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access pricing**

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Synergies and non-discriminatory access pricing

by

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Abstract.

According to the new European telecom regulation, incumbent operators are required to provide access to such bottlenecks on fair, reasonable and non-discriminatory terms. We explore different interpretations of this general rule in a model in which the bottleneck can be used by external (to the bottleneck firm) as well as internal service providers, and also derive some properties of the solution to the bottleneck owner's maximization problem as well as that of a welfare-maximizing regulator. In particular, we derive an ECPR rule that also corrects for synergies. Next, by imposing certain symmetry requirements we establish a benchmark in which the external service provider is a competitive fringe and internal and external end-users face identical prices and buy identical quantities of the two services. This, we argue, can be dubbed a non-discrimination benchmark. We then show that introducing certain synergies makes the bottleneck want to favour external supply, while making the fringe less competitive has the opposite implication.

Keywords: access regulation, discrimination, ECPR, synergies

JEL numbers: L43, L51, L96

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1. Introduction

Within the Telecommunication sector some activities are considered natural monopolies due to the large fixed costs of setting up the necessary production facilities. Such production facilities are accordingly prohibitively costly to duplicate for newcomers and are thus bottlenecks. In order to induce competition, regulators must ensure access to the bottlenecks for newcomers. There is a large body of literature discussing principles for pricing such bottlenecks. An overview of applications in the Telecommunications sector can be found in e.g. Laffont and Tirole (2000).

The European regulatory framework is imposing requirements and recommendations on the national regulation of pricing of bottlenecks. An example is the pricing of access to the local loop, see e.g. the Official Journal of the European Communities (2000). The access price to the local loop is required to be cost orientated (article 1.6). Notice that marginal cost pricing cannot cover all costs since a bottleneck, by definition, is a natural monopoly. Thus a cost based access price has to exceed marginal cost. Furthermore, incumbent operators are required to provide access to such bottlenecks on fair, reasonable and non-discriminatory terms (article 1.7). This includes in particular *the right for newcomers to have access on the same terms as those offered to the incumbents themselves or their associated companies*.¹ Finally it is recommended that the national regulating authorities collect detailed cost accounting information including internal transfer pricing (article 1.8). The combined result of these requirements is that the regulated access price is exceeding marginal cost, and that the integrated incumbent firm is required to use this price as the internal transfer price.² Thus the internal pricing of an incumbent operator is subject to regulation.

This regulation seems to be inconsistent with standard economic theory. In the profit maximization problem of an incumbent firm, marginal costs and marginal revenues are of relevance whereas all internal transfers, due to internal pricing, exactly is cancelled out, the net

¹ See press release, IP/00/750 Brussels, 12 July 2000, *Commission proposes unbundling local loop by end of year*, available at <http://europe.eu.int/ISPO/infosoc/telecompolicy/press/ip00-750en.htm>

² Recently Telenor (former Telecom Norway) was fined for breaching the regulatory clauses of non-discrimination. The price charged internally for terminating telephony traffic on the mobile network of Telenor mobile, deviated from the price charged externally.

effect is always zero. Thus, according to standard economic theory, a regulated internal price is irrelevant in the optimization problem of an integrated firm insofar that it does not affect end user prices. Thus, it has no economic consequences.

The obvious regulatory response to the arguments above is to vertically separate the incumbent firm. Then one can ensure that the transfer price is an external price and thus make sure that it is accounted for in the optimisation. A possible interpretation of the fact that regulators do not go to this step is that they consider it costly to do so. This cost is either the cost of restructuring the industry, and/or it is the increased production costs due to the vertical separation. If it is the latter that is the case, then regulators, implicitly, assume that there are significant economies of scope in the industry. Hence, total production costs are lower in an integrated firm as compared to two separated firms producing the same quantities.

Seen from a management perspective one can argue that the regulation of internal prices results in increased internal coordination costs. By regulating internal prices, the management of an integrated firm is constrained from applying the most commonly used mechanism to provide incentives internally. Thus it will be harder to decentralise decisions by establishing profit centres and the management will have to implement other mechanisms to induce behaviour supporting the ultimate goals of the firm. This can e.g. be achieved by centralising decisions at the cost of providing local incentives and at the cost of increased information processing. Thus one can argue that the costs of running an integrated firm will increase as a result of the regulation of internal prices.

