Two-part Access Pricing and Imperfect Competition[§]

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Abstract

This paper considers a vertically separated industry with an upstream monopolist who supplies an essential input to two downstream Cournot firms. This situation is relevant to a number of sectors, including the telecommunications industry where trunk operators must have access to the local network of an incumbent firm to provide their long-distance service. The paper analyses two-part access pricing and input price discrimination under different regulatory settings, and it finds that discrimination may produce adverse welfare effects when it is practised by the unregulated upstream firm.

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Non-technical abstract

The problem of a monopolist firm that supplies an essential input to other firms that compete in the final downstream market is crucial in many utility industries that use a network. When downstream firms have different degrees of efficiency, then it could be feasible to charge them different access prices for the essential input. This is a typical problem of third-degree price discrimination that has been extensively analysed when it is practised upon final consumers. If discrimination occurs in the wholesale market, then firms are customers with interrelated demand, a feature that distinguishes the problem from final goods price discrimination. In the current phase of liberalisation of the telecommunications industry, regulatory constraints are being progressively removed as competition develops. This paper deals with one of such constraints, namely whether input price discrimination is likely to improve social welfare.

I consider a vertically separated industry with an upstream monopolist who supplies an essential input to two downstream Cournot firms. Since non-linear pricing occurs more often in intermediate markets than in final good markets, I allow for more complex tariffs. The contribution of the paper is twofold. In the first part it solves the problem of regulated access pricing with two-part discriminatory tariffs. In line with the intuition, these access schemes correspond to an increase in the number of regulatory tools, so that they can be used to increase social welfare. In the second part, a similar problem is analysed in an unregulated setting. It is found that discrimination may produce adverse welfare effects when it is practised by the unregulated upstream firm. The results depend on the cost functions of downstream producers and on the concavity of the demand function. I show conditions under which welfare is reduced with price discrimination that generalise previous results in the literature.

1. Introduction

Most regulated and unregulated firms sell some of their outputs as inputs to other firms which use them in their production processes. For instance, in the telecommunications industry it is quite common to observe network operators providing access to competitors that use (part of) their network. The most common and cited case is the one of long-distance calls that require the local loop to be completed. In a rather more general framework, the concept of Open Network Provision (ONP) emphasised by the European Union, is related to a similar idea: every network operator has to provide fair access to rivals. Compatibility standards, interoperability, and so on have become essential features in the process of communications and technological convergence that is transforming open networks into a two-way medium for a plethora of information and entertainment services. Entry is assumed to be beneficial for total welfare because increased competition not only requires incumbent firms to be subject to healthy market mechanisms, but also implies higher product variety and choice for the consumer.

This paper attempts to offer some insights on the issue of access provision in vertically related markets. For the sake of convenience, think of a local calls market as an upstream natural monopoly and of a downstream trunk calls market with two firms operating in it with different cost functions. In order to offer one unit of trunk service, one unit of local loop service is needed. How much to charge downstream firms for this input is the main question addressed here. Downstream firms have different technologies, and it is feasible to distinguish between them and to impose different input prices.

Other controversial issues in telecommunications are the presence of economies of scale and the existence of imperfect competition. In this work it is assumed that market power and barriers to entry play a relevant role. As a consequence, downstream firms are modelled as Cournot competitors. In such a context, we discuss access charges where two-part schemes are used, and where discrimination is allowed. It is shown that the welfare implications of input price discrimination depend critically on whether access prices are regulated or set by the unregulated upstream firm. Related works include Panzar and Sibley (1989) in the case of regulated input prices, and DeGraba (1990) for unregulated ones.

Our main purpose is to provide a framework to study the ability to discriminate when market power is present at different levels of production. It should be noticed that in the market for access, a downstream firm's demand for the input depends not only on the input charge paid to the upstream producer but also on the price charged to the rival downstream firm. Downstream firms are therefore customers of the upstream producer with interrelated demands, a feature that distinguishes third-degree price discrimination on intermediate goods as opposed to final goods.

When the regulator sets access charges only, he will be concerned about productive and allocative efficiency. The ability to discriminate is equivalent to an increase in his limited regulatory power and he will use his discretion to offset imperfect downstream competition and to achieve more efficient production. On the other hand, when access charges are unregulated, the upstream monopolist is negatively affected by double-marginalisation problems. Obviously, the presence of a monopolist firm at some stage of production, implies that final allocations will always be distorted away from efficient levels. What remains to be analysed is the effect of input price discrimination in comparison with uniform pricing on aggregate output as well as on the way output is produced downstream. Intuitively, the upstream firm would be happy to have intense downstream competition, so that there is no separate mark-up in the final product market, and the undistorted monopoly profit could then be extracted. We show that discrimination in access charges by an unregulated firm, is indeed directed at offsetting the externality associated with double-marginalisation, but this may cause welfare losses. A more efficient downstream firm may be penalised, yielding more inefficient production. This is because the input demand of the more efficient firm is perceived by the monopolist as less elastic than that of the rival. However, this result delicately depends on the form of the tariff: if two-part access charges are introduced, then it is more likely that there are welfare gains with discriminatory charges.

The model studied here may also be relevant for examples other than vertically separated local and trunk networks. For instance, it can be applied to the case of interconnection between mobile network operators and a fixed trunk one. Entry in the mobile industry is often regulated by a licensing procedure that limits the number of operating firms. Final prices in the mobile market are not regulated and both anecdotal and empirical evidence from many countries suggest that competition is far from being perfect (see Parker and Röller, 1997). Similarly, value-added services carried over networks by service providers are another good example of a sector where an essential input is needed to supply an unregulated final product.

The market structure examined in this work is just one of the possible versions of a vertical upstream-downstream industry. The decision to keep the two levels separate is motivated by the purpose of studying the effect of access price discrimination for reasons other than market foreclosure. In our setting, there is no room for a dominant firm's practice to deny access to an essential input with the intent of extending monopoly power from one segment to the other (cf. Rey and Tirole, 1996). Problems of ownership are set aside simply because they are discussed elsewhere in the literature. The situation of a dominant and vertically integrated incumbent firm which is regulated and which faces some degree of competition in one or more of its markets has been considered by Armstrong *et al*. (1996), Armstrong and Vickers (1998), Baumol and Sidak (1994), Laffont and Tirole (1994). The interrelated issue of the optimal market structure (integration *versus* partial or complete liberalisation) is considered by Economides (1996) and Valletti (1996). Armstrong and Vickers (1993) show that a firm deciding whether or not to enter a market currently dominated by an incumbent that may also monopolise an essential facility is likely to respond differently if price discrimination for the essential facility is allowed and if the upstream monopolist is vertically integrated.

