# Bill-and-Keep vs. Cost-Based Access Pricing Revisited*

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**Abstract**

We study network competition with two-part tariffs and termination-based price discrimination in the presence of call externalities. We show that both the collusive and the welfare maximizing access charges fall below marginal cost. Moreover, bill-and-keep arrangements are welfare improving compared with cost-based access pricing.

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# 1 Introduction

Most developed economies have experienced dramatically high growth rates in the mobile telecommunications sector during the last years. In the Scandinavian countries markets are close to being covered, and owning a mobile

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phone has become a matter of course even for low income groups. The markets for mobile telecommunications services are typically oligopolistic, with a rather small number of interconnected networks competing in prices. Common features of the price structures are nonlinear pricing and termination-based price discrimination, i.e. different rates depending on whether a call terminates on-net or off-net. Mobile telecommunications markets are subject to several sources of externalities, making them an interesting object of study for economists.

While the usual network externalities vanish if the market gets close to being covered, an important type of externalities remains: the *tariff-mediated network externalities* described by Laffont et al. (1998b). If e.g. on-net calls are priced below off-net calls, customers of a network benefit if this network's market share grows, since then more of their calling partners can be reached on-net. Another important source of externalities are *call externalities.* In the caller-pays system established in the majority of OECD countries, only the caller pays for a call, but clearly both the caller and the receiver benefit from it.

Since interconnection is usually mandatory, part of a network's service consists of terminating calls that originate in a network it competes with. It is common practice that networks pay each other *access charges* on a per-minute basis, which are negotiated between them. A large part of the literature on network competition, starting with the seminal work of Armstrong (1998) and Laffont et al. (1998a, 1998b), has studied the question if networks can use the access charge as an instrument of tacit collusion, if it should be regulated, and if so, how?

In particular, several authors have asked if networks' widespread bill-and-keep arrangements, which correspond to zero access charges and are usually argued to save transaction costs, are actually anticompetitive. A natural benchmark against which the welfare effects of such an agreement can be evaluated is cost-based access pricing, which sets access charges equal to marginal cost, corresponding to conventional regulatory wisdom. Gans and King (2001) favor cost-based access charges and argue that bill-and-keep arrangements may be used to soften competition and are hence undesireable from the social viewpoint. An opposing position is taken by Cambini and Valletti (2003), who demonstrate that bill-and-keep arrangements may be beneficial due to a positive impact on investments in quality prior to the competition stage.

Given the important characteristics of mobile telecommunications markets outlined above, it is surprising that the literature completely lacks a model of a caller-pays system incorporating nonlinear pricing and termination-based price discrimination as well as call externalities.[1]

In a companion paper (Berger, 2004) we analyze network competition in the presence of call externalities, but focus exclusively on linear prices. There we argue that only the interplay of both call externalities *and* discriminatory pricing creates the interesting effects which might be decisive for the outcome of competition. This applies also to the nonlinear pricing case. Without price discrimination, call externalities only change the judgment of welfare, but not the strategic incentives. This was already noted by Armstrong (2002) and Schiff (2001).

[1]Laffont et al. (1998b), Gans and King (2001), and Cambini and Valletti (2003) study the case of nonlinear discriminatory pricing, but without call externalities. Kim and Lim (2001), DeGraba (2003), and Jeon et al. (2004) take into account the call externality, but they concentrate on receiver-pays systems (where the importance of call externalities is more obvious). Hahn's (2003) model has nonlinear pricing and call externalities but studies a monopolistic network. Finally, Armstrong's (2002) extensive survey includes a short study of nonlinear pricing in the presence of call externalities, but without price discrimination.

The present note studies network competition and compares bill-and-keep with cost-based access pricing within the framework of a simple model where two symmetric networks compete in nonlinear and discriminatory prices in the presence of call externalities. In contrast to Gans and King's result, and corroborating the view of Cambini and Valletti, we argue in favor of bill-and-keep, showing that such an arrangement is indeed welfare improving compared to cost-based access pricing.

# 2 The Model

Our analysis is based on the model of Laffont et al. (1998b), which was also utilised by Gans and King and Cambini and Valletti. We extend this model to include call externalities, as in Berger (2004).

Two networks, labeled 1 and 2, are differentiated à la Hotelling. They are located at the endpoints $x_1 = 0$ and $x_2 = 1$ of the unit interval, while a unit mass of consumers is uniformly located in $[0, 1]$. Networks compete in two-part tariffs discriminating between on-net and off-net calls. A customer of network $i$ with volumes $q_{ii}$ of on-net and $q_{ij}$ of off-net calls, respectively, is charged