One cannot rule out the possibility that the business units of the integrated firm indeed are run as fully independent companies. Then the regulation of internal prices will have economic consequences since the internal price in such cases enters the optimisation problem of the downstream subsidiary of the integrated firm. There is at least three reasons why this might be the case: 1) There may be strategic gains in the downstream market by committing to such behaviour (see e.g. Foros, Kind and Sørsgard (2002)). 2) The internal coordination costs discussed above may be prohibitively high, such that the integrated firm is better off by running the subsidiaries as independent companies. 3) And finally we cannot rule out the possibility that regulation for some reason has as a direct effect that the integrated firm is run as a group of independent companies (by declaring it “illegal” to run it as an integrated company as the Norwegian example in footnote 1 indicates).

In either case the regulation of internal prices will have economic consequences. It is however far from evident that the optimal regulatory solution is to set the regulated internal price equal to the regulated external price of access to the bottleneck. As an example, if the integrated firm has market power in the downstream market, a typical result will be double marginalization as we will demonstrate below.

There is a large body of literature discussing the pricing of access to bottlenecks, e.g. Laffont and Tirole (1994 and 2000), Armstrong Doyle and Vickers (1996), Baumol and Sidak (1994), Willig (1979). These papers are based on the assumption that the incumbent indeed is run as an integrated firm. As argued above, this assumption is founded on sound economic reasoning. This is however in contrast to the regulatory framework where internal pricing explicitly is taken into consideration. In the present paper we seek to extend the standard models in the literature in order to analyse whether the regulation of internal prices has some effects previously not accounted for in literature.

In this paper we consider a one way access problem where a vertically integrated incumbent firm provides access to a bottleneck facility as illustrated in Fig. 1 below. The bottleneck is used both by some newcomers and by the vertical firm's own downstream activities.

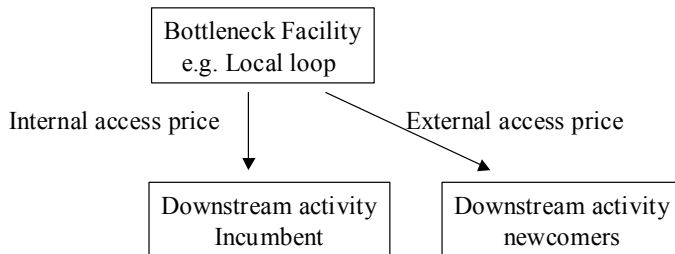


Figure 1: *The industry structure.*

Our contributions are as follows. First, we extend the well-known ECPR rule to situations involving (a particular form of) synergies: the incumbent firm's costs are decreasing in total output from the bottleneck. Next, we establish a benchmark without discrimination – a benchmark in which i) the external service provider is a competitive fringe, ii) there are no synergies, and iii) costs and demand are symmetric. This benchmark is perhaps easiest to

understand if we impose average cost pricing – where the transfer price or access charge is a part of these costs – on the internal service provider.³ (A competitive fringe does the same, by definition.) The virtue of this assumption is to make all action take place in the pricing of access (internally and externally). Without any synergies, this pricing problem becomes identical to the problem facing a two-product monopolist, and the allocations (and the corresponding pricing) are governed by relatively simple and well-known cost and demand considerations. Different access charges can in such a set-up hardly be called discrimination, as a totally integrated industry would have given rise to the same allocation. However, in order to simplify the assessment of the implications of adding different ingredients to the benchmark set-up, we will assume that demand for the two end-user services are symmetric and that, absent any synergies, costs are symmetric.

We would like to stress that there is no such thing as a unique meaningful internal access price – a given allocation can be realized with different combinations of internal access price and (internal) downstream mark up. Associated with profit maximization there is a unique *shadow price* of internal access, but such a shadow price cannot be subject to regulation. It does have meaning, however, to compare internal and external access prices as long as we make assumptions about the downstream mark up. To facilitate such comparisons we will in parts of the subsequent analysis assume that the mark up is the same in the two downstream markets. (This means no mark up on internal access when the fringe is competitive, and the same positive mark up in both lines when the fringe is imperfectly competitive.)

Third, if we allow the average cost of the internal downstream activity to be a decreasing function of total sales, this particular form of synergy makes the bottleneck owner reduce the external access charge, while the internal access charge may increase. Hence it looks like discrimination of external customers is less of a problem than previously perceived; the synergy seems to make the bottleneck owner discriminate against internal access, not against external access. However, the notion of discrimination may be inappropriate here, as the bottleneck owner does only what a totally integrated industry would do (since, by definition, there is no profit in the competitive fringe).