We assume that downstream prices cannot be regulated, and only the terms of access may be subject to the control of a benevolent regulator. The realism of this assumption can be seen in practical situations such as unregulated value-added services or mobile communications that require the fixed network. In many countries, including the U.S. and U.K., regulatory authorities have no jurisdiction over the prices of these services. The regulator cannot directly control the downstream price and only indirect regulation of downstream markets through access tariffs is possible.

The remaining part of the paper is organised as follows. After having set out the model's framework in section 2, in section 3 we consider a regulated environment. The regulator takes the market structure as given (one can think of this decision as being taken by a separate authority, e.g. the government decides on ownership in first instance) and subsequently he sets the interconnection charges. In section 4, we analyse an unregulated situation, where the upstream firm is allowed to impose different tariffs to downstream firms with different cost functions. The main question addressed is: Given these imperfections, will two-part tariffs and access discrimination improve or worsen welfare? Section 5 offers some policy implications and section 6 concludes.

2. The model

An upstream market is monopolised by an incumbent firm. The monopolist supplies an input q to two downstream firms, which use it to produce a homogenous output. The upstream firm has constant marginal costs, normalised to zero, and a positive fixed cost F. It charges two-part tariffs with an access fixed fee A and a usage charge a that may vary across the downstream firms. Total profit to the upstream firm is:

$$\Pi^u = \sum_{i=1}^{2} a_i q_i + \sum_{i=1}^{2} A_i - F.$$

Downstream producers use q to supply final consumers according to *different* cost functions. In particular we assume that downstream firm 1 is more efficient than 2, and the relative inefficiency of firm 2 is measured by a multiplicative factor k. The production technology available to firm i is $k_i C(q_i)$ where $k_i = 1$ for $i = 1$ and $k_i = k > 1$ for $i = 2$, $C'(\cdot) > 0$, $C''(\cdot) \geq 0$. Let $P(Q)$ be the market demand curve, $Q = q_1 + q_2$, $P'(\cdot) < 0$. Total profit to downstream firm i is:

$$\Pi^{d_i} = [P(q_1 + q_2) - a_i]q_i - A_i - k_i C(q_i) .$$

Downstream competition is imperfect, and we model this feature supposing that downstream firms act as Nash competitors using output strategies. In equilibrium the following first-order conditions must hold:

$$(1) \qquad \begin{cases} P(q_1 * + q_2 *) - a_1 + P'(q_1 * + q_2 *)q_1 * - C'(q_1 *) = 0 \\ P(q_1 * + q_2 *) - a_2 + P'(q_1 * + q_2 *)q_2 * - kC'(q_2 *) = 0 \end{cases}$$

The previous conditions imply:

$$(2) \qquad \begin{cases} q_1 * - q_2 * = \dfrac{a_2 - a_1 + (k-1)C'(q_2 *) + [C'(q_2 *) - C'(q_1 *)]}{-P'(Q*)} \\ Q* = q_1 * + q_2 * = \dfrac{2P(Q*) - a_1 - a_2 - C'(q_1 *) - kC'(q_2 *)}{-P'(Q*)} \end{cases}$$

In what follows we will omit asterisks for notational simplicity.

2.1 Benchmark

Let us first consider the efficient allocation. A central planner would initially choose the efficient plant(s) to run downstream by equating the marginal costs of the two available technologies, unless one of the two technologies always dominates the remaining one. Under our specifications we can have that either both plants are used at a level such that $C'(q_1) = kC'(q_2)$, or only plant 1 is used. In order to be concrete, we will further develop two corresponding cases, but results extend to more general settings:

• Case (a), both firms exhibit constant return to scale: $C'(\cdot) = c$. Only downstream firm 1 should be operated at any efficient allocation.
• Case (b), both firms are characterised by a quadratic cost function: $C(q) = q^2/2$. Efficient allocation requires that production is split in such a way that $q_1 = kq_2$.

The case of increasing return to scale is not considered here, but it is obvious that only a single downstream firm should be active.

After the technology choice has been made, a benevolent central planner operating the integrated industry would determine the optimal allocation in order to maximise total welfare subject to the fact that the firm at least breaks even. If total welfare is given by the simple sum of consumer surplus $CS(P)$ $(CS'(\cdot) = -Q)$ and industry profits, efficiency corresponds to the solution to the following programme:

$$\begin{cases} \underset{\{q_1,q_2\}}{\text{Max}}\ W = CS(P(Q)) + \Pi \\ \Pi = P(Q)Q - C(q_1) - kC(q_2) - F \geq 0 \\ \text{either } C'(q_1) = kC'(q_2),\ q_1 + q_2 = Q \\ \text{or } q_1 = Q,\ q_2 = 0 \end{cases}$$

The optimal price is set according to the inverse elasticity rule. In case (a), when a single firm operates downstream:

$$\frac{P(Q) - C'(Q)}{P(Q)} = \frac{\lambda}{1+\lambda}\frac{1}{|\varepsilon|},$$

where λ is the Lagrange multiplier of the firm's budget constraint and ε is the elasticity of demand. Similarly, in case (b) both firms are producing at the same marginal cost:

$$\frac{P(Q) - \frac{k}{k+1}C'(Q)}{P(Q)} = \frac{\lambda}{1+\lambda}\frac{1}{|\varepsilon|}.$$

A central planner who runs the industry, attains both productive and allocative efficiency, the former being a result of the technology choice and the latter using a Ramsey price.

