Regulating an Input Monopolist with Minimal Information: The Local Cap

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Abstract

The "local cap" uses minimal information to establish an optimal price for a monopolized input in a vertically integrated firm. Under it only upstream costs need be known. No demand information is required. It is comparatively welfare efficient, and has a small regulatory footprint. Profits are capped upstream (e.g. in local telecommunications) and unregulated competition enabled downstream (e.g. long distance telephony). It is compatible with upstream regulation including universal service obligations, guarantees access deficit coverage by an efficient provider, and may be implemented as a price cap or a cost-of-service approach. The input (interconnection) price is set by the monopolist rather than the regulator, subject to it being less than the monopolist's downstream price, and to a simple cap: at most upstream retail (local call) and interconnection revenues (including fees imputed to the monopolist's own downstream services) cannot exceed upstream (local transport) costs taking account of social programs imposed on the incumbent. Using Australian data, it is estimated that the local cap could have halved Australian long distance telephone prices in 1989.

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I. Introduction

This paper is concerned with the price of monopolized inputs, especially when these are provided by a vertically integrated firm. Interconnection in telephony provides a well-known example.[1] Here an incumbent commonly controls most of the local network, a necessary input for downstream services such as long distance telephony. As a result, the incumbent may claim or protect downstream monopoly profits through a high interconnection fee (Posner 1971; Brock 1993, 16, suggests AT&T's original ENFIA tariffs did exactly this).

In the last two decades, traditional models of a highly regulated up- *and* downstream monopolist, have fallen into disrepute, essentially for being informationally unworkable and regulating too much. As a result, downstream competition has been increasingly encouraged.[2] But competition must interconnect with the upstream monopolist. This suggests a need for regulation of interconnection. However, any such regulation must avoid the pitfalls of traditional approaches. In particular, it should neither demand large amounts of information and nor require oversight of downstream markets. (On these points see Ralph 1996, Chapter 1.)

This paper presents a mechanism, called a local cap, which results in optimal interconnection prices for the minimal amounts of information it requires. It is comparatively welfare efficient, uses less information than other approaches and has a small regulatory footprint. Under it only local transport costs need be known. Demand information is not required. The mechanism imposes no accounting or operational separations on a vertically integrated incumbent, caps upstream profits, and enables unregulated competition downstream. It is compatible with upstream regulation including universal service obligations, and guarantees coverage of any access deficit (losses an *efficient* upstream provider incurs due to regulatory requirements or because the upstream market is not profitable on a stand-alone basis).[3] It requires neither tax nor subsidy, and may be implemented as a price cap through to a cost-of-service approach.

Under the mechanism, the interconnection price is not set by the regulator, but by the upstream monopolist subject to (1) it being less than the monopolist's downstream price, and (2) a simple cap: upstream (local call and interconnection) revenues (including interconnection fees imputed to the monopolist) cannot exceed upstream (local transport) costs including those of imposed social programs. Regulatory oversight is necessary only to produce the information necessary to test the cap, and ensure enforcement, though this latter action could be left to the courts.

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[1] Interconnection price is only one of many important issues raised when an upstream input is monopolized—see Ergas 1995.

[2] For example, in telephony, regulation culminating in the divestiture of AT&T brought competition to the U.S. publicly-switched long distance market as early as 1977. Long distance competition was allowed in the U.K. in 1983, in Japan in 1987, in New Zealand in 1989, in Australia in 1991, in Finland in 1992, and in Canada, Chile, and China in 1994.

[3] An access deficit due to universal service has been used as a defense for monopoly provision from the earliest days of telephony—see e.g. Faulhaber 1987, 77-8 on AT&T; for more recent statements see Telecom Australia's 1990 submission to the Department of Transport and Communications, and §19 of Bell Canada's press kit of November 30, 1990.

Too much, however, can be made of the problem. The access deficit may be reduced without abandoning social goals (see e.g. Ergas, Ralph, and Sivakumar, 1990, 44-53, and Fuss and Waverman 1993), and the size of the deficit is commonly exaggerated—e.g. independent Australian estimates (BTCE 1989) made with the monopolist's own data, put the 1987-88 access deficit at 2.4 to 5% of the telecom's total revenues, despite Australia's vast and sparsely populated geography and onerous consumer service obligations. In contrast, the incumbent's lowest estimate, based on a fully distributed costs approach, was 15% of revenues.

The low informational requirements of the mechanism, however, mean extranormal rents are earned if there is market power downstream, since only upstream markets are regulated. Thus, if the incumbent has a cost advantage in the downstream market due to economies of scope, then it can claim at least Bertrand profits there. The mechanism also fails in general to deliver the optimal ratio of up- and downstream prices since demand in both cases is not known. However, additional available information may be utilized to improve the range of welfare outcomes—for example, by imposing price floors in markets where marginal costs are known.

Section II of the paper develops a model which allows comparison of various regulatory devices. It then shows (Propositions 1 and 2) that the proposed local cap increases social welfare over the unregulated case. Proposition 3 provides a statement of optimality. In Section III the local cap is favorably compared with a number of interconnection approaches including: charging incremental cost as recommended by Brock 1995, and used in Australia; and Laffont and Tirole’s (1996) “global cap”. The local cap is also superior to fully distributed cost determined interconnection fees (Ralph 1996, Chapter 1), and to the “efficient” components pricing rule attributed to Willig 1979 and Baumol 1983 (Ralph 1996, Chapter 3). Section IV deals with practical application and extensions of the proposed mechanism, while Section V provides an example that conservatively suggests the mechanism could have halved Australian long distance telephone prices in 1989.

II. The model and propositions

In the model an incumbent owns a local sunk telephone network which is a necessary input for the supply of long distance telephony. There is no competition in or for the local market (but see *By-pass* in Section IV below). Competition with the incumbent, however, occurs in long distance.[4] In this market it is assumed that output is homogenous,[5] prices must be quoted as a constant per unit output and made available to all consumers,[6] and competition is Bertrand.[7] The analysis consists of a number of games of complete information,[8] either unregulated, or under a particular interconnection regime. In no case is the regulator a player. All welfare comparisons are surplus based. As is conventional, it is assumed income effects are negligible, and partial equilibrium analysis may be used to measure social welfare (despite Lipsey and Lancaster 1956).

Demand

No assumptions are made about demand in the upstream market, $\Delta(.)$.[9]

The long distance price, p, is assumed to be an integer multiple of δ.[10] Demand is given by a strictly decreasing function, $D(p)$, with the properties:

there exists a $\bar{p} < \infty$ such that $D(\bar{p}) = 0$; and

total revenues in the long distance market $pD(p)$ are single-peaked, that is

$$p^1 < p^2 \le p^M \qquad p^1D(p^1) < p^2D(p^2) \text{ for all } p^1 \text{ and } p^2, \text{ where } p^MD(p^M) \equiv \max_p pD(p),$$

and

$$p^M \le p^3 < p^4 \qquad p^3D(p^3) > p^4D(p^4) \text{ for all } p^3 \text{ and } p^4.$$

Define the set of entrants {1, 2,.., E} indexed e, but allow E to be as small as 1; $\underline{p}_e = \min_e p_e$ for e {1, 2,..., E}; $\underline{E}$ as the number of entrants with price $\underline{p}_e$; $\underline{p} = \min(p_i, \underline{p}_e)$; and $\chi(.)$ be the function which equals 1 when its argument is true, and 0 otherwise.

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[4] This is Posner's 1972 hammer head (local call) monopolist, except with a retail market for hammerheads.

[5] This is simplifying, but reasonable for ordinary telephony, unless subscribers see subjective differences among service providers.

[6] Again simplifying, but violated in practice by widely used non-linear pricing schemes.

[7] Competition in price where players move simultaneously and meet demand at posted prices. This is a vigorous form of rivalry, but arguably accurate for the long run in telecommunications.

[8] While this is false, firms in the industry are likely to know more than anyone else about their own, and other firms' demands and costs.

[9] With the exception of δ, ε, and $\chi(.)$, Greek letters refer to the local market.

[10] Discrete prices are used to ensure agents' best response functions are well-defined.

Demand splits in the usual Bertrand fashion: For $e \in \{1, 2,..., E\}$:

$$D_i(p_i, p_1, p_2,..., p_E) = \begin{cases} D(p_i) & \text{when } p_i < \underline{p}_e \\ D(p_i)/(\underline{E} + 1) & \text{when } p_i = \underline{p}_e \\ 0 & \text{when } \underline{p}_e < p_i; \end{cases}$$

and

$$D_e(p_i, p_1, p_2,..., p_E) = \begin{cases} D(p_e)/(\underline{E} + \chi(p_i = \underline{p}_e)) & \text{when } p_e = \underline{p}_e \leq p_i \\ 0 & \text{when } \underline{p} < p_e. \end{cases}$$

Thus: $$D(\underline{p}) = D_i(p_i, p_1, p_2,..., p_E) + \sum_{e=1}^{E} D_e(p_i, p_1, p_2,..., p_E).$$

Costs

While in general the costs of local transport will vary with subscriber numbers and to a lesser extent traffic volume, for the purposes of this paper it suffices to assume

local transport costs are sunk by the incumbent, implying it will supply local transit at any price greater than zero, and that

these exceed maximized local *retail* revenues, either because the local market is not viable on its own (as mutton might not be without wool production in Marshall's famous example of joint production), or because of local market regulation, e.g. a universal service obligation.

