# Why Mobile Networks Prefer High Termination Rates: An Exploration of Strategic Delegation

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**Abstract**

This paper offers an explanation of both why managers of mobile networks seem to care about revenues and lobby regulators for high mobile termination rates, even though economics would have them care about profits and choose low termination rates in order to reduce competitive intensity. We show that strategic delegation with higher weight on revenues than cost can be an equilibrium outcome under strong tariff-mediated network externalities, and that it will make managers lobby for high termination rates.

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# 1 Introduction

Over the last decade, national telecommunications regulators in Europe have strongly reduced "mobile termination rates" (MTRs), which are the wholesale prices that mobile network operators (MNOs) receive for handing over an incoming call to its recipient on their network. These price have been reduced from levels above 30 €cents down to 1 €cent or less, in some cases. While regulators have argued that lower MTRs lead to lower call prices and higher welfare, most mobile operators fought tooth and nail to keep MTRs high, while small mobile operators and fixed network operators such as BT in the UK wanted to bring them down, too.

These contradictory claims had academic researchers scratching their heads, for a variety of reasons. On the academic side, results from theory exercises are far from clear. While since the work of Wright (2002) it has been uncontroversial that MNOs prefer excessive termination rates for calls from fixed to mobile networks, the academic literature on interconnection between competing mobile networks has come to many contradicting conclusions. Armstrong (1998) and Laffont, Rey and Tirole (1998a) show that if networks use linear tariffs that do not discriminate between calls within or between networks ("on-net" and "off-net" calls, respectively) then high reciprocal MTRs can be used to collude by raising each others' cost. The latter paper also proves that MTRs are profit-neutral under two-part tariffs because any gains are handed back through lower fixed fees. On the other hand, if networks set different prices for on- and off-net calls, then Laffont, Rey and Tirole (1998b, LRT) and Gans and King (2001) show that networks would can collude by setting access prices below cost, which reduces the tariff-mediated networks created by on/off-net differentiation.

A perfunctory reading of the business press, though sheds a different curious light on the issue. A particular puzzling often-stated claim is that lower MTRs are bad for the industry as a whole. This is puzzling because at the industry level all incoming and outgoing termination payments cancel out, as they correspond to revenues and costs of termination. Thus in the aggregate there is no "free cash" left over for investments in customer bases or networks, contrary to what is often claimed. From the point of view of the mobile communications industry, the only exception is the termination of calls from fixed networks, which in recent times has rapidly been losing importance. A closer look, though, reveals that the business press never mentions termination *profits* but *revenues*. Here is an example from the Financial Times:

> "Everything Everywhere, the UK's biggest mobile operator by

> customer numbers, blamed cuts to call termination charges for a revenue decline in the first half of the year.
>
> Ofcom, the telecoms regulator, ordered the company to reduce the fees charged to rival operators for incoming calls to its network – a significant source of income – by a third from April 1. This shaved £70m off group revenue in the first half, pushing the figure down 3 per cent from the same period last year to £1.7bn, said Tom Alexander, chief executive. [...]"[1]

This and similar examples show that MNOs and their executives seem to neglect the *cost* side of mobile termination and focus exclusively on the *revenues*, contrary to what economists would prescribe. Taking for granted that highly-paid CEOs know very well what they are doing, in this paper we examine the hypothesis that they rationally neglect the cost side of termination because they face explicit *incentives* to do so. Indeed, a literature dating back to Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987), has shown that managers' incentives can be tailored to achieve strategic goals. One of the means considered is to base executive pay partly on revenues instead of being purely a function of profits as is normally (implicitly) assumed. A manager who is paid in this way will have a stronger incentive to maximize revenues rather than profits, neglecting a share of costs, and therefore attempts to sell a larger quantity than otherwise. The potential strategic value of this kind of incentive contracts arises from the fact that rival firms' managers observe the incentive scheme and adapt their behavior in expectation of the manager's changed behavior. Thus it should come as now surprise that it has been found that under quantity competition (or more generally, strategic substitutes), owners want to make their managers more aggressive by putting extra weight on revenues, while under price competition (strategic complements) owners prefer "soft" managers in order to reduce the intensity of competition (Sklivas 1987). Yet, Hoernig (2012) has shown that the latter result does not necessarily carry through in the presence of network effects: If the latter are sufficiently strong then owners prefer their managers to be aggressive in order to exploit network effects. Mobile telephony is certainly a market where network effects matter due to the existence of MTRs and the resulting pricing structures, therefore it seems natural to consider how this might affect executive compensation and their revealed preferences about MTR levels.