³ Note that this does not restrict the integrated firm's ability to maximize profit – any given end-user price can be achieved by different combinations of a rule for downstream mark up and an appropriately chosen access charge.

Fourth, if the fringe is not competitive, we will get double marginalization in the fringe but not in the integrated part of the market. If we again impose the symmetric downstream mark up assumption (so that, again, all action is in the determination of the two access charges), it is clear that absent any synergies, the external access charge will now be higher than the internal one. If we combine synergies and imperfect competition in the fringe, it is also clear that either of the two access charges (again, carefully interpreted) may be the higher.⁴

Finally, we derive the welfare maximizing access charge and end user prices for the bottleneck firm and show that they can be implemented by an appropriate price cap.

2. Model

Consider a one way access problem where the vertically integrated incumbent firm provides access to a bottleneck facility as illustrated in Fig. 1. An upstream firm, denoted M, is controlling an essential bottleneck facility that is used in downstream production of end user services. We may think of M as a telecom company controlling the local loop in a specified region. M is also engaged in downstream production of telecom services for which the local loop is an essential input. There are also competing non-facility based operators that depend on access to the local loop controlled by M in order to serve the end user market. We shall think of the set of competitors as a competitive fringe with identical cost structures exhibiting constant returns to scale, and producing services that are perfect substitutes (but possibly an imperfect substitute or complementary to M's product). M has the choice of using the local loop for its own retail service production, or selling access to the competitive fringe to be denoted E.

We shall use the following notation

$X = X(p, q)$ = M's volume of end user services
 $y = y(q, p)$ = E's total volume of end user services
 p, q = M's and E's unit prices respectively.
 a = the price pr unit of access sold to E.
 c_a = M's unit cost⁵ of providing access
 c = M's unit cost of serving the end user market
 c_E = E's unit cost of serving the end user market

⁴ Small synergies and much market power in the fringe make one case, while little market power together with large synergies make the other extreme.

⁵ When referring to unit cost we mean variable unit cost.

$F = M$'s fixed costs

The units are defined such that the total demand for access equals the total supply of end user services for the competitive fringe. In equilibrium in E 's market $q = a + c_E$, and by the assumption of constant returns to scale there is no profit in the competitive fringe in equilibrium.

In the case of M being vertically integrated there are supposed to be cost synergies between the upstream and downstream activities. In that case M 's unit cost of serving the end users is decreasing in the total amount of access as given by $N(p, q) = X(p, q) + y(q, p)$. More specifically we assume that unit cost is given by

$$c = c_0 - f(sN(p, q))$$

where $f(0) = 0, f' > 0$, and $s \geq 0$ is a measure of the strength of the cost synergies. This is clearly not the only way to model synergies, and alternative formulations may give rise to different results.⁶

M 's is choosing p and a in order to maximise

$$\Pi_M = [p - c_0 + f(sN(p, q))]X(p, q) + (a - c_a)y(q, p) - F$$

First order conditions for p and a , respectively, are

$$(1) (p - c)X_p + f'(sN(p, q))s(X_p + y_p)X(p, q) + (a - c_a)y_p + X(p, q) = 0$$

$$(2) (p - c)X_q + f'(sN(p, q))s(X_q + y_q)X(p, q) + (a - c_a)y_q + y(q, p) = 0$$

We define $-\frac{X_q}{y_q} \equiv \delta$ as the marginal crowding out effect on M 's downstream volume from

a marginal increase in E 's supply when the end user services of M and E are substitutes, i.e., the

⁶ For instance, the bottleneck's unit cost could be a decreasing function of internal sales, or the synergy takes the form of reduced fixed costs of either the upstream or downstream activity.

reduction in the demand for M 's service when E is increasing its volume by one unit. If they are complementary, increased sales in the competitive fringe will have a positive effect on the demand for M 's end user service, in which case $\delta < 0$ is a crowding in factor.

The first order condition (2) for a profit maximizing access price can be written as

$$(3) \quad a = c_a + (p - c)\delta - f'(s(N(p, q))s(1 - \delta)X(p, q) + \frac{q}{\eta_y}$$

where η_y is the direct price elasticity of demand for E 's service⁷.