Specifically, let κ be the annualized economic cost[11] of providing local transport, i.e. the cost originating and terminating local and long distance calls, including any imposed social programs, such as a universal service obligation (κ is discussed further in Section IV); ρ be local retail revenues earned by the incumbent;[12] and μ be maximum local retail revenues. Then:

$$\rho \leq \mu < \kappa \qquad \text{(A1).}$$

This is the interesting case—with an access deficit (A1 $\Rightarrow$ $\kappa - \rho < 0$) even an efficient incumbent needs downstream profits to ensure cost coverage. Thus losses may be forced on an efficient

[11] If the incumbent's actual costs exceed κ the difference amounts to waste or rent sharing with factors of production, and may be treated as monopoly profit; similarly for c_i and c_e below.

[12] Perfectly general pricing of local calls is allowed.

incumbent if the interconnect fee is set too low.[13]

If the incumbent provides long distance its costs increase to c_i,[14] the annualized economic cost of its entire operations.

Monopoly provision in both markets is assumed to be profitable, that is:

$$0 < \kappa < c_i < \mu + m \qquad \text{where } m = p^M D(p^M) = \text{monopoly revenues in long distance} \qquad \text{(A2).}$$

A1 and A2 imply $c_i - \kappa < m$.

Entrants respectively pay fixed costs, $c_1, c_2, \ldots, c_E$ to provide long distance. Let $\underline{c}_e = \min(c_1, c_2, \ldots, c_E)$.

If there are economies of scope in the incremental provision of long distance then

$$c_i - \kappa < \underline{c}_e \qquad \text{(A3),}$$

that is, the incumbent's incremental costs are less than the least cost entrant's start-up costs before interconnect fees. This is very reasonable. The contrary

$$\underline{c}_e \leq c_i - \kappa \qquad \text{(\textasciitilde A3)}$$

occurs if there are *dis*economies of scope between local and long distance calling (though switching, billing, advertizing, interconnection standards etc. all suggest the opposite), which cannot be avoided by operating separate subsidiaries, or some entrants have access to technology not available to the incumbent, or downstream competition comes from other incumbents with their own local monopolies, and hence economies of scope.

It will be convenient to strengthen ~A3:

~A3 and at least two entrants with long distance costs $\underline{c}_e$ (~A3').

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13 The restriction $\mu < \kappa$, however, may be relaxed without loss to what follows. In this case A2 below must explicitly require $c_i - \kappa < m$ (downstream provision is profitable to a monopolist), and A4 should be weakened to $m > \underline{c}_e + \max(\kappa - \mu, 0)$.

14 Marginal costs throughout are assumed to be zero, and while this is probably true of phone calls (see footnote 24 and associated text), the results of the model generalize subject to the existence of a unique (in profits up to firms' identities) equilibrium (which sometimes requires at least two least cost entrants).

Allowing at least two entrants with costs $\underline{c}_e$ is uncontroversial if it is believed that the downstream market is capable of supporting competition.

Finally, if A3 holds,[15] $\underline{c}_e$ is assumed to be sufficiently small that, ignoring interconnection fees, some entrant can at monopoly prices profitably provide long distance while subsidizing the local market, that is:

$$\underline{c}_e + \kappa - \mu < m \qquad \text{(A4).}$$

This ensures an entrant can provide effective competition.

Assumptions A1, A2, and A4 are usually implicit in most models that examine interconnection (e.g. Laffont & Tirole 1996). A3 is less common. Laffont & Tirole 1996 have no fixed costs for long distance; Baumol 1993, Baumol & Sidak 1994a and 1994b, etc. assume the unlikely ~A3 (which implies A4). It is also common to assume firms face constant, but not necessarily equal, marginal costs in both markets (again e.g. Laffont & Tirole 1996).

The unregulated game

The players. There is an incumbent and some entrants, respectively subscripted i and 1, 2,..., E.

The strategies. The game has two stages. In the first the incumbent chooses its local retail pricing structure, generating local call revenues, $\rho \quad [0, \mu]$. The incumbent also announces an interconnect charge, $\gamma \quad [0, \infty)$, being a per call (or call minute etc.) charge for terminating the entrant's long distance traffic. In the second stage, the incumbent and each entrant simultaneously and respectively choose long distance prices, $p_i, p_1, p_2, \ldots, p_E \quad (0, \delta, 2\delta, 3\delta, \ldots, \bar{p})$.[16]

The players' objective functions

The incumbent's profit function is:

$$u_i(\gamma, p_i, p_1, p_2, \ldots, p_E) = \rho + p_i D_i(p_i, p_1, p_2, \ldots, p_E) + \gamma \sum_{e=1}^{E} D_e(p_i, p_1, p_2, \ldots, p_E) - \kappa - \chi(p_i = \underline{p})(c_i -$$

[15] A2 and ~A3 A4.

[16] That interconnect fees are announced ahead of long distance prices tallies with common-sense since long distance price setting depends crucially on these. This also characterizes actual practice, e.g. in Australia, New Zealand, the U.K., and the U.S.

κ),

while the $e \in \{1, 2,..., E\}$ entrants' profits are:

$$u_e(\gamma, p_i, p_1, p_2,..., p_E) = (p_e - \gamma)D_e(p_i, p_1, p_2,..., p_E) - \chi(p_e = \underline{p})c_e$$

For notational simplicity, sometimes some of the arguments of u_i, u_e, D_i, and D_e, for $e \in \{1, 2,..., E\}$ will be supressed.

Let SPE* indicate a sub-game perfect equilibrium (SPE) with no dominated strategies used in the Nash equilibrium of any round.

Proposition 1. The SPE* of the unregulated game is unique in price and profits—the monopoly price p^M prevails and the incumbent, under A3 excludes entry and earns $\mu + m - c_i$; or under ~A3' allows entry and earns arbitrarily close to $\mu + m - \kappa - \underline{c}_e$. Entrants make (arbitrarily close to) zero profits.

Proof:

A3: The incumbent can guarantee itself maximal industry profits, $\mu + m - c_i$, with the following strategy: In the first round the incumbent sets $\rho = \mu$ and γ such that $m - \gamma D(p^M) - \underline{c}_e < 0$. In the second round $p_e > p^M$ for $e \in \{1, 2,..., E\}$ since any $p \leq p^M$ is weakly dominated by $\bar{p}$ ($\bar{p}$ guarantees zero profits while $p \leq p^M$ only non-positive and in some cases negative profits—for a proof see Lemma 1 of Ralph 1996). The incumbent's second round best response after elimination of these strategies is $p_i = p^M$. $(u_i, u_1, u_2,..., u_E) = (\mu + m - c_i, 0, 0,..., 0)$.

~A3': Maximum cartel profits are $\mu + m - \underline{c}_e - \kappa$. The incumbent can claim arbitrarily close to these by setting $\gamma | \gamma D(p^M) = m - \underline{c}_e - \varepsilon$, for ε arbitrarily small: Such a γ implies $(p^M - \gamma)D(p^M) - \underline{c}_e = \varepsilon$ (entry is profitable at p^M for an entrant with costs $\underline{c}_e$). Note $\underline{p} > p^M$ is not a Nash (one of the minimum cost entrants could profitably undercut this); for $p_i > p^M$ $u_i = \mu + m - \underline{c}_e - \kappa - \varepsilon > \mu + m - c_i$ (the incumbent will not undercut entry at p^M); and for ε sufficiently small $(p^M - \delta - \gamma)D(p^M - \delta) - \underline{c}_e < 0$ (another entrant cannot profitably undercut p^M). Entry at p^M then is a Nash, if at least one player posts a price $p^M + \delta$, unique up to the identity of the successful entrant and the player which sets price $p^M + \delta$.

If A3 is replaced by the assumption that solo production on the part of the incumbent maximizes industry profit, the proof holds with perfectly general costs functions. A version of the proposition also holds for the remaining case, ~A3 with only one least cost entrant, but requires the incumbent be granted a first mover advantage in setting long distance prices. A similar equilibrium can emerge even when there is a single least cost entrant and the incumbent does not have a first mover advantage, but it is no longer unique (for this and other variations see Appendix A.I). With more general cost functions and ~A3 there *may* be no equilibrium with entry, and possibly no equilibria at all.

The game under the local cap

Application of the proposed local cap implies two changes on the unregulated game. First, the incumbent's strategy set is limited somewhat—its long distance price is now constrained to exceed the interconnect fee, that is, $p_i > \gamma$. This ensures the incumbent's long distance price can support the interconnection charge whether or not the its long distance operations actually face such a transfer price. Second, the incumbent's earnings from the local network, *including imputed interconnection charges on its own calls*, are capped at the cost of the local transport, κ. Local earnings are defined as the sum of:

revenues from local call charges, ρ,

interconnect fees billed to entrants by the incumbent, $\gamma \sum_{e=1}^{E} D_e(p_i, p_1, p_2, \ldots, p_E)$, and

interconnect fees *imputed* to the incumbent, $\gamma D_i(p_i, p_1, p_2, \ldots, p_E)$.[17]

If, at the end of an accounting period, the cap is not violated, that is

$$\rho + \gamma \sum_{e=1}^{E} D_e(p_i, p_1, p_2, \ldots, p_E) + \gamma D_i(p_i, p_1, p_2, \ldots, p_E) \leq \kappa \qquad (3),$$

then consumers are billed ρ for local telephony, and each entrant for e $\{1, 2, \ldots, E\}$ respectively $\gamma D_e(p_i, p_1, p_2, \ldots, p_E)$ for interconnection.[18]

If the cap is instead violated, that is

[17] The cap does not require the incumbent to bill itself any amount at all—γD_i is simply computed to determine whether the cap has been met.

