$$A^B = b\left(1 - \frac{Q_0}{X^B}\right) + \left(P_0 - c\right)\frac{Q_0}{X^B} \tag{13}$$

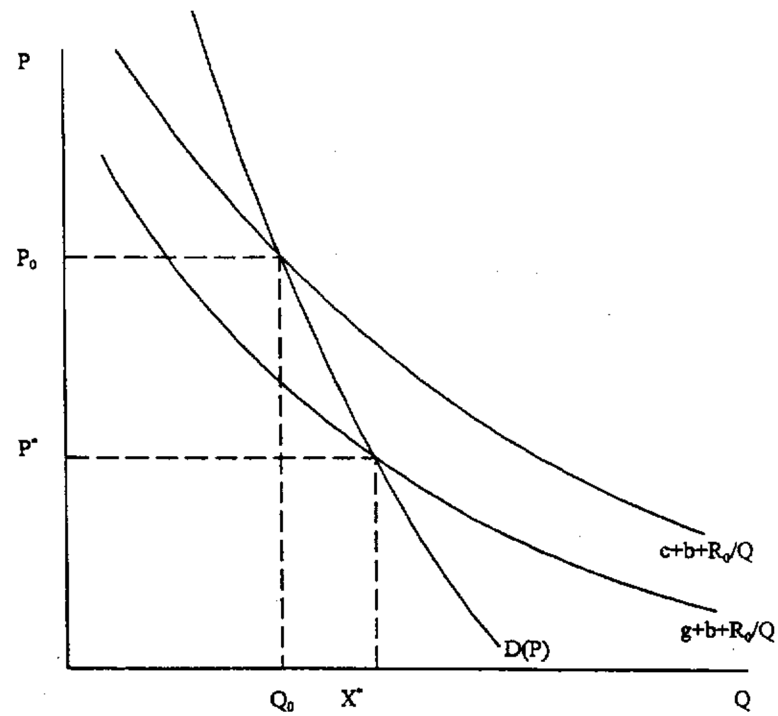

FIGURE 1. The Bertrand–Nash equilibrium price and output.

Under Bertrand–Nash price competition with entry, the decline in the market price is due to the lower cost of more efficient entrants and to the additional scale economies achieved through higher sales. The expansion of demand allows the recovery of the incumbent's opportunity costs to be spread over more units of output.

Proposition 3. In the Bertrand–Nash equilibrium, the access price A^B and the market price P^B are increasing in the entrant's cost g.

Therefore, the more efficient are the entrants, that is, the lower g, the lower will be the equilibrium price, and the greater will be output and the corresponding demand for access. This allows the access price to be lower while still satisfying the voluntary access condition. To show this result, differentiate equation (11),

$$\frac{\partial A^B}{\partial g} = \frac{R_0 D'(P)}{\left(D(P)\right)^2 + R_0 D'(P)}$$

Thus, the access price is increasing in g, since $R_0 D'(P^B)/[D(P^B)]^2 > -1$, as shown earlier.

4. *Cournot–Nash Competition*

This section examines network access pricing when entrants must make capacity commitments at cost g per unit of output and entrants incur set-up costs f. The post-entry market equilibrium is modeled as a Cournot–Nash game representing capacity competition.[4]

The Cournot–Nash equilibrium of the capacity game between entrants has the standard representation. An entering firm maximizes profit by choosing output q given the equilibrium output of the other firms Q_-, where profit is defined by

$$\Pi(q,Q_-^C) = (P(q + Q_-^C) - g - A)q - f$$

The Cournot–Nash equilibrium output per firm, q^C, solves the first-order condition.

$$P'(nq^C)q^C + P(nq^C) - g - A = 0 \tag{14}$$

The following assumption is used to define the equilibrium access charge.

Assumption 3. The following condition holds:

$$P''(X)X^2/2n + P'(X)X + R_0/X < 0 \tag{15}$$

This condition is sufficient for the firm's second-order condition to be satisfied because $P''X/n + 2P' < -R_0/X^2 < 0$.