Condition (3) is a version of the efficient component pricing rule (ECPR) adjusted by the crowding out (in) factor, the marginal synergy effect on M 's downstream costs from the net change in total supply of access and the elasticity adjusted price in E 's end user market. If E is facing a perfectly elastic demand for its service, the last term on the right hand side of (3) would vanish. With a downward sloping demand curve M can extract profits in the fringe through the choice of a which calls for a higher access price. M 's opportunity cost of providing access to competing non-facility based operators would then consist of the direct marginal costs, M 's loss (gain) in its end user market due to the crowding out (in) factor, and on the marginal impact on M 's unit costs in the downstream activity which depends on the effect on the total provision of access from selling an additional unit of access to E , i.e., $1 - \delta$. The marginal impact on M 's downstream cost must be multiplied by M 's volume in the downstream market in order to capture the full marginal cost effect from the change in the use of the essential facility.

From condition (3) we have

Proposition 1. *If the end user services of M and E are perfect substitutes, the synergy effects are fully internalised in M 's unit cost. With imperfect substitutes or complements and $s > 0$, the profit maximising access price will ceteris paribus be lower than in the perfect substitute case.*

Proof: The proof follows from (3) as $\delta = 1$. In all other cases the total demand for access will increase when M sells a unit of access to E , creating a positive externality for M 's downstream

⁷ Price elasticities are defined as positive numbers.

production. As the service providers in E do not take this synergy effect into account when demanding access, this calls for M to internalize this externality by lowering the access price.

If the competitive fringe is facing a downward sloping demand curve, whereas each provider in E considers the market price as given, then M can exert monopoly power in E 's end user market through the access price. This monopoly profit is given by $(a-c_a-c_E)y(q)$, and disregarding the cost synergy and the profit shifting effect, the profit maximizing access price yielding equilibrium in the E -market such that $q=a+c_E$ is given by $a = c_a + (a + c_E)/\eta_y$ which constitutes the first and the last term on the right hand side of (3).

If also the profit shifting and synergy effects are taken into account, the optimum access price is given by

$$(4) \quad a = \frac{1}{1-1/\eta_y} \left[c_a + (p-c)\delta - f'(sN(p,q))s(1-\delta)X(p,q) + \frac{c_E}{\eta_y} \right]$$

From (4) we see that the relevant cost base for the monopoly mark up in the external access market is the direct costs consisting of M 's marginal cost of providing access and the elasticity adjusted cost of serving the end users through E plus the profit shifting (minus profit creation if complementary) net of the synergy effect.

In the subsequent analysis we let $S(p,q) \equiv f'(sN(p,q))sX(p,q)$ denote the marginal effect on M 's total cost in the end user market (synergy effect) from increasing the total supply of access by one unit.

Adding c_E on both sides of (3), we get an expression for the profit maximizing equilibrium price in the E 's end user market

$$(5) \quad q \equiv a + c_E = \frac{1}{1-1/\eta_y} [(c_a + c_E) + (p-c)\delta - S(p,q)(1-\delta)]$$

The bracketed term on the right hand side of (5) is the net total marginal cost of routing a unit of access through E 's end user market.

We let c_a^* denote this synergy adjusted marginal cost of providing access. Then (5) can be rewritten as

$$(6) \quad \frac{q - c_a^*}{q} = \frac{1}{\eta_y}$$

which is the familiar inverse elasticity rule for optimal monopoly pricing.

The first order condition for the optimal price in M 's end user market is given by (1). For simplicity we assume that end users have quasi-linear utility functions. Thus, there will be no income effects in demand so that the cross-price effects will be pure substitution effects and hence symmetric. We make the simplifying assumption that the crowding out factor δ will on the margin be the same irrespective of whether it is due to a reduction in q or an increase in p , i.e., $X_q/y_q = X_p/y_p$. Hence, $-y_p / X_p = 1/\delta$, which is the reduction in E 's volume when M increases its downstream volume by one unit. Moreover, η_x and η_y will be compensated elasticities and hence strictly positive.

Substituting (3) into (1) and assuming for the moment that $s = 0$, we get

$$(7) \quad p = \frac{1}{1 - \frac{1}{\eta_x}(1 - \eta_y)} \left[c - \frac{c_a + c_E}{\delta} \right]$$

We see from (7) that the monopoly mark up in M 's end user market depends on the demand elasticities in both end user markets. Moreover, since $\eta_y > 1$ by (4), the profit maximising mark up in M 's retail market must be less than one. The term in the square brackets is the net increase in total costs in the two markets seen together when M is increasing its downstream volume by one unit. The cost change consists of M 's marginal cost in serving the end user market minus the cost reduction for E as a unit increase in M 's volume is reducing the volume for the competitive fringe by $1/\delta$ units.