Foros et al. (2007) interpreted the imposition of a non-discrimination constraint under one-way access to an essential infrastructure as a form of

[1] "Everything Everywhere hit by cut to fees", Financial Times, July 27, 2011 (accessed July 28, 2011).

strategic delegation.[2] Taking this idea to its conclusion, they consider how firms would adjust the "aggressiveness" of their managers to changes in the regulatory environment. Foros et al. assume that firms compete in quantities downstream and build on the usual finding that firms opt for more aggressive managers in order to argue that a non-discrimination constraint may lead to lower rather than higher retail prices.

By introducing strategic delegation, this paper adds to a burgeoning literature about network competition and two-sided access that attempts to square theoretical predictions with observed reality. Recent attempts extend *Laffont et al.* into different directions. Jullien, Rey and Sand-Zandtman (2012) assume that some customers receive significantly more calls than they make; they show that above-cost MTRs are desirable in order to increase these consumers' participation. Tangeras (2010) shows that if income effects are sufficiently strong then again networks prefer above-cost MTRs, while Hoernig, Inderst and Valletti (2011) find the same outcome if calling patterns are sufficiently unbalanced.

Finally, Hurkens and Lopez (2012) change the assumption about how consumers form their expectations about equilibrium network size. Traditionally, it is assumed that consumers adjust their expectations immediately to the equilibrium values which would obtain for the given (even out-of-equilibrium) tariffs, i.e. expectations are "active". Hurkens and Lopez assume instead the expectations are "passive", i.e. that consumers have some fixed expectations of network size which do not react to variations in tariffs offered, but which *ex post* must coincide with realized market shares at equilibrium tariffs. Since passive expectations tone down the strength of network effects, firms no longer prefer low termination rates but rather prefer to set them above cost.

Expectations matter in the presence of network effects, and in this paper we have set out to combine both the active and passive approaches to expectation formation and how they interact with strategic delegation. First, and as a useful by-product of this study, in the benchmark without strategic delegation we provide the new result, extending both LRT and Hurkens and Lopez (2012) to a common expectations framework, that firms would prefer above-cost MTRs if and only if at least half of their clients have passive expectations.

Second, we show that strategic delegation that makes managers more aggressive lowers the expectation thresholds above which both managers *and* owners prefer above-cost MTRs. Thus both would lobby in favour of keeping

[2]Sibley and Weisman (1998) first made this connection, without presenting a formal model.

MTRs high. Finally, we show that strategic delegation that makes managers more aggressive can occur in equilibrium if the present level of MTRs is high enough so that tariff-mediated network effects are strong. This is a significant result because without network effects owners would prefer soft managers. Indeed, if managers' contracts adjust to future lower MTRs levels, our model predicts that they should become softer competitors (and stop complaining about regulated MTR levels being too low).

Section 2 lays out the model and determines equilibrium retail tariffs. Section 3 considers preferences for high MTRs, while Section 4 analyzes equilibrium strategic delegation. Section 5 discusses the results and Section 6 concludes.

# 2 Model Setup and Equilibrium Tariffs

## 2.1 Assumptions about Networks and Consumers

There are two mobile networks $i = 1, 2$ who compete in multi-part tariffs $(F_i, p_{ii}, p_{ij})$, comprising a fixed fee $F_i$, a price for on-net calls $p_{ii}$ and a price for off-net calls $p_{ij}$ to network $j \neq i$. They are located at the extremes of a Hotelling line of length one, i.e. at locations 0 and 1. A consumer at location $x \in [0, 1]$ incurs "transport cost" $tx$ or $t(1-x)$ if he buys from network 1 or 2, respectively, where $t > 0$ measures the strength of horizontal product differentiation.

The marginal cost of calls is constant and consists of the cost of origination and transmission $c_0$ and the cost of termination $c_t$. However, off-net calls involve a the payment of an access charge (or mobile termination rate, MTR) $a$ to the terminating network. Thus the perceived marginal cost of an on-net call is $c = c_0 + c_t$ and that of an off-net call is $c_0 + a = c + m$, where $m = a - c_t$ is the termination margin. Networks also incur a fixed cost $f$ per client.