Let X^C represent industry output and let n^C be the number of firms including the incumbent's subsidiary. Then, the Cournot–Nash equilibrium with entry (X^C, n^C) is defined by the first-order condition for firm profit maximization and the entry condition.

$$P'(X^C)X^C + n^C(P(X^C) - g - A) = 0 \tag{16}$$

[4] Kreps and Scheinkman (1983) show that with a particular rationing rule, the Nash equilibrium of a two-stage capacity investment duopoly, with price competition in the second stage, yields the Cournot–Nash outcome. They apply the efficient rationing rule, which specifies that a firm's residual demand equals market demand net of the other firm's capacity. In contrast, Davidson and Denekere (1986) show that the Cournot–Nash outcome fails to occur with different rationing rules.

$$(P(X^C) - g - A)X^C - n^C f = 0 \tag{17}$$

The equilibrium values (X^C, n^C) are uniquely determined by the access price A. A higher access charge reduces industry output,

$$dX^C/dA = 2/[P''(X^C)X^C/n^C + 2P'(X^C)] \tag{18}$$

The derivative is negative by the second-order condition for the individual firm maximization problem.

Entrants, including the incumbent's competitive subsidiary, earn zero profit. The incumbent's opportunity cost equals the initial net revenue minus the net earnings of the subsidiary, $\Delta = R_0$. The social welfare function is therefore

$$W(A) = \int_{P^C}^{\infty} D(z)dz + (A - b)D(P^C) \tag{19}$$

The regulator's welfare maximization problem is to maximize $W(A)$ subject to the voluntary access condition $(A - b)X^C \geq R_0$.

Proposition 4. (i) Under Cournot–Nash competition with entry, $X^C(A)$, $n^C(A)$, the unconstrained welfare-maximizing access charge solves

$$A^* = b - P''(X^C(A^*))(X^C(A^*))^2/2n^C(A^*) \tag{20}$$

so that A^* is greater than (less than) b if P'' is less than (greater than) zero.

(ii) Under Cournot–Nash competition with entry, $X^C(A)$, $n^C(A)$, the voluntary access constraint is binding for the regulator's problem if

$$-P''(X^C(A^*))(X^C(A^*))^2/2n^C(A^*) < R_0/X^C(A^*) \tag{21}$$

so that the unique constrained optimal access charge solves

$$A^C = b + R_0/X^C(A^C) \tag{22}$$

Otherwise, if equation (21) does not hold, the optimal access charge equals $A^* \geq A^C$.

The proof is given in the appendix.

Proposition 4 shows that the welfare-maximizing access charge can be greater than or less than the unit cost of access. It exactly equals the unit cost of access for linear demand. Condition (21) holds for all linear or convex demand functions, and serves as a lower bound on the second derivative of a concave demand function. Also, the proposition establishes that the welfare-maximizing access charge can *exceed* the charge that solves the voluntary access condition. This is the case when a high post-entry output, high output per firm or high $-P''$ makes the term $(-P'')(X^C)^3/2n^C$ larger than the incumbent firm's initial quasirent.

Consider next the welfare effects of entry and the incentives from network access pricing. We first solve for the Cournot equilibrium with entry, X^C, n^C, by substituting for the access charge from equation (22) into equations (16) and (17),

$$P'(X^C)X^C + n^C(P(X^C) - g - b - R_0/X^C) = 0 \tag{23}$$

$$(P(X^C) - g - b - R_0/X^C)X^C - n^C f = 0 \tag{24}$$

The equilibrium depends on initial quasirent R_0 and the cost parameters g, b and f.

The welfare effects of entry are now examined for the Cournot–Nash equilibrium.

Proposition 5. (i) Entry occurs under Cournot–Nash competition if and only if the cost savings on production of the service cover the cost of entry, $(c - g)Q_0 \geq n^C f$. (ii) The welfare effects of entry are positive,

$$G = \int_{P^C}^{P_0} D(z)\mathrm{d}z > 0$$

The proof is given in the appendix. The demonstration that $P^C < P_0$ and $X^C > Q_0$ is illustrated in Figure 2.

