Network financing with two-part and single tariffs *

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Abstract

In this paper, we compare two types of access pricing: a two-part tariff where the fixed part aims to cover (part of) the network's fixed cost while the variable part covers the network's usage costs and a single tariff where both the usage and (part of) the infrastructure costs are covered by a per-unit access charge. We compare how the regulator trades-off the degree of competition induced by the access charges and the network financing.

Keywords: Access pricing, market structure, network financing.

JEL Classification: L11, L51.

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1 Introduction

The need of competition in network industries (telecommunication, energy, railways,...) is now commonly accepted. Because the network constitutes a bottleneck input that cannot be cheaply duplicated[1], competition in these industries requires that the network's owner gives third party access (TPA) to competitors. With TPA, competitors can apply for network capacity (for which they pay an access charge) and supply services to final consumers. TPA is particularly important when there is no alternative technology to reach the consumers -that is there is no possibility to bypass the network.

Since the network is a bottleneck input, the network owner has incentives to use its dominant position to monopolize downstream segments of the market (foreclosure). Then, introducing competition does not suppress the need for regulation. In particular, regulating both the access conditions and the access price is of prime importance.[2] For examples, in the European Union, it is required that the network's owner gives a non discriminatory access to its infrastructure[3] (regulation of access conditions) or, in the UK, BT's interconnection services are subject to access charge controls by Ofcom, an independent regulator (regulation of access prices).

Access charges play two roles in TPA: first, they influence the entry and the supply decisions of the competitors and thereby influence the market structure. Second, access charges are used to recover the costs of the net-

[1] Bottleneck inputs like the rail-tracks and stations, the electricity transmission grid or the local-loop are called essential inputs (or facilities).

[2] Access control is one of the proposed remedy to prevent foreclosure. Other solutions like divesture or shared-ownership can also be considered (see Rey and Tirole, 2005).

[3] The European directive 96/92/EC concerning the internal market in electricity imposes a non-discriminatory tariff for the use of the transmission and distribution system; in the rail directive 2002/14/EC, it is required that: "The charging and capacity allocation schemes should permit equal and non-discriminatory access for all undertakings".

work.[4] In particular, they should cover the cost of using the network and part of the network's fixed cost which includes building, maintenance and development costs. Therefore, there is a two dimensional conflict between granting generous access that reduces downstream profits and the possibility of recovering the infrastructure's cost.

This paper compares two types of access pricing: a two-part tariff where the fixed part aims to cover (part of) the network's fixed cost and the variable part covers the network's usage costs and a single tariff where both the usage and (part of) the infrastructure costs are covered by a per-unit access charge. In both cases, the regulator trades-off the degree of competition induced by the access charges and the need to finance the network. The paper compares the market structure and the social welfare under these two systems. The originality of this work is to consider an endogenous market structure: the entrant's cost condition and thereby its entry and supply decisions are not known ex-ante by the regulator. Hence, the regulatory environment has an impact on both the entry and the supply decision of the competitor.

Both the two-part and the single tariff are currently used for pricing access. In Germany, DB Netz, the owner of the rail-tracks network should cover operation, maintenance and depreciation costs by the track charges. Between 1998 and 2001, DB Netz applied a two-part tariff consisting of a fixed charge and a variable part per train-km. The fixed part aimed to cover the infrastructure's cost and the variable part was kept as close as possible to usage costs. Along with the two-part tariff, a single tariff with a higher per train-km fee was accessible to smaller carriers. Since 2001, DB Netz applies a single tariff with a constant price per train-km that depends on

[4] In addition, the access charges should induce the efficient amount of bypass (Laffont and Tirole, 2000). An issue which is not consider here since we assume that the network is an essential input i.e. an input that cannot be duplicated.

the train's and the tracks' characteristics.[5] In the UK, the rail users paid to the network owner -Network Rail- a track access charge consisting of a fixed annual payment and a variable track usage charge that covers usage costs. In the Netherlands, the train access charge consists only in a variable fee per train/km.

Model overview and results

There are two firms that can potentially supply downstream services to consumers, for examples passengers rail services or long distance calls. Both firms share the same network (rail tracks or telecommunication transmission facility) to reach the consumers. The network is owned by an incumbent operator that gives TPA to a unique potential entrant. The industry regulator contracts with the incumbent and specifies the supply of the incumbent, the public contribution to the network financing and the access condition for the third party. After observing the regulatory environment, the potential entrant decides whether or not it will be active on the downstream market. If it decides to enter, it pays the access price and supplies services without being further regulated. Hence, the incumbent is fully regulated while the entrant is not. Market liberalization does not always suppress the regulation of the incumbent operators. In the passenger rail market for example, the regulators often impose a minimum level of services to the historical operators while entrants are not subject to the same obligations. Similarly, universal services obligations are imposed to the historical operators in the telecommunication and the postal markets.

The model developed hereafter sheds light on the impact of the regulatory environment on the entry of competitors and shows how regulation should be adapted to the endogenous market structure. The framework can easily be adapted to those situations where the regulator controls only

[5] Link (2003), Pittman (2004).

the access prices and the incumbent decides on its supply of downstream services.[6]

Regulation takes place under asymmetric information. For the regulator, a major uncertainty at the time of opening the market to competition concerns the technology of the entrant. Is the competitor more cost effective than the incumbent operator? Throughout this paper, we assume that, the regulator does not know if the entrant is more cost effective than the incumbent operator. Consequently, entry does not always take place, the entry decision is endogenous and it depends on the regulatory environment.

The cost of the network is partially covered by a transfer of costly public funds from the regulator. The remaining part is covered by the incumbent's profit (if any) and the contribution of the entrant through access charge. This paper compares two access pricing systems, a **two-part tariff** in which the entrant contributes to the network financing through a fixed access charge and a **single tariff** in which it contributes through a per-unit access charge. In both cases, these charges aim to cover the network's fixed cost i.e. they come in addition to marginal cost of using the network.