[18] Consumers of course also receive bills for long distance telephony amounting to $p_i D_i + p_e D_e$.

$$\rho + \gamma\sum_{e=1}^{E} D_e(p_i, p_1, p_2,..., p_E) + \gamma D_i(p_i, p_1, p_2,..., p_E) > \kappa \quad (4),$$

then the jth entrant pays $D_j/\sum_{e=1}^{E} D_e$ of the larger of $\kappa - \rho - \gamma D_i$ and zero, the sum of which is by (4) less than $\gamma\sum_{e=1}^{E} D_e$.

Consumers pay ρ, unless

$$\kappa - \rho - \gamma D_i(p_i, p_1, p_2,..., p_E) < 0 \quad (5),$$

then not only do the entrants pay nothing for interconnection, but consumers pay the larger of zero and $\kappa - \gamma D_i$ ($< \rho$ by 5).

The player's objective functions.

Let $(\alpha)_+ = \max(\alpha, 0)$ and $(\alpha)_- = \min(\alpha, 0)$. The incumbent's revenues under the cap from provision of local service are:

$$\rho + \gamma\sum_{e=1}^{E} D_e \qquad \text{if } \rho + \gamma\sum_{e=1}^{E} D_e + \gamma D_i \le \kappa \text{ (the cap is not violated)}$$

and

$$(\kappa - \gamma D_i)_+ \qquad \text{if } \rho + \gamma\sum_{e=1}^{E} D_e + \gamma D_i > \kappa \text{ (the cap binds),}$$

that is, revenue from the local network is:

$$\min[\rho + \gamma\sum_{e=1}^{E} D_e, (\kappa - \gamma D_i)_+].$$

The incumbent also earns $p_i D(p_i)$ and must pay κ, and if $D_i > 0$, an additional $c_i - \kappa$. The incumbent's profits under the cap are then:

$$u_i(\rho, \gamma, p_i, p_1, p_2,..., p_E) = \min[\rho + \gamma\sum_{e=1}^{E} D_e, (\kappa - \gamma D_i)_+] + p_i D_i - \kappa - (c_i - \kappa)\chi(D_i > 0) \quad (6).$$

Taking advantage of the structure offered by the Bertrand game:

$$u_i(\rho, \gamma, p_i, p_1, p_2,..., p_E) =$$

$$\begin{cases} \min[\rho, (\kappa - \gamma D(p_i))_+] + p_i D(p_i) - c_i & \text{for } p_i < \underline{p}_e \le \overline{p} \\ \min[\rho + \underline{E}\gamma D(p_i)/(\underline{E} + 1), (\kappa - \gamma D(p_i)/(\underline{E} + 1))_+] + p_i D(p_i)/(\underline{E} + 1) - c_i & \text{for } p_i = \underline{p}_e \le \overline{p} \\ (\rho + \gamma D(\underline{p}_e) - \kappa)_- & \text{for } \underline{p}_e < p_i \le \overline{p} \end{cases}$$

(6a).

Similarly, Entrant e faces a profit function:

$$u_e(\rho, \gamma, p_i, p_1, p_2, ..., p_E) = p_e D_e - \chi(D_e > 0)\{\min[\gamma D_e, (\kappa - \rho - \gamma D_i)_+/(\underline{E} + \chi(p_i = \underline{p}))] + c_e\} =$$

$$\begin{cases} 0 & \text{for } \underline{p} < p_e \leq \bar{p}, \\ p_e D(p_e)/(\underline{E} + 1) - \min[\gamma D(p_e)/(\underline{E} + 1), (\kappa - \rho - \gamma D(p_e)/(\underline{E} + 1))_+/\underline{E}] - c_e & \text{for } p_e = \underline{p} = p_i \leq \bar{p} \\ p_e D(p_e)/\underline{E} - \min[\gamma D(p_e)/, (\kappa - \rho)_+]/\underline{E} - c_e & \text{for } p_e = \underline{p} < p_i \leq \bar{p} \end{cases}$$

(7).

Proposition 2.1. Under the local cap and ~A3' the SPE is unique in price and profits, and welfare is improved over the unregulated case. All firms earn zero profits except a single entrant with costs $\underline{c}_e$ which supplies long distance at the smallest $p|\ pD(p) - (\kappa - \rho) - \underline{c}_e \geq 0$; all other prices exceed this, but at least one by no more than δ.

Proof: See Appendix A.II.

Proposition 2.2. Under the local cap and A3:

(a) The SPE* as δ goes to zero is unique in profits with u_i arbitrarily close to $\underline{c}_e - (c_i - \kappa)$ and all entrants earning 0, with prices such that $p_i \leq p^M$ and $\rho \leq \mu$, where one of these inequalities is strict, thereby increasing welfare over the unregulated case.[19]

(b) To achieve this the incumbent chooses ρ, γ, and p_i, such that an entrant cannot undercut p_i without making losses, and so that the price cap is met. A variety of prices meet these criteria—a lower ρ allows a higher γ and hence p_i under the cap.

Specifically, the incumbent's SPE* strategies which survive as δ becomes small are:

ρ such that: $(\kappa + \underline{c}_e - m)_+ \leq \rho$, with $\rho > 0$ if $\kappa \geq \underline{c}_e$ (feasible by A4) (8);

$p_i = p^*$, the smallest p such that $pD(p) - (\kappa - \rho) \geq \underline{c}_e$ (9)

and note; $p^* > 0$ as $p^* = 0$ implies $-(\kappa - \rho) \geq \underline{c}_e$ but $\rho \leq \mu < \kappa$,

[19] Strictly, to guarantee increased welfare $\rho < \mu$ must be combined with a requirement that original upstream prices remain available.

$$p^* \leq p^M, \text{ and}$$

$$(p^* - \delta)D(p^* - \delta) - (\kappa - \rho) < \underline{c}_e \text{ (ruling out entry); and}$$

γ such that: $\gamma < p^*$, (10a)

and if $\rho > 0$ then $\gamma D(p^*) = \kappa - \rho$ (10b)

and if $\rho = 0$ then $\gamma D(p^*) \geq \kappa$ (10c),

(but in this case payments by the entrant never exceed κ).

(c) Entrants' surviving SPE* strategies as δ becomes small are, for e $\{1, 2,..., E\}$:

> $p_e \geq p^* + \delta$ if $p^* < p^M$ (with the equality holding for at least one entrant at the SPE*) and $p_e > p^M$ otherwise.

Proof: See Appendix A.II.

The optimality of the local cap under minimal information availability

A formal proof of the local cap's optimality requires some structure on the priors about the relationship between $c_i - \kappa$, and $\underline{c}_e$, and a loss function associated with making an error. In particular, it is assumed that:

$$0 < \Pr(c_i - \kappa < \underline{c}_e) < 1 \quad \text{(A5);}$$

and

the possibility that a firm could be forced to operate at a loss cannot be allowed (A6).[20]

A5 simply says there is some chance that either A3 or ~A3 holds. A6 is quite strong. It views forced losses as infinitely costly. This, however, is reasonable because such a possibility vitiates the mechanism itself. Negative profits are not sustainable requiring *ad hoc* policy adjustments.

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[20] If it is known $\underline{c}_e = c_i - \kappa$, as is likely when the incumbent faces downstream competition from other local monopolists (e.g. in the U.S.), then assumptions A5 and A6 are unnecessary.

Proposition 3. Setting the local cap at κ is optimal given A6 and no knowledge of $\Delta(.)$, D(.), $c_i - \kappa$ and $\underline{c}_e$, except A5.

Proof: Surplus in the long distance market is maximized by minimizing p (marginal costs are zero). Given a set of upstream retail prices which generate ρ^* in revenues, surplus subject to cost coverage is maximized by the lowest p| pD(p) = $\min(c_i, \kappa + \underline{c}_e) - \rho^*$. The local cap for upstream retail prices fixed delivers a long distance price equal to the lowest p| pD(p) = $\kappa + \underline{c}_e - \rho^*$ (revealing $\underline{c}_e$). This is immediately optimal under ~A3 for upstream retail prices fixed. It is optimal under A3 by A5 and A6 because setting a more rigorous cap (e.g. $\kappa - \varepsilon$) raises the possibility that the incumbent could be forced to operate at a loss.

Under the cap, however, upstream retail prices are not fixed. Thus the mechanism allows the range of price outcomes described in Proposition 2. However, since nothing is known about $\Delta(.)$ and D(.), any one of these is as likely to generate higher surplus as any other—i.e. is optimal from the vantage point of a regulator.

