Access Charges in the Presence of Call Externalities *

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Abstract

We introduce call externalities in the standard model of network competition with termination-based price discrimination, and employ a simple graphical analysis to study the outcome of competition. In contrast to recent results in the literature, we find that even under linear pricing, access charges *below* marginal cost are used as a collusion device, while off-net prices are *above* on-net prices in equilibrium. Moreover, "bill and keep" arrangements may be welfare improving compared with cost-based access pricing.

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1 Introduction

1.1 Literature Overview

The telecommunications industry has undergone rapid change in several aspects during the last years. Many countries have experienced exorbitantly high growth rates in the mobile telephony market. This has shifted the focus of research in telecommunications to markets characterized by two-way interconnection. In such a market, competing service providers are interconnected, and part of their service consists of terminating calls that originate on their rivals' networks. Since this is costly, firms collect per-minute *access charges* from each other for termination. These access charges are usually negotiated on a reciprocal basis, and regulatory intervention is only necessary if negotiations fail.

In the second half of the 1990s, serious concerns have been raised in the literature about firms' ability to use a cooperatively determined access charge as a collusion device. The first to show the negative welfare effects of cooperatively determined access charges within an explicit model were Armstrong (1998) and Laffont et al. (1998a, 1998b) – henceforth LRTa and LRTb. They employ models where two networks are differentiated in the Hotelling style and compete for customers in prices. The models of LRTa and LRTb, for uniform pricing and termination-based price discrimination, respectively, are by now widely accepted as the "standard models" of two-way interconnection, and most of the subsequent literature uses them as a starting point. These models predicts that under a linear pricing rule, the negotiated access charge is used as a collusive device and exceeds the marginal cost of access.

Subsequently, however, it has been shown that also access pricing *below* marginal cost may be the outcome of competition, if networks compete in two-part tariffs with discriminatory prices (Gans and King, 2001), if demand for subscription is elastic (Dessein, 2003, Schiff, 2002), or if ex-ante investments have to be made (Cambini and Valletti, 2003). Gans and King (2001) also conclude that the widespread "bill and keep" arrangements, corresponding to a zero access charge, may be used to soften price competition, and hence are undesirable from the consumers' perspective. This view is reinforced by the results of Dessein (2003).

1.2 Call Externalities

All of the papers discussed above share the assumption that only the caller benefits from a call, but not the receiver. This is obviously not the case. The fact that a call generates utility also for the receiver has been recognized, but nonetheless widely neglected in the literature.[1]

In this paper we introduce *call externalities* into LRTb. As we show, this has a significant effect in the presence of termination-based price discrimination.[2] The reason for this is that if consumers care about being called,

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[1] See the discussion in Hahn (2003). Call externalities are only studied in the context of a *receiver pays* system, e.g. Kim and Lim (2001), Jeon et al. (2003), or DeGraba (2003).

[2] Under nondiscriminatory pricing the analysis of competition remains unchanged, see Armstrong (2002). The only impact of call externalities then lies in the judgement of

networks set higher off-net prices to make subscription to the rival less attractive. In order to bring down these off-net rates below the monopoly price, the negotiated access charge will often be set below cost. Nevertheless, contrary to Gans and King's (2001) results, on-net prices are below off-net prices, and "bill and keep" might even be welfare improving, compared to cost based access pricing.

Another novelty of the current approach is that we derive all the comparative statics results from a simple graphical analysis. This greatly facilitates the understanding of the model, and also allows us to clarify two small mistakes in LRTb.

The remainder of this paper is structured as follows. In Section 2 we introduce the model, existence of equilibrium is derived in Section 3, and the graphical analysis is carried out in Section 4. We present some comparative statics results in Section 5 and turn to the collusive role of the access charge in Section 6. Section 7 concludes with a discussion.

2 The Model

There are two networks, labeled 1 and 2. The marginal cost of originating or terminating a call is c_0, and therefore the total marginal cost of a call is $c = 2c_0$. The reciprocal unit access charge is $a \geq -c_0$.[3] Networks compete in linear prices p_{ii} (for on-net calls within network i) and p_{ij} (for off-net calls

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welfare implications.