Including the cost synergies in M 's downstream production the profit maximising price in M 's retail market is given by

$$(8) \quad p = \frac{1}{1 - \frac{1}{\eta_x}(1 - \eta_y)} \left[c - \frac{1}{\delta} \{c_a + c_E + S(p, q)(1 - \delta)\} \right]$$

As before the first two terms in the curled parentheses of (8) are the reduced costs by reducing the sales in the E -market by one unit. When M is increasing its use of access by one unit, E 's demand for access is reduced by δ . Hence, the last term is the increased cost synergies in M 's downstream supply from the increased net supply of access. Dividing by δ , all cost effects are in terms of cost per unit increase in M 's retail supply. Thus, the term in the squared brackets is M 's synergy-adjusted marginal cost in the retail market minus the net cost reduction including the reduced synergy effect due to the fact that M is crowding out E 's supply and hence demand for access. The reason why M is basing its pricing policy in its own retail market on the combined marginal cost for both markets is due to the fact that an increase in M 's volume reduces E 's demand for access via the substitution effect in the demand for E 's end user service and hence the profit in the access market will be reduced accordingly. As M is reaping the profit in the E -market through the access price, the relevant opportunity cost for M 's retail supply is M 's marginal cost net of the cost-saving in the competitive fringe due to reduced sales there. Hence, for $0 < \delta < 1$ the marginal opportunity cost for M 's supply in the retail market will depend on how a marginal increase in M 's supply will affect the allocation of access between M and E .

Letting c^* denote the cost term in the squared brackets in (8), the profit maximising pricing rule can be written as

$$(9) \quad \frac{p - c^*}{p} = \frac{1 - \eta_y}{\eta_x}$$

which is the modified inverse elasticity rule in this particular case with two related markets. Hence, we see that the control of the market for competitive services reduces the optimal relative profit margin in M 's end user market.

3. Benchmark: competitive fringe, no synergies and symmetry

As discussed in the introduction, discrimination in access may be difficult to spot unless we make an effort to make internal and external access comparable. To be more specific, if we find out that internal access is sold cheaper than external access, we would like to filter out explanations that have nothing to do with the control (ownership) structure. Other sources of

price differences are differences in demand, costs and downstream markup. Consequently, we establish a benchmark in which there are no cost differences (and therefore no synergies either), symmetric demand and in which the bottleneck owner imposes the same mark up rule internally as is used in the fringe.

Formally, no synergies implies that $s=0$ and therefore that $c = c_0$. Moreover, demand symmetry implies that $X(p,q) \equiv y(q,p)$ for all p,q (note that $X(p,q)$ may still differ from $y(q,p)$ unless $p=q$), and that $c_E = c = c_0$. Furthermore, symmetry in access costs implies that $c_a = 0$. Finally, since the internal transfer price is irrelevant to the decision problem, we will w.l.o.g. assume that the bottleneck sets an internal access charge of a_I while its downstream subsidiary sets price equal to marginal cost: $p = c_0 + a_I$. By definition, the competitive fringe does the same: when facing an access price a_E , competition ensures that $q = c_0 + a_E$. Letting $X(a_I + c_0, a_E + c_0) \equiv D(a_I, a_E) \equiv y(a_E + c_0, a_I + c_0)$, the monopolist's profit can be written

$$\Pi_M = a_I D(a_I, a_E) + a_E D(a_E, a_I) - F$$

with first order conditions

$$\begin{aligned} D(a_I, a_E) + a_I D_1(a_I, a_E) + a_E D_2(a_E, a_I) &= 0 \\ D(a_E, a_I) + a_E D_1(a_E, a_I) + a_I D_2(a_I, a_E) &= 0 \end{aligned}$$

Noting that the profit expression (and thereby also the first order conditions) are symmetric in the two access prices, maximizing profits will normally entail a symmetric solution in which $a_I = a_E$.⁸ We state this as Lemma 1:

Lemma 1. *In the benchmark, $a_I = a_E$, $p=q$ and $X=y$.*

⁸ This is easiest to see in the case of independent demand: Let $d(a) \equiv D(a, \tilde{a})$. Then both first order conditions for maximization of profit can be written $ad'(a) + d(a) = 0$, yielding the same solution. Continuous, non-negative and downward-sloping demand is sufficient for existence and uniqueness. For interdependent demand things are technically more complicated, but the symmetric solution still exists and is unique for well-behaved demand systems, essentially requiring that the cross effects are smaller than the own effects, which anyway is a natural property of symmetric demand systems.