The mechanism, of course is not first best, which would require pricing at marginal cost and lump sum taxes (e.g. non-exclusionary and probably discriminatory access prices) to bring total revenues in line with costs. This, however, is ruled out both by regulatory ignorance and an inability to levy taxes or grant subsidies. These constraints also sharply limit traditional second best regulatory approaches including Ramsey pricing, rate-of-return regulation, and Loeb-Magat (i.e. incentive-compatible) mechanisms.

The local cap is in general sub-optimal compared with cost-covering Ramsey prices in two respects:

(1) It allows at least Bertrand rents downstream and more if firms have downward sloping demand curves, but zero profits would be allocatively efficient.

(2) Relative prices between up and downstream markets need not be optimal—that is, in general welfare could be increased by raising upstream and lowering downstream prices, or *vice versa* (a wide range of prices deliver profit $c_e - (c_i - \kappa)$ to the incumbent), but under the informational assumptions made the optimal price schedule is not known.

More information about downstream costs would of course allow reduction of Bertrand profits (e.g. by setting the cap equal to $\kappa - c_e + c_i$). Even so, Bertrand profits should not be of serious concern. It is these which generate innovation in highly competitive and dynamic markets. Patents, copyrights, registered designs, and just being there first, all create Bertrand profits, even though these imply static efficiency losses. Similar incentives apply to the proposed mechanism: the lower the least cost firm's costs the higher its profits.

Additional information may also be used to narrow the range of equilibrium prices towards the optimal. For example, a floor $\underline{\rho}$ on ρ[21] narrows the incumbent's strategy space (ρ is constrained to lie between $\underline{\rho}$ and μ instead of zero and μ), restricting the incumbent's ability to maintain a high long distance price, but leaves profits unchanged. Now no more than $\kappa - \underline{\rho}$ can be shifted to the long distance market, compared with κ before, guaranteeing some long distance price reductions. An obvious candidate for $\underline{\rho}$ would be the incremental cost of local transit. Even requiring $\underline{\rho} = \mu$, fixing the game's outcomes in prices as well as profits, is plausible—μ after all is determined by regulation in the local market. Similarly, if information about demand elasticities is known, the incumbent's prices could be constrained according to a Ramsey rule, to lie in a range consistent with available information about demand elasticities. For example, independent demands require mark-up ratios which are proportional to the inverse of own-price demand elasticities (see e.g. Laffont and Tirole 1993, 30 ff):

$$(p_j - MC)/p_j = k/\eta(p_j),$$

where MC = marginal cost
p_j = price in the jth market
k = a constant applied in all markets
$\eta(.)$ = the elasticity of demand.

[21] Alternatively, the regulator may place an upper bound $\kappa - \underline{\rho}$ on how much may be collected in imputed and actual interconnection fees.

III. Comparisons with alternative interconnect devices

It remains to compare, using the model of Section II, the proposed mechanism with other methods for establishing interconnect fees. The first three devices considered mandate an interconnection charge—the lump sum and per unit charge are chosen to cover the access deficit, while the third fee covers the long run incremental upstream costs of downstream operations. The fourth, Laffont and Tirole’s (1996) global price cap, allows the incumbent to set the interconnection fee subject to regulatory constraint. In this respect it is similar to the local cap, and the “efficient” component pricing rule (on which see Ralph 1996, Chapter 3 for a critique using the present model).

A lump sum fee intended to cover the access deficit

A particularly simple interconnect device (due to Ergas) would be to levy a lump sum charge on entrants, sufficient to cover the access deficit, $\kappa - \rho$. In the “lump sum game” ρ is first set, and then players simultaneously announce long distance prices. As before, long distance costs, including an interconnection charge $(\kappa - \rho)/(\underline{E} + \chi(p_i = \underline{p}))$, are incurred by any firm which faces positive demand.

Define p^B as the smallest $p|\ pD(p) \geq \kappa - \rho + \underline{c}_e$, and note $p^B < p^M$ is the equilibrium price which emerges under the local cap ρ given.

Lemma 1. The lump sum game’s SPE* delivers the same welfare as the proposed local cap for a given choice of ρ.

Proof: Profits and prices are identical in both games for δ small: By the elimination of dominated strategies (proof similar to Lemma 3A) $p_e \geq p^B$ for e {1, 2,..., E}. A shared market is not an SPE by proof similar to Lemma 5A. At an SPE, respectively for A3/~A3' $p_i/\underline{p}_e \leq p^B$ otherwise an/another entrant could profitably drop price. Further, $p_j = p^B$ maximizes u_j subject to $p_j \leq p^B < p_k$ for j, k {i, 1, 2,..., E} and $j \neq k$ (since pD(p) is single-peaked and $p^B < p^M$). This implies $p_i/\underline{p}_e = p^B$ with some firm pricing at $p^B + \delta$ at the SPE* and $u_i = \underline{c}_e - c_i + \kappa/0$, and $u_e = 0/0$ for e {1, 2,..., E}.

The regulator can set the lump sum fee *ex post* thereby requiring no more information than the local cap. Alternatively, this is the equivalent of applying the local cap where γ, chosen by the incumbent, is a lump sum rather than a per call or per minute fee. Practically, however, the lump sum fee penalizes entry. Under it, an entrant pays $(\kappa - \rho)/(\underline{E} + 1)$ regardless of the size of the market it is initially able to serve. Since in reality entrants cannot claim markets share overnight—the Bertrand game models a long run outcome—the lump sum fee represents a serious barrier to entry.

A per unit charge intended to cover the access deficit

An alternative to a lump sum fee, is to charge a fixed per unit interconnect fee (per subscriber line, call or call minute), such that the deficit in the local market would be covered overall. This would give a one-shot game where after ρ is announced the regulator sets γ to $(\kappa - \rho)/D(p^B)$, p^B defined in the previous sub-section. By an unprovided proof virtually identical to Lemma 1 this interconnection charge delivers the same welfare levels as the local cap. It also does not penalize new entrants in transition to their long run market share. However, it is much more informationally demanding than the local cap—κ, $\underline{c}_e$, and $D(p^B)$ must be estimated *ex ante*, requiring demand information from both local and long distance markets.[22]

Interconnect at incremental cost

The incremental cost game has the incumbent choose ρ in the first round, followed by Bertrand competition in long distance where firms choose long distance price with the interconnection fee set to the incremental cost of carrying the entrant's traffic (zero in the model).

Define p^I as the smallest p such that $pD(p) \geq \underline{c}_e$. Note $p^I < p^B < p^M$ for δ small.

Lemma 2. The SPE* of the incremental cost game under A3/~A3' is, for δ small, unique: $p_i/p_e = p^I$ with some other firm setting a price $p^I + \delta$; $u_i = \mu + \underline{c}_e - c_i$ (which may be less 0)/$\mu - \kappa < 0$, $u_e = 0/0$ for $e \quad \{1, 2,..., E\}$; and social welfare is greater than under the local cap.

Proof: The incumbent's choice of ρ is independent of the long distance market, so will be set to μ.

Profits and prices are identical in both games for δ small: By the elimination of dominated strategies (proof similar to Lemma 3A) $p_e \geq p^I$ for $e \quad \{1, 2,..., E\}$. A shared market is not an SPE by proof similar to Lemma 5A. At an SPE, respectively for A3/~A3' $p_i/\underline{p}_e \leq p^I$ otherwise an/another entrant could profitably drop priceFIX. Further, $p_j = p^I$ maximizes u_j subject to $p_j \leq p^I < p_k$ for $j, k \quad \{i, 1, 2,..., E\}$ and $j \neq k$ (since pD(p) is single-peaked and $p^I < p^M$). This implies $p_i/\underline{p}_e = p^I$ with some firm pricing at $p^I + \delta$ at the SPE* and $u_i = \mu + \underline{c}_e - c_i/\mu - \kappa$, $u_e = 0/0$ for $e \quad \{1, 2,..., E\}$, and $p^I < p^B \quad$ greater social welfare under the incremental cost approach.

While the incremental cost approach delivers greater welfare given the proposed mechanism, it will force an efficient incumbent to supply local service at a loss under ~A3' and under A3 if $\underline{c}_e < c_i - \mu$.[23]

The approach is also pro-competitive since incremental costs are often very low, for example, in articulated network industries such as gas, electricity and telephone distribution. Unfortunately, incremental costs are in general difficult to estimate (though Brock 1995 argues in telecommunications they are close to zero.[24])

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[22] In fact, the informational demands are considerably higher than this since in general there are many downstream markets (in telecommunications the number of long distance markets alone is vast), each potentially requiring a different interconnection charge (see Section IV as to why a uniform charge is likely to be problematic). This problem arises for any mechanism which requires information about downstream markets, but not the local cap. Under the local cap, it is the incumbent, not the regulator that sets price, and the incumbent is relatively well informed about downstream market conditions, and has strong incentives to get its estimates right.