Both the two-part and the single tariffs affect the entry decision - a larger access price deters entry- but only the single tariff distorts the supply decision of an active entrant provided that the variable part of the two-part tariff is equal to the network's usage cost. The paper compares the welfare and the resulting market structure under these two access pricing systems. In both cases, entry is not efficient[7]: a more cost effective entrant may not enter the downstream market. This means that the regulator optimally

[6]But in this case, if the incumbent remains the first mover, it could use its first-mover advantage to prevent entry on the downstream segment of the market. Hence, regulation of the incumbent's supply can be imposed to prevent market foreclosure.

[7]The market structure is inefficient if there is a positive probability that a more (a less) cost effective producer stays out (enters) the market, (Armstrong, 2001).

reduces the entry in order to increase the entrant's financial contribution to the network's cost. There is, however, more entry if the regulator uses a single tariff i.e. a duopoly on the downstream market is more likely in this case.

The optimal access charge system depends on the incumbent's production cost. When the incumbent has a high cost, entry is profitable both for consumers and the entrant. In this case, a two-part tariff is preferred because (i) it does not distort the entrant's supply decision and (ii) the regulator can raise a large contribution from the entrant through a large lump sum fixed fee. If the incumbent has a low cost, using a fixed access charge is not optimal because it deters entry too much and the regulator prefers the single tariff. The cost of public funds used to partially finance the network also influences the choice between these two pricing schemes.

Related literature

In this paper, the market structure is endogenous and it depends on the regulatory environment. The paper is then closely connected to the literature on the design of a private industry (Auriol and Laffont, 1992, Dana and Spier, 1993, Jehiel and Moldovanu, 2004) that considers the market structure as a part of the regulatory environment. In these papers, the regulator fully controls the market structure while it is not the case with TPA. In Dana and Spier, for example, firms compete ex-ante for the market and, in some circumstances, they also compete ex-post on the market. With TPA, competition takes place only ex-post on the market.

The structure of the model presented here is similar to Caillaud (1990), where a regulated incumbent faces the threat of entry on the downstream market but in Caillaud's model the entrants bypass the incumbent's input and there is no access pricing problem. Gautier and Mitra (2003) analyze

TPA without bypass but they focus only on two-part tariff for access.[8]

Three different kinds of access pricing formulas are proposed in the literature: the efficient access pricing (Ramsey prices for access)[9], the efficient component pricing rule (ECPR)[10] and cost-based access prices like the TSLRIC (total service long run incremental cost). In the Ramsey approach, the regulator fixes the access and the retail prices in order to maximize the social welfare while guaranteing that the network owner breaks even. It results that, for each retail product, the associated Lerner index is inversely related to the *superelasticity* of the product. This approach usually takes the market structure as given i.e it does not take into account the impact of access prices on the entry decisions of the competitors. Our derivation of optimal access charge is similar to this efficient access pricing approach except that it does not consider the market structure as given. Moreover, we consider quantity rather than price competition on the downstream market. As an alternative to Ramsey pricing, the ECPR prescribes that the access price should be equal to the incumbent's opportunity cost for the retail services. With this type of access pricing, (a) potential entrants can enter profitably the market only if they are more cost efficient and (b) entry is neutral with respect to the incumbent's profit. In this approach, entry is endogenous and the market is always served by the most efficient firm. Under some conditions the ECPR is equivalent to Ramsey pricing (see Laffont and Tirole, 1994, 2000, Armstrong, Doyle and Vickers, 1996).[11] In the model presented in this paper, the regulator optimally departs from efficient entry.

Finally, Gans (2001) studies the relationship between the access pricing

[8]Without restricting the variable part of the tariff to be equal to the network usage cost.

[9]Laffont and Tirole (1994, 2000).

[10]Willig (1979), Baumol (1983) and Armstrong (2001).

[11]The optimal access charge is not equivalent to the ECPR when the entrant has market power which is the case in this paper.

and the incentive to invest in the infrastructure in a dynamic context. This paper considers in a static context the link between access prices and network financing.

2 Model

Demand, costs and information

Two firms, a regulated incumbent (I) and a potential entrant (E) are possibly active on the downstream market. The downstream demand is given by $P(Q) = a - bQ$ with $a > 0$, $b > 0$ and where Q is the quantity demanded and $P(Q)$ is the market clearing price corresponding to Q. The firms share the incumbent's network to supply downstream services to consumers. The network's building (or maintenance) cost is C. Using the network involves a constant unit cost denoted ψ. In addition, the firms produce the service at a constant marginal cost. We denote the incumbent's and the entrant's marginal cost by θ and ϕ respectively.

The regulator knows the incumbent's cost parameters C, θ and ψ. For example, the regulator could have learned the incumbent's costs from past regulatory experiences.[12] We restrict the parameter sets to $C > 0$, $\psi \geq 0$ and $\theta \in [\underline{\theta}, \overline{\theta}]$, with $0 < \underline{\theta} < \overline{\theta} < a$. We call $\Delta = \overline{\theta} - \underline{\theta}$. At the time the regulator specifies the access conditions, it does not know entrant's cost ϕ. This assumption captures the fact that when the regulator allows TPA to the network, it ignores whether or not potential entrants are more cost effective than the incumbent. It is however common knowledge that ϕ follows a uniform distribution $g(\phi)$ over the same interval $[\underline{\theta}, \overline{\theta}]$, that is $g(\phi) = \frac{1}{\Delta}$.