4. The effect of synergies

It is time to reintroduce the synergies. First we do it heuristically and assume independent demand. Then the only thing that happens in the fringe is that the synergy creates a positive externality from the fringe activity. In order to fully exploit this externality, the monopolist will want to reduce the external access charge, such that q will go down and sales up. This is obvious. Less obvious is what happens internally. Average cost pricing implies that the synergy makes the price p go down, both directly (the unit cost goes down as the synergy is introduced, for any given level of X and y) and as a consequence of boosting external sales. An interesting question is whether the synergy makes the access prices differ. The answer is yes, for rather simple reasons: First, the external access charge goes down to add to the synergy. In contrast, there are two forces working on the internal access charge: it should go down to add to the synergy, but to “harvest” the gains from the synergy the access charge should go up. In sum, this leads to a situation in which the internal access charge is higher than the external, meaning that the external service providers are not discriminated against as a consequence of the synergy. On the contrary, they are favored! (A caveat is warranted here: as mentioned in the introduction, notions like discrimination should be used with care in a setting like the present one.)

Proposition 2. *As we introduce synergies to the benchmark setup,*

- i. both X and y increases,*
- ii. p and q decreases, and*
- iii. a_E decreases more than a_I .*

Proof: The integrated firm’s profit can be written

$$\Pi_M = [p - c_0 + f(s(X(p, c_0 + a_E) + y(c_0 + a_E, p)))]X(p, c_0 + a_E) + a_E y(c_0 + a_E, p) - F .$$

The corresponding first order conditions (for p and a_E) are as follows:

$$\frac{\partial}{\partial p} \Pi_M = [p - c_0 + f]X_p + a_E y_p + [1 + f's(X_p + y_p)]X = 0$$

$$\frac{\partial}{\partial a_E} \Pi_M = [p - c_0 + f]X_q + a_E y_q + y + f's(X_q + y_q)X = 0$$

Rewriting (using that $p = a_I + c_0 - f$ and $q = a_E + c_0$) yields the following simpler form:

$$X + a_I X_p = -a_E y_p - f's(X_p + y_p)X$$

$$y + a_E y_q = -a_I X_q - f's(X_q + y_q)X$$

The left hand sides of these two equations represent the “normal” marginal profit from increasing the price or the markup. Absent any synergies, the right-hand sides represent the demand externality. Suppose we start with $a_I = a_E$ in a situation in which the synergies are relatively small. Suppose further that the demand system is linear. Then $y_p = X_q$ and the two right hand sides are identical. The left hand sides, however, differ: $X = X(a_I + c_0 - f, a_E + c_0) > y(a_E + c_0, a_I + c_0 - f) = y$. To satisfy both first order conditions, the access charges must therefore satisfy $a_I > a_E$. A similar logic applies when the demand system is not linear. Q.E.D.

Another interesting question is whether the internal access charge goes down at all in response to introduction of the synergy. This is not clear, and our next result demonstrate that for a class of demand functions and parameters the internal access charge will actually increase as a consequence of the synergy:

Proposition 3. *With independent and linear demand and $f(sN) \equiv sN$, a_I is increasing in s .*

Proof: Without loss of generality, suppose $X = 1 - p$ and $y = 1 - q$. Then the first order conditions reduces to

$$1 - p - a_I = s(1 - p)$$

$$1 - q - a_E = s(1 - p)$$

The first of these can be written (after substitution)

$$1 - (a_I + c_0 - s(1 - p + 1 - q)) - a_I = s(1 - p)$$

⇕

$$1 - (a_I + c_0 - s(1 - a_E - c_0)) - a_I = 0 \Leftrightarrow a_I = \frac{1 - c_0}{2} + \frac{s}{2}(1 - a_E - c_0)$$

Consequently, a_I is increasing in s . *Q.E.D.*

5. The effect of imperfect competition in the fringe

If there is imperfect competition in the fringe (for instance only one or a handful firms), the fringe will typically set a price that is a mark up over the costs. The result is double marginalization in the external line. To facilitate comparison we have to change the benchmark: assume now (again without loss of generality) that a similar mark up is also imposed on the incumbent downstream firm. Still all action goes through the access charges, and the task is to compare the two equilibrium access charges.