[23] The Australian data presented in Section IV below, suggest losses there could be as high as -\$A945 million ($u_i = \mu + c_e - c_i$). These losses have not yet emerged because the entrant has less than 30% of the market (in contradiction to the Bertrand assumptions of the model). The Australian regulatory authorities have foreshadowed an increase in interconnect charges when the new entrant gains a large enough share of the market, thus the incumbent is never likely to be forced to operate at a loss, but unfortunately this also provides a framework for *de facto* profit sharing whereby each party tacitly accepts given market shares, limiting total output.

[24] In telecommunications, Mitchell 1990 estimates the 1988 annualized cost of the busiest calling hour of the year at between \$216 and \$369, the bulk of which was capital costs (maintenance amounted to \$7 to \$18). In addition, he estimates a 30¢ to 90¢ cost per call attempt in that busy hour. Incremental costs outside this period are virtually zero, and even *average* incremental cost figures are

Laffont and Tirole's global price cap

Laffont and Tirole 1996 propose a price cap[25] which includes the incumbent's interconnection fees as well as retail prices. The cap, appropriately implemented, will lead the incumbent to set optimal Ramsey prices. It can also be combined with a profit sharing (245) rule, and thereby maintain the high powered incentives for cost-reduction of a Littlechild-style price cap. The approach, however, is extremely demanding informationally. It requires fixed quantity weights that are set proportional to realized, that is *ex post*, output levels. These rather difficult forecasts are what deliver Ramsey relative prices. In addition, to ensure the correct price level and hence optimal Ramsey prices, the incumbent's global costs must also be known.

The cap has the form:

$$\alpha\pi\Delta^x + \alpha\gamma D_e^x + \alpha p_i D_i^x \leq p^{cap}$$

where $\alpha > 0$,

π is the local price set by the incumbent, and

superscript ^{x} indicates an exogenous estimate of the *ex post* realized variable,

Δ is local call demand,

p^{cap} is the price cap.

This can be immediately rewritten:

$$\pi\Delta^x + \gamma D_e^x + p_i D_i^x \leq c_i \quad (9)$$

since α is arbitrary (though it must equal p^{cap}/c_i to ensure zero profits). The incumbent can choose any π, γ, and p_i, subject to (9), where Δ^x, D_e^x, and D_i^x are fixed. With $p^{cap} = \alpha c_i$, and Δ^x, D_e^x, and D_i^x set to optimal output levels, a profit maximizing incumbent will set Ramsey prices (see Laffont and Tirole 1996, 244).

The cap may also be implemented with the "efficient" component pricing rule or ECPR (Laffont and Tirole, 245-7). This is appropriate if the incumbent and entrant's demands and costs are symmetric, and has two benefits: the regulator no longer needs to estimate downstream market shares, and the ECPR prevents predation (this is not important if the cap's quantity weights can be accurately estimated, but becomes important if the regulator must grope towards these). However, as already outlined, the ECPR has strong informational demands of its own.

Implementation of the Laffont and Tirole global cap with or without application of the ECPR is

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low. For example, using these figures Brock 1995 estimates the average incremental cost per call minute (which is not an incremental cost) at 0.2¢ (or 2.1¢ per peak hour call minute). The Australian regulatory authority in 1995 estimated the average per minute incremental cost of a phone call to be A3.3¢ per minute (actual fees vary with the type of exchange area, time-of-day, etc. but are still average incremental costs estimates).

[25] A price cap may in general refer to a regulatory regime where the firm sets n prices subject to some cap of the form $\sum_{i=1}^{n} p_i \leq p^{cap}$, a broad usage employed by Laffont and Tirole 1996, 245. However, a fundamental aspect of the price cap as originally proposed by Littlechild 1983 was that the regulator would not readjust p^{cap} once set. This makes the regulated firm the claimant of any residual profit, and thereby provides incentives for cost reduction. In this paper "price cap" is used conventionally, that is referring to Littlechild-style mechanisms, while "cost-of-service regulation" will refer to the case where the regulator continually re-estimates a firm's costs, even if for the purpose of resetting some price cap.

probably too difficult. The strong informational demands required to estimate optimal output and global cost levels are essentially equivalent to those required to directly estimate optimal Ramsey prices. But Ramsey prices have virtually no history of implementation, and are widely agreed to be beyond regulatory capability—see for example Baumol 1993, 32.

Laffont and Tirole (1996) and Tirole in correspondence suggest an alternative method of implemention. The regulator can iteratively adjust quantity weights (Laffont and Tirole 1996, 246), and its cost estimates, until Ramsey prices are achieved. Similarly, if the ECPR is utilized, incremental cost estimates may be checked *ex post* by competitor's complaints (247).

Regulatory *tâtonnement* however is not very convincing. Even in a stable environment where only aggregate costs are unknown, convergence under the process will be slow. In a dynamic environment it may never occur. When optimal output levels are also unknown, the problem to be solved by regulatory groping increases significantly, further slowing convergence. Worse, it is not obvious that even in a stable environment, the regulator will have enough information to adjust its output estimates towards Ramsey optimal levels.

More seriously, the *tâtonnement* process leaves the door wide open to unpredictable and idiosyncratic decisions on the part of the regulator, and worse, to regulatory capture. The regulator's task here is very complex, and requires an enormous amount of discretionary power. It must at certain intervals (which also must be chosen) estimate:

(1) the total cost of the incumbent's operations;

(2) optimal output levels for literally tens of thousands of services (or whether and how to aggregate these);

and if the ECPR approach is taken:

(3a) some service incremental costs, with implied choices about the order and speed in which protests will be entertained (as many entrants will tell you, the time a regulator takes to make a decision is often more important than the decision itself—see e.g. Davies 1985);

or if the ECPR is not utilized

(3b) market share data, and supervision to ensure predation does not occur while the regulator gropes.

IV. Policy considerations and the local cap

A fundamental attraction of the local cap is the relatively little amount of information required for its implementation. For cost-of-service regulation, only five pieces of information are required:

ρ, total revenues earned in the retail local market,

γ, the interconnection fee,

$D_e(p_i, p_e)$, long distance traffic carried by the entrant,

$D_i(p_i, p_e)$, long distance traffic carried by the incumbent, and

κ, the annualized cost of local transport.[26]

All these items may be estimated *ex post*. ρ is probably already subject to observation and in any case, difficult to misrepresent, while γ and D_e are known to the incumbent and Entrant e for e $\{1, 2,..., E\}$, who provide the regulator with adversarial sources of information.[27] D_i, may be more difficult to assess, but is also difficult to misrepresent at least in the broad.

Gauging κ, the cost of providing local transport, is the most difficult task the regulator faces. However, there are three reasons why, at least in telecommunications, it should not be too onerous:

(1) Due to the highly supervised nature of local telecommunications, regulatory authorities commonly have already accumulated a good deal of expertise and a substantial knowledge base in these matters. In fact, exactly this information is commonly required to effectively implement standard local market regulation, including rate-of-return and price cap regulation.

(2) Local network structures are fairly simple, and hence readily subject to engineering modeling and similar (work by the BTCE 1989 in Australia; Caves et al 1989 in the UK; and Bridger Mitchell 1989, 1990 in the US, Gabel 1996 in New Zealand, for example, already provide good independent cost estimates).

(3) Installation of local loop is an on-going activity which can readily be contracted out, thus the regulator can require yard-stick operations via commercial tender. Similar comparisons can if there are several geographically based local operators.

While the mechanism makes no allocation of local transport costs between upstream (local) and downstream (long distance) *calls*, if costs are shared between local and long distance *transport* then some cost separations are required. For example, a switch solely used to route (local and long distance) calls within the local network is an element of the cost of local transit. However, if that switch also routes calls in the long distance network its cost cannot be solely attributed to local transport. The salary of the firm's CEO provides another example.

While the cost of local transit must include at least the incremental and no more than the stand alone

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[26] To implement the mechanism as a price cap the regulator would additionally need to estimate future movements in total factor productivity and nominal costs relative to some exogenous price index (such as the CPI). The regulator must also decide what units of output are relevant in constructing the cap, an important and difficult task.

[27] The incumbent's profits are increased by the amount it can inflate κ, and by the amount it can deflate ρ, and $\gamma[D_i(p_i, p_e) + D_e(p_i, p_e)]$, since $\rho + \gamma[D_i(p_i, p_e) + D_e(p_i, p_e)] - \kappa$ must be returned to the entrant or local consumers. Of course, entrants and consumers benefit by the obverse.

costs of its joint inputs, choice between these polar extremes is a matter of judgement.[28] The definition of c_i in Section II implicitly defines κ as including the stand alone costs of local transit. This allows the incumbent to reap the full benefit of any economies of scope it can generate leading to dynamic efficiency. It also requires no estimation of long distance costs—only optimal local transport costs are needed. A caveat, however, applies—the incumbent has a strong incentive to shift costs from long distance to local transport since this lowers its long distance costs, increasing its (potential to earn under ~A4) Bertrand profits and lowering social welfare. As a result, the incumbent should bear the burden of proof when seeking to claim cost sharing, while the regulator should view such claims skeptically.

The polar opposite would estimate local transport costs including only the incremental cost of joint inputs. Call this κ' ($\leq \kappa$). This lowers the incumbent's profits compared with using κ, and improves in-period allocative efficiency. However, it removes any incentive for the incumbent to seek out economies of scope between local and long distance transit, and requires estimation of some long distance transit costs. Any allocation between these two extremes also requires information about long distance costs, but provides some incentive to the incumbent to exploit economies of scope.