[3] If the access charge were smaller, a network could generate profits by installing a computer which permanently calls into the rival network.

originating in network i).[4]

From the consumers' point of view the networks are horizontally differentiated in a Hotelling style. The networks are located at the end points $x_1 = 0$ and $x_2 = 1$ and each consumer is located at some address $x \in [0, 1]$. The total number of consumers, normalized to 1, is distributed uniformly on this interval. The degree of horizontal differentiation is measured by the "transport costs" t. A consumer located at x faces a disutility of $t|x - x_i|$ if he subscribes to network i. The utility derived from an active call of length q is given by the function $u(q)$ specified below. Consumers also benefit from receiving calls. The utility of receiving a call (*passive utility*) of length q is $\bar{u}(q)$. A consumer with income y, subscribed to network i and located at x, deriving utility u from active and $\bar{u}$ from passive calls, enjoys a total utility of $v_0 + y + u + \bar{u} - t|x - x_i|$, where v_0 is some (large) fixed surplus from being connected.

The timing is as follows. First, a reciprocal access charge is chosen, either by the regulator, or by a cooperative agreement of the networks. Then networks set on- and off-net prices. Consumers subscribe to a network and choose their call volume. Let demand be $q(p) = \text{argmax}_q\{u(q) - pq\}$, writing q_{ij} short for the demand for on- and off-net calls $q(p_{ij})$. Denoting net surplus by $v(p) = \max_q\{u(q) - pq\}$, and given the market shares α_1 and $\alpha_2 = 1 - \alpha_1$, network i offers its subscribers a total net surplus of $w_i = \alpha_i[v(p_{ii}) + \bar{u}(q_{ii})] +$

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[4] In Berger (2004), we also provide an analysis of the nonlinear pricing case, i.e., the Gans and King (2001) framework, with call externalities. However, this does not yield qualitative results substantially different from theirs, and hence is not included here.

$\alpha_j[v(p_{ij}) + \bar{u}(q_{ji})]$, where $\{i, j\} = \{1, 2\}$. Letting $h_{ij} = v(p_{ij}) + \bar{u}(q_{ji})$, we may write

$$w_i = \alpha_i h_{ii} + \alpha_j h_{ij}. \tag{1}$$

3 Equilibria

For fixed prices, a *consumer equilibrium* is given if the market shares are such that no consumer has an incentive to unilaterally switch to the other network. In a shared market equilibrium, the consumer located at $x = \alpha_1$ is indifferent between the networks. The market share $\alpha_1 = \alpha$ can thus be calculated from the indifference condition $w_1 - t\alpha = w_2 - t(1 - \alpha)$, and reads $\alpha = \frac{1}{2} + \sigma(w_1 - w_2)$, where $\sigma = (2t)^{-1}$ measures the substitutability between the two networks. Inserting from (1) and solving for α yields

$$\alpha = \frac{H_1}{H_1 + H_2}, \tag{2}$$

with $H_i = 1/2 + \sigma(h_{ij} - h_{jj})$. For a shared market equilibrium to exist, H_1 and H_2 must have the same sign, and following the analysis in LRTb, we conclude that it is stable, if H_1 and H_2 are positive.

Imagine prices are fixed and a stable consumer equilibrium has been realized. If in this situation neither network can gain by unilaterally changing its prices or fixed charge (taking into account the influence on the consumer equilibrium), then these values constitute a *network equilibrium.* For the remainder of this paper we concentrate on *symmetric* network equilibria.

For given prices and a corresponding stable consumer equilibrium α, profit of network 1 is given by

$$\pi_1 = \alpha^2(p_{11} - c)q_{11} + \alpha(1-\alpha)[(p_{12} - c)q_{12} + (a - c_0)(q_{21} - q_{12})],$$

and an analogous equation holds for π_2. If we write $M_{ij} = [p_{ij} - c(1+m)]q_{ij} + mcq_{ji}$ for the *unit profit* of network i (the profit a single customer of network i generates with one active call to and one passive call from network j), denoting by $m = (a - c_0)/c > -1$ the (relative) markup on access, profit of network i can also be written in the form $\pi_1 = \alpha^2 M_{11} + \alpha(1-\alpha)M_{12}$. Taking into account that M_{ii} depends only on p_{ii}, the first order conditions for a shared market equilibrium are given by