The subscriber market share of network $i$ is $\alpha_i \geq 0$, with $\alpha_1 + \alpha_2 = 1$. A share $\gamma$ of consumers has passive expectations $\alpha_i^0 \geq 0$ as in Hurkens and Lopez (2012), i.e. these consumers believe that independently of observed tariffs network $i$ will have an equilibrium market share of $\alpha_i^0$, with $\alpha_1^0 + \alpha_2^0 = 1$. The other $1 - \gamma$ consumers have active expectations $\alpha$ as in LRT. Each consumer has a uniform calling pattern, i.e. makes the same number of calls to any potential recipient.[3] The indirect utility derived from making a call at price $p$ is $v(p)$, with corresponding call length $q(p) = -v'(p)$. For $i, j = 1, 2$ let $q_{ij} = q(p_{ij})$ and $v_{ij} = v(p_{ij})$. The surplus from pertaining to network $i$

[3] See Hoernig, Inderst and Valletti (2011) for an exploration of unbalanced calling pattern and their effects on the setting of MTRs.

of consumers with active and passive expectations, before transport cost, is given by

$$w_i^a = \alpha_i v_{ii} + \alpha_j v_{ij} - F_i, \quad w_i^p = \alpha_i^0 v_{ii} + \alpha_j^0 v_{ij} - F_i.$$

In Hotelling fashion, market shares result from the indifferent consumer in each group, i.e.

$$\alpha_i = (1-\gamma)\left(\frac{1}{2} + \frac{w_i^a - w_j^a}{2t}\right) + \gamma\left(\frac{1}{2} + \frac{w_i^p - w_j^p}{2t}\right),$$

or, letting $\Delta = v_{ii} + v_{jj} - v_{ij} - v_{ji}$,

$$\alpha_i = \frac{1}{2} + \frac{v_{ij} - v_{jj} + \left[\gamma\alpha_i^0 + (1-\gamma)\,\alpha_i\right]\Delta - F_i + F_j}{2t}. \tag{1}$$

Solving this expression for $\alpha_i$, while holding $\alpha_i^0$ fixed, shows that the outcome is stable in expectations iff $2t - (1-\gamma)\,\Delta > 0$. This observation already implies that the presence of more consumers with passive expectations reduces tariff-mediated network effects.

Networks obtain revenues from fixed fees, calls originated on their network and termination payments. Thus network $i$ has revenues

$$R_i = \alpha_i\left(\alpha_i p_{ii} q_{ii} + \alpha_j p_{ij} q_{ij} + \alpha_j a q_{ji} + F_i\right). \tag{2}$$

Costs occur due to customer access and originated and terminated calls:

$$C_i = \alpha_i\left(\alpha_i c q_{ii} + \alpha_j\left(c + m\right) q_{ij} + \alpha_j c_t q_{ji} + f\right). \tag{3}$$

The owners' objective is to maximize profits $\pi_i = R_i - C_i$.[4] We model strategic delegation through incentive schemes for the managers who choose retail tariffs. The manager's pay may give different weights to profits and revenues. More precisely, it is proportional to $M_i = \lambda_i \pi_i + (1-\lambda_i) R_i = R_i - \lambda_i C_i$, for some $\lambda_i > 0$.[5] While $\lambda_i = 1$ implies a profit-maximizing manager, i.e. no strategic delegation, $\lambda_i < (>)\ 1$ makes the manager a more (less) aggressive competitor.

Consumer surplus and welfare are given by $(w_i = \gamma w_i^p + (1-\gamma)\, w_i^a)$

$$\begin{aligned} CS &= \sum_{i=1,2} \int_0^{\alpha_i} \left(w_i - tx\right) dx = \alpha_1 w_1 + \alpha_2 w_2 - \frac{t}{2}\left(\alpha_1^2 + \alpha_2^2\right), \\ W &= CS + \pi_1 + \pi_2. \end{aligned}$$

[4] We assume here that the manager's pay is a small part of networks' total profits and can be neglected as compared to the effects of the manager's actions.

[5] Jansen *et al.* (2007) compare strategic delegation based on market share and sales.

The timing of the game is as follows: We start by assuming that the access charge has been set at some level $a$. Given this access charge, in a first stage network owners simultaneously choose $\lambda_i$, $i = 1, 2$, which are observed by both managers. In a second stage, managers compete in two-part tariffs and state publicly what their jointly preferred access charge level would be. Our equilibrium concept is subgame-perfect Nash equilibrium, with the condition that passive expectations are fulfilled in the second-stage Nash equilibrium.

