Entry, Access Pricing, and Welfare in the Telecommunications Industry

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Abstract

This paper investigates the effects of entry on welfare in the Telecommunications industry. Equilibrium pricing parameters for monopoly and duopoly situations are determined where access charges are chosen non-cooperatively. Welfare comparisons between alternative access pricing regimes are also performed.

Keywords: Networks, Telecommunications, Competition Policy, Interconnection, Access Pricing.

JEL: D4, K21, L41, L51, L96

1 Introduction

Originating in the work of Armstrong (1998) and Laffont, Rey, and Tirole (LRT, 1998), theorizing about competition in the Telecommunications industry has been placed within the framework of horizontal product differentiation models. Much of the current public policy debate focuses on the issue of whether to allow inflated access charges as a (hidden) way to cross-subsidize new networks and to encourage further entry or at least to prevent exit, a policy that is based on the premise that having more competing networks in the industry will benefit consumers.

In Germany, the Monopolkommission has argued that a subsidization of new firms allowing them to recoup the large initial outlays of building their networks with inflated access charges may not be desirable from a social welfare point of view. It conjectures that firm exit, following for example a cost based regulation of access charges may in fact *increase* social welfare (see Monopolkommission, 2003, p.98).

In the present paper we investigate the social welfare implications of entry in the Telecommunications industry. We model the competitive outcome extending the basic framework of the theoretical economics literature with firms choosing the access charges non-cooperatively.

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2 Monopoly

The setup builds upon LRT, 1998 using a product differentiation model with mass one consumers distributed uniformly on the unit interval. The additively separable utility function of a consumer located at some $x \in [0,1]$ purchasing from the monopoly network (M) is

$$u(q, x, \beta) = \frac{\beta^{\frac{1}{\eta}} q^{1-\frac{1}{\eta}}}{1-\frac{1}{\eta}} + (1-x)t \tag{1}$$

with vertical preference parameter for outgoing calls $\beta > 0$, a horizontal preference parameter $t > 0$ for the benefit that results from connection independent of the amount of calls initiated q, and $\eta > 1$ being a constant elasticity of demand parameter. Here t represents the *maximum pure benefit of being connected* to the monopolist.

Utility maximization implies that individual demand for the service is

$$q(p) = \beta p^{-\eta} \tag{2}$$

and the consumer vertical valuation function net of unit cost is

$$v(p, \beta) = \frac{\beta^{\frac{1}{\eta}} q^{1-\frac{1}{\eta}}}{1-\frac{1}{\eta}} - pq(p) = \beta \int_p^{\infty} q(\zeta) d\zeta \tag{3}$$

which is decreasing and strictly convex in price.

The monopoly produces at constant marginal cost c per unit of its service and incurs a fixed cost $F > 0$. It uses a two-part tariff consisting of a unit price p and a fixed charge G and thus per capita consumer valuation given location $x \in [0, 1]$ is

$$U_x \equiv V_x + (1 - x)t = \beta \int_p^\infty q(\zeta)d\zeta - G(p, \beta) + (1 - x)t \tag{4}$$

so that V_x is a consumer's utility net of the two-part tariff resulting from active calls only. There exists a voluntary participation constraint as consumers are assumed to have a zero outside option so that $U_x \geq 0$ for all $x \in [0, 1]$. We assume that first degree price discrimination of the monopolist is prevented (by law or convention). We first find the optimal pricing strategy of the monopolist.

2.1 Welfare in Monopoly

As is standard in competition with multi-part tariffs, optimal retail prices will be set at marginal cost whereas the optimal fixed charge is capturing all consumer utility generated from active consumption. The profit of the monopolist is thus given as

$$\Pi^M = \left\{ \beta \int_{p^M = c}^\infty q(\zeta)d\zeta - F \right\} \tag{5}$$

Total consumer utility in the monopoly case is given as

$$CU_{n=1} = t \int_0^{\hat{x}} (1 - \zeta)d\zeta + \hat{x}V_{\hat{x}} \tag{6}$$

For a profit maximizing two-part tariff of the monopolist there will be no net surplus to the marginal consumer $\hat{x}$ over and above his horizontal preferences for the services of the monopolist network, i.e. $V_{\hat{x}} = 0$ for any $\hat{x} \in [0,1]$. Total consumer utility thus simplifies to $CU_{n=1} = (1/2)t$.

3 Duopoly

We now consider a duopoly situation where an incumbent network (M) is located at the origin and the entrant (E) is located at unity.

We specify the common marginal costs as $c \equiv 2c_0 + c_1$ for a call within one network resulting from origination and termination (c_0) and the intermediate line service cost c_1 which we assume to occur at the originating end of the call. Network $E's$ perceived marginal cost for a call from its network to the other network M is $c + a^M - c_0$ as it has to pay the access charge a^M.