Implementation—Cost-of-service regulation, price caps, tâtonnement with profit sharing

In practice, the proposed mechanism may be implemented in a variety of ways.[29] The static model of Section II most naturally suggests viewing the local cap as a form of cost-of-service regulation—at the end of some determined accounting period a regulator would estimate κ and then apply the local cap. This approach provides the incumbent with incentives to reduce long distance costs ($c_i - \kappa$), and κ, but in this latter case, only if the regulator allows profit sharing on any economies of scope between up- and downstream markets.

The mechanism, however, may also be developed as a price cap providing strong incentives to reduce κ. In this case future price and productivity movements would be estimated alongside κ. In the base year total revenues would be required not to exceed κ as in the simple static model. In subsequent years overall price rises would be limited by a price cap.[30] Allowing price cap adjustments, say after a certain period of time, or at certain high or low profit triggers (perhaps determined by *ex post* political processes), moves the cap toward cost-of-service regulation (see for example Liston 1993, Pint 1992).

The local cap could also be implemented by a process of *tâtonnement* in the manner suggested by Laffont and Tirole 1996. This would amount to a cost-of-service approach, but with some profit sharing to maintain incentive compatibility.

By-pass

Interconnection charges provide incentives for technically inefficient local competition, i.e. by-pass of the incumbent's local network. While this can still be welfare improving (see Ralph 1996, Chapter 4, §IV), these incentives are eliminated by directly charging interconnection fees to final users, including those on the incumbent's long distance network, whether or not their calls are routed

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[28] Consider a switch with an annualized cost of \$100 that is utilized in both markets, and assume separate switches for the local and long distance markets would cost respectively \$80 and \$65. At least \$35 (= \$100 - \$65, the incremental cost floor) of the \$100 switch can be attributed to local transit, but no more than \$80, the stand alone cost ceiling.

[29] A detailed comparison of the approaches discussed here is found in Ralph 1996, Chapter 1.

[30] For example, a CPI-x rule, where x is the forecast difference between the CPI and input prices plus forecast total factor productivity.

through the incumbent's network. This ensures "interconnection" revenues are not reduced by technically inefficient local entry, but does not prevent efficient entry.

Structural separation: When the incumbent is forbidden to supply downstream

While the proposed mechanism in no way requires structural separation between up and downstream markets (e.g. as in US fixed line telecommunications), it may be applied under such a regime. However, in this case two or more entrants are critical to its success (appropriate proofs are similar to those in Appendix A.1). Prices, however, will be higher than if joint operations were possible because vertical separation excludes the exercise of economies of scope.

Multiple upstream monopolists

The proposed mechanism may be independently applied to multiple access monopolists (e.g. the U.S. baby Bells). The relevant interconnection fee becomes the price of traversing a firm's local network once, either in origination or termination (that is half the interconnect fee defined in Section II). With technology freely available, downstream competition between at least two upstream monopolists will lead to optimal cost-covering prices. The presence of multiple local monopolists also allows the application of yardstick competition in setting the local cap.[31]

Multiple downstream markets

While the model of Section II allows for only one downstream market, in general there will be many (e.g. in telephony there are multiple long distance markets, not one). In this case, the regulator must set an interconnect fee in any downstream markets for which the costs of entry exceed monopoly revenues. These downstream markets may also be regulated but this is not necessary for implementation of the proposed cap. In all other markets, the incumbent sets an interconnect fee (as many as one per market), subject to: (1) each fee not exceeding the retail price charged by the incumbent in that market; and (2) an extended version of the cap—that the sum of ρ plus all interconnect earnings, imputed and actual, must be less than κ.

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[31] The local cap that each incumbent would face is adjusted by the change in average costs of all incumbents (see Schliefer 1989; water supply in the United Kingdom provides an example). If regulated firms are similar, this avoids the problems of forecast uncertainty inherent in standard price cap regulation.

V. Estimating the impact of the mechanism—An example from Australian telecommunications

Using conservative estimates, the proposed local cap if applied in Australia in 1989, could have halved long distance prices increasing long distance traffic by 50%.

Up until the beginning of 1993 Telecom Australia, a government-owned commission, held a statutory right to carriage of domestic publicly-switched telecommunications traffic in Australia. In 1989 the Bureau of Transportation and Communications Economics (BTCE), with the cooperation of Telecom, estimated Telecom's incremental and stand alone costs and revenues by subscriber groups for fiscal 1988. The study was conducted at a high level of disaggregation, and took account of incoming as well as outgoing calls. Using this data, and modeling from Ergas, Ralph, and Sivakumar (ER&S) 1990, various estimated outcomes of the proposed interconnect regime can be illustrated. All costs and revenues are in millions of 1988 Australian dollars, and prices are in 1988 Australian dollars.

Based on the BTCE data and international comparisons, ER&S estimated the efficient cost of the national network c_i to be $4558. Gauging κ is a little more difficult. Efficient operating expenses were estimated by ER&S to be $2527 with implied overheads of $1137 (compared to an actual cost of $2995 and overheads of $1605). Assuming 80% of overheads must be incurred in administrating local services, the stand alone cost of the local network, κ, is something like $4331 (somewhat larger than the $4302 estimate of the stand alone cost of local calls).

Monopoly calling revenues from publicly switched markets were $1944 for local and community calls, $1169 for line rentals, $279 for connections (thus μ = $3392), and $1912 (= m) for long distance, giving an access deficit, k - μ = $939, and total profits, μ + m - ci = $746.

No accurate cost estimate exists for the new entrant—Optus has only been in the market since January of 1993. Assume ce to be $500, something above the incumbent's incremental cost of long distance $227 (ci - k). This implies the incumbent's profits under the local cap, ce - ci + k = $273 are almost a third of monopoly levels.

In 1987-88 1035 million long distance calls were made at an average price (p^M) of $1.85 per call. While entry was forbidden in this market, it could have been prevented by setting γ ≤ $1.36 per call, that is, the smallest γ such that $m - \gamma D(p^M) - c_e \leq 0$. If under the cap the incumbent held ρ = μ = $3392 then $\gamma D(p_i) = \kappa - \mu$ = $939, and $p_i D(p_i) = c_e + \kappa - \mu$ = $1439. Estimates of what γ, p_i and $D(p_i)$ would emerge under the cap require an estimate of the elasticity of long distance demand. This is unlikely to be less than 0.7, and probably much higher—arguably an elasticity in excess of 1.0 might be applied since Telecom Australia was probably pricing as an unfettered monopolist at the time of the study. Table A1 presents equilibrium interconnect and final output prices for given elasticities.

Table A1—Prices and output under monopoly and the local cap for given elasticities

Prices & output under monopoly		
γ	p^M	$D(p^M)$
$1.36	*$1.85*	*1035 m*

	Prices & output under the local cap

Demand elasticity	γ	p_i	$D(p_i)$
0.6	$0.74	$1.13	1277 m
0.7	$0.70	$1.08	1338 m
0.8	$0.67	$1.03	1403 m
0.9	$0.64	$0.98	1464 m
1.0	$0.61	$0.93	1550 m
1.1	$0.58	$0.88	1629 m
1.2	$0.55	$0.84	1712 m

The average long distance call length in Australia in 1988 is estimated to be three minutes.

At the alternative extreme, the incumbent can stay under the cap by holding $p_i = p^M$ = \$1.85, and reducing p (from μ = \$3392 to \$2919), which allows γ = \$1.65. The incumbent's profits, of course, are \$273 in both cases.

These estimates for γ and p_i are, however, significantly over-stated for the following reasons: local retail revenues, μ, have risen with a shift towards "cost-based" pricing; more efficient supply of social obligations, technological changes, and most importantly, cost-cutting measures taken with the advent of competition, have reduced local loop costs, κ, by at least five percent (\$215) if not twice that[32]; no account was taken of other downstream services which utilize the local network, but these contribute to the access deficit under the proposed cap (mobile telephony alone increases traffic by three percent); and per capita calling rates, holding price constant, have increased since 1988.

[32] Holding demand constant, a reduction of \$100 in κ (or c_e) reduces γ and p_i each by 10¢ (the reverse holds for μ).

VI. Summarizing conclusions and other comments

The proposed mechanism uses less information and involves less regulation than any of the other interconnect devices considered. It however delivers less welfare than the incremental cost approach, and Laffont and Tirole's global cap. The incremental cost approach, on the other hand, can force losses on an efficient incumbent, and therefore may not be sustainable in the long run. It may also be informationally demanding, though in telecommunications, incremental costs may be sufficiently close to zero to obviate the need for any cost estimations. The global cap, in contrast to the other approaches considered, achieves optimal Ramsey prices, but requires either information that is unavailable, or a tremendous amount of discretion on the part of the regulator, opening the door to regulatory capture. Baumol and Willig's efficient components pricing rule on its own fails to improve welfare, and is demanding informationally. These demands are significantly increased if additional regulation is applied as recommended by ECPR proponents (see Ergas and Ralph, 1996; Ralph 1996, Chapter 3).