## 2.2 Pricing Equilibrium

Manager $i$ chooses the tariff $(F_i, p_{ii}, p_{ij})$ such as to maximize $M_i$ given the other network's tariff $(F_j, p_{jj}, p_{ji})$. The Nash equilibrium candidate is described in the following Proposition. Since it is essentially equivalent to a Nash equilibrium in two-part tariffs for two networks with asymmetric costs, the relevant computations are identical to those presented in Hoernig (2011) for the more general case of multiple asymmetric networks.

**Proposition 1** *Given strategic delegation parameters $(\lambda_1, \lambda_2)$, call prices and fixed fees in fulfilled expectations Nash equilibrium are:*

$$\begin{aligned} p_{ii} &= \lambda_i c, \; p_{ij} = \lambda_i (c + m), && (4) \\ F_i &= \lambda_i f + \alpha_i (2t - (1-\gamma)\Delta) + (\alpha_i - \alpha_j)(a - \lambda_i c_t) q_{ji}. && (5) \end{aligned}$$

**Proof.** Manager 1 maximizes

$$M_i = \alpha_i \left[ \alpha_i (p_{ii} - \lambda_i c) q_{ii} + \alpha_j (p_{ij} - \lambda_i (c+m)) q_{ij} + \alpha_j (a - \lambda_i c_t) q_{ji} + F_i - \lambda_i f \right]$$

Call prices can be determined by the usual process of adjusting the fixed fee so that market shares are held constant, or from (1) $\partial F_i / \partial p_{ii} = -\left[\gamma \alpha_i^0 + (1-\gamma)\alpha_i\right] q_{ii}$ and $\partial F_i / \partial p_{ij} = -\left(1 - \left[\gamma \alpha_i^0 + (1-\gamma)\alpha_i\right]\right) q_{ij}$. First-order conditions for call prices become

$$\begin{aligned} 0 &= \frac{\partial M_i}{\partial p_{ii}} = \alpha_i \left( \alpha_i q_{ii} + \alpha_i (p_{ii} - \lambda_i c) q'_{ii} - \left[\gamma \alpha_i^0 + (1-\gamma)\alpha_i\right] q_{ii} \right), \\ 0 &= \frac{\partial M_i}{\partial p_{ij}} = \alpha_i \left( \alpha_j q_{ij} + \alpha_j (p_{ij} - \lambda_i (c+m)) q'_{ij} - \left(1 - \left[\gamma \alpha_i^0 + (1-\gamma)\alpha_i\right]\right) q_{ij} \right) \end{aligned}$$

or

$$\frac{p_{ii} - \lambda_i c}{p_{ii}} = \frac{\gamma}{\eta(p_{ii})} \left(1 - \frac{\alpha_i^0}{\alpha_i}\right), \quad \frac{p_{ij} - \lambda_i (c+m)}{p_{ij}} = \frac{\gamma}{\eta(p_{ij})} \left(1 - \frac{1 - \alpha_i^0}{1 - \alpha_i}\right).$$

Fixed fees are then determined from the first-order condition

$$0 = \frac{\partial M_i}{\partial F_i} = \frac{d\alpha_i}{dF_i} \frac{M_i}{\alpha_i} + \alpha_i \left( -\frac{d\alpha_i}{dF_i} (a - \lambda_i c_t) q_{ji} + 1 \right),$$

where from (1) we obtain $\frac{d\alpha_i}{dF_1} = -1/\left(2t - (1-\gamma)\Delta\right)$. Then equilibrium fixed fees are given by

$$F_i = \lambda_i f + \alpha_i \left(2t - (1-\gamma)\Delta\right) + (\alpha_i - \alpha_j)\left(a - \lambda_i c_t\right) q_{ji}.$$

■

Equilibrium call prices correspond to the standard outcome of two-part tariff competition, as they are equal to "perceived marginal cost",[6] where under strategic delegation managers perceive these costs differently from owners. For $\lambda_i < (>)\ 1$, call prices are set below (above) marginal cost, and tariff-mediated network externalities are reduced (increased) since $p_{ij} - p_{ii} = \lambda_i m$. Thus while strategic delegation makes managers more aggressive if $\lambda_i < 1$, at the same time it also dampens network effects.

Fixed fees are set as a function of the tariff-mediated network externalities captured by $\Delta$ and termination profits. The effect of strategic delegation on fixed fees is ambiguous.