$$\begin{aligned}
\frac{\partial \pi_1}{\partial p_{11}} &= 2\alpha \frac{\partial \alpha}{\partial p_{11}} M_{11} + \alpha^2 \frac{\partial M_{11}}{\partial p_{11}} + \frac{\partial \alpha}{\partial p_{11}}(1-2\alpha)M_{12} = 0, \\
\frac{\partial \pi_1}{\partial p_{12}} &= 2\alpha \frac{\partial \alpha}{\partial p_{12}} M_{11} + \alpha(1-\alpha) \frac{\partial M_{12}}{\partial p_{12}} + \frac{\partial \alpha}{\partial p_{12}}(1-2\alpha)M_{12} = 0,
\end{aligned}$$

and the respective equations for network 2. At a symmetric shared market equilibrium, where $p_{11} = p_{22}$, $p_{12} = p_{21}$, and $\alpha = 1/2$, the first order conditions for network 1 read

$$\frac{\partial \alpha}{\partial p_{11}} M_{11} + \frac{1}{4}\frac{\partial M_{11}}{\partial p_{11}} = 0, \qquad \frac{\partial \alpha}{\partial p_{12}} M_{11} + \frac{1}{4}\frac{\partial M_{12}}{\partial p_{12}} = 0.$$

We now invoke LRTb's explicit utility function $u(q) = \frac{q^{1-1/\eta}}{1-1/\eta}$, with $\eta > 1$, which yields the constant elasticity demand function $q(p) = p^{-\eta}$, indirect utility $u(q(p)) = \frac{\eta}{\eta-1}p^{1-\eta}$, net surplus $v(p) = \frac{1}{\eta-1}p^{1-\eta}$, and a monopoly price[5]

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[5] The monopoly price is the price a monopolistic network would charge, $p^M = \mathrm{argmax}_p (p - c)q(p)$.

of $p^M = \frac{\eta c}{\eta - 1}$. Furthermore, we assume that the utility from passive calls is a fixed fraction $\beta \geq 0$ of the utility from active calls: $\bar{u}(q) = \beta u(q)$. With these specifications, inserting from (2) and rearranging terms, the first order conditions for network 1 can be expressed by the following system of equations.

$$p_{12}^{-1} = \frac{1}{1+m}\left(\frac{1}{p^M}\frac{2\beta\eta}{1+\beta\eta} + \frac{1-\beta\eta}{1+\beta\eta}p_{11}^{-1}\right), \tag{3}$$

$$p_{12}^{-1} = \left[\frac{p^M}{\eta(p^M - p_{11})p_{11}^{\eta-1}} - \frac{\eta - 1}{2\sigma(1+\beta\eta)}\right]^{\frac{1}{\eta-1}}. \tag{4}$$

We have intentionally written these equations so as to describe the reciprocal value of the off-net price as a function of the reciprocal value of the on-net price. This allows us to draw the graphs of the two functions, and find all symmetric candidate equilibria as points of intersection of the corresponding curves.

The next proposition establishes the existence of a unique, stable, symmetric equilibrium for low substitutability. The proof relies on the quasi-concavity of the profit function in the limit as $\sigma \to 0$. It is analogous to the proof of Proposition 1 in LRTb, and hence not presented here.[6]

Proposition 1 *For given access charge, if σ is small enough, there exists a unique, stable, symmetric equilibrium. Its price constellation is given by the intersection of (3) and the downward sloping part of (4).*

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[6] The result is slightly different from LRTb's, however. Note that the call externality prevents the existence of equilibrium in the case of too high substitutability even for $a = c_0$.

In the following we will analyze the graphs of (3) and (4) more closely, allowing us to derive quickly and easily a variety of comparative statics results.