3. Regulated setting

In many situations the regulator cannot impose the price of the final good but can only determine some conditions of access. As an example, think of BT's network (with effective accounting separation) providing access to a downstream unregulated industry (mobile operators). A planner (Oftel) can indirectly regulate the final market through the design of optimal access charges that maximise welfare subject to firms' participation constraints and Nash equilibrium conditions. In formal terms, the regulator solves the following programme:

$$\begin{cases} \underset{\{a_i, A_i\}}{\text{Max}}\ W = CS(P(Q)) + \Pi^{u} + \sum_{i=1}^{2} \Pi^{d_i} \\ \Pi^{u} \geq 0 \\ \Pi^{d_i} \geq 0, i = 1,2 \\ (1) \end{cases}$$

The general solution can be obtained from the maximisation of the associated Lagrangian:

$$(3) \qquad L(a_i, A_i) = CS(P(Q)) + (1+\lambda)\Pi^{u} + \sum_{i=1}^{2}(1+\mu_i)\Pi^{d_i}.$$

3.1 Non-discriminatory access charges

When access charges are not discriminatory, the regulator sets $a_i = a$ and $A_i = A$, $i = 1, 2$. First note from (2) that it is always the case that the more efficient firm 1 produces more than the rival. In fact we have:

case (a): $$q_1 - q_2 = \frac{(k-1)c}{-P'} > 0,$$

case (b): $$q_1 - q_2 = \frac{k-1}{-P'+1} q_2 > 0, \quad q_1 - kq_2 = \frac{P'(k-1)}{-P'+1} q_2 < 0.$$

It is interesting to note that any allocation will always be productively inefficient not only in case (a), but also in case (b) since it can never be that $q_1 = kq_2$. In both cases downstream firm 1 under produces compared to the efficient allocation, while firm 2 over produces.

The solution to programme (3) is discussed in the Annex. Among the results, we show that the optimal usage charge takes one of two expressions. One possibility is that firms make positive profits and the access charge is negative (we assume that such a subsidy is implementable; in section 5 we will comment on its realism). This fact also necessarily implies that $A > 0$ in order to recover upstream fixed costs and access losses. Imperfect competition leaves rents to downstream firms which are extracted with the fixed fee, while a is used to reduce downstream market power and achieve a more efficient allocation. The expression for a results to be:

(4) $$a = \frac{P'(\sum_{i=1}^{2} q_i \, \partial q_i / \partial a)}{\partial Q / \partial a} < 0.$$

The other possibility arises when the inefficient firm just breaks even as well as the bottleneck firm, while firm 1 still makes profits even after the fixed fee is paid. The corresponding usage charge is:

(4') $$a = \frac{\lambda (q_1 - q_2) + P'[-(q_1 \frac{\partial q_1}{\partial a} + q_2 \frac{\partial q_2}{\partial a}) + 2\lambda q_2 \frac{\partial q_1}{\partial a})]}{-(1+\lambda)\frac{\partial Q}{\partial a}}$$

It is not possible to sign unambiguously the expression, but we note that it can still be the case that a is set negative. This happens when the fixed costs to be recovered are not excessive, so that λ takes a small value. In any case, we show in the Annex that it is always optimal to set a positive fixed fee. This allows to reduce the usage charge and increase total industry output, without imposing losses overall on the upstream firm. The analysis developed in this section offers the following:

Result 1. When the regulator is able to impose two-part access fees (a, A), he will always exploit his opportunity and set $A > 0$. This allows him to decrease the variable access tariffs below the level that would otherwise result if $A = 0$. Total output increases, which has a positive impact on consumers, and the fixed part is calibrated to transfer profits between firms. In some cases a may be set below usage costs.

An implication of the previous result is that two-part access pricing can be seen as a good regulatory instrument. The regulator uses access prices to offset market power in the downstream market by setting low or even negative usage charges. The fixed component is set so that the fixed costs of the upstream monopolist are covered. Still the regulator has to accept productive inefficiencies if he desires both firms to participate downstream for the beneficial effects of increased competition. As a remark, note that the efficient firm is always rewarded since it is allowed to make positive profits at any optimal equilibrium.

3.2 Discriminatory access charges

When the regulator is allowed to choose different pairs (a_i, A_i) for each downstream firm *i*, the Kuhn-Tucker conditions corresponding to the maximisation of (3) change. Despite the apparent increased complexity of the program, the plausible combinations of the multipliers are still limited. Intuitively, a higher number of instruments allows the regulator to do at least as well as in the non-discriminatory case and possibly better, getting closer to the efficient outcome.

We discuss the solutions in the Annex, where it is shown that two cases may arise. In the more interesting case, all firms just break even and we prove that discriminatory two-part tariffs are imposed and the usage fee of firm 1 is *lower* than the one required from firm 2. Firm 1 (the efficient one) thus increases its share of total output in presence of discrimination, being rewarded relatively to the more inefficient firm 2. The optimal variable component for firm *i* is:

$$(5) \qquad a_i = \frac{-P'(\lambda q_j - q_i)}{1+\lambda}, \quad i,j = 1,2, \; i \neq j.$$

Note that both access charges can be negative if the budget constraint is not too tight. Recalling equation (2) we also obtain that $C'(q_1) = kC'(q_2)$, i.e. in case (b) discrimination makes it possible to reach productive efficiency.

The other case is relevant when neither constraint is binding (all firms earn profits and multipliers are zero). The usage charge for each firm simplifies to:

$$(5') \qquad \frac{a_i}{P} = -\frac{1}{|\varepsilon|}\frac{q_i}{Q} < 0 \qquad i, = 1,2.$$

Both a_i are set below marginal costs, and the fixed parts allow the upstream firm to recoup losses. The usage fee gives a reward to the firm that produces more, which turns out to be the more efficient one. Clearly this case is not consistent with downstream constant returns to scale and all active firms. On the other hand, in case (b) production is split in the efficient way. The analysis derived in this section leads to the following:

Result 2. A benevolent regulator should price discriminate if allowed to do so, since this unambiguously increases total welfare. Price discrimination induces the more productive firm to produce more. Discriminatory access tariffs, possibly below usage cost, are used to reduce inefficiencies without leaving downstream firms with extra profits. In case (b), full productive efficiency is reached.

Results 1 and 2 are obtained under quite strong assumptions, namely that the regulator wants two firms to be operating downstream, and that he can effectively discriminate between them. The first point is related to the optimal structure chosen for the market, and from a welfare-maximisation standpoint, in case (a) it is clearly inefficient to have both firms participating downstream. If the regulator were not concerned about the *number* of downstream operating firms, he could induce the optimal behaviour in a very simple way by concentrating only on the efficient firm. The combination of a suitable variable access charge set below marginal cost, and a fixed fee that takes away all profits, can induce the downstream monopolist to produce at the socially desirable level. If at the same time the access fee to the other firm is set so high that it will not enter the market, the second best can be attained. Despite its simplicity, the alternative of imposing "very" discriminatory access charges is not consistent with current political agendas in various countries which include competition as an objective *per se*.