Several interconnect devices designed for multilateral monopsony, that is where multiple local monopolists need to terminate traffic in each other's networks, are not examined in this paper. These are: settlement-style regimes where an agreed per unit charge is paid by the net exporter (see Brock 1993, and Dansby and Luciano 1987); revenue sharing arrangements.

None of these rules is particularly satisfying from a regulatory perspective: a settlements regime has been widely used in international telephony, producing extraordinary monopoly profits[33]; while revenue sharing encourages cartel behavior, and is commonly forbidden by anti-trust laws.

Cost allocation procedures are also not discussed. For a general overview of these applied to telecommunications see Sharkey 1994; Henriet and Moulin 1996 provide an allocation device based on each user's share of terminating traffic.

[33] Johnson 1989, 22-34, presents a number of estimates of very high rates of return, for example, DGT is estimated to make between an 8 and a 19 percent rate of return on international calls over and above the *fully distributed cost* rate of return which AT&T makes on its own international calls. Müller 1989, 35, argues these numbers are too low! ¶The U.S. General Accounting Office estimated AT&T's rate of return at 36.5 per cent for international calls in 1979. Ergas 1988, 12-3 provides evidence of very high rates of return for international carriage by European operators (see also Kwerel 1987, 24 ff) and for the Pacific operations of Cable and Wireless.

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Appendices

A.VII. The unregulated game when ce ≤ ci - k (~A3)

The unregulated game under ~A3 with a single low cost entrant (called Entrant e in this section) generates multiple and not always convincing equilibria. The incumbent's equilibrium profits are highest when it sets $\gamma|\ \gamma D(p^M) = m - \underline{c}_e$, $p_i > p^M$, *and* $p_e = p^M$ (all $p \leq p^M$ are weakly dominated for all other entrants). However, the incumbent cannot guarantee $p_e = p^M$: $p_e > p^M$ may be an equilibrium so long as the entrant with next lowest costs cannot profitably undercut p_e, and at p_e the incumbent earns as much from interconnection as from entry, i.e. $\gamma D(p_e) \geq m - c_i + \kappa$. Equilibria also exist such that $p_e < p_i \leq p^M$, but these require the incumbent to choose a γ which lowers its equilibrium profit interval compared to that obtained by choosing $\gamma|\ \gamma D(p^M) = m - \underline{c}_e$, so can be discounted by an argument similar to that which eliminates Nash equilibria which are not sub-game perfect.

If the incumbent has a first mover advantage, however, an equilibrium unique in monopoly price reemerges under ~A3 with a single low cost entrant (Lemma 1A below). Granting the incumbent such an advantage seems highly reasonable—after all it was there first, and it is the entrant which must adjust to its presence.

Lemma 1A. If the incumbent announces price ahead of entrants' simultaneous announcements, ~A3 holds, and there is a single low cost entrant (Entrant e), then $p_e = p^M$ at the SPE*[34] of the unregulated game; $u_i = \mu + m - \underline{c}_e - \kappa - \varepsilon$, $u_e = \varepsilon$, and all other entrants earn 0.

Proof: The incumbent earns maximal industry profits (less ε) by setting $\rho = \mu$, γ such that $\gamma D(p^M) = m - \underline{c}_e - \varepsilon$, and $p_i = p^M + \delta$. Any price below $p^M + \delta$ is weakly dominated for all entrants except the least cost entrant, whose best response is p^M.

So long as there is more than one least cost entrant, a monopoly price equilibrium also emerges when the entrants simultaneously price long distance ahead of the incumbent. The incumbent sets γ exactly as in Lemma 1A, and competition among entrants drives the equilibrium price to p^M. The incumbent then sets $p_i > p^M$. In contrast, if there is only one entrant under ~A3 and it is granted the first mover advantage in announcing long distance price, then the (unique) equilibrium price can lie both above and below p^M. The entrant will set p_e to maximize its profits subject to $\gamma D(p_e) \geq m - c_i + \kappa$ (this prevents the incumbent from undercutting p_e). Absent this entry prevention constraint $p_e > p^M$ since $\gamma > 0$ (the incumbent chooses γ to maximize $\gamma D(p_e)$), but the constraint may force p_e below p^M at equilibrium. Since industry rents are maximized by p^M when $p_e \neq p^M$ the entrant is splitting a smaller pie, but one in which it gains a larger absolute piece.

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[34] If there is only one entrant this is the game's SPE.

A.VIII. The local cap—Proofs of Propositions 2.1 and 2.2

Proposition 2.1, the case when ~A3', is proved first.[35] The proof requires a definition and lemma.

Define p'' as the smallest p| $pD(p) - \min(\gamma D(p''), \kappa - \rho) - \underline{c}_e \geq 0$.

Lemma 2A. Under the local cap and ~A3, an SPE with entry implies $u_i \leq 0$, while no entry implies $u_i < 0$.

Proof: From (6a) $\underline{p}_e < p_i$ (entry) $u_i \leq 0$. $p_i = \underline{p}_e$ cannot be an SPE by a similar argument to that of Lemma 5A. This leaves $p_i < \underline{p}_e$, which is only possible at an SPE if $p_i \leq p''$ (otherwise entry would be a profitable strategy). There are two possible cases, but in both $u_i < 0$:

(1) If $\rho \leq (\kappa - \gamma D(p''))_+$ then $\rho \leq \kappa - \gamma D(p'')$ and

$$u_i = \rho + pD(p'') - c_i \qquad \text{(by 6a)},$$

and by the definition of p'' this may be rewritten

$$u_i = \rho + \gamma D(p'') + \underline{c}_e - o(\delta) - c_i < 0.$$

(2) If $\rho > (\kappa - \gamma D(p''))_+$ then $\min(\gamma D(p''), \kappa - \rho) = \kappa - \rho$, and

$$u_i = (\kappa - \gamma D(p''))_+ + pD(p) - c_i < \rho + pD(p'') - c_i,$$

and by the definition of p'' this may be rewritten

$$u_i < \rho + \kappa - \rho + \underline{c}_e - o(\delta) - c_i < 0.$$

Proof of Proposition 2.1 (the local cap under ~A3'):[36]

The incumbent can achieve maximum profits, $u_i = 0$, by choosing ρ and γ such that p'' is defined and $\rho + \gamma D(p') \geq \kappa$. A range of such ρ and γ exist, from $\rho = \mu$, through to the smallest ρ| $m - \kappa + \rho - \underline{c}_e \geq 0$ for sufficiently large γ. In the game's second round a least cost entrant will supply long distance at p'' (a higher price will induce entry by a second entrant; entry by the incumbent is ruled out by Lemma 2A; a lower price will result in losses on the part of the successful entrant). For the Nash one of the game's other players must set a price $p'' + \delta$.

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[35] The unregulated case under ~A3 with a single least cost entrant has no unique SPE. As in Lemma 2A the best the incumbent can earn is zero, and this only by allowing entry and collecting maximum interconnection fees, $\kappa - \rho$. Many γ and resulting p_e realize this. The SPE can also have ambiguous welfare effects compared with the unregulated case. Let $p_e^M = \arg\max_p (p - \gamma)D(p)$, and note $p^M < p_e^M$ for all $\gamma > 0$. For an SPE: the incumbent must set ρ and γ so that the entrant's profit maximizing choice of p_e ensures $\gamma D(p_e) \geq \kappa - \rho$; and $\rho + m - c_i \leq 0$ so the incumbent cannot profitably undercut $p_e > p^M$. If $\gamma D(p_e^M) = \kappa - \rho$ then the entrant's marginal cost is γ and $p_e = p_e^M > p^M$, lowering welfare, but $\rho < \mu$ (since $\mu + m - c_i > 0$ by A2) raising welfare. (However, if $\gamma D(p_e^M) > \kappa - \rho$ then welfare is improved for δ small: the entrant's marginal cost is zero, and $p_e = p^M$, so $\rho < \mu$ at an SPE.)

[36] This proof covers ~A3' when the inequality is strict. For the case when $\underline{c}_e = c_i - \kappa$ the proofs under A3 apply with minor modifications.

Welfare is strictly improved over the unregulated case: $u_i = 0$ $\gamma D(p'') \geq \kappa - \rho$ (by the definition of p'') $m - (\kappa - \rho) - \underline{c}_e \geq 0$ $p'' \leq p^M$ and $\rho \leq \mu$ with one inequality strict (otherwise by A4 and the definition of p'' entry could occur).

The proof of Proposition 2.2—the case under A3—is slightly more complex relying on five lemmas. The proof is first stated, and the lemmas follow.

Proof of Proposition 2.2 (the local cap under A3):

For δ small and ρ and γ chosen as in the proposition: Lemma 3A shows by the elimination of dominated strategies in the game's second round, $p_e > p^*$; and Lemma 4A that, after the elimination of dominated strategies $(u_i, u_1, u_2,.., u_E) = (\underline{c}_e - c_i + \kappa, 0, 0,..., 0)$ is the only remaining second round Nash, and so may be forced by the incumbent.

For δ small: Lemma 5A shows that $p_i = p_e$ cannot be an SPE; and Lemma 6A that at any SPE $u_i \leq \underline{c}_e - c_i + \kappa$ (and that if $p_i < p_e$ then $u_e \leq 0$) so the Nash of Lemma 4A maximizes the incumbent's profits.