In symmetric equilibrium, with $\lambda_i \equiv \lambda$ and $\alpha_i = \frac{1}{2}$, we find on-net and off-net call prices $p_{on} = \lambda c$, $p_{of} = \lambda(c+m)$ and fixed fee $F = \lambda f + t - (1-\gamma)(v_{on} - v_{of})$, where $v_k = v(p_k)$, $q_k = q(p_k)$, $k = on,\ of$. Consumer surplus and welfare become

$$\begin{aligned} CS &= \left(\frac{3}{2} - \gamma\right) v_{on} - \left(\frac{1}{2} - \gamma\right) v_{of} - \frac{5t}{4} - \lambda f, \\ W &= \frac{1}{2} v_{on} + \frac{1}{2} v_{of} - c\left(q_{on} + q_{of}\right) - f - \frac{t}{4}. \end{aligned}$$

The effect of strategic delegation on consumer surplus and welfare is as follows:

**Corollary 1** *Making managers soft ($\lambda > 1$) always lowers welfare. Making managers more aggressive ($\lambda < 1$) lowers welfare unless the termination margin $m$ is high enough. Soft (aggressive) managers decrease (increase) consumer surplus unless the share of consumers with passive expectations is very low or access charges are close to cost.*

**Proof.** For $\lambda > 1$, we have $p_{of} > p_{on} > c$, i.e. call prices are above the efficient level. For $\lambda < 1$, we have $p_{ij} = \lambda(c+m) < c$ iff $m < c(1-\lambda)/\lambda$. In this case both call prices are suboptimally low. As concerns consumer surplus, we have

$$\frac{dCS}{d\lambda} = -\left(\frac{3}{2} - \gamma\right) c q_{on} + \left(\frac{1}{2} - \gamma\right)(c+m)\, q_{of} - f,$$

[6] If consumers were to overestimate network size ($\alpha_0 > \alpha$) then $p_{11} < \lambda_1 c$, i.e. on-net (off-net ) prices would be below (above) perceived marginal cost (see Hoernig 2008 for a similar result).

which is negative if $\gamma$ is high enough ($\gamma \geq \frac{1}{2}$ is sufficient but not necessary) or if $m$ is small. ■

In the previous literature, strategic delegation which makes managers more aggressive tends to raise welfare and no lower it. This is due to the type of tariffs employed by firms. Here firms use multi-part tariffs, where equilibrium prices are equal to perceived marginal cost. Strategic delegation here distorts on-net prices away from their efficient level, while bringing off-net prices closer if the termination margin is high enough. With linear tariffs both prices would be above cost at their profit-maximizing levels and thus strategic delegation has the potential to raise welfare by decreasing them.

Consumer surplus, increases with more aggressive managers due to lower prices, but also decreases because, as we noted above, tariff-mediated network effects are reduced. The former effect dominates in particular when the share of consumers with passive expectations is high enough, in itself dampens network effects.

# 3 When do Managers and Owners Prefer Above-Cost MTRs?

**Managers.** We will now consider managers' and owners' preferred level of the reciprocal termination rate in a symmetric equilibrium where $\lambda_i \equiv \lambda$. That is, while we continue to assume that the termination margin $m = a - c_t$ is set exogenously by a regulator, we will determine the level of $m$ that industry representatives would publicly lobby for.

The managers' objective function in symmetric equilibrium is

$$M = \frac{1}{4}\left(2t + 2\left(1-\gamma\right)\left(v_{of} - v_{on}\right) + \left(m + \left(1-\lambda\right)c_t\right)q_{of}\right).$$

This is maximized at

$$m_M = \frac{\left[1 - 2\lambda\left(1-\gamma\right)\right]c + \left(\lambda - 1\right)c_t\eta_{of}}{\eta_{of} - 1 + 2\lambda\left(1-\gamma\right)},$$

where $\eta_{of} = -p_{of}q'_{of}/q_{of}$ is the demand elasticity of off-net calls, and the denominator is positive if and only if $p_{of} > 0$.[7] Now we are ready to state our result about managers' preferences:

[7] The sufficient second-order condition holds with constant-elasticity demand.