$$T_i(q_{ii}, q_{ij}) = F_i + p_{ii}q_{ii} + p_{ij}q_{ij} , \tag{1}$$

where $F_i$ is a fixed fee and $p_{ij}$ is the price for a call from network $i$ to network $j$. Consumers derive utility $u(q)$ from sending and $\bar{u}(q)$ from receiving calls of volume $q$. For simplicity, we assume that $\bar{u} = \beta u$, where $0 < \beta < 1$ measures the strengthr of the call externality. Furthermore, we assume $u' > 0$, $u'' < 0$, and the Inada conditions $u'(q) \to \infty$ for $q \to 0$ and $u'(q) \to 0$ for $q \to \infty$. Indirect utility is denoted by $v(p) = \max_q\{u(q) - pq\}$, and demand for on-net and off-net calls by $q_{ij} = \text{argmax}_q\{u(q) - p_{ij}q\}$ for $i, j \in \{1, 2\}$. Given the market shares $\alpha_i$ and $\alpha_j = 1 - \alpha_i$ of networks $i$ and $j$, total surplus of a consumer with income $y$, located at $x$ and subscribing to network $i$ is $v_0 + y - \frac{|x-x_i|}{2\sigma} + w_i$, where $v_0$ is a fixed surplus from being connected, $\sigma$ is the inverse of the transport costs, and $w_i$ denotes net surplus

$$w_i = \alpha_i[v(p_{ii}) + \bar{u}(q_{ii})] + \alpha_j[v(p_{ij}) + \bar{u}(q_{ji})] - F_i \,. \tag{2}$$

The market share of network $i$ is determined by the indifferent consumer, for whom $w_i - \frac{\alpha_i}{2\sigma} = w_j - \frac{\alpha_j}{2\sigma}$, and is given by $\alpha_i = \frac{1}{2} + \sigma(w_i - w_j)$, or

$$\begin{aligned} \alpha_i = \frac{1}{2} &+ \sigma\alpha_i[v(p_{ii}) - v(p_{ji}) + \bar{u}(q_{ii}) - \bar{u}(q_{ij})] - \\ &- \sigma\alpha_j[v(p_{jj}) - v(p_{ij}) + \bar{u}(q_{jj}) - \bar{u}(q_{ji})] + \\ &+ \sigma(F_j - F_i) \,. \end{aligned} \tag{3}$$

The marginal cost of originating or terminating a call is $c_0$ and the marginal cost of transmitting a call is $c_1$, so total marginal cost is $c = 2c_0 + c_1$. The fixed costs of connecting and billing a customer are $f$, and the reciprocal unit access charge is denoted by $a \geq -c_0 - c_1$.

# 3 Equilibrium

Under the assumption of a balanced calling pattern, profit of network $i$ is

$$\pi_i = \alpha_i^2(p_{ii} - c)q_{ii} + \alpha_i\alpha_j[(p_{ij} - c)q_{ij} + (a - c_0)(q_{ji} - q_{ij})] + \alpha_i(F_i - f) \,. \tag{4}$$

Given the choices of the other network, we can derive the first order conditions in the following way:[2] Imagine that first, for fixed market shares, a network maximizes profits holding its market share constant. It does this

[2]This section is actually identical to a part of Section 5 of Jeon et al. (2004, p. 104). While they study a receiver-pays system, they briefly consider the case of a zero reception charge, which coincides with our model.

by choosing optimal prices $p_{ii}$ and $p_{ij}$, while the fixed fee is used to offset deviations of the market share. In a second step, the network chooses its profit maximizing market share. If $\alpha_i$ is held constant, differentiating (3) with respect to $p_{ii}$ yields $0 = \alpha_i[v'(p_{ii}) + \bar{u}'(q_{ii})q'(p_{ii})] - \frac{\partial F_i}{\partial p_{ii}}$. This can be rewritten as

$$\frac{\partial F_i}{\partial p_{ii}} = \alpha_i[\bar{u}'(q_{ii})q'(p_{ii}) - q_{ii}]\,. \tag{5}$$

On the other hand, maximizing profit (4) with respect to $p_{ii}$ for constant market shares yields $0 = -\alpha_i[q_{ii} + (p_{ii} - c)q'(p_{ii})] - \frac{\partial F_i}{\partial p_{ii}}$, or

$$\frac{\partial F_i}{\partial p_{ii}} = \alpha_i[(c - p_{ii})q'(p_{ii}) - q_{ii}]\,. \tag{6}$$

Comparing (5) and (6), we derive the identity $c - p_{ii} = \bar{u}'(q_{ii})$, and since $\bar{u} = \beta u$ and $u'(q_{ii}) = p_{ii}$,

$$p_{ii} = \frac{c}{1+\beta}\,. \tag{7}$$

Hence the profit maximizing on-net price is always at the social optimum,[3] regardless of the market share. Analogously, we can differentiate with respect to $p_{ij}$ and compare the expressions for $\frac{\partial F_i}{\partial p_{ij}}$. This yields

$$p_{ij} = \frac{(1-\alpha_i)(c + a - c_0)}{1 - \alpha_i(1+\beta)} \tag{8}$$

for $\alpha_i < 1/(1+\beta)$. For $\alpha_i \to 1/(1+\beta)$ from below, the optimal off-net price goes to $+\infty$, i.e. for $\alpha_i \geq 1/(1+\beta)$, it is optimal for network $i$ to deter any off-net call.