The access pricing rule is said to be efficient because it permits cost-saving entry. Entry reduces costs if the cost savings on the regulated firm's output outweigh total entry costs, where n is the equilibrium number of entrants, including the incumbent's subsidiary. As in the Bertrand–Nash case, entry can change the industry output and price. The condition does *not* state that entry occurs for any pair of entry costs f and market structure n. Rather, the market structure must be an equilibrium that is consistent with entry costs and the access pricing rule. Thus, given the network access pricing rule, entry

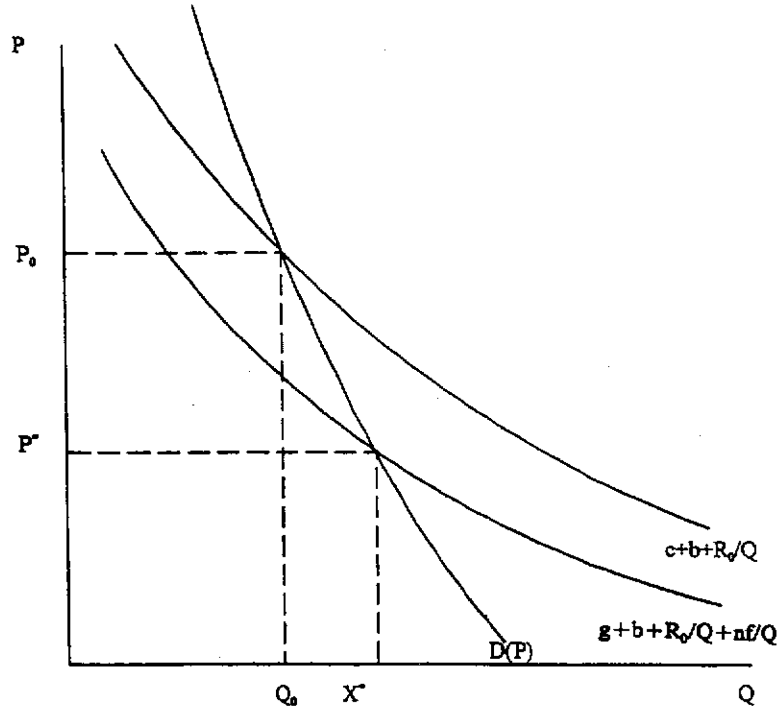

FIGURE 2. The Cournot–Nash equilibrium price and output.

is efficient if the equilibrium number of firms can produce the incumbent's output at lower cost.

The more cost-efficient entrants are, the lower will be the access charge and the Cournot–Nash equilibrium price.

Proposition 6. In the Cournot–Nash equilibrium, the access price A^C and the market price P^C are increasing in the entrant's operating cost g and setup cost f.

The result holds because $\partial X^C/\partial g < 0$ and $\partial X^C/\partial f < 0$, by Assumption 3. The access charge can be represented in two other ways. From the Cournot–Nash entry condition, equation (21), the access charge equals

$$A^C = P^C\left(1 - \frac{1}{n^C\eta}\right) - g \tag{25}$$

where $\eta = -D'(P^C)P^C/X^C$ is the elasticity of market demand. Alternatively, using the entry condition equation (21), subtract per-unit entry cost from the entrant's mark-up,

$$A^C = P^C - g - f/(X^C/n^C)$$

The access charge is less than the mark-up over marginal cost to account for entrants' operating profits, or equivalently, to account for entry costs. Therefore, given capacity competition and entry costs, the network access charge should reflect the cost of entry per unit of output.

5. *Product Differentiation*

In this section, we consider a market equilibrium with product differentiation. We apply the Perloff and Salop (1985) differentiated products model, which combines elements of the Hotelling (1929) spatial competition model and the Chamberlin (1933) competition model. Because total consumption remains constant, firms compete for market shares. We show that there are incentives for efficient entry and that entry improves social welfare. That is, prices fall below the regulated level if and only if there are cost savings at the monopoly output. Cost savings occur when operating cost savings at the regulated firm's output level exceed total entry costs.

There are L consumers each of which purchases one unit of service. Before deregulation, all consumers purchase the incumbent's brand. There are L consumers, so that with universal service, $Q_0 = L$. Initial quasirent equals $R_0 = (P_0 - c - b)L$. After deregulation, the incumbent's brand competes with those of new entrants. Assume that the incumbent pays the same access charge as entrants do for using the network. The incumbent supplies the final product through an independent subsidiary that has the same operating and set-up costs as entrants. Because entrants earn zero profit in equilibrium, the incumbent's voluntary access condition is $(A - b)L \geq R_0$.