The utility of the marginal consumer satisfies

$$\begin{aligned} U_{\hat{x}} \equiv \; & (1-\hat{x})\beta \int_{p_{on}^{E}}^{\infty} q(\zeta)d\zeta + \hat{x}\beta \int_{p_{off}^{E}}^{\infty} q(\zeta)d\zeta - G^{E} + \hat{x}t = \\ & \hat{x}\beta \int_{p_{on}^{M}}^{\infty} q(\zeta)d\zeta + (1-\hat{x})\beta \int_{p_{off}^{M}}^{\infty} q(\zeta)d\zeta - G^{I} + (1-\hat{x})t \end{aligned} \tag{7}$$

the '*Hotelling indifference condition*'.

Entrant and incumbent will chose their pricing instruments *simultaneously* after having chosen their access charges a^E, a^M non-cooperatively. The pricing parameter vector of the entrant is

$$\Xi^E \equiv \left\{p^E_{on}(a^E, a^M), p^E_{off}(a^E, a^M), G^E(a^E, a^M)\right\} \tag{8}$$

so that the entrant maximizes the program

$$\max_{\Xi^E} \left\{\Pi^E(\Xi^E; \Xi^M)\right\} = \left\{ \begin{array}{c} (1-x) \times \left[\begin{array}{c} G^E + \left(p^E_{on} - c\right)(1-x)q^E_{on} + \\ \left(p^E_{off} - (c + a^M - c_0)\right) x q^E_{off} \end{array} \right] + \\ x(1-x) \underbrace{(a^E - c_0) q^M_{off}}_{\equiv \pi(a^E)} - F \end{array} \right\} \tag{9}$$

s.t. (7) and given the vector Ξ^M of the incumbent network M.

We are looking for an equilibrium in the model with non-cooperatively chosen access charge markups

$$\Delta^i(x) \equiv \frac{a^i - c_0}{c} \ \ i = E, M \tag{10}$$

We find

Proposition 1 *The vector of symmetric equilibrium pricing parameters is*

$$\Xi^* = \left\{p^*_{on} = c, p^*_{off}(a^*) = c + a^* - c_0, G^*\right\}$$

with a fixed charge of

$$G^* = t - \beta \int_{p_{on}^*}^{\infty} q(\zeta) d\zeta + \beta \int_{p_{off}^*(a^*)}^{\infty} q(\zeta) d\zeta.$$

and an equilibrium non-cooperative access charge markup of

$$\Delta^* \approx \frac{1}{\eta - 1} > 0$$

for large t.

Proof:

See Behringer, (2004).■

The result implies that with non-cooperatively chosen access charges, i.e. in a laissez-faire regime, the duopoly equilibrium implies a strictly positive access charge markup.

3.1 Welfare in Duopoly

Total consumer utility in the duopoly case is

$$CU_{n=2}(a) = 2t \int_0^{\hat{x}} (1 - \zeta) d\zeta + V_{\hat{x}} \tag{11}$$

where from above

$$V_{\hat{x}} = \hat{x}\beta \int_{p_{on}}^{\infty} q(\zeta) d\zeta + (1 - \hat{x})\beta \int_{p_{off}(a)}^{\infty} q(\zeta) d\zeta - G(p, \beta) \tag{12}$$

In symmetric equilibrium total consumer utility is therefore

$$CU_{n=2}(a) = \frac{1}{2}\left(3\beta\int_{p_{on}}^{\infty} q(\zeta)d\zeta - \beta\int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta - \frac{1}{2}t\right) \tag{13}$$

We now provide a technical shorthand.

Lemma 2 *The term*

$$\Psi(\eta, a, \beta) \equiv 3\beta\int_{p_{on}}^{\infty} q(\zeta)d\zeta - \beta\int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta$$

is monotone decreasing in the access charge a *and strictly positive for* $a \leq a^*$.

Proof:

By substitution.■

4 Welfare comparison of Monopoly and Duopoly

We are now interested in the question of how consumer welfare, as measured by means of Marshallian aggregate utility, changes with a second network.

Lemma 3 *The duopoly equilibrium outcome involves strictly lower consumer welfare than monopoly without violating participation constraints iff*

$$\Psi(\eta, a, \beta) > t > \frac{2}{3}\Psi(\eta, a, \beta).$$

Proof:

See Appendix.■

Also:

Lemma 4 *The duopoly equilibrium outcome involves strictly larger profit for the former monopolist than monopoly without violating participation constraints iff*

$$\Psi(\eta, a, \beta) > t > \Psi(\eta, a, \beta) - \frac{1}{2}\pi(a).$$

Proof:

See Appendix.■

Combining the two results we find the following:

Proposition 5 *Under any regime, there exists a range of t such that the duopoly equilibrium outcome involves strictly lower consumer welfare and strictly lower* *profit for the former monopolist than monopoly.*

Proof:

See Appendix.■

When looking at the effect of the duopoly equilibrium outcome on *total welfare*, i.e. taking into account the profit of the second network, we find the following, even more drastic result that is *independent* of any non-cost based access pricing regime chosen by the regulator.