**Proposition 2** *Managers prefer above-cost termination rates ($m \geq 0$) if and only if the share of consumers with passive expectations is high enough, i.e.*

$$\gamma \geq \gamma_M(\lambda) = \frac{1}{2} + \frac{1}{2}\frac{\lambda - 1}{\lambda}\left(1 - \frac{\eta_{of} c_t}{c}\right). \tag{6}$$

*If the off-net demand elasticity is small enough ($\eta_{of} < c/c_t$), then aggressive managers are more likely to prefer above-cost termination rates.*

**Proof.** The first statement is obtained by solving $m_M \geq 0$ for $\gamma$, while the second follows from $\gamma'_M(\lambda) > 0$ iff $c > \eta_{of} c_t$. ■

Thus we find that managers' propensity to prefer MTRs above cost depends on the composition of their clientele. A higher share of consumers with passive expectations makes a preference for $m > 0$ more likely. This should not be surprising since we have noted above that the presence of more such consumers reduces network effects, until the raise-each-others'-cost effect becomes dominant. Furthermore, off-net call demand must not expand too rapidly, so that neglecting part of their cost is not too costly. Empirical work tends to show that the off-net call elasticity is even smaller than 1, so that we can safely assume that $\eta_{of} < c/c_t$ holds.

In the traditionally considered case where only consumers with active expectations are present, we have $\gamma = 0 \geq \gamma_M(\lambda)$ iff $\lambda \leq \left(c - \eta_{of} c_t\right) / \left(2c - \eta_{of} c_t\right)$, which implies that $\lambda$ must lie below $1/2$. This seems quite a strong condition, therefore in the following we will continue values $\gamma$ closer to $1/2$.

Summing up, we have found that aggressive managers do prefer above-cost termination charges if some conditions are verified: Either they are aggressive enough, or network effects are not too strong to start with.

On the other hand, (6) also allows us to determine the cut-off in the absence of strategic delegation, i.e. $\lambda = 1$. That is, as a by-product of our investigation on strategic delegation we obtain a clarification of the relationship between assumptions about expectation formation and preferred termination rates in the existing literature.

**Corollary 2** *In the absence of strategic delegation, firms (both managers and owners) prefer above-cost termination rates if and only if at least half of consumers have passive expectations, i.e. $\gamma \geq 1/2$.*

**Proof.** This follows directly from $\gamma_M(1) = 1/2$. ■

The finding of Gans and King (2001) that firms prefer below-cost termination rates refer to the case $\gamma = 0$, while Hurkens and Lopez (2011) find the opposite for $\gamma = 1$. Neither is a knife-edge result concerning expectations formulation.

**Owners.** For our exploration of strategic delegation, it would be rather unfortunate if managers' interests were to diverge from owners'. Concerning MTRs, at least this is not the case.

Owners' profits in symmetric equilibrium are

$$\pi = \frac{t}{2} - \frac{1-\gamma}{2}\left(v_{on} - v_{of}\right) + \frac{1}{4}mq_{of} + \frac{1}{2}\left(\lambda - 1\right)\left[\frac{1}{2}cq_{on} + \frac{1}{2}\left(c+m\right)q_{of} + f\right].$$

The latter is maximized at

$$m_O = c\frac{\lambda\left(2\gamma - 1\right) - \left(\lambda - 1\right)\eta_{of}}{\lambda\left(\eta_{of} + 1 - 2\gamma\right)}.$$

**Proposition 3** *Owners prefer above-cost termination rates ($m \geq 0$) if and only if the share of consumers with passive expectations is high enough, i.e.*

$$\gamma \geq \gamma_O(\lambda) = \frac{1}{2} + \frac{\lambda - 1}{\lambda}\frac{\eta_{of}}{2}. \tag{7}$$

*They are more likely to prefer above-cost termination rates if managers are aggressive.*

**Proof.** The first statement is obtained by solving $m_O \geq 0$ for $\gamma$, while the second follows from $\gamma_O'(\lambda) > 0$. ■

Thus similarly to managers, owners prefer above-cost MTRs if and only if managers are aggressive and if network effects are not too strong to start with. For $\lambda < 1$ we have $\gamma_O(\lambda) < \gamma_M(\lambda)$ if $\eta \geq 1$, so that if managers lobby for high MTRs then owners will agree with them.

# 4 Optimal Delegation and Network Effects

As a final step in our exploration of whether strategic delegation can give rise to managers lobbying for above-cost MTRs, we consider whether and when owners would actually want managers to be aggressive ($\lambda_i < 1$) in the first place. It is known from standard models of price competition (for example, Sklivas 1987) that owners want managers to be soft and not aggressive. This result is reversed, however, if sufficiently strong network effects are present (Hoernig 2012). In the context of network competition with interconnection, network effects arise if access charges are above cost. Thus one should expect that at $m = 0$ owners will want managers to be soft and that a large enough $m > 0$ is needed for owners to prefer aggressive managers.[8]

[8] An additional reason for aggressive managers, not modeled here, would be an expanding market. An aggressive manager speeds up his network's growth and increases the resulting network effects. In the long run, as market growth levels off, owners would revise managers' incentives in order to make them softer.