Regulation

The regulator maximizes the consumer surplus net of the transfer to the incumbent. Transfers are costly; this is captured by introducing a

[12] Dana and Spier (1994) and Jehiel and Moldovanu (2004) have a similar hypothesis.

shadow cost of public funds $\lambda \geq 1$. The regulator's objective is to maximize $W(Q,t) = S(Q) - P(Q)Q - \lambda t$ where $S(Q) = \int_0^Q P(x)dx$ and t is the amount of transfer paid by the regulator to the incumbent.[13] In this context, transfer t is meant to finance the infrastructure. The regulatory contract should guarantee to the incumbent at least a zero profit (participation constraint). With the linear demand specification, we have: $W(Q,t) = b\frac{Q^2}{2} - \lambda t$.

The regulator contracts only with the incumbent. Depending on the known cost θ, the regulatory contract, denoted $M(\theta)$, specifies three variables: (1) the supply of the incumbent $q_i(\theta)$, (2) the transfer to the incumbent $t(\theta)$ and (3) the access conditions to the network. There are two possible access charge systems: a two-part tariff in which entrant pays a fixed fee $A(\theta)$ and a per unit fee equal to the marginal cost of using the network ψ or a single tariff where the entrant pays $\psi + \alpha(\theta)$ for each unit supplied on the downstream market. The per-unit fee can be decomposed in two terms: a payment ψ for covering the costs of using the network and a payment $\alpha(\theta)$ for covering the infrastructure cost. Without loss of generality, we now set the network usage cost to zero: $\psi = 0$.

We assume that the access charges are independent of the entrant's technology. This assumption is in line with the European practices that impose a non discriminatory access to third parties. With non discriminatory access, two types of entrant with cost ϕ' and ϕ'' face the same entry conditions.

Firms compete in quantities. The entrant's quantity decision is taken after observing the quantity supplied by the incumbent (which is specified in $M(\theta)$). Hence, the entrant is a Stackelberg follower in the quantity game.

Timing of the events

[13] We consider a pro-consumer regulator that does not include the firms' profits in the welfare function. Including the profits in the welfare is a source of non-concavity in the regulatory problem (see Gautier and Mitra, 2003).

1. The regulator observes the cost conditions of the incumbent and chooses between the single and the two-part tariff.

2. The regulator designs the regulatory contract.

3. The entrant learns its cost ϕ and observes the regulatory contract.

4. The entrant decides on entry.

5. The regulated incumbent produces the quantity specified in the regulatory contract, the entrant, if active, decides on quantity. The price is set to clear the market.

Benchmark: the regulated monopoly case

Suppose that the incumbent firm does not face the threat of entry, that is the incumbent is a monopolist. The regulatory mechanism specifies for each known $\theta \in [\underline{\theta}, \overline{\theta}]$ a quantity transfer pair $\langle q_i(\theta), t(\theta) \rangle$ chosen to maximize the welfare and that guarantees to the incumbent at least a zero profit. That is the regulator solves:

$$\max_{q_i(\theta), t(\theta)} W(q_i(\theta), t(\theta)) = b\frac{q_i(\theta)^2}{2} - \lambda t(\theta),$$

subject to

$$(P(q_i(\theta)) - \theta)\, q_i(\theta) - C + t(\theta) \geq 0.$$

In this problem, the participation constraint is binding. Integrating the constraint in the objective function, the regulator solves:

$$\max_{q_i(\theta)} b\frac{q_i(\theta)^2}{2} + \lambda[(P(q_i(\theta)) - \theta)q_i(\theta) - C].$$

The solution to this problem is:

PROPOSITION 2.1 *For any known $\theta \in [\underline{\theta}, \overline{\theta}]$, the optimal quantity transfer pair for a monopolist is:*

1. $q_i(\theta) = \frac{\lambda}{2\lambda-1}\frac{a-\theta}{b}$,

2. $t(\theta) = C - \frac{\lambda-1}{2\lambda-1}(a-\theta)q_i(\theta)$.

PROOF: Take the first order condition of the above problem. ■

The optimal contract that the regulator applies to a monopolist is such that (i) when there is no cost of public funds ($\lambda = 1$), the market clearing price is equal to the firm's marginal cost θ and the network cost is fully financed by public funds: $t(\theta) = C$. (ii) When λ increases, the regulator raises the market price above the marginal cost and consequently reduces its transfer ($t(\theta) < C$).

3 Optimal access charges

3.1 The entrant's entry and supply decisions

In the presence of an entry possibility, the regulatory mechanism specifies a triple: $M^f(\theta) = \langle q_i^f(\theta), A^f(\theta), t^f(\theta)\rangle$ in the two-part tariff case or $M^v(\theta) = \langle q_i^v(\theta), \alpha^v(\theta), t^v(\theta)\rangle$ in the single tariff case for any given and commonly known marginal cost $\theta \in [\underline{\theta}, \overline{\theta}]$ of the incumbent. The entry decision is taken after the regulator has designed the regulatory mechanism. Therefore, even if the entrant is not regulated, the regulatory mechanism affects the entry decision and the quantity supplied by the entrant.

With a two-part tariff, the profit of an entrant with cost ϕ is either

$$\Pi_e(q_e, M^f(\theta), \phi) = \{P(q_i^f(\theta) + q_e) - \phi\}q_e - A^f(\theta)$$

if it enters the market and supplies the quantity q_e or zero if it does not enter the market. Assuming entry takes place, the entrant supplies the quantity $q_e^{f*}(M^f(\theta), \phi) = \max_{q_e} \Pi_e(q_e, M^f(\theta), \phi)$. The solution to this problem is

$$q_e^{f*}(M^f(\theta), \phi) = \frac{a - bq_i^f(\theta) - \phi}{2b}. \tag{3.1}$$

Then, entry takes place if $\Pi_e(q_e^{f*}(M^f(\theta),\phi), M^f(\theta),\phi)$ is greater than zero, that is, if:

$$\phi \leq k^f(\theta) = P(q_i^f(\theta)) - 2\sqrt{bA^f(\theta).} \tag{3.2}$$

$\frac{k^f(\theta)}{\Delta}$ is the probability of entry associated with the regulatory mechanism $M^f(\theta)$.