Each entrant offers a different brand, $i = 1, 2, \ldots, n$. Each of the L consumers has a preference vector that assigns relative values to each of the brands, $\theta = (\theta_1, \theta_2, \ldots \theta_n)$. Given n brands from which to choose, the consumer purchases the brand that maximizes his surplus,

$$s_i = \theta_i - p_i, \qquad i = 1, \ldots n \tag{26}$$

where p_i is the price of brand i and s_i is the surplus from purchasing brand i. Consumers purchase the best buy, regardless of whether surplus may be negative.

Each of the elements of a consumer's preference vector, θ_i, are independent draws from the uniform distribution on the unit interval. Also, the preference vectors of each consumer are statistically independent from each other. Define a function $I(x)$ such that $I(x) = 0$ if $x < 0$, $I(x) = x$ if $0 \leq x \leq 1$ and $I(x) = 1$ if $x > 1$. Then, the demand for firm i's brand equals

$$D_i(p_1, p_2, \ldots, p_n) = \Pr\left(s_i \geq \max_{j \neq i} s_j\right)L = \int_0^1 \prod_{j \neq i}^{n} I\left(\theta_i - p_i + p_j\right) d\theta_i L \quad (27)$$

Firms choose prices to maximize profits in a Bertrand–Nash equilibrium. Profits are defined by

$$\Pi_i(p_1, p_2, \ldots, p_n) = (p_i - g - A)D_i(p_1, p_2, \ldots, p_n) - f \quad (28)$$

The first-order conditions at the Nash equilibrium are determined by maximizing over p_i in equation (28), taking as given the equilibrium values of p_j, $j \neq i$. The first-order conditions are

$$\left(p_i * - g - A\right)\frac{\partial D_i\left(p_1 *, p_2 *, \ldots, p_n *\right)}{\partial p_i} + D_i\left(p_1 *, p_2 *, \ldots, p_n *\right) = 0 \quad (29)$$

Following Perloff and Salop, we restrict attention to single-price equilibria and show that if such an equilibrium exists, it is unique. Thus, in equilibrium all prices are equal, $p_i^* = P$, $i = 1, \ldots, n$, and output per brand is Q_i, which equals

$$Q_i = D_i\left(p_1 *, p_2 *, \ldots, p_n *\right) = L\int_0^1 \theta_i^{n-1} d\theta_i = \frac{L}{n} \quad (30)$$

The slope of each brand's demand curve is

$$\frac{\partial D_i}{\partial p_i} = -(n-1)\int_0^1 \theta_i^{n-2} d\theta_i = -L \quad (31)$$

The first-order condition for each firm's profit maximization problem then is simply $p_i(1 - 1/\eta_i) = g + A$. Substitute from equations (30) and (31) to calculate the elasticity of demand, $\eta_i = np_i$. Let P^D, n^D denote the equilibrium price and market structure in the Perloff–Salop differentiated products model. The equilibrium price equation is therefore

$$P^D = g + A + 1/n^D \qquad (32)$$

Now consider entry of firms, each of which supplies a different product. Entry drives profits to zero,

$$(P^D - g - A)(L/n^D) = f \qquad (33)$$

Combine the price condition (32) and the zero-profit entry condition (33) to solve for the equilibrium price and market structure. The equilibrium number of firms does not depend on the access charge, $n^D = (L/f)^{1/2}$. The equilibrium price is $P^D = g + A + (f/L)^{1/2}$.

With competition, each consumer purchases the brand that yields the greatest surplus. At the single-price equilibrium, the expected value of the best buy for any consumer is the expected value of the maximum-order statistic, which equals $n/(n + 1)$ for a sample of size n from the uniform distribution. Thus, the total expected net consumers' surplus under competition is

$$S = (n^D/(n^D + 1) - P^D)L \qquad (34)$$

Consider now the regulator's welfare function. Entrant profits are zero, so that producers' surplus equals access revenues, $(A - b)L$. If consumers' surplus and producer surplus were weighted equally, social welfare would not be affected by the access charge because of the model's demand assumptions and the equal weighting of consumer and producer surplus. This is because the access charge terms cancel out when adding consumer and producer surplus, and substituting for P^D. To examine the effects of access charges on net benefits, suppose that the regulator places a greater weight on consumer surplus, $S(A)$, than on producer surplus. Letting $\lambda > 1/2$, the weighted welfare function is

$$W(A) = \lambda(n^D/(n^D + 1) - P^D)L + (1 - \lambda)(A - b)L \qquad (35)$$

Proposition 7. For all $\lambda > 1/2$, maximizing welfare subject to the voluntary access constraint, the constraint is binding and the access charge equals

$$A^D = b + R_0/L \qquad (36)$$

The result holds because marginal welfare equals $W'(A) = 1 - 2\lambda < 0$. Substituting into equation (36) by the definition of R_0, the access charge equals the difference between the initial price and the incumbent's cost, $A^D = P_0 - c$.