In order to analyze this question, we now return to the ex ante asymmetric case where the owners of networks 1 and 2 simultaneously and noncooperatively set the delegation parameters $\lambda_1$ and $\lambda_2$. For a given rival's parameter $\lambda_j$, network $i$ chooses the level of $\lambda_i$ that maximizes $\pi_i = R_i - C_i$ from (2) and (3), with equilibrium call prices and fixed fees (4) and (5). We first present the following technical result.

**Lemma 1** *Profits $\pi_i$ are increasing in $\lambda_i$ at $\lambda_i = \lambda_j = 1$ if and only if*

$$\frac{t - v_{on} + v_{of} + mq_{of}}{3t - (3 - 2\gamma)(v_{on} - v_{of}) + 2mq_{of}} \geq \frac{(1-\gamma)(p_{of}q_{of} - p_{on}q_{on})}{2f + p_{on}q_{on} + p_{of}q_{of}}. \tag{8}$$

**Proof.** Owner $i$'s profits are

$$\begin{aligned} \pi_i &= \alpha_i \left[ (\lambda_i - 1)(\alpha_i c q_{ii} + \alpha_j (c + m) q_{ij} + f) + \alpha_i (2t - (1-\gamma)\Delta) \right. \\ &\quad \left. + \alpha_j m q_{ji} + (\alpha_i - \alpha_j)(a - \lambda_i c_t) q_{ji} \right]. \end{aligned}$$

The condition $\partial \pi_i / \partial \lambda_i |_{\lambda_1 = \lambda_2 = 1}$ is equivalent to

$$\begin{aligned} & \frac{\partial \alpha_i}{\partial \lambda_i} (2t - 2(1-\gamma)(v_{on} - v_{of}) + mq_{of}) + \frac{1}{4}(2f + p_{on}q_{on} + p_{of}q_{of}) \\ \geq \; & \frac{1-\gamma}{4}(p_{of}q_{of} - p_{on}q_{on}), \end{aligned}$$

where

$$\frac{\partial \alpha}{\partial \lambda_i} = -\frac{1}{4} \frac{2f + p_{on}q_{on} + p_{of}q_{of}}{3t - (3 - 2\gamma)(v_{on} - v_{of}) + 2mq_{of}}.$$

Reordering terms leads to (8). ■

While condition (8) seems rather unintuitive at first sight, from it we can quickly derive some clear-cut impossibility results.

**Proposition 4** *Owners prefer managers to be soft if access charges are close to cost, or if most customers have passive expectations, or if call demand is elastic.*

**Proof.** For $m \to 0$ or $\gamma \to 1$, the right-hand side of (8) converges to zero, while the left-hand side remains strictly positive. With elastic demand, i.e. $\eta(x) > 1$ over the relevant range, revenues decrease with higher prices, or $p_{of}q_{of} \leq p_{on}q_{on}$, which implies that the right-hand side is at most zero. ■

As we have seen above, both low MTRs or passive expectations reduce the effect of tariff-mediated network effects. Low MTRs do so because they bring off-net prices closer to on-net levels, and passive expectations result in smaller reactions of consumers to market share differences. With weaker

network effects, the standard result applies than under price competition owners want managers to be soft.

Taking this "negative" result as a starting point, incentives for aggressive managers can only appear if the share of passive consumers $\gamma$ is low enough, demand is inelastic and access charges are high enough. More precisely, owners prefer aggressive managers under the conditions outlined below.

**Corollary 3** *Owners prefer managers to be aggressive if call demand is inelastic, the share of consumers with passive expectations is*

$$1-\frac{3t-v_{on}+v_{of}+2mq_{of}}{4\left(v_{on}-v_{of}\right)}-\frac{\sqrt{R}}{4}<\gamma<1-\frac{3t-v_{on}+v_{of}+2mq_{of}}{4\left(v_{on}-v_{of}\right)}+\frac{\sqrt{R}}{4},$$

*and if*

$$R\equiv\frac{\left(3t-v_{on}+v_{of}+2mq_{of}\right)^{2}}{\left(v_{on}-v_{of}\right)^{2}}-8\frac{\left(t-v_{on}+v_{of}+mq_{of}\right)\left(2f+p_{on}q_{on}+p_{of}q_{of}\right)}{\left(p_{of}q_{of}-p_{on}q_{on}\right)\left(v_{on}-v_{of}\right)}\geq 0.$$

**Proof.** The result follows from solving (8) for $\gamma$, taking into account that $p_{of}q_{of}>p_{on}q_{on}$ for inelastic demand. ■

Since it is not straightforward to show when the latter two conditions are satisfied, we provide an example where this is the case.