The practicability of discrimination is subject to question since it implies that the regulator has accurate cost information on downstream production function and that discrimination is permissible in law. However, the main point of this paper is not to propose two-part discriminatory access prices as a good regulatory scheme, but to point out adverse consequences that may arise in an unregulated setting, as it is shown in the next section.

4. Unregulated setting

This section considers the setting of access prices by the upstream firm. We suppose now that the industry is not regulated. The timing is as follows: first the monopolist quotes the access tariffs, then downstream firms compete imperfectly as Cournot duopolists. Market competition is the same as before and its equilibrium is characterised by equations (1). Thus the monopolist solves:

$$(6) \qquad \begin{cases} \text{Max } \Pi^u \\ \Pi^{d_i} \geq 0, \ i = 1{,}2 \\ (1) \end{cases}$$

As we have already anticipated in the introduction, the upstream firm is concerned about vertical externalities. The upstream monopolist might find it advantageous to equalise cost differences through the levying of differential charges.

The fixed fee does not affect the level of production of each participating downstream firm at the margin, but can be used to extract residual downstream profits after a variable access charge has been paid, or even to exclude a firm from the downstream market. This may turn out to be of crucial importance and this is why we will study two situations according to whether the monopolist can discriminate over both the usage charge and the fixed part or just over usage. The difference is also relevant in practical terms, and it reflects the ability of the monopolist to compute (possibly discriminatory) wholesale schedules or to set just the variable component. The latter case will be referred to as "variable", while the former as "complete". The "complete" case corresponds to a simultaneous calculation of the components of the wholesale schedule. On the other hand, the results of the "variable" case are also valid in the presence of an exogenously fixed entry fee A that simply shifts rents and does not drive any firm out of the market. In order to be able to obtain closed solutions, we will sometimes provide explicit expressions using a linear specification of the demand function: $P = b - dQ$.

4.1 Non-discriminatory access charges

The optimal access charges chosen by the upstream monopolist when he is not allowed to discriminate over prices are calculated in the Annex. When a fixed fee is imposed, it takes the form $A \leq \min(\Pi^{d_i}(a))$. Expressions for the usage part in the "variable" and "complete" cases are respectively:

(7) $$a = -\frac{Q}{\frac{\partial Q}{\partial a}} > 0,$$

(7') $$a = \frac{q_1 - q_2 + 2P'\frac{\partial q_1}{\partial a}q_2}{-\frac{\partial Q}{\partial a}} > 0.$$

The monopolist always chooses to charge a variable fee higher than marginal costs in order to reduce total quantity produced and sold. Obviously, in the "complete" case the access charge can be reduced more than in the "variable" case in order to offset double marginalisation. As an example, under linear demand and constant marginal costs, (7) would simplify to $a = b/2 - c(k + 1)/4$ and (7') to $a = (2b - 7c + 5kc)/8$ which is always less than the previous charge when firms make non-negative profits. Similarly, it can be shown that in case (b) the access "variable" charge would be $b/2$ and the access "complete" charge would always be lower than $b/2$ although strictly increasing in k.[1] In all cases, as k increases, the difference between "variable" and "complete" charges diminishes. It is not obvious how the vertical externality problem is addressed once discrimination is introduced. Even less obvious is whether the monopolist, given a certain output, is interested in having production split in an efficient way. This is what we turn to next.

4.2 Discriminatory access charges

The general solution to the problem when access price discrimination is permitted is studied in the Annex. The fixed component takes the form $A_i \leq \Pi^{d_i}(a_i)$ while usage charges in the "variable" and "complete" cases are respectively:

$$(8) \qquad a_i = \frac{q_j \dfrac{\partial q_j}{\partial a_i} - q_i \dfrac{\partial q_j}{\partial a_j}}{\dfrac{\partial q_1}{\partial a_1}\dfrac{\partial q_2}{\partial a_2} - \dfrac{\partial q_1}{\partial a_2}\dfrac{\partial q_2}{\partial a_1}},$$

$$(8') \qquad \frac{a_i}{P} = \frac{1}{|\varepsilon|}\frac{q_j}{Q}, \quad i,j = 1,2, i \neq j$$

It is shown in the Annex that it is possible to compare (7) and (8) under general conditions. We obtain results that are in contrast to the unambiguous welfare-improving property of regulated discrimination. As an example, in the "variable" case with linear demand and constant returns to scale, the non-discriminatory access charge would be $a = b/2 - c(k + 1)/4$, while the discriminatory ones $a_1 = (b - c)/2$, $a_2 = (b - kc)/2$. In other words, the monopolist which is allowed to price discriminate, charges a higher price to the most efficient firm that also ends up producing less than in the absence of discrimination. In this very simple example, consumer surplus is unaffected (it can be shown that the same total quantities are produced in the two cases), and under price discrimination the less efficient firm produces more output. The associated higher costs of producing the same quantity imply that price discrimination reduces total welfare. If the inverse-demand function is concave, then the aggregate output produced under price discrimination can be less than that produced under non-discriminatory charges. In case

[1] For instance, when $d = 1$, $a = b(3k^2 + 6k - 1)/[2(k+1)(3k+7)]$, so that $a = .21b$ when $k = 1.1$ and $a = .4b$ when $k = 4$.

(b), under any demand schedule, an equal usage fee would be charged to both firms exactly as in the non-discriminatory case. Contrary to the regulated case, the monopolist does not exploit its ability to discriminate to induce more efficient production.

Turning to the "complete" charges, in case (a), there would be a contrast between the tendency to exclude the inefficient firm from producing and the structural regulation that requires both downstream firms to be active. Fixed fees would bring about the exit of the least efficient firm. On the other hand, unit discriminatory charges given by (8) are valid in case (b) and they would be used to reach the pure monopoly output. Under many circumstances, it also possible to show that the variable fee for each firm is set lower than the variable fee under non-discriminatory two-part prices.[2] This discussion can be summarised in the following:

Result 3. Unregulated access price discrimination may not be socially desirable when it levels downstream firms by penalising the firm with lower marginal cost and increases inefficiencies. This is more likely to happen when downstream firms have constant returns to scale and when discrimination involves only the setting of unit access charges rather than two-part discriminatory fees.