Similarly, with the single tariff, the profit of the entrant is either

$$\Pi_e(q_e, M^v(\theta), \phi) = (P(q_i^v(\theta) + q_e) - \phi - \alpha^v(\theta))\, q_e$$

if it enters the market with quantity $q_e > 0$ or zero otherwise. Assuming entry takes place, the entrant supplies the quantity $q_e^{v*}(M^v(\theta),\phi)$ that maximizes its profit:

$$q_e^{v*}(M^v(\theta),\phi) = \frac{a - bq_i(\theta) - \phi - \alpha^v(\theta)}{2b}. \tag{3.3}$$

Entry takes place if $\Pi_e(q_e^{v*}(M^v(\theta),\phi), M^v(\theta),\phi) \geq 0$, that is if:

$$\phi \leq k^v(\theta) = P(q_i^v(\theta)) - \alpha^v(\theta). \tag{3.4}$$

$\frac{k^v(\theta)}{\Delta}$ is the probability of entry associated with the regulatory mechanism $M^v(\theta)$.

3.2 Two-part tariff

With the two-part tariff, the expected surplus is for any known $\theta \in [\underline{\theta}, \overline{\theta}]$:

$$\hat{W}^f(\theta) = \frac{1}{\Delta}\int_{\phi=\underline{\theta}}^{\phi=k^f(\theta)} b\frac{(q_i^f(\theta) + q_e^{f*}(M^f(\theta),\phi))^2}{2} d\phi$$
$$+\frac{1}{\Delta}\int_{\phi=k^f(\theta)}^{\phi=\overline{\theta}} b\frac{(q_i^f(\theta))^2}{2} d\phi - \lambda t^f(\theta). \tag{3.5}$$

The first term is the expected consumer surplus when entry takes place, the second term is the expected consumer surplus when entry does not occur and the last, the transfer to the firm. The regulator selects the regulatory mechanism $M^f(\theta)$ that maximizes $\hat{W}^f(\theta)$ and that guarantees to the incumbent at least a zero profit. Defining $\hat{P}^f(\theta)$ as the expected market clearing price $\hat{P}^f(\theta) = \frac{1}{\Delta}\int_{\phi=\underline{\theta}}^{\phi=k^f(\theta)} P(q_i^f(\theta)+q_e^{f*}(M^f(\theta),\phi))d\phi + \frac{1}{\Delta}\int_{\phi=k^f(\theta)}^{\phi=\overline{\theta}} P(q_i^f(\theta))d\phi$, the incumbent's participation constraint is:

$$(\hat{P}^f(\theta)-\theta)q_i^f(\theta) + \frac{1}{\Delta}\int_{\phi=\underline{\theta}}^{\phi=k^f(\theta)} A^f(\theta)d\phi + t^f(\theta) - C \geq 0. \tag{3.6}$$

The solution to the above problem is given in the following proposition:

PROPOSITION 3.2 *For any known $\theta \in [\underline{\theta},\overline{\theta}]$, the optimal mechanism $M^f(\theta)$ is:*

1. *For $\theta \in [\underline{\theta},\hat{\theta}]$ where $\hat{\theta} = \frac{(1+2\lambda)\underline{\theta}+(\lambda-1)a}{3\lambda}$,*
   - *(a) $q_i^f(\theta) = \frac{\lambda}{2\lambda-1}\frac{a-\theta}{b}$,*
   - *(b) $A^f(\theta) \geq \frac{(P(q_i^f(\theta))-\underline{\theta})^2}{4b}$,*
   - *(c) $t^f(\theta) = C - \{P(q_i^f(\theta)) - \theta\}q_i^f(\theta)$.*
2. *For $\theta \in [\hat{\theta},\overline{\theta}]$,*
   - *(a) $q_i^f(\theta) = \frac{\lambda}{2\lambda-1}\frac{a-H^f(\theta)}{b}$, with $H^f(\theta) \geq \theta$ in the relevant range and $H^f(\theta)$ increasing and convex in θ,*
   - *(b) $A^f(\theta) = \frac{4(P(q_i^f(\theta))+(\lambda-1)a-\lambda\underline{\theta})^2}{b(1+6\lambda)^2}$,*
   - *(c) $t^f(\theta) = C - \{\hat{P}(q_i^f(\theta)) - \theta\}q_i^f(\theta) - \frac{k^f(\theta)-\underline{\theta}}{\Delta}A^f(\theta)$.*

PROOF: See appendix A.1 ■

Increasing the access charge $A^f(\theta)$ has the following impacts on the welfare: first, it decreases the probability of entry and the market is therefore less competitive. As consequences, the consumer surplus decreases and the expected market price $P^f(\theta)$ increases, implying an increase in the incumbent's operational profit and an associated reduction in the transfer $t^f(\theta)$.

Second, the increase in the access charge increases the expected contribution of the entrant to the infrastructure financing ($\frac{k^f(\theta)-\underline{\theta}}{\Delta}A^f(\theta)$) as long as $A^f(\theta)$ does not exceed $\frac{(P(q_i^f(\theta))-\underline{\theta})^2}{9b}$. Hence, increasing the access charge up to that point contributes further to reduce the transfer. But the possibility of reducing the transfer by increasing the access price is limited by the fact that, at a point, further increase in $A^f(\theta)$ either reduces the incumbent's profit or deters all types of competitor to enter the market.

Similarly, a decrease in the incumbent's supply decreases the consumer surplus but increases the incumbent's profit and consequently reduces $t^f(\theta)$.