**Example 1** *Let* $v\left(p\right)=\left(10-p\right)^{2}/2$ *with* $q\left(p\right)=10-p$, $c=1$, $f=1$,$t=17$. *If* $\gamma=1/2$, *owners prefer aggressive managers if* $m>4.544$, *while they prefer soft managers for* $m<4.544$.[9] *If* $m=5$, *then owners prefer aggressive managers for* $0.348<\gamma<0.752$. *The proof of both statements follows from applying condition (8). In equilibrium, both owners and managers prefer above-cost MTRs.*[10]

This example is necessarily stylized, but empirical work usually finds that call demand is indeed inelastic; furthermore, the condition that $m$ needs to be high enough is precisely the case that we wish to consider. Thus the above example captures reasonably well some relevant features of the mobile telephony market.

[9] In this example, the equilibrium is stable in expectations if $m<5.394$.

[10] We will attempt to determine the equilibrium degree of delegation for this example.

# 5 Discussion

Summing up the above results, we have found that since in the mobile market firms are considered to compete in prices, strategic delegation is predicted to lead to aggressive managers only if sufficiently strong tariff-mediated network effects are present. This result is consistent with Hoernig (2012), who found a similar outcome for price competition with market-level network effects. Together with Propositions 2 and 3, we have found that it is precisely in this case that managers (and their shareholders) would defend above-cost termination rates.

The necessity of tariff-mediated network externalities for this outcome is underlined if we consider the same market under uniform retail pricing, i.e. with firms competing in two-part tariffs $(F_i, p_i)$ that do not distinguish between on- and off-net calls.[11] First, we find that aggressive (soft) managers prefer to maximize (minimize) access revenue $aq$, i.e. prefer a high (zero) access price. Second, if managers are aggressive (soft) then owners prefer to minimize (maximize) $cq$, which implies preferences about access prices that are close to the managers'. Finally, we also find that with competition under uniform pricing owners would never want their managers to be aggressive. Since competition under uniform pricing lacks network-level network effects, the standard result obtains that with price competition owners prefer soft managers.

Maybe the most interesting conclusion from Sections 3 and 4 concerns the question of how mobile networks will react to the ongoing reductions in MTRs. While our model predicts that when starting from the *status quo* the firms' managers will protest and claim that MTRs should be kept high, it also predicts that in the medium run, after MTRs have been fixed close to zero, these protests will subside as managers' incentive contracts are adjusted to changed circumstances.[12] Most interestingly, though, an unintended side-effect of lowering MTRs that has so far gone unnoticed would be that owners will eliminate managers' incentives to be aggressive and build market share. Instead, they would rather want managers not to compete too fiercely for new customers, and concentrate instead on profits per existing customer. Whether this prediction applies is in essence an empirical question, in particular with respect to how consumers form expectations about network size.

[11] Detailed calculations are available from the author.

[12] As mentioned above, markets approaching full penetration could be another reason for incentive contracts to make managers softer over time.

# 6 Conclusions

In this paper we have considered how competition between mobile networks would be affected by strategic delegation, how the latter would change revealed preference of industry participants for high mobile termination rates, and what type of strategic delegation firms owners would prefer. While it is generally accepted that under price competition (or more generically, strategic complements), owners would give incentives to their managers to be softer competitors, this is no longer true in the presence of sufficiently strong network effects. In the context competition between interconnected networks, these are created both by retail tariffs which distinguish between price for calls to the same and to other networks, and by regulation which allows networks to charge wholesale prices for receiving calls that are significantly above marginal cost.

In essence, we have found that indeed managers are more likely to lobby for high termination rates when the latter have been high, because then strategic delegation makes managers concentrate on revenues and neglect the cost side of their business. On the other hand,

Naturally, interconnection pricing levels will not be the only drivers of strategic delegation in network industries. As mentioned above, in a fast-growing network market one should expect to find incentives for being aggressive, while in a market that approach full penetration these incentives should give way to incentives for being soft. Equally, a transition from competition in voice calls to one based on quality (bandwidth) could give rise to a similar change in strategic interactions. Both processes take place in mobile telephony markets, and we leave the analysis of their individual effects and interactions for future research.

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