4 Graphical Analysis

Let us first have a closer look at (3). The right hand side of this equation is an affine linear function of p_{11}^{-1}, which depends on the parameters m, η, and β, but not on σ. Its slope decreases with β, falling from $(1+m)^{-1}$ for $\beta = 0$ to zero for $\beta = 1/\eta$ and approaching $-(1+m)^{-1}$ for $\beta \to \infty$. At the monopoly price $p_{11} = p^M$, we have $p_{12}^{-1} = \frac{1}{(1+m)p^M}$, which is independent of β. Graphically this means that by increasing the relative importance β of passive utility, the line in the p_{11}^{-1}- p_{12}^{-1}-plane given by (3) is rotated clockwisely around the point $\left(\frac{1}{p^M}, \frac{1}{(1+m)p^M}\right)$. Note that without the call externality, i.e. for $\beta = 0$, equation (3) reduces to $p_{12} = (1+m)p_{11}$, the *proportionality rule* from LRTb. For $\beta\eta = 1$, the line (3) is horizontal at $p_{12} = (1+m)p^M$.

If we increase the access charge a, and hence the markup m, holding all other parameters fixed, the line (3) rotates clockwisely (if its slope is positive, $\beta\eta < 1$) or counterclockwisely (if its slope is negative, $\beta\eta > 1$) around the point $\left(\frac{2(\beta\eta-\beta)}{c(\beta\eta-1)}, 0\right)$, where it intersects the horizontal axis. In both cases the equilibrium moves downwards[7] along the curve (4).

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[7] It cannot reach the horizontal axis, however, since the point of intersection of (3) with this axis is always either on the negative side or to the right of $2/c$, i.e. outside the relevant region $c < p_{11} < p^M$. Hence, their is no scope for connectivity breakdown, meaning $p_{12} \to \infty$, contrary to Jeon et al.'s (2004) result for the nonlinear pricing case.

Turning to (4), we can see that this equation does not involve a, the access charge. Whenever $1/(\eta - 1)$ is not an integer, the right hand side of (4) is defined only if the expression in square brackets is nonnegative. The second term of this expression is a negative constant, it does not depend on p_{11}. The first term is positive for $p_{11} < p^M$ and – viewed as a function of p_{11}^{-1} – downward sloping from its vertical asymptote at $p_{11} = p^M$ to its minimum at $p_{11} = c$. For $p_{11}^{-1} > c^{-1}$ the function given by (4) is strictly increasing and unbounded, its slope converging to $\eta^{-1/(\eta-1)}$ for $p_{11}^{-1} \to \infty$. Furthermore, this function is convex at least for values of p_{11} slightly below p^M. The second term in square brackets shifts the curve up (for $\sigma \to \infty$) or down (for $\sigma \to 0$). Since (4) has a negative slope in the relevant region $c < p_{11} < p^M$, there exists at most one point of intersection with (3), if the slope of this line is nonnegative, i.e. if $\beta\eta \leq 1$. If β exceeds $1/\eta$, the slope of (3) is negative, and there exist two points of intersection. However, the second point is outside the relevant region if σ is small.

From now on we concentrate on the case where substitutability is low enough to guarantee existence of a unique stable equilibrium. We then ask, in which way the equilibrium depends on the parameters of the model. All the results are derived using the graphical analysis applied to Figure 1.

5 Comparative Statics

The next lemma shows that while the on-net price always decreases with the substitutability parameter σ, the direction of movement of the off-net