The regulator then faces the following trade-off: increasing $A^f(\theta)$ (or decreasing $q_i^f(\theta)$) has a negative impact on the consumer surplus but a positive impact on the incumbent's profit -at least as long as $A^f(\theta)$ is not too big- and, consequently, less public funds should be invested to cover the infrastructure cost. There is then a clear trade-off for the regulator between the benefit of more competition on the market (higher supply) and the cost (more public funds).

When the regulator faces a relatively efficient incumbent firm, the potential benefit of entry on the consumer surplus is limited because the incumbent is efficient and regulated. Moreover, the potential contribution of the entrant to the infrastructure financing is limited too. For these reasons, when the incumbent's cost lies in $[\underline{\theta}, \hat{\theta}]$, entry decreases the welfare and the regulator deters the entry of all types of competitor by setting a large fixed access charge. The reason is that the benefit of allowing for entry in term of consumer surplus does not compensate the cost in term of more public funds invested to cover the increase in the incumbent's losses. Then, in this case, the solution applied is identical to the regulated monopoly case.

When the incumbent is relatively less efficient, the benefits of entry both for the consumers and the infrastructure financing increase and the regulator allows the entry and $k^f(\theta) > \underline{\theta}$ for $\theta \in (\hat{\theta}, \overline{\theta}]$. However, entry is not efficient (see proposition 4.4 hereafter). Entry is limited to increase the financial contribution of the types of entrant active on the downstream market. There is a clear trade-off between financing infrastructure through a larger fixed tariff and the competition induced on the downstream market. When there is a positive probability of entry, the incumbent supplies less than in the regulated monopoly case. When θ increases, the regulator partially replaces the incumbent's production by the production of a more cost effective entrant. This substitution has a positive impact on the consumer surplus and on the entrant's profit. The regulator captures part of this profit increase by setting a larger access charge $A^f(\theta)$.

Finally, when public funds become more costly (λ increases), the regulator increases the parameter space in which entry never occurs ($\hat{\theta}$ increases). The regulator prefers to finance the network through higher prices and a lower transfer than through a larger contribution of the entrant. To limit the transfer of public funds, the regulator raises the price by limiting entry.

3.3 Single tariff

With a single tariff, the regulator maximizes the expected surplus

$$\hat{W}^v(\theta) = \frac{1}{\Delta}\int_{\phi=\underline{\theta}}^{\phi=k^v(\theta)} b\frac{(q_i^v(\theta) + q_e^{v*}(M^v(\theta),\phi))^2}{2}d\phi$$

$$+\frac{1}{\Delta}\int_{\phi=k^v(\theta)}^{\phi=\overline{\theta}} b\frac{(q_i^v(\theta))^2}{2}d\phi - \lambda t^v(\theta). \tag{3.7}$$

subject to the incumbent's participation constraint:

$$(\hat{P}^v(\theta)-\theta)q_i^v(\theta) + \frac{1}{\Delta}\int_{\phi=\underline{\theta}}^{\phi=k^v(\theta)} \alpha^v(\theta)q_e^{v*}(M^v(\theta),\phi)d\phi + t^v(\theta) - C \geq 0, \tag{3.8}$$

where $\hat{P}^v(\theta) = \frac{1}{\Delta}\int_{\phi=\underline{\theta}}^{\phi=k^v(\theta)}(a - b(q_i^v(\theta) + q_e^{v*}(M^v(\theta),\phi))d\phi + \frac{1}{\Delta}\int_{\phi=k^v(\theta)}^{\phi=\overline{\theta}}(a - bq_i^v(\theta))d\phi$.

PROPOSITION 3.3 *For any known $\theta \in [\underline{\theta}, \overline{\theta}]$, the optimal mechanism $M^v(\theta)$ is:*

1. $q_i^v(\theta) = \frac{\lambda}{2\lambda-1}\frac{a-H^v(\theta)}{b}$, *with $H^v(\theta) > \theta$ for all $\theta \in (\underline{\theta}, \overline{\theta}]$ and $H^v(\theta)$ increasing and convex in θ.*
2. $\alpha^v(\theta) = \frac{(a-\underline{\theta})(2\lambda-1)+bq_i^v(\theta)(2\lambda-3)}{6\lambda-1} > 0$
3. $t^v(\theta) = C - \frac{\lambda-1}{2\lambda-1}(a-\theta)q_i^v(\theta) - \frac{1}{\Delta}\int_{\underline{\theta}}^{k^v(\theta)} \alpha^v(\theta)q_e^{v*}(M^v(\theta), \phi)d\phi.$

PROOF: See appendix A.2 ■

With a single tariff, the expected market clearing price is identical to the regulated monopoly case: $\hat{P}^v(\theta) = \frac{(\lambda-1)a+\lambda\theta}{2\lambda-1}$. This means the following. First, that the transfer to the network owner is smaller than in the regulated monopoly case. The transfer is reduced by $\alpha^v(\theta)\frac{1}{\Delta}\int_{\underline{\theta}}^{k^v(\theta)} q_e^{v*}(M^v(\theta), \phi)d\phi$. Second, if in average consumers pay the same price than under the regulated monopoly regime, the consumer surplus is higher.

Entry takes place whenever the price without entry is higher than the entrant's marginal cost plus the per-unit access charge. At the solution, the cost of increasing the access price (lower production by the active types of entrants and lower entry) equals its benefit (an increase in the entrant's contribution to network financing and thereby a lower transfer).

4 Comparisons

4.1 Market structure

In this model, the entrant is active on the downstream market only if its marginal cost ϕ is below $k(\theta)$. This threshold value depends on the regulatory environment. Figure 1 represents the market structure for all possible realizations of $(\theta, \phi) \in [\underline{\theta}, \overline{\theta}]^2$. In region (**I**), the entrant is less cost effective than the incumbent and remains out of the market. In region (**II**), entry does not take place even though the entrant is more cost effective. In region (**III**), entry occurs only if the regulator uses a single tariff. Finally, in region (**IV**), the entrant is active on the downstream market for both types of tariff.