Now it is clear that absent synergies, internal access charges will be lower than external access charges. It can however be discussed whether this is discrimination in the normal sense: it can just as well be dubbed “self discrimination”.

Blending the effect of synergies and imperfect competition in the fringe should produce no surprises when it comes to setting of the access charges: adding synergies to a setup with imperfect competition in the fringe will clearly contribute to more even access charges. Depending on the strength of the synergy and the market power in the imperfectly competitive fringe, discrimination may be partially or entirely eliminated, and even be reversed (the latter may happen when synergies are strong and the fringe has little market power, while the former will happen in the opposite situation).

6. Regulation

As long as the fringe is competitive, the only concern for the welfare maximizer is the profit level, which can be taken down by an appropriately set price cap (on p and a). With an imperfectly competitive fringe, the regulator may want to regulate also the fringe. It should be

clear that if the fringe is regulated in an optimal way, it is regulated to act like a competitive fringe, and then imperfect competition does not affect regulation of the bottleneck.

Formally, we assume that end user utilities are identical and linear in income so that cross price effects will be pure substitution effects and hence end user services will be substitutes. Quasi linear utilities means that distributional concerns do not matter and a socially efficient policy is maximising the sum of consumer and producer surplus. Moreover, with constant returns to scale there are no equilibrium profits in the competitive fringe so that the producer surplus equals M 's profits. We have however assumed that the incumbent monopoly is subject to fixed costs due to maintaining and operating the local loop (and possibly also USO), and that these costs are to be covered in the market. Hence, the optimal pricing policy is subject to the constraint that M at least breaks even.

We let $V(p,q)$ be total consumer surplus (aggregate indirect utility function). By the assumption of quasi-linearity of utility and the envelope property of consumer optima we have that

$$V_p = -X(p,q) \text{ and } V_q = -y(q,p).$$

The constrained social optimisation problem takes the form

$$(10) \text{ Max } V(p, a+c_E) + (1+\lambda)\Pi_M(a,p)$$

where $\lambda \geq 0$ is the shadow price of the constraint $\Pi_M(a,p) \geq 0$ such that $\lambda\Pi_M(a,p) = 0$ at the optimum, and λ is strictly positive whenever the constraint is binding. Let $\varphi(\lambda) \equiv \lambda/(1+\lambda)$ be the normalised shadow price. Then $\varphi(0) = 0$, and $\varphi(\lambda)$ approaches 1 as λ goes to infinity.

The first order conditions for maximising (10) with respect to p and a are given by

$$(11) \quad (p-c)X_p + f'(sN(p,q))s(X_p + y_p)X(p,q) + (a-c_a)y_p + \varphi(\lambda)X(p,q) = 0$$

$$(12) \quad (p-c)X_q + f'(sN(p,q))s(X_q + y_q)X(p,q) + (a-c_a)y_q + \varphi(\lambda)y(q,p) = 0$$

Solving for a and p we get from (12)

$$(13) \quad a = \frac{1}{1 - \varphi/\eta_y} \left\{ c_a + (p - c)\delta - S(p, q)(1 - \delta) + \frac{\varphi}{n_y} c_E \right\}$$

Rewriting (13) in terms of the optimal end user price for the traffic that is routed through the competitive fringe yields

$$(14) \quad a + c_E \equiv q = \frac{1}{1 - \varphi/\eta_y} \{ c_a + c_E + (p - c)\delta - S(p, q)(1 - \delta) \}$$

(14) can be rewritten as

$$(15) \quad \frac{q - c_a^*}{q} = \frac{\varphi}{\eta_y}, \quad 0 \leq \varphi \leq 1$$

which is the inverse elasticity rule for the efficient end user price in the E-market. If $\varphi = 0$ (the budget constraint is not binding), the synergy adjusted efficient component pricing rule will be welfare maximising, while on the other hand the socially efficient relative profit margin is approaching the monopoly margin as the shadow price of the budget constraint is increasing.