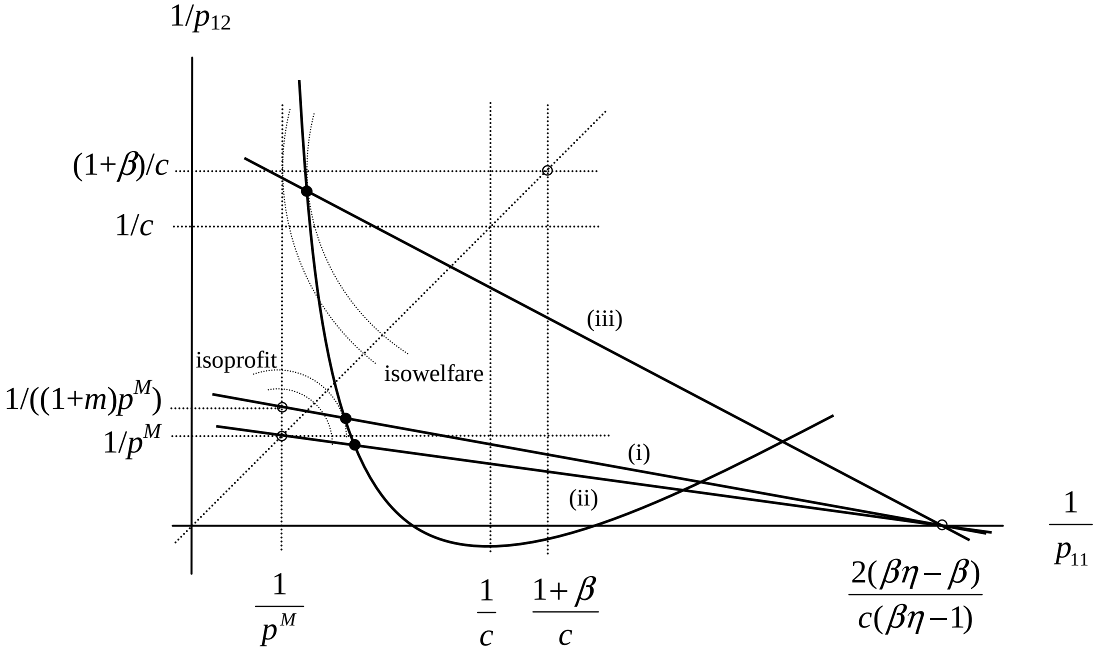

Figure 1: The curve given by (4) and three different positions of the line (3): (i) collusive choice of a, (ii) cost based access pricing, (iii) socially optimal choice of a. Here, $\beta\eta > 1$.

price depends on the strength of the call externality and on the elasticity of demand. On the other hand, an increase in the access charge always lowers the on-net price and raises the off-net price.

Lemma 1 *(i) The on-net price decreases with σ and the off-net price decreases with σ if $\beta\eta < 1$, increases with σ if $\beta\eta > 1$, and is constant at $p_{12} = (1+m)p^M$ if $\beta\eta = 1$.*

(ii) The on-net price decreases in a, while the off-net price increases in a.

Proof: An increase in σ shifts the graph of (4) upwards and does not influence the graph of (3). The point of intersection thus moves to the right, i.e. p_{11}^{-1} increases. The vertical direction of movement depends on the slope of (3). If $\beta\eta < 1$ (this includes the LRTb case $\beta = 0$), the slope is positive, so also p_{12}^{-1} increases. If $\beta\eta > 1$ the slope is negative and the intersection point moves down, and if $\beta\eta = 1$ the line is horizontal at $p_{12}^{-1} = [(1+m)p^M]^{-1}$. Increasing a or, equivalently, m, shifts the line (3) downwards. Since (4) slopes downward in the relevant region, the point of intersection moves down and to the right. This means p_{11} falls and p_{12} rises. QED

In contrast to the result in LRTb,[8] more substitutability exerts upward pressure on the off-net price, if β is large enough. Intuitively, if the call externality induced negative effect of an increasing off-net price on the rival's customers is large, higher substitutability creates incentives for the networks to exploit this effect and raise the off-net price while lowering the on-net price to compensate their own customers.

6 The Collusive Role of the Access Charge

Part (ii) of Lemma 1 states that varying the access charge results in the equilibrium prices moving in opposite directions. We know that the equilibrium on-net price is always below the monopoly price. If this is also the case for the off-net price, the impact on profits of varying the access charge is

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[8] Part (ii) of the lemma appears to contradict with LRTb, since the case of no call externality is not excluded. On p. 48 they state that the off-net price may *decrease* in a if σ is not small enough, and give a numerical example for this. However, the values they provide ($\eta = 2$ and $\sigma = c = m = 1$) lead to the candidate equilibrium prices $p_{11} = 1 = c$ and $p_{12} = 2$. A small increase in a then does indeed decrease the off-net price, but simultaneously the on-net price falls below marginal cost and in this region any candidate equilibrium is *unstable* and will therefore not be realized.

ambiguous.[9] If, however, the off-net price is above the monopoly price, both prices will move towards this monopoly price (and hence raise profits) only if the access charge is lowered. Imagine $\beta\eta > 1$. This is not an unrealistic case, since $\eta > 1$ and β may well be only slightly below 1. The slope of (3) is then negative, and for $\sigma > 0$ we have $p_{12} > (1 + m)p^M$ in equilibrium. Now let the access charge equal marginal termination cost, so $m = 0$. Then the off-net price exceeds the monopoly price, and we have the situation described above. In order to maximize equilibrium profits, both networks will negotiate an access charge a below c_0.