In a symmetric shared market equilibrium we have $\alpha_i = \alpha_j = 1/2$ and hence

$$p^*_{ii} = \frac{c}{1+\beta}\,, \qquad p^*_{ij} = \frac{c + a - c_0}{1-\beta}\,. \tag{9}$$

[3]Since $\bar{u} = \beta u$, this price maximizes $u(q(p)) + \bar{u}(q(p)) - cq(p)$.

As usual when competing in two-part tariffs, networks set prices so as to maximize social welfare, and then extract consumer surplus via the fixed fee. For the on-net price, the call externality is internalized by the network's pricing decision, while this is not the case for the off-net price. If a network lowers its off-net price, also its rival's customers benefit through the call externality. In equilibrium this leads to prohibitively high off-net prices if $\beta$ is large. Indeed, as already noted by Jeon et al. (2004), for $\beta \to 1$ the off-net price goes to $+\infty$, resulting in *connectivity breakdown*.

# 4 Profit Maximizing Access Charge

In a symmetric equilibrium, where $\alpha_i = 1/2$ and $p_{ij} = p_{ji}$, differentiating profit with respect to the fixed fee yields

$$\frac{\partial \pi_i}{\partial F_i} = \frac{\partial \alpha_i}{\partial F_i}[(p_{ii} - c)q_{ii} + F_i - f] + \frac{1}{2}\,. \tag{10}$$

From (3), $\partial \alpha_i / \partial F_i$ can be replaced by

$$\frac{\partial \alpha_i}{\partial F_i} = \frac{\sigma}{2\sigma[v(p_{ii}) - v(p_{ij}) + \bar{u}(q_{ii}) - \bar{u}(q_{ij})] - 1}\,, \tag{11}$$

leading to

$$F_i = \frac{1}{2\sigma} + f - [v(p_{ii}) - v(p_{ij}) + \bar{u}(q_{ii}) - \bar{u}(q_{ij})] - (p_{ii} - c)q_{ii}\,. \tag{12}$$

In a symmetric equilibrium, network profit is given by

$$\pi_i = \frac{1}{4}(p_{ii} - c)q_{ii} + \frac{1}{4}(p_{ij} - c)q_{ij} + \frac{1}{2}(F_i - f)\,. \tag{13}$$

Differentiating with respect to $a$ and inserting the equilibrium values of $p_{ij}$ and $F_i$ derived above yields a profit maximizing access charge implicitly given by

$$a^{\pi} = c_0 + \frac{(1-\beta)q(p^*_{ij})}{(1+2\beta)q'(p^*_{ij})} - \frac{3\beta c}{1+2\beta}\,. \tag{14}$$

Note that since $q'$ is negative, $a^\pi$ is smaller than $c_0$. Hence networks will invariably negotiate an access charge below marginal cost. Inserting (14) into (9) yields

$$p_{ii}^* - p_{ij}^* = \frac{1}{1+2\beta}\left(\frac{\beta c}{1+\beta} - \frac{q(p_{ij}^*)}{q'(p_{ij}^*)}\right) > 0\,. \tag{15}$$

Hence the resulting off-net price is always below the on-net price, independently of $\beta$. While the off-net price for any *given* access charge goes to $+\infty$ for $\beta \to 1$, this is not the case for the off-net price resulting from the collusive choice of the access charge — both the nominator and the denominator go to zero at the same rate in the expression $p_{ij}^* = (c + a^\pi - c_0)/(1-\beta)$. Intuitively, connectivity breakdown cannot be optimal for networks which are maximizing joint profits.

# 5 Welfare Maximizing Access Charge

The socially optimal access charge $a^w$ would be the one giving rise to equilibrium prices $p_{ii} = p_{ij} = c/(1+\beta)$. From (9), this is achieved by

$$a^w = c_0 - \frac{2\beta c}{1+\beta}\,. \tag{16}$$

Clearly, the socially optimal access charge is below marginal cost. On the other hand, comparing (14) and (16) yields

$$a^\pi - a^w = \frac{1-\beta}{(1+\beta)(1+2\beta)}\left((1+\beta)\frac{q(p_{ij}^*)}{q'(p_{ij}^*)} - \beta c\right) < 0\,, \tag{17}$$

and this means that the profit maximizing access charge is even smaller than the socially optimal one. Summarizing,

$$-c_0 - c_1 < a^\pi < a^w < c_0\,. \tag{18}$$

This shows that with two-part tariffs and discriminatory prices, cost-based access pricing can never be optimal from the social viewpoint, if the call externality is taken into account.

If we agree that 'realistic' values of $\beta$ exceed 1/3, then from (16) we always have $a^w < 0$. It follows that from the social viewpoint, bill-and-keep, i.e. $a = 0$, is an improvement over cost-based access pricing. Indeed, bill-and-keep is exactly socially optimal if $\beta = \frac{c_0}{3c_0+2c_1}$.

Some authors, e.g. DeGraba (2003), have suggested that the caller and the receiver share the value of a call, i.e. $\beta \approx 1$. Since for $\beta \to 1$, both $a^\pi$ and $a^w$ decrease to $-c_0 - c_1$, this implies that networks' and regulators' incentives are almost perfectly aligned, eliminating the need for regulatory intervention altogether.

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