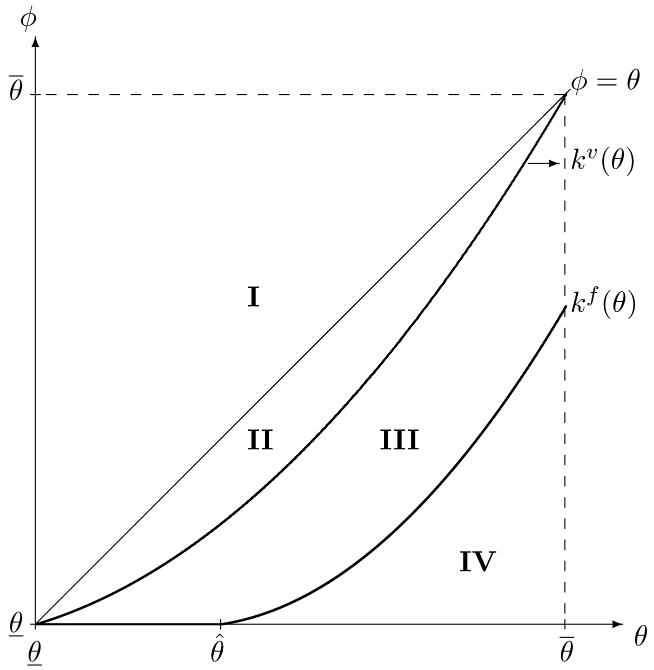

Figure 1: The market structure with fixed and per-unit access charge.

Two observations should be made. First, entry is not efficient in the sense that a more cost effective entrant is not necessarily active on the downstream market. For efficient entry, the access charge should have been such that $k(\theta) = \theta$. This could be achieved with a fixed access charge $A^f(\theta) = \frac{P(q_i(\theta))-\theta)^2}{4b}$ or a per-unit charge $\alpha^v(\theta) = P(q_i(\theta)) - \theta$.[14] The regulator (optimally) limits the entry of firms with a little cost advantage

[14]This last expression is the efficient component pricing rule, Armstrong (2001).

over the incumbent in order to increase the financial contribution of entering firm. Second, there is a higher probability of entry when the regulator uses a single tariff compared to the two-part tariff. With a two-part tariff, the entrant manages to cover the fixed part of the tariff only if it has a large cost advantage over the incumbent while there is no problem of this kind with the single tariff. Hence, the single tariff generates more entry.

These two observations are summarized in the next proposition:

PROPOSITION 4.4 $k^f(\underline{\theta}) = k^v(\underline{\theta}) = \underline{\theta}$, $k^f(\theta) < k^v(\theta) < \theta$ *for all* $\theta \in (\underline{\theta}, \overline{\theta})$ *and* $k^f(\overline{\theta}) < k^v(\overline{\theta}) = \overline{\theta}$.

PROOF: See appendix A.3 ■

4.2 Welfare

Before turning to the welfare comparisons, it is important to remember that if the regulator would know the entrant's cost, it would always prefer the two-part tariff because, first, this instrument is non distortionary and, second, it can tax all the entrant's profit through the fixed part of the tariff. This is no longer true when the regulator is unaware of the entrant's cost and depending on the entrant's marginal cost θ and the cost of transfers λ, the optimal pricing system will be either the two-part or the single tariff. We can establish that:

PROPOSITION 4.5 *There exists* θ^* *such that (1)* $\hat{\theta} \leq \theta^*$ *and (2) the regulator prefers the single tariff for all* $\theta \in [\underline{\theta}, \theta^*]$.

PROOF: The welfare functions $\hat{W}^f(\theta)$ and $\hat{W}^v(\theta)$ are both continuous and decreasing in θ. Since for $\theta \in [\underline{\theta}, \hat{\theta}]$, the solution with the two-part tariff is identical to the regulated monopoly case, we have $\hat{W}^v(\theta) \geq \hat{W}^f(\theta)$ and the single tariff dominates. Define θ^* as the solution of $\hat{W}^v(\theta) = \hat{W}^f(\theta)$, by continuity of the welfare function, $\theta^* \geq \hat{\theta}$. ■

When $\theta \leq \hat{\theta}$, there is no entry if the regulator uses the two-part tariff. This however does not mean that entry is not profitable. In particular, if the regulator uses the single tariff, there is a positive probability of entry and the welfare is higher. For larger values of θ, there is a positive probability of entry with both tariffs. We have established that up to θ^*, the single-tariff is the preferred access pricing. Though we cannot prove it formally, numerical simulations show that (1) for $\theta \in [\theta^*, \overline{\theta}]$, the two-part tariff gives a higher welfare and (2) that the cut-off point θ^* increases with the cost of public funds λ.

For example, with the following parameters: $P(Q) = 10 - Q$, $\underline{\theta} = 1$, $\overline{\theta} = 6$ and $C = 2$, the values of $(\hat{\theta}, \theta^*)$ are $(1, 1)$ when $\lambda = 1$, $(\hat{\theta}, \theta^*) = (1.27, 1.6)$ when $\lambda = 1.1$, $(\hat{\theta}, \theta^*) = (1.5, 2.1)$ when $\lambda = 1.2$, and $(\hat{\theta}, \theta^*) = (1.69, 2.52)$ when $\lambda = 1.3$. Hence, the parameter spaces $[\hat{\theta}, \overline{\theta}]$ where there is entry with the two-part tariff and $[\theta^*, \overline{\theta}]$ where it dominates the single tariff decreases with the cost of public funds.