Competition lowers prices and increases product variety. Thus, the value of entry to consumers is greater than the cost savings from more efficient entrants. Because profits are zero in equilibrium, the welfare benefits of entry are equal to the change in consumer surplus due to competition, $G = \lambda(S(A) - S_0)$.

Proposition 8. (i) Entry occurs with monopolistic competition if and only if the cost savings on production of the service cover the cost of entry, $(c - g)L \geq n^D f$. (ii) The welfare effects of entry are positive,

$$G = \lambda[L[n^D/(n^D + 1) - 1/2 + (c - g)] - n^D f] \tag{37}$$

The proof is given in the appendix.

The greater the number of competing brands, the higher the advantage of competition over a single brand available with universal service. Moreover, consumer surplus can increase even if prices rise as long as the price increase does not exceed the gains from variety. In other words, since $G = \lambda[(n^D/(n^D + 1) - 1/2) - (P^D - P_0)]$, $G \leq 0$ if

$$P^D - P_0 \leq \frac{(n^D - 1)}{2(n^D + 1)} \tag{38}$$

Entry raises consumer surplus by increasing variety even with *less* efficient entrants as long as the cost difference is not excessive. That is, substituting for $(P^D - P_0)$, $G \leq 0$ if

$$g - c \leq \frac{n^D}{n^D + 1} - \frac{1}{2} - \frac{1}{n^D} \tag{39}$$

The right hand side of equation (39) is negative if there are three firms or less; it is positive if there are four or more firms. So, a cost advantage over the incumbent is necessary with fewer than four firms. If four or more firms can enter, the competitive equilibrium improves consumer surplus even with entrants that are less efficient than the incumbent. Thus, less cost-efficient entry can occur with differentiated products as long as entry costs are not too large. The upper bound on fixed cost such that $n^D = (L/f)\,1/2 \geq 4$ is $f \leq L/16$. In the basic framework, the incentives for efficient entry are not altered by the access pricing rule. Limiting the price to not exceed the initial price P_0 would rule out variety-enhancing entry by less efficient competitors. This suggests that with differentiated products, the desirable deregulation strategy is to remove all price controls on the final service and to allow access prices that satisfy the incumbent's individual rationality condition. This will allow competitive entry to determine the appropriate level of product differentiation.

6. *Comparison with a Benchmark Case*

In this section, we consider the benchmark case due to Baumol and Sidak (1994a,b), whose key feature is that *the market price does not change after entry*. (The access charge in this case corresponds to what is generally understood as the efficient component pricing rule.) Then we review a criticism of ECPR by Economides and White (1995).

Prices remaining constant after deregulation can occur under several different scenarios. First, there may be a regulatory price floor that freezes prices at their initial level, so that both incumbents and entrants must continue to charge the initial regulated price. Second, the incumbent may be a 'dominant' firm with one or more price-taking entrants acting as a competitive fringe. Finally, the incumbent may face competition only from a single price-setting entrant that sets a limit price and captures some share of the market. In the latter case, the incumbent is constrained from reducing prices due either to regulatory constraints or to the need to maintain solvency in the presence of fixed costs k such that $R_0 = k$.

Generally, with entry at existing prices, the entrant has some share of the market, $X = \gamma D(P_0)$, $0 \leq \gamma \leq 1$, and the incumbent retains a share $D(P_0) - X = (1 - \gamma)D(P_0)$. Because the price does not change, the incumbent's opportunity cost is $\Delta = (P_0 - c - b)X$. The lowest access price that satisfies the incumbent's individual rationality constraint recovers the incremental cost plus the opportunity cost of the regulated firm,

$$A_0 = b + \Delta/X = P_0 - c \tag{40}$$

The entrant's profit is thus

$$\Pi = (P_0 - g - A)X = (c - g)X \tag{41}$$

Thus, Baumol and Sidak show that competitors enter the market if and only if their cost of providing the service is less that of the incumbent, $g < c$. Welfare is positive if entry occurs since $G = (c - g)X > 0$.