The model we have presented is *ad hoc*. Its obvious limitation derives from imposing both downstream firms to be active. However, the argument appeals to the empirical facts that regulators like to see competition downstream, with the latter identified by the number of active firms. We emphasise once more that the points addressed by this work are not related to the optimal market structure either from the collective or from the private point of view. On the other hand, we have discussed the different behaviours of a regulator and of an unregulated incumbent firm that react to the possibility of discriminating over access, given that there exists imperfect competition among a fixed number of firms in the downstream market.

5. Policy implications

The analysis developed in the previous sections, points towards two main results:

(a) regulated discriminatory access prices are welfare improving;

(b) unregulated discriminatory access prices may have adverse effects.

[2] In the case of linear demand with $d = 1$, it results $a_1 = b/(3k+2)$, $a_2 = kb/(3k+2)$. It is easy to see that $a_1 < a_2 < a$ where a takes the value reported in footnote 1.

Result (a) is obtained under general conditions and it is immediately intuitive. Discrimination gives discretionary power to the regulator, who can more effectively address problems arising from inefficient production and market power even when final markets are unregulated. The same idea applies to two-part tariffs. However, the result is probably of little practical use. In fact, the kind of two-part access prices that we have discussed can be seen as taxes levied on firms in a rather flexible way. In reality, this is beyond the powers of modern regulators. Moreover, it would reflect an interventionist approach which is contrary to the general trend observed in many utility sectors.

The impact of existing regulation on the efficiency of networks is a big issue. Open access to networks is necessary for competition to develop, but the degree of cream skimming and inefficient competition depend on the price that competitors pay to access the main networks. At the European level, the Commission favours access prices based on long run incremental costs. The accounting simplicity of cost-based rules is criticised by economists for having very little economic logic. It is usually shown that optimal access prices have a more complex structure: They should differ according to the end product type, the final operator, and so forth for what is an identical service being supplied to customers. This reasoning can be pushed even further, by arguing that full pricing flexibility is essential to avoid undermining competition. Thus Grout (1996) fears that the lack of flexibility could prevent the emergence of new products, such as value added services to the home.

The policy question concerning the correct balance between pricing flexibility and protection of competition is still open. Result (b) can be used to discuss the amount of access pricing discretion that should be allowed to incumbents. We agree that a fair amount of flexibility should be granted since it is always better to pay for the network by raising prices relatively more on low-price-elasticity products (if no equity or redistributive concerns are present). However, sophisticated pricing has disadvantages. In our model, we point out that discriminatory charges may worsen productive efficiency. If this result is added to the findings of the relevant literature on predation and foreclosure mentioned in the introduction, it appears that flexibility should be constrained. In practical terms, we are proposing limits to the degree of discretion given to incumbents, but to allow access charges to depart from network costs. We are in favour of different charges according to product type that could be implemented by larger price caps. However, the price list for access inputs should be published by the network owner and should be available to everybody.

6. Conclusions

This paper has examined two interrelated categories of problems, access tariffs and price discrimination. When access tariffs are regulated, then discriminatory prices can be used by a benevolent regulator to improve inefficient situations deriving from downstream imperfect competition and from different cost functions. On the other hand, the welfare implications of access price discrimination are often reversed in an unregulated setting when an upstream monopolist makes take-it-or-leave-it offers to downstream producers. The monopolist has no incentive to induce the more efficient firm to produce a higher output as the regulator would do. An immediate implication of our results is that discriminatory interconnection charges have uncertain consequences.

In many imperfectly competitive industries, the regulation of market power is often indirect. The problem has shifted from the design of optimal rules, to a *laissez faire* approach. The belief that explicit regulation can be replaced and improved by competitive mechanisms is not robust in industries complicated by naturally monopolistic activities and complex vertical structures. Here, we have presented a theoretical framework to address the effects of imperfect competition on productive and allocative efficiency, suggesting that unregulated discrimination may be worse for welfare than the setting of unregulated non-discriminatory access charges.

Our analysis depends crucially on differences among technologies, which is justifiable in a short-term perspective. Possible extensions include the removal of entry barriers and free entry downstream. In an unregulated setting our results may be even reinforced. Intuitively, consider the situation of firms choosing their technology before entering the downstream market, with different available technologies, one with higher fixed costs and lower marginal costs. Following the analysis presented in section 4, firms with lower marginal costs can be adversely affected by discriminatory access charges (of the "variable" type), and this may make entrants more inclined to choose a technology with higher marginal costs.

References

Armstrong, Mark, Chris Doyle and John Vickers, 1996, "The Access Pricing Problem: A Synthesis," *Journal of Industrial Economics* 44(2): 131-50

Armstrong, Mark and John Vickers, 1998, "The Access Pricing Problem with Deregulation: A Note," *Journal of Industrial Economics* 46(1): 115-21

Armstrong, Mark and John Vickers, 1993, "Price Discrimination, Competition and Regulation," *Journal of Industrial Economics* 41(4): 335-357

Baumol, William J. and J. Gregory Sidak, 1994, *Toward Competition in Local Telephony* (MIT Press, Cambridge (MA))

DeGraba, Patrick, 1990, "Input Market Price Discrimination and the Choice of Technology, "*American Economic Review* 80(5): 1246-53

Economides, Nicholas S., 1996, "The Economics of Networks," *International Journal of Industrial Organization* 14(6): 673-99

Grout, Paul A., 1996, "Promoting the Superhighway: Telecommunications Regulation in Europe," *Economic Policy* April: 111-54

Panzar, J. C. and David S. Sibley, 1989, "Optimal Two-part Tariffs for Inputs," *Journal of Public Economics* 40: 237-49

Parker, Philip M. and Lars-Hendrik Röller, 1997, "Collusive Conduct in Duopolies: Multimarket Contact and Cross-Ownership in the Mobile Telephone Industry," *RAND Journal of Economics* 28(2): 304-22

Rey, Patrick and Jean Tirole, 1996, "A Primer on Foreclosure," *Mimeo*, Université de Toulouse

Valletti, Tommaso, 1996, "Accesso alla rete e regolamentazione: alcune considerazioni teoriche," *Rivista Internazionale di Scienze Sociali* 104(3): 441-66