Substituting (13) into (11) we get

$$(16) \quad p = \frac{1}{1 - \frac{1}{\eta_X}(\varphi - \eta_y)} \left\{ c - \frac{1}{\delta} [(c_a + c_E) + S(p, q)(1 - \delta)] \right\}$$

As before, (16) can be rewritten as

$$(17) \quad \frac{p - c^*}{p} = \frac{\varphi - \eta_y}{\eta_X},$$

which has the same structure as the profit maximising price except for $\varphi < 1$.

For the special case that $\varphi = 0$, it is seen from (16) that the socially efficient mark up on the synergy adjusted marginal opportunity cost of M 's end user service is given by $\eta_X/(\eta_X + \eta_y)$, and hence less than one whenever $\eta_X < \infty$, and approaches one as this elasticity goes to infinity.

However with $\eta_X < \infty$ the optimal price will be less than the marginal opportunity cost, and for the particular case of equal elasticities the scalar linking the end user price to marginal opportunity costs will be exactly 0.5.

The socially efficient prices can be implemented by subjecting the vertically integrated monopoly to a price cap including both the access price and the retail price for the end user service.

Letting ω_X and ω_Y be the weights for the price for the end user service and the access service, respectively, the monopoly subjected to a price cap would maximise

$$\Pi_M(a,p)$$

subject to $\omega_Y a + \omega_X p \leq P^*$

where P^* is the cap. Letting κ denote the shadow price of the price cap constraint, the first order condition for a profit maximising access price is given by

$$(18) \quad (q - c_a^*)y_q + y(q, p) = \kappa\omega_a$$

On the left hand of (18) is the marginal change in the unconstrained monopoly profit from a marginal increase in the access price, while the term on the right hand side represents the marginal cost due to the fact that if the price cap is binding, the end user price must be reduced accordingly.

The inefficiency of monopoly pricing is generally due to the fact that with a linear price the monopoly cannot extract the consumer surplus, so that the decrease in consumer surplus due to monopoly pricing is not internalised as a cost. Thus, we see that the price cap is pulling the profit maximising price in the right direction. If the weights in the price capping constraint are given by the optimum quantities, the imposed marginal cost through the price cap would be proportional to the marginal loss in consumer surplus.

In that case the profit maximising prices would be given by

$$(19) \quad \frac{q - c_a^*}{q} = (1 - \kappa) \frac{1}{\eta_Y}$$

and

$$(20) \quad \frac{p - c^*}{p} = \frac{1 - \eta_y - \kappa}{\eta_x}$$

We summarize this in

Proposition 4. *The budget constrained social optimum given by (16) and (17) can be implemented by a price cap comprising both access and end user services.*

Proof. The result follows by choosing the cap P^* such that $1 - \kappa = \varphi$.

The cap is adjusting the level of the access and end user price so that the monopoly breaks even, while the monopoly in its own interest chooses the optimal relative price between the use of capacity in the access and end user market.

7. Concluding remarks

In this paper we have discussed profit maximizing prices for providing external access to bottleneck facilities controlled by an incumbent monopoly under increasing returns in the total supply of access and how profit maximizing prices relates to non-discriminatory prices. We show that the profit maximizing access price takes the form of a generalized version of the efficient component pricing rule in the sense that it is derived as a monopolistic mark up on the opportunity cost of providing access, where the latter consists of the direct marginal access cost and the monopoly's profit loss in the end user market per unit of external access minus the synergy effect from the net effect on the total supply of access. After defining a non-discriminatory benchmark as to pricing of internal and external access to the bottleneck facility, we show that there are two opposing forces causing deviation from this benchmark. First, the synergy effect from the increased net demand for access calls for a lower access price for the external operators as compared to the monopoly's own demand. Second, imperfect competition in the external line of end user services leads to double marginalization, and this leads to a lower internal access price for internal access. Thus by introducing both synergies in the supply of total

access and imperfect competition in the external end user market the net effect on the price differential between internal and external access may go either way as compared with the benchmark.

It may be argued that the way we have defined non-discrimination may seem somewhat contrived. The general problem is that M 's economic sacrifice of providing a unit of external access is in the nature of an opportunity cost which apart from the direct marginal cost also includes the effect on profits in M 's end user market. For the provision of an extra unit of external access to be profitable, the external access charge must match this opportunity cost. It does not, however, make any economic sense to impose this opportunity cost on the internal use of the bottleneck. Thus, the idea that non-discrimination presupposes that newcomers should have access on the same terms as those offered to the incumbents themselves or their associated companies seems to be ill-conceived if this is to be taken literally.

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