Compare the efficient access price in the Bertrand, Cournot and Chamberlin cases with the benchmark case.

Proposition 9. The efficient access prices in the Bertrand, Cournot and Chamberlin cases are less than or equal to that in the benchmark case.

In the Bertrand case, the efficient access price is less than the benchmark price due to expansion of output, $A_0 - A^B = R_0(1/Q_0 - 1/X^B) > 0$. Similarly, in the Cournot case, the efficient access price is lower than the benchmark case by $A_0 - A^C = R_0(1/Q_0 - 1/X^C) > 0$. In the Chamberlin case, the efficient access price equals the benchmark case $A_0 - A^D = 0$, because output is constant in the Perloff–Salop model.

Economides and White (1995) criticize the benchmark model. They suggest that access pricing should not reflect the incumbent's opportunity cost because such a situation would protect possible monopoly profits of the incumbent. When the incumbent's price is above the incumbent's marginal cost, they argue that even ***inefficient*** entry is desirable because it lowers the incumbent's margin, thereby increasing consumer surplus. To allow inefficient entry, the access price must be lower than the minimum price that satisfies the incumbent's individual rationality constraint. They assume that entrants are inefficient, $g > c$, and that $P_0 > g + b$. In response to the threat of entry, the incumbent lowers the price to the unit costs of entrants, $P = g + b$. Again, the entrant captures some share of the market, $X = \gamma D(P_0)$, $0 \leq \gamma \leq 1$.

In the Economides and White framework, access need not be voluntary. The regulator is not bound by the voluntary access condition, but instead is constrained only by the need to cover the operating cost of the network. Thus, the regulator sets the lowest possible price for access at the per-unit operating cost for the network, $A = b$. Consumer welfare increases because the price falls from P_0 to $g + b$. Then, the welfare effect of entry is as follows,

$$G = \int_{P}^{P_0} D(z)\mathrm{d}z + (P - c - b)(1 - \gamma)D(P) + (P - g - b)\gamma D(P) - (P_0 - c - b)D(P_0)$$

Substitute for $P = g + b$ and integrate demand by parts so that $D' < 0$ and $g > c$ implies

$$G = \int_{P}^{P_0} D'(z)\left[(c+b) - z\right]dz - (g-c)\gamma D(P)$$

The welfare gain with inefficient entry is positive only if the share parameter γ is small or demand is highly elastic.

To understand their result observe that given zero profit for entrants, $P = g + b$, the welfare gain from entry is

$$G = \int_{P}^{P_0} D(z)dz - \Delta$$

Thus, for entry to increase welfare, it must be the case that the gain in consumer's surplus exceeds the incumbent's opportunity cost.

Consider the incumbent's voluntary access condition. If entry increases efficiency, $g < c$, the incumbent's opportunity cost is positive. If entry decreases efficiency, $g > c$, the incumbent makes a positive profit after entry. However, a fall in the incumbent's sales, $[D(P_0) - (1 - \gamma)D(P)] > 0$, is sufficient for opportunity cost to be positive because $\Delta > (g - c)[D(P_0) - (1 - \gamma)D(P)]$. In this case, access at the unit price b is involuntary.

7. *Conclusion*

Our analysis demonstrates that voluntary exchange is consistent with efficiency in network access pricing. Network access charges are a means of recovering the network provider's incremental cost and opportunity costs of service. The opportunity costs of service are due to the loss in net revenue from the displacement of the incumbent's sales, offset by the earnings that the incumbent can achieve from employing its previously regulated assets in the new competitive environment. Thus, several common criticisms of the efficient component-pricing rule are misplaced. First, the access price derived in our analysis permits the market price to fall and output to expand for the final product relative to the price and output that had obtained under regulation. Second, that result holds under a variety of market structures and competitive strategies. With Bertrand–Nash competition, Cournot–Nash competition and monopolistic competition with product differentiation, the access charge that satisfies the incumbent's individual rationality condition rewards entry by more efficient rivals and produces lower prices for the final product. The equilibrium access for each of these competitive situations is less than or equal to the access price that would obtain in the stylized benchmark case in which the incumbent is permitted to receive the initial regulated mark-up over the incremental cost of the final service. The greater the output expansion under competition, the lower should be the equilibrium network access price. The extent of the output expansion depends on initial prices and technology, the elasticity of demand and the cost efficiency of entrants.