Annex: Proofs

Proof of Result 1

The Kuhn-Tucker conditions for the maximisation of (3) are:

$$\frac{\partial L}{\partial a} = a(1+\lambda)\sum_{i=1}^{2}\frac{\partial q_i}{\partial a} + \sum_{i=1}^{2}(\lambda-\mu_i)q_i + P'\sum_{\substack{i,j=1\\ j\neq i}}^{2} q_i\left(-\frac{\partial q_i}{\partial a}+\mu_i\frac{\partial q_j}{\partial a}\right) = 0;$$

$$\frac{\partial L}{\partial A} = \sum_{i=1}^{2}(\lambda-\mu_i) \leq 0, A \geq 0, A\frac{\partial L}{\partial A} = 0;$$

$$\frac{\partial L}{\partial \lambda} = \Pi^{u} \geq 0, \lambda \geq 0, \lambda\frac{\partial L}{\partial \lambda} = 0;$$

$$\frac{\partial L}{\partial \mu_i} = \Pi^{d_i} \geq 0, \mu_i \geq 0, \mu_i\frac{\partial L}{\partial \mu_i} = 0, i = 1,2.$$

From the Nash FOCs (1) we can do some comparative static exercises:

$$\partial q_1/\partial a = [P'(Q) - (q_1 - q_2)P''(Q) - kC''(q_2)]/D < 0$$
$$\partial q_2/\partial a = [P'(Q) + (q_1 - q_2)P''(Q) - C''(q_1)]/D < 0$$
$$\partial Q/\partial a = [2P'(Q) - C''(q_1) - kC''(q_2)]/D < 0$$
$$D = (2P' + P''q_2)[P' - C''(q_1)] + (2P' + P''q_1)[P' - kC''(q_2)] + kC''(q_1)C''(q_2) - P'^2$$

The previous signs stem from the condition for local stability ($D > 0$), and from the concavity of the objective functions. For the latter, it suffices that the inverse-demand function be concave ($P''(\cdot) \leq 0$), which is also sufficient for quantities to be strategic substitutes. In case (a) D simplifies to the more familiar condition $P'(3P' + P''Q) > 0$. We also have that $\partial q_1/\partial a$ - $\partial q_2/\partial a \leq 0$ (equality holds with linear demand and constant marginal cost). Intuitively, as a goes up cost differences between the two firms tend to reduce and, according to (2), q_2 gets closer to q_1. For the gap to become narrower, q_1 has to decrease more than q_2. Before proceeding further, we note that there are 8 possible combinations for the multipliers, but only some of them are plausible:

Case:	1	2	3	4	5	6	7	8
λ	+	+	+	+	0	0	0	0
μ_1	+	+	0	0	+	+	0	0
μ_2	+	0	+	0	+	0	+	0
plausible:	no	no	yes	no	no	no	no	yes

• Case 4 (5) cannot be optimal since the monopolist would be at a zero (positive) profit and downstream firms at positive (zero) profits. If the fixed access fees were increased (decreased) by a unit, net welfare would increase by the positive multiplier(s) of the upstream (downstream) firm(s). A similar argument also rules out cases 6 and 7.

• Case 2 implies that the upstream monopolist and firm 1 are breaking even, while 2 is making profits. This cannot happen in case (a), since a break-even condition for firm 1 would imply losses for firm 2. In case (b), the price has to be $P = a + q_1/2 + A/q_1$. This implies $\Pi^{d_2} = -q_2(kq_2 - q_1)/\ 2 - A(q_2 - q_1)/q_1 < 0$, contradicting $\mu_2 = 0$.

• Perhaps more surprisingly, also case 1 cannot be true at an optimal allocation. Zero downstream profit for both firms implies $P - a = [C(q_1) - kC(q_2)]/\ (q_1 - q_2)$. Using this expression to rearrange profits, we get contradictions

$$\Pi^{d_i} = \frac{C(q_1)q_2 - kC(q_2)q_1}{q_1 - q_2} - A = \begin{cases} -(k-1)q_1 q_2 c/(q_1 - q_2) - A < 0 & \text{case (a)} \\ q_1 q_2 (q_1 - kq_2)/\ 2(q_1 - q_2) - A < 0 & \text{case (b)} \end{cases}$$

• We are left with only two possible combinations of the multipliers. Starting with case 8, from the first Kuhn-Tucker condition we can derive expression (4) reported in the text. The negative access charge implies that a positive fixed fee is set to recover fixed costs.

• Case 3 is slightly more complex. We can first show that the regulator always chooses to set a positive A. Obviously, if the access charge is set below its cost, then a positive entry fee is needed to allow the upstream firm to recoup its losses. Assume next that $a > 0$ and $A = 0$, then $P = a + kC(q_2)/q_2$. Perturb infinitesimally the system by decreasing the usage charge and increasing the fixed fee in a way such that firm d_2 still breaks even:

$$\mathrm{d}\Pi^{d_2} = (P' \frac{\partial q_1}{\partial a} - 1)q_2 \mathrm{d}a - \mathrm{d}A = 0.$$

Consumer surplus and profits of the remaining firms are affected as follows:

$$\mathrm{d}CS(P) = CS'(P)[\frac{kC'(q_2)}{q_2}\frac{\partial q_2}{\partial a}\mathrm{d}a + \frac{\mathrm{d}A + q_2 \mathrm{d}a}{q_2} - \frac{kC(q_2) + A}{q_2^{\,2}}\frac{\partial q_2}{\partial a}\mathrm{d}a] =$$

$$= -Q\{\frac{k\,\partial q_2/\partial a}{q_2}[\frac{C(q_2)}{q_2} - C'(q_2)] + P'\frac{\partial q_1}{\partial a}\}\mathrm{d}a,$$

$$\mathrm{d}\Pi^{u} = (a\frac{\partial Q}{\partial a} + Q)\mathrm{d}a + 2\mathrm{d}A = [\frac{\partial q_1}{\partial a}(a + 2P'q_2) + a\frac{\partial q_2}{\partial a} + q_1 - q_2]\mathrm{d}a,$$

$$\mathrm{d}\Pi^{d_1} = (P'\frac{\partial q_2}{\partial a} - 1)q_1 \mathrm{d}a - \mathrm{d}A = [-(q_1 - q_2) + P'(q_1\frac{\partial q_2}{\partial a} - q_2\frac{\partial q_1}{\partial a})]\mathrm{d}a.$$

The previous expressions can be signed, showing negative impacts for a positive increment d*a*. In conclusion, starting from $A = 0$, if a is lowered and A is raised we can improve total welfare and it must be $A > 0$ at the optimum. Having obtained this result, the Kuhn-Tucker condition for A states that $2\lambda = \mu_2$, and optimal usage charge a simplifies to expression (4') in the main text.