Proposition 6 *The duopoly equilibrium outcome involves strictly lower total welfare than monopoly iff consumers' horizontal valuations are low relative to the vertical valuation even in the absence of sunk fixed costs.*

Proof:

See Appendix.■

The proposition shows that unlike in the generic homogeneous good 'natural monopoly' case where the duplication of effort, i.e. the fixed and sunk cost of entering the industry is responsible for entry being welfare reducing, (e.g. Mankiw & Whinston (1986)) the industry specifics of the Telecommunications industry and the need for interconnection between networks may lead to inefficient welfare results even independently of such sunk costs.

5 Welfare comparison of alternative access pricing regimes

A paper by Gans & King (2001) notes that the *jointly negotiated* reciprocal access charges will be strictly below the true cost of terminating a call.

Lemma 7 *Gans & King (2001): The optimal negotiated access charge in the symmetric equilibrium is*

$$\Delta^{**} = -\frac{1}{1+\eta} < 0.$$

Proof:

See Appendix.■

We refer to a regime that helps firms to implement their profit maximizing reciprocal access charge as an 'interventionist' regime.

Another alternative regime is 'bill and keep' where firms are not allowed to make any charges for the costs of access to its network which are assumed to be small.

Comparing consumer welfare under these regimes:

Lemma 8 *From the perspective of consumers we find*

$$\Psi(\eta, a^*, \beta) > \Psi(\eta, 0, \beta) > \Psi(\eta, a^{**}, \beta) \tag{14}$$

Proof:

By Lemma 2.■

Also:

Lemma 9 *From the perspective of networks we find*

$$\Pi^*(a^{**},\beta) > \Pi^*(0,\beta) > \Pi^*(a^*,\beta) \tag{15}$$

Proof:

By substitution.■

We find that the preferences of a regulator aiming to maximize total welfare are:

Proposition 10 *In the duopoly equilibrium outcome access pricing regimes are ranked according to total welfare as*

$$W_{n=2}(0) > W_{n=2}(a^*) > W_{n=2}(a^{**}).$$

Proof:

See Appendix.■

Gans & King (2001, Proposition 2), investigating an 'interventionist' regime have emphasized the theoretical finding that such negative access charge markups will soften price competition. Whereas the authors have also touched upon the qualitative consequences of a 'laissez-faire' regime (Proposition 1), thereby accommodating present regulatory concerns, the full complexity of the underlying effects have been disentangled only very recently by Armstrong & Wright (2008) for symmetric and by Behringer (2008) for asymmetric networks.

We eventually compare the effect of different regimes on *total* welfare and it is here that the 'bill and keep' regime compares most favorably, and independently of any investment incentives as investigated in Cambini & Valletti, (2003). The above proposition shows that the alternative of leaving firms to choose their access charges in a 'laissez-faire' regime (or an 'interventionist' regime) will lead to total welfare consequences that are worse than under a 'bill and keep' regime although the former will be best from the consumer's point of view.

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8 Appendix

Proof of Lemma 3:

Entry is strictly decreasing consumer utility iff $CU_{n=1} > CU_{n=2}$ and hence

$$\frac{1}{2}t > \frac{1}{2}\left(3\beta\int_{p_{on}}^{\infty} q(\zeta)d\zeta - \beta\int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta - \frac{1}{2}t\right) \tag{16}$$

As $\Psi(\eta, a, \beta) > 0$ for access charges $a \leq a^*$ entry will be welfare deteriorating if consumer vertical valuation is low enough and/or the services offered by the two networks are bad enough substitutes.■

Proof of Lemma 4:

The incumbent monopoly profit

$$\Pi^M = \left\{\beta\int_{p^M}^{\infty} q(\zeta)d\zeta - F\right\} = \left\{\beta\int_{p_{on}}^{\infty} q(\zeta)d\zeta - F\right\} \tag{17}$$

exceeds the duopoly profit

$$\Pi^D(a) = \left\{\frac{1}{2}t - \frac{1}{2}\left(\beta\int_{p_{on}}^{\infty} q(\zeta)d\zeta - \beta\int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta\right) + \frac{1}{4}\pi(a) - F\right\} \tag{18}$$

without violating the participation constraints iff the above inequality holds.■

Proof of Proposition 5:

For this range of t to exist we need

$$\frac{2}{3}\Psi(\eta, a, \beta) < \Psi(\eta, a, \beta) - \frac{1}{2}\pi(a) \tag{19}$$

for $a = a^*$. The difference

$$\frac{1}{3}\Psi(\eta, a, \beta) - \frac{1}{2}\pi(a) \tag{20}$$

is non-monotonic in a so that we cannot claim the result for any $a \leq a^*$. Checking for all different access charge regimes determined below we find

$$\frac{1}{3}\Psi(\eta, a, \beta) - \frac{1}{2}\pi(a) > 0 \tag{21}$$

for each $a \in \{a^{**}, 0, a^*\}$.■

Proof of Proposition 6:

From above we find

$$W_{n=1} = CU_{n=1} + \Pi^M = \frac{1}{2}t + \beta \int_{p_{on}}^{\infty} q(\zeta) d\zeta - F \tag{22}$$

and

$$
\begin{aligned}
&W_{n=2}(a) = CU_{n=2}(a) + 2 \times \Pi^*(a) = \\
&\frac{1}{2}\left(3\beta \int_{p_{on}}^{\infty} q(\zeta)d\zeta - \beta \int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta\right) - \frac{1}{4}t + \\
&2 \times \left\{\frac{1}{2}\left(t - \beta \int_{p_{on}}^{\infty} q(\zeta)d\zeta + \beta \int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta\right) + \frac{1}{4}\pi(a) - F\right\} = \\
&\frac{3}{4}t + \frac{1}{2}\left(\beta \int_{p_{on}}^{\infty} q(\zeta)d\zeta + \beta \int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta\right) + \frac{1}{2}\pi(a) - 2F
\end{aligned} \tag{23}
$$

Now

$$
\beta \int_{p_{on}}^{\infty} q(\zeta)d\zeta > \frac{1}{2}\left(\beta \int_{p_{on}}^{\infty} q(\zeta)d\zeta + \beta \int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta\right) + \frac{1}{2}\pi(a) \tag{24}
$$

always holds as we have that

$$
\partial\left(\int_{p}^{\infty} q(\zeta)d\zeta\right)/\partial p = \frac{\partial v(p, \cdot)}{\partial p} = -q(p) \tag{25}
$$

and may rewrite the inequality as

$$
\frac{v(c + a - c_0) - v(c)}{(a - c_0)} - v(c + a - c_0)' < 0 \tag{26}
$$

for *any* $a \neq c_0$ by the strict convexity of the valuation function.■

Proof of Lemma 7:

Using the optimal symmetric fixed charge G^*,

$$\Pi(a) = \left\{ \begin{array}{c} (1-x)\left[(-2x)\beta\left(\int_{p^*_{on}}^{\infty} q(\zeta)d\zeta - \int_{p^*_{off}(a)}^{\infty} q(\zeta)d\zeta\right) + t(2x-1) + t\right] + \\ x(1-x)(a-c_0)\beta(c+a-c_0)^{-\eta} - F \end{array} \right\} \tag{27}$$

The first order condition with respect to a negotiated optimal access charge is

$$\frac{\partial\Pi(a)}{\partial a} = (1-x)x\left[-2q_{off} + \beta(c+(a-c_0)(1-\eta))\,(c+a-c_0)^{-(\eta+1)}\right] \overset{!}{=} 0 \tag{28}$$

for $x \in (0,1)$. Using the envelope theorem

$$\partial\left(\int_{p^*_{off}(a)}^{\infty} q(\zeta)d\zeta\right)/\partial a = -q(p) \tag{29}$$

as $v(p,\cdot) \equiv \max_q \ \{u(q,\cdot) - pq\}$ we solve for the jointly negotiated access charge

$$a^{**} = c_0 - \frac{c}{1+\eta} \tag{30}$$

which is strictly below cost for any $\eta > 1$. The second order condition holds as

$$\left.\frac{\partial^2\Pi(a)}{\partial a^2}\right|_{a=a^{**}} = -\eta^{-\eta-1}\,(\eta+1)^{\eta+1}\,c^{-\eta-1} < 0 \tag{31}$$

.■

Proof of Proposition 10:

Total welfare in duopoly is

$$W_{n=2}(a) = \frac{3}{4}t + \frac{1}{2}\left(\beta \int_{p_{on}}^{\infty} q(\zeta)d\zeta + \beta \int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta\right) + \frac{1}{2}\pi(a) - 2F \quad (32)$$

We focus on the behaviour of

$$T(a) \equiv \int_{p_{off}(a)}^{\infty} q(\zeta)d\zeta + \pi(a) \quad (33)$$

for different access pricing regimes. By substitution we find $T(0) > T(a^{*}) > T(a^{**})$.■