5 Concluding remarks

In this paper we have shown that depending on the incumbent's technology and on the cost of transfer, it is optimal to use either a single tariff or a two-part tariff. The reason is that when the market structure is endogenous, both types of tariff are distortionary. The two-part tariff distorts the entry decision while the single tariff distorts both the entry and the supply decisions of the entrant. Quantity distortions induced by the single tariff reduces the welfare and hence, the regulator prefers this type of pricing only when the two-part tariff induces too little entry. When the probability of entry on the downstream market is large enough, i.e. the entrant is able to recover the entry fee with its downstream profit, the regulator prefers to use an instrument that does not distort the supply decision of the entrant.[15]

This analysis departs from Armstrong (2001) where the access price is set to induce an efficient entry decision and from the literature on access pricing (for example Laffont and Tirole, 1994) where the market structure is considered as given. Our analysis considers an endogenous market structure where the entry decision depends on the regulated access fee. In this context, the optimal access prices reflect the trade-off between promoting entry and financing the infrastructure. The resulting market structure is not efficient since it could leave a producer which is more efficient than the regulated incumbent out of the market.

There is another type of inefficient market structure when the regulator allows the entry of a less efficient competitor ($k(\theta) > \theta$). This second kind of inefficiency could arise when the regulator does not know the incumbent's cost parameter θ. In this case, the mechanism is the same modulo the fact that, from the regulator's point of view, the cost of the incumbent is not its marginal cost θ but a virtual marginal cost $z(\theta)$[16], that is the marginal cost of producing plus the marginal cost of fulfilling the incumbent's incentive constraint. Since the virtual marginal cost is above the marginal cost there is more entry when the regulator ignores the incumbent's marginal cost θ (it simply comes from proposition 4.4) and there could be entry of a less efficient competitor (typically it will be the case with the single access charge for high values of θ).

However, integrating this second source of asymmetric information in

[15]More intense competition on the downstream market would limit the market power of the entrants and could be an instrument to limit the distortions induced by the single-tariff.

[16]If the regulator knows that θ is distributed according to a continuous density function $f(\theta)$, the virtual marginal cost is $z(\theta) = \theta + L(\theta)$ where $L(\theta)$ is the hazard function associated to the distribution $f(\theta)$.

the model creates non-concavities in the problem and the solution involves a certain amount of bunching. These non-concavities are inherent to the problems of regulation with endogenous market structure.[17] To keep the problem tractable, we assumed that the cost parameters of the historical operator are common knowledge.

The analysis so far neglected an important issue: the incentives of the network's owner for developing or expanding its network infrastructure and the incentives of the competitor to invest in its own network. The different access pricing formulas and the different resulting market structures generate different incentives to invest in the network capacity (see Gans, 2001). Integrating this dimension in the model is an important issue for future research.

[17]Caillaud (1990),Gautier and Mitra (2003).

A Proof of propositions

A.1 Proposition 3.2

Like in the monopoly case, we can integrate the binding participation constraint of the incumbent into the regulator's objective function. The regulator problem is then:[18]

$$\max_{q_i^f(\theta), A^f(\theta)} b\frac{q_i^f(\theta)^2}{2} + \int_{\phi=\underline{\theta}}^{\phi=k^f(\theta)} b\frac{(2q_i^f(\theta)+q_e^{f*})q_e^{f*}}{2\Delta}d\phi$$
$$+\lambda\left((\hat{P}^f(\theta)-\theta)q_i^f(\theta) + \frac{k^f(\theta)-\underline{\theta}}{\Delta}A^f(\theta) - C\right),$$

where q_e^{f*} is given by (3.1)

Taking the first order condition with respect to $A^f(\theta)$, we have:

$$\frac{\partial \hat{W}}{\partial A^f(\theta)} = \frac{A^f(\theta)b(1+6\lambda) - 2\sqrt{bA^f(\theta)}(\lambda(a-\underline{\theta}) - bq_i^f(\theta))}{2\Delta\sqrt{bA^f(\theta)}} = 0 \quad \text{(A.9)}$$

hence,

$$A^f(\theta) = \frac{4(P(q_i^f(\theta)) + (\lambda-1)a - \lambda\underline{\theta})^2}{b(1+6\lambda)^2}. \quad \text{(A.10)}$$

Taking the first order condition with respect to $q_i^f(\theta)$, incorporating the value of $A^f(\theta)$ given by (A.10), and solving for $q_i^f(\theta)$ we have: $q_i^f(\theta) = \frac{\lambda}{2\lambda-1}\frac{a-H^f(\theta)}{b}$, where: $H^f(\theta) = a - \frac{2\lambda-1}{\lambda}(c_1 + c_2\sqrt{h(\theta)})$ and

$$c_1 = \frac{[a(3+6\lambda(1+12\lambda)) - 4\overline{\theta}(1+6\lambda)^2 + \underline{\theta}(1+6\lambda(7+12\lambda))]}{27b(4\lambda^2-1)}, \quad \text{(A.11)}$$

$$c_2 = \frac{2(1+6\lambda)}{27b(4\lambda^2-1)} \quad \text{(A.12)}$$

[18] When the regulator allows for entry, the probability of entry depends on two variables of the regulatory mechanism: $q_i^f(\theta)$ and $A^f(\theta)$. As a consequence, the expected welfare is no longer quadratic as in the benchmark case but it becomes cubic. This is a potential source of non concavity in the problem.

and

$$h(\theta) = 9a^2(\lambda-1)^2+(2(1+6\lambda)\overline{\theta}-(3+3\lambda)\underline{\theta})^2-6a(\lambda-1)(\overline{\theta}(6\lambda-1)-\underline{\theta}(3\lambda-2))$$

$$-2\underline{\theta}^2 - \underline{\theta}\overline{\theta}(10 - 72\lambda^2) - 54\theta\Delta\theta\lambda(1 + 2\lambda) \qquad \text{(A.13)}$$

We observe that $\frac{\partial h(\theta)}{\partial\theta} < 0$ and $h(\theta) > 0$ for all $\theta \in [\underline{\theta}, \overline{\theta}]$. Hence, $H^f(\theta)$ is an increasing and convex function of θ. The solution is found by replacing the optimal value of $q_i^f(\theta)$ in (A.10).