If $\beta\eta = 1$, the equilibrium off-net price is $(1 + m)p^M$, independently of σ. For $a = c_0$ then p_{12} is at the monopoly level, while p_{11} is below p^M. Starting from these values, a small decrease in a raises p_{11} towards the monopoly price and thereby has a positive first-order effect on profits from on-net calls, but only a second-order (negative) effect on profits from off-net calls. In sum, profits rise. By continuity this continues to hold if $\beta\eta$ is not too far below 1. This shows that networks may prefer an access discount even for $\beta\eta < 1$. For very low values of β, of course, this need not be the case.

Graphically, this can easily be seen if we keep in mind that since (4) is independent from the access charge, networks can only shift the line (3) up or down by varying the access charge. Thereby they can select any point

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[9] In a symmetric equilibrium, access charges payed and received cancel out. Thus, the relevant monopoly price for off-net calls is based on technical marginal costs c, not on perceived marginal costs $(1 + m)c$, and coincides with the monopoly price p^M for on-net calls.

on (4), subject to the restriction $m > -1$. Maximizing profits, they will choose the point where their isoprofit curve is tangent to (4). The point of tangency is unique, at least if σ is not too large, since (4) is convex in the vicinity of $p_{11} = p^M$ and the equilibrium profit function is quasi-concave in equilibrium prices (the upper-contour sets of the isoprofit curves are convex), peaking at the "monopoly point" $(1/p^M, 1/p^M)$. It follows immediately that the tangency point will lie northeast from the monopoly point, as illustrated in Figure 1. This means that with the negotiated profit-maximizing access charge, both on- and off-net prices are smaller than the monopoly price. If the slope of (3) is negative or only slightly positive, of course, this implies that this line intersects $\{p_{11} = p^M\}$ above the monopoly point. Hence $[(1+m)p^M]^{-1} > (p^M)^{-1}$, or $m < 0$. This analysis proves the first part of the next proposition.

Proposition 2 *Fix $\sigma > 0$ small enough. There exists $0 < k < 1$ such that if $\beta\eta > k$, networks will agree on an access discount, if $\beta\eta < k$, networks will negotiate an access markup, and if $\beta\eta = k$, networks will agree on $a = c_0$.*

The case $\beta = 0$ is the case without passive utility, and we could in principle just refer to Proposition 2 of LRTb for the proof. In this proposition they state that for small $\sigma > 0$ (and for $\beta = 0$) the profit maximizing access charge exceeds c_0. While this statement turns out to be true, unfortunately their proof is flawed,[10] so we give the correct proof here.

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[10] In their proof, LRTb (p. 49) argue that for small $\sigma > 0$ their *Lemma 2 shows that*

Proof: It suffices to show that networks will negotiate a markup on access if $\beta = 0$. Given the analysis in the last paragraph, the second and third part of this proposition then follow immediately from continuity of the negotiated access charge in $\beta\eta$ and from the intermediate value theorem, respectively. Note, that for $a = c_0$ and $\beta = 0$, the line (3) is the diagonal $\{p_{12} = p_{11}\}$. By symmetry of the equilibrium profit function in p_{11} and p_{12}, the slope of the isoprofit curves is equal to -1 along the diagonal. The slope of (4) at the intersection with the diagonal, on the other hand, converges to $-\infty$ as the point of intersection approaches the monopoly point, i.e. as $\sigma \to 0$. Thus, for small σ the point of tangency is below the diagonal (see Figure 1), where $p_{11} < p_{12}$, and by the proportionality rule, $m > 0$, i.e. a markup on access, is a necessary condition for this. QED

As noted, for small σ the profit maximizing point of tangency lies below the diagonal. Since networks will choose an access charge which lets this point become an equilibrium, we obtain the following corollary:

Corollary 1 *If σ is positive but small and networks may cooperatively determine the access charge, then the resulting equilibrium prices will show a markup on off-net calls.*

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both on-net and off-net prices increase with the access charge. From this they infer that *starting from $a = c_0$, a small increase in the access charge raises both prices toward the monopoly level and therefore leads to higher profits.* However, actually their Lemma 2 (correctly) states that for small $\sigma > 0$ the on-net price *decreases* in a. Hence it is not obvious that an increase in a does indeed raise profits.