Our analysis focused on access pricing in the absence of alternative networks. When competing transmission networks are available and access is a homogeneous commodity, the opportunity cost of selling access is the difference between the market price of transmission service and the incremental cost of service. Thus, the minimum access charge that satisfies the individual rationality constraint is simply the market price of access. How the market price of access is determined when multiple networks compete is certainly of interest. Further complications in pricing access can arise when competing networks interconnect, and originate and terminate transmission for each other. These questions suggest the need for additional study of access pricing when there is competition between networks.

References

Armstrong, M., C. Doyle and J. Vickers, (1995), *The Access Pricing Problem: A Synthesis*. University of Southampton.

Baumol, W. J. (1983), 'Some Subtle Issues in Railroad Regulation,' *International Journal of Transport Economics*, 10, 341–355.

Baumol, W. J. and J. G. Sidak (1994a), 'The Pricing of Inputs Sold to Competitors,' *Yale Journal on Regulation*, 11, 171–202.

Baumol, W. J. and J. G. Sidak, (1994b), *Toward Competition in Local Telephony*. MIT Press: Cambridge, MA.

Chamberlin, E. H. (1933), *The Theory of Monopolistic Competition*. Harvard University Press: Cambridge, MA.

Davidson, C. and R. Denekere (1986), 'Long-run Competition in Capacity, Short-run Competition in Price and the Cournot Model,' *Rand Journal of Economics*, 17, 404–415.

Doane, M. J. and D. F. Spulber (1994), 'Open Access and the Evolution of the U.S. Spot Market for Natural Gas,' *Journal of Law and Economics*, 37, 477.

Economides, N. and L. J. White (1995), 'Access and Interconnection Pricing: How Efficient Is the 'Efficient Component Pricing Rule,' *The Antitrust Bulletin*, Fall, 557–577.

Ergas, H. and E. Ralph (1994), 'Pricing Network Interconnection: Is the Baumol–Willig Rule the Answer?' mimeo, Australian Trade Practices Commission.

Hotelling, H. (1929), 'Stability in Competition,' *Economic Journal*, 39, 41–57.

Kahn, A. E. and W. E. Taylor (1994), 'The Pricing of Inputs to Competitors: A Comment,' *Yale Journal on Regulation*, *11*, 2225–240.

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

Laffont, J.-J. and J. Tirole (1994), 'Access Pricing and Competition,' *European Economic Review*, 38, 1673–1710.

Laffont, J.-J. and J. Tirole (1995), *Creating Competition Through Interconnection, Theory and Practice*. IDEI.

MacAvoy, P. W. (1996), *The Failure of Antitrust and Regulation to Establish Competition in Markets for Long-distance Telephone Services*. MIT Press: Cambridge, MA.

Perloff, J. M. and S. C. Salop (1985), 'Equilibrium with Product Differentiation,' *Review of Economic Studies*, 52, 107–120.

Sidak, J. G. and D. F. Spulber (1996), 'Deregulatory Takings and Breach of the Regulatory Contract,' *New York University Law Review*, 71, 851.

Sidak, J. G. and D. F. Spulber (1997), 'The Tragedy of the Telecommons: Government Pricing of Unbundled Network Elements Under the Telecommunications Act of 1996,' *Columbia Law Review*, 97, 1081–1161.

Tye, W. B. (1994), 'The Pricing of Inputs to Competitors: A Response,' *Yale Journal on Regulation*, 11, 203–224.

Willig, R. D. (1979), 'The Theory of Network Access Pricing,' in H. M. Trebing (ed.), *Issues in Public Utility Regulation*. Michigan State University Public Utilities Papers.