Proof of Result 2

The proof is similar to the previous one and we just provide a sketch. The Kuhn-Tucker conditions corresponding to the maximisation of (3) are:

$$\frac{\partial L}{\partial a_i} = (1+\lambda)\sum_{j=1}^{2} a_j \frac{\partial q_j}{\partial a_i} + (\lambda - \mu_i) q_i + P' \sum_{\substack{j,s=1 \\ s\neq j}}^{2} q_j \left(-\frac{\partial q_j}{\partial a_i} + \mu_j \frac{\partial q_s}{\partial a_i}\right) = 0, \quad i = 1,2;$$

$$\frac{\partial L}{\partial A_i} = \lambda - \mu_i \leq 0, A_i \geq 0, A_i \frac{\partial L}{\partial A_i} = 0, i = 1,2;$$

$$\frac{\partial L}{\partial \lambda} = \Pi^u \geq 0, \lambda \geq 0, \lambda \frac{\partial L}{\partial \lambda} = 0;$$

$$\frac{\partial L}{\partial \mu_i} = \Pi^{d_i} \geq 0, \mu_i \geq 0, \mu_i \frac{\partial L}{\partial \mu_i} = 0, i = 1,2.$$

Totally differentiating the FOCs (1) we can derive the expressions for $\partial q_i/\partial a_j$:

$$\frac{\partial q_i}{\partial a_i} = \frac{2P'(Q) + q_j P''(Q) - k_j C''(q_j)}{D}$$

$$\frac{\partial q_i}{\partial a_j} = \frac{-P'(Q) - q_i P''(Q)}{D}, \quad i, j = 1,2, i \neq j.$$

Without having to rely on specific functional forms, we are still able to sign the following sum and difference of derivatives, which will turn to be useful in the subsequent analysis:

$$\frac{\partial q_i}{\partial a_i} + \frac{\partial q_j}{\partial a_i} = \frac{P' - k_j C''(q_j)}{D} < 0, \quad i = 1,2, \; i \neq j$$

$$B_i = \frac{\partial q_i}{\partial a_i} - \frac{\partial q_i}{\partial a_j} = \frac{3P' + QP'' - k_j C''(q_j)}{D} < 0, \quad |B_1| \geq |B_2|.$$

The last expressions say that: (i) the reduction in the quantity produced by firm i due to an increase in its usage fee can only be partially offset by an equal increase of the usage fee of the other firm; (ii) effect (i) is bigger in absolute value for the more efficient firm (equality holds in case (a)). The plausible combinations of the multipliers are summarised in the following table.

Case:	1	2	3	4	5	6	7	8
λ	+	+	+	+	0	0	0	0
μ_1	+	+	0	0	+	+	0	0
μ_2	+	0	+	0	+	0	+	0
plausible:	yes	no	no	no	no	no	no	yes

• Cases 4, 5, 6 and 7 are ruled out for the same reasons exposed in the previous proof.
• Cases 2 and 3 cannot be optimal since a unit increase in the fixed fee for the downstream firm making profits would increase total welfare by λ without violating the other firm's participation constraint.
• In case 1 all firms just break even and a positive fixed fee is imposed downstream, the multipliers are positive and all equal. Expression (5) in the text gives the optimal access charge. After subtracting and rearranging the Kuhn-Tucker conditions for a_i's, we also get that the usage fee of firm 1 is lower than the one required from firm 2:

$$(1+\lambda)(B_1 a_1 - B_2 a_2) = P'[q_1(B_1 + \lambda B_2) - q_2(B_2 + \lambda B_1] > 0.$$

• Case 8. When neither constraint is binding (all multipliers are zero), the usage charge for each firm simplifies to expression (5') in the text.

Proof of Result 3
We solve for the monopolist's problem (6). Results are obtained in a way very close to Results 1 and 2. The only change is in the objective function. Notice also that the solution to the "complete" case includes the "variable" case. The difference is that in the latter situation A is either absent or "sunk", then the multipliers are necessarily zero in the condition for the usage charge while the Kuhn-Tucker condition on the fixed part is not relevant.

• The FOCs in the non-discriminatory case are:

$$\frac{\partial L}{\partial a} = q_1(1-\mu_1) + q_2(1-\mu_2) + (a + \mu_2 P' q_2)\frac{\partial q_1}{\partial a} + (a + \mu_1 P' q_1)\frac{\partial q_2}{\partial a} = 0,$$

$$\frac{\partial L}{\partial A} = \sum_{i=1}^{2}(1-\mu_i) \leq 0, A \geq 0, A\frac{\partial L}{\partial A} = 0.$$

In the "variable" case, one immediately gets expression (7). In the "complete" situation, possible combinations are reduced only to the case in which the efficient firm makes profits and the inefficient one just breaks even (its multiplier is therefore equal to 2). Rearranging leads to expression (7') reported in the text.

• The FOCs under discrimination are:

$$\frac{\partial L}{\partial a_i} = (1-\mu_i)q_i + \sum_{j=1}^{2} a_j \frac{\partial q_j}{\partial a_i} + P' \sum_{\substack{j,s=1 \\ s\neq j}}^{2} \mu_j \frac{\partial q_s}{\partial a_i} q_j = 0,$$

$$\frac{\partial L}{\partial A_i} = 1-\mu_i \leq 0, A_i \geq 0, A_i \frac{\partial L}{\partial A_i} = 0, i = 1,2.$$

In the "variable" case, the expression for access charges is (8) in the text. The difference between FOCs also gives:

$$B_1 a_1 - B_2 a_2 = -(q_1 - q_2)$$

Recalling the Nash FOCs (2), we can simplify:

case (a) $\quad a_1 - a_2 = \frac{(k-1)c}{1+P'B} = \frac{(k-1)c}{2} > 0$

case (b) $\quad (1+P'B_1)a_1 - (1+P'B_2)a_2 = kq_2 - q_1$

In case (a), a_1 is always set above a_2. This is not clear in case (b), since the coefficient of a_1 is greater than that of a_2, but we cannot tell unambiguously if discrimination favours one firm when the RHS is positive. A necessary condition for discrimination to have adverse welfare effects is clearly that firm 2 has to over produce.