Lemma 7A shows that at an SPE* $p_i \leq p^M$, a corollary of which is that the equilibrium strategies of the proposition characterize the SPE*. Finally, note (8), (9) and A4 imply that if $\rho = \mu$ then $p^* < p^M$, and if $p^* = p^M$ then $\rho < \mu$, which implies welfare is improved over the unregulated case.

The lemmas associated with the proof of Proposition 2.2

Lemma 3A. With ρ and γ set as in Proposition 2.2, any $p_e \leq p^*$ for e {1, 2,..., E} is weakly dominated by $\bar{p}$ (recall $D(\bar{p}) = 0$) for δ small.

Proof: Setting $p_e = \bar{p}$ guarantees $u_e = 0$ for all p_i.

Since $p_e > \underline{p}$ $u_e = 0$ in all cases by (7), the lemma is proved if $p_e = \underline{p} \leq p^*$ $u_e \leq 0$ with $u_e < 0$ in some case. This is shown first for $\rho > 0$, then for $\rho = 0$.

$\rho > 0$ (10b)

$p_e = \underline{p} < p_i$ $u_e = \underline{p}D(\underline{p})/\underline{E} - \min(\gamma D(\underline{p}), \kappa - \rho)/\underline{E} - c_e \leq \underline{p}D(\underline{p}) - \min(\gamma D(\underline{p}), \kappa - \rho) - c_e \leq \underline{p}D(\underline{p}) - (\kappa - \rho) - \underline{c}_e \leq p^*D(p^*) - (\kappa - \rho) - \underline{c}_e = o(\delta)$ (the last inequality is strict for all $p_e < p^*$ since pD(p) is single-peaked and $p^* \leq p^M$),

$p_e = \underline{p} = p_i$ $u_e = \underline{p}D(\underline{p})/(\underline{E} + 1) - \min[\gamma D(\underline{p})/(\underline{E} + 1), (\kappa - \rho - \gamma D(\underline{p})/(\underline{E} + 1))_+/\underline{E}] - c_e \leq (\underline{p} - \gamma)D(\underline{p})/(\underline{E} + 1) - \underline{c}_e < (\underline{p} - \gamma)D(\underline{p}) - \underline{c}_e$ (since $\underline{p} = p_i > \gamma$ by 10a) $\leq o(\delta)$,

so for $\rho > 0$ as δ becomes small, $p_e = \underline{p} \leq p^*$ $u_e \leq 0$ with the inequality always strict in some case (when $p_e < p^*$ and $p_e < p_i$, or $p_e = p^* = p_i$);

$\rho = 0$ (10c and $\kappa < \underline{c}_e$ from 8)

$p_e = \underline{p} < p_i$ $u_e = \underline{p}D(\underline{p})/\underline{E} - \min(\gamma D(\underline{p}), \kappa - \rho)/\underline{E} - c_e \leq \underline{p}D(\underline{p}) - \min(\gamma D(\underline{p}), \kappa - \rho) - c_e \leq \underline{p}D(\underline{p}) - \kappa - \underline{c}_e$ (by 10c) $\leq p^*D(p^*) - \kappa - \underline{c}_e = o(\delta)$ (again the inequality is strict for all $p_e < p^*$),

$p_e = \underline{p} = p_i$ $u_e = p_eD(p)/(\underline{E} + 1) - \min[\gamma D(\underline{p})/(\underline{E} + 1), (\kappa - \rho - \gamma D(\underline{p})/(\underline{E} + 1))_+/\underline{E}]$ -

c_e:

if $\kappa - \gamma D(\underline{p})/(\underline{E} + 1) > 0$ then $u_e = (\underline{p} + \gamma)D(\underline{p})/(\underline{E} + 1) - \kappa - c_e$ (by 10c) < $\underline{p}D(\underline{p}) - \kappa - \underline{c}_e$ (since $p_e = \underline{p} = p_i > \gamma$ by 10a) $\leq o(\delta)$ by 9,

if $\kappa - \gamma D(\underline{p})/(\underline{E} + 1) \leq 0$ then $u_e = \underline{p}D(\underline{p})/(\underline{E} + 1) - c_e \leq (\kappa - \underline{c}_e)/(\underline{E} + 1) + o(\delta)$ (by 9) $< o(\delta)$ (since $\kappa < \underline{c}_e$ here),

so again as δ becomes small, $p_e = \underline{p} \leq p^*$ $u_e \leq 0$ with the inequality always strict in some case (when $p_e < p^*$ and $p_e < p_i$, or $p_e = p^* = p_i$).

Lemma 4A. With ρ and γ fixed as in Proposition 2, $(u_i, u_1, u_2,..., u_E) = (c_e - c_i + c_e, 0, 0,..., 0)$ is, as δ becomes small, the only surviving Nash in undominated strategies in the game's second round.

Proof: By the elimination of dominated strategies for e {1, 2,..., E}, $p_e > p^*$ for δ small (Lemma 3A). The incumbent's best response for δ small is $p_i = \max(\underline{p}_e - \delta, p^M)$ since $p^* \leq p^M$ (see the note to 9). However, for an equilibrium $p_i \leq p^*$ (any higher price will induce entry by 9), and if $p^* < p^M$ then some p_e must equal $p^* + \delta$, otherwise the incumbent will wish to raise price.

Lemma 5A. A shared market ($p_i = \underline{p}_e$ and/or $\underline{E} > 1$) cannot be an SPE.

Proof: If $p_i > \underline{p}$ and $\underline{E} > 1$ then for any e {1, 2,..., E}| $p_e = \underline{p}$ it is profitable for a firm to cut price for δ small (proof omitted). This leaves the case when $p_i = \underline{p}_e$.

Without loss of generality, the rest of the proof focuses on Entrant 1. It is shown, either $u_i(p, p, p + \delta, p + \delta,..., p + \delta) < u_i(p - \delta, p, p + \delta, p + \delta,..., p + \delta)$ or $u_1(p, p, p + \delta, p + \delta,..., p + \delta) < u_1(p, p - \delta, p + \delta, p + \delta,..., p + \delta)$ for δ small. This result holds *a fortiori* when $\underline{E} > 1$.

There are three cases:

$$\rho + \gamma D(p) \leq \kappa \quad (11)$$

$$\rho + \gamma D(p)/2 < \kappa < \rho + \gamma D(p) \quad \gamma D(p) \quad (12)$$

$$\kappa \leq \rho + \gamma D(p)/2 \quad (13)$$

Under (11) $u_1(p, p, p + \delta, p + \delta,..., p + \delta) = (p - \gamma)D(p)/2 - c_1 < (p - \gamma)D(p) - c_1 = u_1(p, p - \delta, p + \delta, p + \delta,..., p + \delta)$ as δ approaches zero.

Under (12) $u_1(p, p, p + \delta, p + \delta,..., p + \delta) = (p + \gamma)D(p)/2 - \kappa + \rho - c_1 < pD(p) - \kappa + \rho - c_1 = u_e(p, p - \delta, p,..., p)$ as δ approaches zero, for all $\gamma < p$.

Under (13) $u_i(p, p, p + \delta, p + \delta,..., p + \delta) = pD(p)/2 - c_i < pD(p) - c_i = u_i(p - \delta, p, p + \delta, p + \delta,..., p + \delta)$ as δ approaches zero.

Lemma 6A. At an SPE $u_i \leq \underline{c}_e - c_i + \kappa$ for δ arbitrarily small.

Proof: If $\underline{p} < p_i$ at an SPE then $u_i \leq 0$ (from 6a), and a shared market cannot be an SPE (Lemma 5A). If $p_i < \underline{p}_e$ at an SPE entry must be unprofitable so (dropping the subscript on p_i):

$$u_i \leq \max_{\rho, \gamma, p} \min[\rho, (\kappa - \gamma D(p))_+] + pD(p) - c_i$$

subject to for e {1, 2,..., E} $u_e(\rho, \gamma) \leq 0$ for all $p_e \leq p$.

In particular, the constraint requires for all e {1, 2,..., E} and $p_e < p$

$$p_e D(p_e) - (\kappa - \rho) - c_e \leq 0,$$

hence at $p_e = p - \delta$

$$(p - \delta)D(p - \delta) + \rho - \kappa - c_e \leq 0$$

but $u_i \leq \rho + pD(p) - c_i \leq \underline{c}_e - c_i + \kappa + o(\delta)$.

Lemma 7A. At an SPE* $p_i \leq p^M$.

Proof: Since the incumbent can force positive profits (Lemma 4A) only $p_i < \underline{p}_e$ is possible at an SPE* ($p_i > \underline{p}$ $u_i \leq 0$ by 6a, and $p_i = \underline{p}_e$ is ruled out by Lemma 3A). If $m - (\kappa - \rho) > \underline{c}_e$ then $_i$ $\leq p^M$ otherwise entry is profitable (since interconnection fees cannot exceed $\kappa - \rho$). If $m - (\kappa - \rho) \leq \underline{c}_e$ then for $p > p^M$: $\rho + pD(p) - c_i < \rho + m - c_i \leq \underline{c}_e - (c_i - \kappa)$ so $p_i > p^M$ is not a best response.