The solution is valid if $k^f(\theta) \geq \underline{\theta}$. Taking the optimal values of $A^f(\theta)$ and $q_i^f(\theta)$, this condition is satisfied if:

$$\theta \geq \hat{\theta} = \frac{(1 + 2\lambda)\underline{\theta} + (\lambda - 1)a}{3\lambda}. \qquad \text{(A.14)}$$

$\hat{\theta}$ is strictly greater than $\underline{\theta}$ iff $\lambda > 1$. Hence, for $\lambda > 1$ and $\theta \in [\underline{\theta}, \hat{\theta}]$, the above solution is not valid since the associated value of $k^f(\theta)$ is smaller than the lowest possible entrant's cost $\phi = \underline{\theta}$. For $\theta \in [\underline{\theta}, \hat{\theta}]$, the regulator maximizes the expected welfare taking $k^f(\theta) = \underline{\theta}$. This corresponds to an access charge given by:

$$A^f(\theta) = \frac{(P(q_i^f(\theta)) - \underline{\theta})^2}{4b}. \qquad \text{(A.15)}$$

Without entry, the regulator selects quantity $q_i^f(\theta)$ and transfer $t^f(\theta)$ that corresponds to the regulated monopoly case.

The second order conditions of the above problem guarantee that the solution described is indeed a maximum.

A.2 Proposition 3.3

Like in proposition 3.2, we integrate the transfer $t^v(\theta)$ given by the bidding participation constraint in the objective function, which is cubic in both $q_i^v(\theta)$ and $\alpha^v(\theta)$. The first order condition with respect to $\alpha^v(\theta)$ gives two solution for $\alpha^v(\theta)$: (1) $\alpha^v(\theta) = P(q_i^v(\theta)) - \underline{\theta}$, which implies a total entry ban and (2)

$$\alpha^v(\theta) = \frac{(a-\underline{\theta})(2\lambda-1) + bq_i^v(\theta)(2\lambda-3)}{6\lambda-1}. \tag{A.16}$$

Taking the first order condition with respect to $q_i^v(\theta)$, incorporating the value of $\alpha^v(\theta)$ given by (A.16), and solving for $q_i^v(\theta)$ gives the following solution: $q_i^v(\theta) = \frac{\lambda}{2\lambda-1}(a - H^v(\theta))$ where: $H^v(\theta) = a - \frac{2\lambda-1}{\lambda}(c_1 + c_2\sqrt{h(\theta)})$,

$$c_1 = \frac{1}{8b(2\lambda-1)^2}[a\lambda(2\lambda-1) - \overline{\theta}(6\lambda-1)^2 + \underline{\theta}(1-4\lambda 20\lambda^2)], \tag{A.17}$$

$$c_2 = \frac{(6\lambda-1)\sqrt{\Delta}}{8b(2\lambda-1)^2} \tag{A.18}$$

and

$$h(\theta) = \overline{\theta}(6\lambda-1)^2 - \underline{\theta}(1+2\lambda)^2 - 16\theta(2\lambda-1)\lambda \tag{A.19}$$

$\frac{\partial h(\theta)}{\partial\theta} < 0$ and clearly $H^v(\theta)$ is an increasing and convex function of θ. The solution is found by replacing the optimal value of $q_i^v(\theta)$ in (A.16). At that point, $k^v(\theta) \geq \underline{\theta}$ for all $\theta \in [\underline{\theta}, \overline{\theta}]$.

The second order conditions of the above problem guarantee that the solution described is indeed a maximum.

A.3 Proposition 4.4

1) We first prove that $k^v(\theta) < \theta$ for all $\theta \in (\underline{\theta}, \overline{\theta})$: (1) $k^v(\theta)$ is increasing and convex in θ; (2) simple computation gives $k^v(\underline{\theta}) = \underline{\theta}$ and $k^v(\overline{\theta}) = \overline{\theta}$. Hence $k^v(\theta) < \theta$ for all $\theta \in (\underline{\theta}, \overline{\theta})$.

Similarly, $k^f(\theta)$ is increasing in θ in the range $[\hat{\theta}, \overline{\theta}]$, with $k^f(\hat{\theta}) = \underline{\theta}$ and $k^f(\overline{\theta}) < \overline{\theta}$. Hence, $k^f(\theta) < \theta$ for all $\theta \in (\underline{\theta}, \overline{\theta}]$.

2) Ignoring the region $[\underline{\theta}, \hat{\theta}]$ where $k^f(\theta) = \underline{\theta}$, we can express the entry points as: $k^f(\theta) = f_1 + f_2\sqrt{f_3 + f_4\theta}$ and $k^v(\theta) = f_5 + f_6\sqrt{f_7 + f_8\theta}$, where f_i, $i = 1, ..., 8$ are constant depending on the parameters of the model. The equation $f_1 + f_2\sqrt{f_3 + f_4\theta} = f_5 + f_6\sqrt{f_7 + f_8\theta}$ has two roots θ' and θ''. θ'

is smaller or equal (when $\lambda = 1$) to $\underline{\theta}$. Given that $k^v(\underline{\theta} + \epsilon) > k^f(\underline{\theta} + \epsilon)$, the other root θ'' is necessarily outside the interval $(\underline{\theta}, \overline{\theta}]$.

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