It is possible to say something about the access prices in the two different pricing regimes by following a different strategy. We look at the sign of the first-order partial derivative of the upstream firm's profit function w.r.t. the discriminatory prices at the profit-maximising uniform price a given by eq. (7):

$$\left.\frac{\partial \Pi^u}{\partial a_i}\right|_{a_1=a_2=a} = q_i + a\left(\left.\frac{\partial q_1}{\partial a_i}\right|_{a_1=a_2=a} + \left.\frac{\partial q_2}{\partial a_i}\right|_{a_1=a_2=a}\right) = q_i - \frac{Q}{D}\frac{-k_j C''(q_j)}{2P' - C''(q_1) - kC''(q_2)}$$

The previous expression simplifies in the two cases:

case (a) $\left.\frac{\partial \Pi^u}{\partial a_1}\right|_{a_1=a_2=a} = -\left.\frac{\partial \Pi^u}{\partial a_2}\right|_{a_1=a_2=a} = q_1 - Q/2 = (q_1 - q_2)/2 > 0$

case (b) $\left.\frac{\partial \Pi^u}{\partial a_1}\right|_{a_1=a_2=a} = \left.\frac{\partial \Pi^u}{\partial a_2}\right|_{a_1=a_2=a} = q_1 - Q\frac{k-P'}{k+1-2P'} = \frac{(1-P')q_1-(k-P')q_2}{k+1-2P'} = 0$

This proves that it is possible to compare expressions (7) and (8). In particular, when marginal costs are constant (case (a)), then the discriminatory access prices bracket the uniform price: the access price for the most efficient firm is higher than the optimal uniform price which is higher than the price of the least efficient firm ($a_1 > a > a_2$). DeGraba (1990) obtained this result for the linear demand case, here we have extended it to more general conditions. On the other hand, under decreasing returns to scale in the downstream sector (case (b)) the upstream monopolist does not gain anything from his ability to discriminate.

In case (a) it is of interest to ascertain the conditions under which total output decreases under discrimination compared to the non-discrimination case. For simplicity of notation we refer to the discriminatory variables with a superscript *d*, while the non-discriminatory variables are without superscript. By adding the two FOCs (1) both under discrimination and uniform pricing, and then subtracting one from the other, we get:

$$a_1 + a_2 - 2a = 2(P^d - P) - P'Q + (P'Q)^d$$

From eqs. (7) and (8) and using the previous results on comparative statics, we also get:

$$a_1 + a_2 - 2a = -3(P'Q)^d - 2[P''(q_1^2 + q_2^2)]^d + Q(3P' + P''Q)$$

By equating the RHS of the last two expressions, we finally obtain:

(9) $$P^d - P = 2[P'Q - (P'Q)^d] - [P''(q_1^2 + q_2^2)]^d + P''Q^2/2$$

By studying (9) under different types of curvature of the inverse demand, we can try to sign the change in aggregate output caused by a switch in the pricing regimes. Clearly, if demand is linear there is not change in total output from discrimination to uniform pricing. We concentrate on the case of strictly concave demand ($P'' < 0$).

If P'' is constant, then discriminatory charges reduce total output. Imagine, on the contrary, that $P^d < P$ $Q^d > Q$. Since marginal revenue is decreasing with quantity, the first bracket of the RHS of (9) is positive. Also the remaining terms of the RHS are positive because $(q_1^2 + q_2^2)^d \geq (Q^2)^d / 2 > Q/2$. But this contradicts the fact that the LHS is negative when $P^d < P$.

If P'' is not constant, a sufficient condition to have decreased total output under discrimination is that the expression $z(q) = 2P'(q)q + P''(q)q^2 / 2$ is decreasing in q. In fact we can rewrite (9) as:

$$P^d - P < 2[P'Q - (P'Q)^d] - [P''Q^2 / 2]^d + P''Q^2 / 2 = z(Q) - z(Q^d)$$

If $P^d < P$, then the LHS is negative but the RHS is positive, again a contradiction.

In the "complete" case, all downstream firms just break even and a positive fixed fee is imposed to both downstream firms, the multipliers are all equal to unity. Access discrimination cannot be used with fixed fees in case (a) because it would always exclude firm 2 from the market. Expression (8') in the text gives the optimal usage charge valid only in case (b). Rearranging the Kuhn-Tucker conditions for a_i's, we get:

$$B_1 a_1 - B_2 a_2 = P'(q_1 B_2 - q_2 B_1)$$

With linear demand, discrimination would be advantageous to the efficient firm. This is not true in general because the sign of the expression into the brackets depends on the concavity of demand.

As before, we can look at the sign of the first-order partial derivative of the upstream firm's profit function w.r.t. the discriminatory prices at the profit-maximising uniform price a under a two-part tariff given by expression (7'):

$$\left.\frac{\partial \Pi^u}{\partial a_i}\right|_{a_1=a_2=a} = a\left(\left.\frac{\partial q_1}{\partial a_i}\right|_{a_1=a_2=a} + \left.\frac{\partial q_2}{\partial a_i}\right|_{a_1=a_2=a}\right) + P'\left(q_j \left.\frac{\partial q_i}{\partial a_i}\right|_{a_1=a_2=a} + q_i \left.\frac{\partial q_j}{\partial a_i}\right|_{a_1=a_2=a}\right)$$

Using the comparative statics results and the fact that $q_1 = q_2(k - P')/(1 - P')$ without discrimination, we get after manipulations:

$$\left.\frac{\partial \Pi^u}{\partial a_1}\right|_{a_1=a_2=a} = -(k-1)\{k^2(1 - 2P' - P''q_1) - P'[6P'^2 - P'(4 - P''Q) - 2P''q_2] +$$

$$k[7P'^2 - P''q_2 - 2P'(2 - P''q_1)]\}/[(1 + k - 2P')(1 - P')] < 0$$

when demand is (weakly) concave. The monopolist would then choose to decrease the access price for the efficient firm compared to the non-discriminatory situation. As far as the inefficient firm is concerned, we can get:

$$\left.\frac{\partial \Pi^{u}}{\partial a_2}\right|_{a_1=a_2=a} = \frac{-(k-1)[k(1-2P'-P''q_1)-2P'-P''q_2+P'^{2}(3+P''Q)]}{(1+k-2P')(1-P')}$$

The previous expression is negative as long as the demand is not too concave. For instance, in the linear demand case, both firms would face lower variable charges with two-part tariffs under discrimination than without.