Appendix

Proof of Proposition 1. (i) Marginal welfare equals $W'(A) = (A - b)D'(P^B)$, which is positive (negative) as A is less than (greater than) b. Thus, in the absence of the voluntary access constraint, the welfare-maximizing access charge is the unit cost of transmission, b. (ii) Because of voluntary access, the constrained maximum access charge is strictly greater than b. To verify that the access charge that solves equation (11) exists and is uniquely defined, note that given the concavity of the incumbent's net revenue, the inverse demand function $P(Q)$ crosses the average initial revenue curve R_0/Q from above. To see why this is so, note that by definition $P(Q_0) > R_0/Q_0$. Also, since $P_0 \le P_M$, it follows that $P'(Q_0)Q_0 + P(Q_0) - c - b \le 0$. Therefore, $P'(Q_0)Q_0^2 + R_0 \le 0$. The term $P'(Q)Q^2$ is decreasing in Q by the concavity of net revenue in Q. Thus,

$$P'(Q) < -R_0/Q^2$$

which shows that inverse demand $P(Q)$ crosses the average net revenue R_0/Q from above. This implies that $(d/dA)[b + R_0/D(A^B + g)] < 1$. Thus, the right hand side of equation (11) is increasing and crosses the 45° line exactly once. QED

Proof of Proposition 4. (i) Differentiating in equation (19), marginal welfare equals

$$W'(A) = -X^C(A)X^{O}(A)/D'(P^C) + X^C(A) + (A - b)X^{O}(A)$$

Setting $W'(A) = 0$ and using equation (18) yields A^* in equation (20). (ii) The access charge that solves equation (22) exists and is unique by Assumption 3, which guarantees that $(d/dA)[\, b + R_0/X^C(A)] < 1$. Since $b + R_0/X^C(A)$ is increasing in A, it crosses the 45° line exactly once. By equation (21), $A^* < b + R_0/X^C(A^*)$, so that, given Assumption 3, $A^* < A^C$. By the same reasoning, if equation (21) does not hold, $A^* \geq A^C$. QED

Proof of Proposition 5. Differentiate equations (23) and (24) and solve to find the effect of entry cost on the equilibrium output,

$$\frac{\partial X^C}{\partial f} = \frac{n^C/f}{P''X^C + 2n^C P' + 2n^C R_0/X^2}$$

By Assumption 3, the denominator is negative, so X^C is decreasing in f. Let f_0 be the level of entry costs at which total output equals the regulated output, $X^C(f_0) = Q_0$.

There are two possibilities that we consider in turn. Suppose first that entry costs are greater than or equal to the critical level, $f \geq f_0$. Then, $X^C(f) \leq Q_0$ and $P^C(f) \geq P_0$, so that, were entry to occur, the market price would remain at P_0. Then, the minimum access charge that satisfies the incumbent's individual rationality constraint is $A = P_0 - c$. The zero profit condition for a potential entrant is $(c - g)Q_0/n_0 = f$. Therefore, entry occurs if and only if the cost savings on the regulated output cover the cost of entry.

Alternatively, suppose that entry costs are strictly below the critical level, $f < f_0$. Then, $X^C(f) > Q_0$ and the market price will fall below the initial price, $P^C(f) < P_0$. The access charge is $A^C = b + R_0/X^C(f)$. The market price is $P^C = g + b + R_0/X^C + n^C f/X^C$ from equation (24). Thus, $P^C < P_0$ if and only if

$$g + b + R_0/X^C + n^C f/X^C < c + b + R_0/Q_0$$

Consider the implications of this inequality. Figure 2 shows two curves that represent $P = c + b + R_0/Q$ and $P = g + b + R_0/Q + n^C f/Q$. The gap between the two curves widens as output increases. It then follows from $P^C < P_0$ that the initial price curve $P = c + b + R_0/Q$ must lie above the other curve when both are evaluated at Q_0:

$$g + b + R_0/Q_0 + n^C f/Q_0 < c + b + R_0/Q_0$$

Canceling terms, we have $(c - g)Q_0 > n^C f$, that is, the cost savings on production of the service must cover the cost of entry. Conversely, let X^C, n^C be a Cournot–Nash equilibrium, where $(c - g)Q_0 \geq n^C f$. Then, by Figure 2, $P^C < P_0$ and $X^C > Q_0$. QED

Proof of Proposition 8. (i) As a result of regulation, entry occurs only if entrants can price lower than incumbents,

$$P^D - P_0 = c - g - (f/L)^{1/2} = c - g - n^D f/L$$

(ii) The initial expected value of the regulated firm's brand to any consumer equals 1/2 because values of brands are uniformly distributed. So, expected total surplus under regulation is $S_0 = L(1/2 - P_0)$ and the change in total surplus is

$$S(A) - S_0 = L[((n^D)^2 + n^D + 2)/(2(n^D + 1)n^D) + c - g] > 0$$

QED