6.1 Welfare and the Socially Optimal Access Charge

From the social viewpoint, the optimal access charge is the access charge that maximizes welfare, the sum of profits and consumer surplus, in equilibrium:

$$W(p_{11}, p_{12}) = \frac{1}{2}[(1+\beta)u(q_{11}) - cq_{11} + (1+\beta)u(q_{12}) - cq_{12}]. \tag{5}$$

To maximize welfare, the caller would have to be induced to extend the length of his calls up to the point where marginal *total* utility created equals marginal cost. This means $(1+\beta)u'(q_{ij}) = c$ and is induced by a price of $p_{ij} = (1+\beta)^{-1}c$. Of course these prices cannot be sustained in an equilibrium, since they are below marginal cost for $\beta > 0$.

Assume a benevolent regulator can set an arbitrary access charge subject to the technical constraint $a > -c_0$. By symmetry, the iso-welfare curves surrounding the unconstrained optimum have a slope of -1 along the diagonal $\{p_{11} = p_{12}\}$. Since the slope of (4) at the intersection with the diagonal is smaller than -1 for small σ, we can conclude that for small σ the point of tangency of (4) and the iso-welfare curves lies above the diagonal, and therefore also above the profit maximizing point on (4), as shown in Figure 1. This means that the welfare maximizing access charge is below marginal cost and also below the profit-maximizing access charge. Moreover, we can show that the welfare maximizing access charge might actually fall below zero. It follows from the additively separable form of (5) that the iso-welfare curves have vertical tangents at $p_{12} = c(1+\beta)^{-1}$. Since (4) becomes vertical at $p_{11} = p^M$ for $\sigma \to 0$, the point of tangency approaches $(1/p^M, (1+\beta)/c)$. Denoting the socially optimal access charge by a^w, this implies that $(1 + \frac{a^w - c_0}{c})p^M$ converges to $\frac{c}{1+\beta}$, or $a^w \to c_0 \left(1 - 2\frac{1+\beta\eta}{\eta+\beta\eta}\right)$. It can be seen that the sign of a^w depends on the relative size of β and η. Note that for $\eta < \frac{2}{1-\beta}$ the expression in brackets is negative, and so is a^w. The profit maximizing access charge a^π, on the other hand, is always positive for small $\sigma > 0$. We summarize this as follows.

Proposition 3 *(i)* $a^w < c_0$ *for small* σ.
(ii) If $\eta < \frac{2}{1-\beta}$, *then* $a^w < 0 < a^\pi$ *for small* σ.
(iii) If $\eta > \frac{2}{1-\beta}$, *then* $0 < a^w < a^\pi$ *for small* σ.

The more relevant of the cases (ii) and (iii) of this proposition seems to be (ii), especially if we assume that β is close to 1. Note that in this case networks may actually agree on a “bill and keep” arrangement, setting $a = 0$. This might result from the consideration that in existing mobile phone networks, “bill and keep” helps to save transaction costs of interconnection, a point not included in our model. If transaction costs are substantial and were taken into account, “bill and keep” might indeed turn out to be profit maximizing. Note, however, that contrary to the view of Gans and King (2001), from Proposition 3(ii) it follows that “bill and keep” is also welfare improving compared with cost-based access pricing.

7 Discussion

Corroborating the findings of Gans and King (2001), Dessein (2003), and others, this work emphasizes the point that collusion over the access charge will result in access sold at a discount. Nevertheless, we seem not to encounter this phenomenon in existing mobile phone networks, and regulators are usually struggling with bringing access charges down to cost.

The reason for this might be the nonexistence of a fixed-line network in our models. Indeed, if networks are not allowed to price discriminate in access, high access charges may well be the result of networks' incentives to boost profits from incoming calls originating on the fixed-line network. Alternatively, as Gans et al. (2004) suggest, even with price discrimination in access, networks may agree to keep mobile-to-mobile access charges at high levels in order to prevent customer arbitrage, i.e. consumers' substitution of mobile-to-mobile calls with fixed-to-mobile calls. However, a detailed study of these arguments is beyond the scope of this paper.

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